

(19)



(11)

EP 2 868 353 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
06.05.2015 Bulletin 2015/19

(51) Int Cl.:
A63B 53/04 (2015.01)

(21) Application number: **14191362.4**

(22) Date of filing: **31.10.2014**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME

(30) Priority: **04.11.2013 US 201361899724 P**

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(54) **Iron-type golf clubs and golf club heads with contoured surfaces**

(57) Iron-type golf club heads according to at least some example aspects of this disclosure include a ball striking surface, a rear surface, and a sole surface. The sole surface may have a maximum width and a minimum width. The minimum width may be located adjacent to a heel edge. The maximum width may be located between a ball striking centerline and a toe edge. The width of the sole surface may monotonically increase from the mini-

mum width to the maximum width. Further, a sole trailing edge may have an S-shaped profile that extends between the maximum width and the minimum width. A lower rear surface region may have a substantially flat portion located to the toe-side of the centerline and an indented, complexly-curved portion located to the heel-side of the centerline.

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Description**FIELD OF THE DISCLOSURE**

5 **[0001]** The present disclosure relates to golf clubs and golf club heads. Particular example aspects of this disclosure relate to iron-type golf clubs and iron-type golf club heads.

BACKGROUND

10 **[0002]** Golf is enjoyed by a wide variety of players - players of different genders and dramatically different ages and/or skill levels. Golf is somewhat unique in the sporting world in that such diverse collections of players can play together in golf events, even in direct competition with one another (e.g., using handicapped scoring, different tee boxes, in team formats, etc.), and still enjoy the golf outing or competition. These factors, together with the increased availability of golf programming on television (e.g., golf tournaments, golf news, golf history, and/or other golf programming) and the rise
15 of well-known golf superstars, at least in part, have increased golf's popularity in recent years, both in the United States and across the world.

[0003] Golfers at all skill levels seek to improve their performance, lower their golf scores, and reach that next performance "level." Manufacturers of all types of golf equipment have responded to these demands, and in recent years, the industry has witnessed dramatic changes and improvements in golf equipment.

20 **[0004]** Being the sole instrument that sets a golf ball in motion during play, golf clubs have been the subject of much technological research and advancement in recent years. For example, the market has seen dramatic changes and improvements in putter designs, golf club head designs, shafts, and grips in recent years. In certain examples, different golf club head geometries have been developed to provide certain ball striking benefits to the golfer. Such geometries, however, can also affect other characteristics of the golf club head such as center of gravity, moment of inertia, etc.
25 Additionally, other technological advancements have been made in an effort to better match the various elements and/or characteristics of the golf club and characteristics of a golf ball to a particular user's swing features or characteristics (e.g., club fitting technology, ball launch angle measurement technology, ball spin rates, etc.).

[0005] While the industry has witnessed dramatic changes and improvements to golf equipment in recent years, there is room in the art for further advances in golf club technology as prior art designs continue to have certain limitations.
30 The present invention seeks to overcome certain of these limitations and other drawbacks of the prior art, and to provide new features not heretofore available.

SUMMARY OF THE DISCLOSURE

35 **[0006]** The following presents a general summary of aspects of the disclosure in order to provide a basic understanding of the disclosure and various aspects of it. This summary is not intended to limit the scope of the disclosure in any way, but it simply provides a general overview and context for the more detailed description that follows.

[0007] Iron-type golf club heads according to at least some example aspects of this disclosure include a ball striking surface, a rear surface, and a sole surface. The sole surface may extend rearward from a sole leading edge to a sole trailing edge and may extend lengthwise from a sole heel edge to a sole toe edge. The sole surface may have a maximum width and a minimum width. The minimum width may be located adjacent to the sole heel edge. Optionally, the minimum width may be located between a heel-side boundary line and the ball striking centerline. The maximum width may be located between the ball striking centerline and the sole toe edge. Optionally, the maximum width may be located between the centerline and a toe-side boundary line. The width of the sole surface may monotonically increase from the minimum width to the maximum width, from the sole heel edge to the centerline, and/or from the heel-side boundary line to the centerline. According to certain embodiments, the sole trailing edge may have an S-shaped profile (*i.e.*, a convex curvature and a concave curvature with a point of inflection therebetween) that extends between the maximum width and the minimum width.

[0008] Iron-type golf club heads according to other example aspects of this disclosure include a ball striking surface configured for striking a ball and having a grip-enhancing area defining a heel-side boundary line, a toe-side boundary line and a ball striking centerline. The club head further includes a rear surface opposite the ball striking surface. The rear surface may have an upper rear surface region, a lower rear surface region and an interface line defining the boundary therebetween. The upper rear surface region may be oriented substantially parallel to the ball striking surface and may be bounded by the upper edge and the interface line. The lower rear surface region may have a toe-side portion that extends at least from the ball striking centerline to the toe-side boundary line. Further, the toe-side portion may be oriented substantially vertically when the club head is in a reference position. The lower rear surface region may also have a heel-side portion that extends from the toe-side portion to the heel. The heel-side portion may have a rear profile dimension measured perpendicular to the ball striking surface that monotonically decreases as it approaches the heel.

[0009] Iron-type golf club heads according to even other example aspects of this disclosure include a ball striking surface configured for striking a ball and having a grip-enhancing area defining a heel-side boundary line, a toe-side boundary line and a ball striking centerline. The club head further includes a rear surface opposite the ball striking surface, the rear surface having an upper rear surface region, a lower rear surface region and an interface line defining the boundary therebetween. The club head includes a sole surface extending rearward from the ball striking surface to the rear surface and extending from a heel edge to a toe edge. The sole surface has a maximum width and a minimum width, the widths measured horizontally when the club head is in a reference position. The width of the sole surface may monotonically increase from the heel edge to the centerline. When viewed from above and parallel to the ball striking surface, the lower rear surface region may have a complexly-curved rear profile that monotonically increases as it extends from the heel edge to the centerline. Further, the lower rear surface region may have a convexly-curved rear profile extending between the centerline and the toe edge.

[0010] Additional aspects of this disclosure relate to golf club structures that include golf club heads, *e.g.*, of the types described above. Such golf club structures further may include one or more of: a shaft member attached to the club head (optionally via a separate hosel member or a hosel member provided as an integral part of one or more of the club head or shaft); a grip or handle member attached to the shaft member; additional weight members; etc. Additional aspects of this disclosure relate to ball striking devices as described above for a golf club head or golf club structure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present disclosure is illustrated by way of example and not limited in the accompanying figures, in which like reference numerals indicate similar elements throughout.

FIG. 1 is a rear perspective view of an illustrative embodiment of a golf club structure having a golf club head according to aspects of the disclosure.

FIG. 2 is a bottom-angled rear perspective view of the golf club head illustrated in FIG. 1 according to aspects of the disclosure.

FIG. 3 is a bottom perspective view of the golf club head illustrated in FIG. 1 according to aspects of the disclosure.

FIG. 4 is a rear perspective view of the golf club head illustrated in FIG. 1 according to aspects of the disclosure.

FIG. 5 is top-angled rear perspective view of the golf club head illustrated in FIG. 1 according to aspects of the disclosure.

FIG. 6 is a rear-angled heel-side perspective view of the golf club head illustrated in FIG. 1 according to aspects of the disclosure.

FIG. 7 is a front perspective view of the golf club head illustrated in FIG. 1 according to aspects of the disclosure.

FIG. 8A is a cross-sectional view of the golf club head illustrated in FIG. 1 taken along Line L1-L1 in FIG. 3 according to aspects of the disclosure.

FIG. 8B is a cross-sectional view of the golf club head illustrated in FIG. 1 taken along Line L2-L2 in FIG. 3 according to aspects of the disclosure.

FIG. 8C is a cross-sectional view of the golf club head illustrated in FIG. 1 taken along Line L3-L3 in FIG. 3 according to aspects of the disclosure.

FIG. 8D is another cross-sectional view of the golf club head illustrated in FIG. 1 taken along Line L1-L1 in FIG. 3 according to aspects of the disclosure.

FIG. 9 is a top perspective view of a prior art golf club head.

FIG. 10 is a top perspective view of the golf club head illustrated in FIG. 1 according to aspects of the disclosure.

FIG. 11A is a front perspective view of a prior art golf club head.

FIG. 11B is a cross-sectional view of the prior art golf club head illustrated in FIG. 11A taken along Line 11B-11B in FIG. 11A.

FIG. 12A is a front perspective view of the golf club head illustrated in FIG. 1 according to aspects of the disclosure.

FIG. 12B is a cross-sectional view of the golf club head illustrated in FIG. 1 and 12A taken along Line 12B-12B in FIG. 12B according to aspects of the disclosure.

[0012] It should be understood that the appended drawings are not necessarily to scale, presenting a somewhat simplified representation of various features illustrative of specific aspects of the invention. Certain features of the illustrated embodiments may have been enlarged or distorted relative to others to facilitate visualization and clear understanding. In particular, thin features may be thickened, for example, for clarity of illustration.

DETAILED DESCRIPTION

[0013] In the following description of various examples of the invention, reference is made to the accompanying drawings, which form a part hereof, and in which are shown by way of illustration various example structures, systems, and steps in which aspects of the invention may be practiced. It is to be understood that other specific arrangements of parts, structures, example devices, systems, and steps may be utilized and structural and functional modifications may be made without departing from the scope of the present invention. Also, while the terms "top," "bottom," "front," "back," "side," and the like may be used in this specification to describe various example features and elements of the invention, these terms are used herein as a matter of convenience, e.g., based on the example orientations shown in the figures and/or the orientation at the reference position. Nothing in this specification should be construed as requiring a specific three dimensional orientation of structures in order to fall within the scope of this invention.

[0014] As described above, aspects of this disclosure relate to iron-type golf club heads and golf clubs. Iron-type golf club heads according to at least some example aspects of this disclosure may have a contoured rear surface and/or a contoured sole surface. The contoured sole surface according to at least some examples of this disclosure may provide heel relief. Heel relief may be defined as the combination of the removal of material from the heel of the sole with smooth or soft transition edges, which allows for the club sole to lie at an angle and opens the face and increases lift. For example, heel relief may provide the ability for a consumer-type golfer to perform well in the bunker and in turf-type conditions. Heel relief generally provides and allows a wider, more stable sole surface in the toe-side of the club head.

[0015] Iron-type golf clubs generally can generally be divided into three categories: blades, muscle backs, and cavity backs. Typically, the thickness of the blades are substantially uniform from heel to toe and from sole to top line, although there may be some tapering from sole to top line. Further, the rear surface of a blade-type club head generally has a substantially planar appearance. Typically, a muscle back type club head resembles a blade with an extra ridge of material, i.e., a thickened portion, located on the rear surface. The extra ridge of material may be formed as a rib that extends from the heel to the toe and may be positioned toward the bottom of the club head to thereby lower the club head center of gravity. A cavity back type club head typically is provided with a thickened portion located on the rear surface of the club head that extends around the perimeter of the club head and defines a cavity or recess within its boundaries. The dimensions of the thickened portion may be constant around the perimeter or the thickness and/or width may vary. Often the thickened portion of a cavity back type club head has its greatest cross-section along the lower edge of the perimeter.

[0016] A club head with a lower center of gravity than the ball center of gravity may facilitate getting the golf ball airborne. Because blade and muscle back designs generally have a small "sweet spot," which is a term that refers to the area of the face that results in a desirable golf shot upon striking a golf ball, these designs are typically only used by skilled golfers. However, these designs allow the skilled golfer a greater degree of control over the well-hit ball.

[0017] Given the general description of various example aspects of the disclosure provided above, more detailed descriptions of various specific examples of golf clubs and golf club head structures according to the disclosure are provided below.

[0018] The following discussion and accompanying figures describe various example golf clubs and golf club head structures in accordance with the present disclosure. When the same reference number appears in more than one drawing, that reference number is used consistently in this specification and the drawings to refer to the same or similar parts throughout.

[0019] Examples and features of iron-type golf club heads and golf club structures according to this disclosure will be described in detail below in conjunction with the example golf club structures illustrated in FIGS. 1-8D, 10, 12A, and 12B. In more specific aspects of the invention, the examples and features of the iron-type golf club heads and golf club structures may be representative of wedge-type golf clubs and golf club heads, i.e., pitching wedge, lob wedge, gap wedge, sand wedge. Wedge-type clubs may also be listed or identified by loft angle in degrees, i.e., 48-degree wedge,

50-degree wedge, 53-degree wedge, 59-degree wedge, 62-degree wedge as some examples. Without departing from this invention, any degree wedge (or named wedge) may be utilized using the below described invention.

[0020] FIG. 1 generally illustrates an example of an iron-type golf club 100 according to aspects of the disclosure. As seen in FIG. 1, the iron-type golf club head 100 may include a golf club head 102 in accordance with the present disclosure. In addition to the golf club head 102, the overall golf club structure 100 of this example may include a hosel 104, a shaft member 106 received in and/or inserted into and/or through the hosel 104, and a grip or handle member 108 attached to the shaft member 106 or be considered a part of the shaft member 106. Shaft member 106 defines an axis 106a extending along its centerline.

[0021] Optionally, if desired, the hosel 104 may be eliminated and the shaft member 106 may be directly inserted into and/or otherwise attached to the golf club head 102 (e.g., through an opening provided in the top of the club head 102, through an internal hosel member (e.g., provided within an interior chamber defined by the club head 102), etc.). The hosel 104 may be integrally formed as part of the club head structure 102, or it may be separately formed and engaged therewith (e.g., by adhesives or cements; by welding, brazing, soldering, or other fusing techniques; by mechanical connectors; etc.). Conventional hosels and their inclusion in an iron-type club head structure may be used without departing from this disclosure.

[0022] The shaft member 106 may be received in, engaged with, and/or attached to the club head 102 in any suitable or desired manner, including in conventional manners known and used in the art, without departing from the disclosure. As more specific examples, the shaft member 106 may be engaged with the club head body 102 via the hosel 104 and/or directly to the club head structure 102, e.g., via adhesives, cements, welding, soldering, mechanical connectors (such as threads, retaining elements, or the like), etc.; through a shaft-receiving sleeve or element extending into the club head 102; etc. If desired, the shaft 106 may be connected to the golf club head 102 in a releasable manner using mechanical connectors to allow easy interchange of one shaft for another on the head.

[0023] The shaft member 106 also may be made from any suitable or desired materials, including conventional materials known and used in the art, such as graphite based materials, composite or other non-metal materials, steel materials (including stainless steel), aluminum materials, other metal alloy materials, polymeric materials, combinations of various materials, and the like. Also, the grip or handle member 108 may be attached to, engaged with, and/or extend from the shaft member 106 in any suitable or desired manner, including in conventional manners known and used in the art, e.g., using adhesives or cements; via welding, soldering, brazing, or the like; via mechanical connectors (such as threads, retaining elements, etc.); etc. As another example, if desired, the grip or handle member 108 may be integrally formed as a unitary, one-piece construction with the shaft member 106. Additionally, any desired grip or handle member materials may be used without departing from this disclosure, including, for example: rubber materials, leather materials, rubber or other materials including cord or other fabric material embedded therein, polymeric materials, and the like.

[0024] Aspects of the disclosure relate to particular structures of the golf club head 102. FIGS. 1-8D, 10, 12A, and 12B illustrate various views of a golf club head 102 according to one embodiment of this disclosure. As seen in FIGS. 2-8D, the golf club head 102 may include a heel 110, a toe 112, a ball striking surface 114, a rear surface 116, a top surface 118 and a sole surface 120.

[0025] According to aspects of the disclosure, as illustrated in FIGS. 1-8D, 10, 12A, and 12B, the heel 110 may be located generally adjacent to the hosel 104. The toe 112 may be located generally opposite the heel 110 and the hosel 104. Additionally, the ball striking surface 114 (FIG. 7) may be located generally at the front of the golf club head 102 and the ball striking surface 114 may be used to strike a golf ball. The ball striking surface 114 may extend generally from the heel 110 to the toe 112. The ball striking surface 114 forms an angle relative to the ground (i.e., the loft angle) when the club is oriented in a reference position.

[0026] FIGS. 7-8D illustrate a golf club head 102 oriented in a reference position. In the reference position, the shaft axis 106a (and/or hosel axis) lies in a vertical plane as shown in Fig. 8A-8D.

[0027] As illustrated in FIG. 7, the shaft axis 106a (and/or hosel axis 128) may be oriented at a lie angle. A lie angle is defined as the angle formed between the shaft axis 106a and a horizontal plane contacting the sole surface 120, which may be the ground plane. The lie angle selected for the reference position may be the golf club 100 manufacturer's specified lie angle. If a specified lie angle is not available from the manufacturer, a lie angle of approximately 64 degrees may be used for wedges, depending on shaft length and/or club head geometry, as would be understood by one of ordinary skill in the art. For example, a contemporary wedge may be oriented at a lie angle of 64 about degrees. The face may be oriented at a loft angle and face angle for the reference position at the golf club manufacturer's specified loft and face angles.

[0028] A loft angle is defined as a measurement between an axis normal or perpendicular to a face center axis and an axis normal or perpendicular to the ground plane. The face center axis is defined as the axis from the face center Cs and normal to the face 114. Similarly, the loft angle may be defined as a measurement between a face center axis and the ground plane. It is recognized that each of these loft angle definitions may yield a similar or exactly the same loft angle measurement. Additionally, a face angle is measured by utilizing the face center axis and a right plane or a plane perpendicular to the X axis.

[0029] Club head parameters or characteristics may be measured physically, or in a computer-aided-design (CAD) environment. Generally, if a 3-dimensional (3D) model of club head 102 is not readily available, one may be created by performing a 3D scan of the interior and exterior of a physical example of the club head 102 and creating a model file from the scan data and/or physical measurements, such that the model is substantially representative of the physical club head. In the CAD environment, the model of club head 102 may be set in the reference position with the face 110 oriented at the base face angle and/or the base loft angle within the CAD environment such that the model is fully constrained.

[0030] In another aspect of this invention, the golf club 100 may be physically oriented in the reference position using a fixturing system. As was described above, the shaft axis 106a (and/or hosel axis) may be aligned at a lie angle according to the golf club manufacturer's specification, or at an appropriate lie angle as determined by one of skill in the art. The golf club head 102 may rest with its sole surface 120 contacting a horizontal surface or ground plane with the ball striking face 114 positioned at the face angle and/or loft angle using conventional loft and face angle measurement gauges known to one of skill in the art.

[0031] Referring to FIG. 7, the ball striking surface 114 has a generally flat or planar surface extending from the sole surface 120 to the top surface 118 and from the toe 112 to a front-surface heel-side line 111. The front-surface heel-side line 111 (shown dashed) demarcates where the generally flat ball striking surface 114 joins a curved transition surface that extends into the hosel 104. The ball striking surface 114 has a length L defined in a heel-to-toe direction from the toe 112 to the front-surface heel-side line 111 and a height H defined in a top-to-bottom direction from the top surface 118 to the ground. The length L is measured horizontally and the height H is measured vertically when the club is in the reference position.

[0032] Further, the ball striking surface 114 may be provided with score lines 115, grooves, or other surface features or textures enhancing the ability of the club head to grip the golf ball during impact. A grip-enhanced area or a ball striking area 114a may be generally defined by a heel-side score line (or other grip-enhancing surface feature) boundary L1 (shown dashed) and a toe-side score line (or other grip-enhancing surface feature) boundary L2 (shown dashed) and by segments of the top and bottom perimeter edges 118, 120 of the ball striking surface 114 extending between by those heel-side and toe-side boundary lines L1, L2. Thus, the ball striking area 114a has a length L_S (extending between boundary L1 and boundary L2) and a height H_S (extending between top edge 118 and sole surface 120). Generally, this height increases in the toe direction. A centerline L3 of the ball striking area 114a may be located halfway along the length L_S of the ball striking area 114a. A face center C_S of the ball striking area 114a may be located halfway along the height H_S at the centerline L3 (see FIG. 7). (Lines L1, L2 and L3 may be associated with through-the-thickness cross-sections as illustrated in FIG. 3 and FIGS. 8A, 8B and 8C, respectively. Thus, points on the rear surface 116 and/or on the sole surface 120 may be defined by reference to lines L1, L2 and/or L3.)

[0033] According to aspects of the invention, and referring also to FIGS. 1 and 8A-8C, the club head 102 may be characterized as having a blade-type portion 130 and a thickened portion 140 (i.e., a portion of the club head 102 that is generally thicker than the blade portion 130). The blade portion 130 generally is provided in the upper portion of the club head 102 and the thickened portion 140 is generally provided in the lower portion of the club head 102.

[0034] The blade portion 130, which is relatively thin, generally encompasses the entire upper portion of the club head 102. According to some embodiments, the blade portion 130 may have a substantially constant thickness T_B (see FIGS. 8A-8C) that may be less than, for example, about 6.35 mm. The thickness T_B is measured perpendicular to the ball striking surface 114. According to other embodiments, the blade portion 130 may have a thickness T_B that varies from top to bottom. For example, the thickness T_B of the blade portion 130 may gradually increase, with the minimal thickness being at the top. Other variations in thickness T_B of the blade portion 130 may be apparent to persons of ordinary skill in the art. For example, the thickness T_B of the blade portion 130 may gradually and monotonically increase from the heel 110 to the toe 112. Optionally, the blade portion 130 may have localized reinforcement ribs or perimeter weighting (not shown).

[0035] The thickened portion 140 generally is provided on a lower portion of the club head 102 and allows for the redistribution of weight within the club head 102. Thus, this thickened portion 140 may help balance the club head 102 thereby improving the swing dynamics of the user and the trajectory of the struck golf ball. When compared to a conventional blade-type club head, the thickened portion 140 may shift the center of gravity downward and toward the toe. When compared to a conventional muscle back-type club head, the thickened portion 140 may shift the center of gravity toward the toe. The thickened portion 140 has a thickness T_C (see FIGS. 8A-8C) that is everywhere greater than that of the blade portion 130. The thickness T_C , which is measured perpendicular to the ball striking surface 114, varies across the length and height direction of the club head 102.

[0036] According to some aspects and referring back to FIG. 2 and to FIGS. 8A-8C, the lower rear surface region 116b defines one side of a thickened area, i.e., the thickened portion 140 of the club head 102. A second side of the thickened portion 140 is defined by the sole surface 120. A third side of the thickened portion 140 is defined by the ball striking surface 114. Thus, the cross-sectional shape of the thickened portion 140 may be generally triangular.

[0037] The rear surface 116 is located at the rear or back of the golf club head 102 opposite the ball striking surface

114. The rear surface 116 extends generally from the heel 110 to the toe 112 and from the top 118 to the sole 120. Referring to the figures, the rear surface 116 includes two general regions: an upper rear surface region 116a and a lower rear surface region 116b. The upper rear surface region 116a is associated with the blade-type portion 130 and the lower rear surface region 116b is associated with the thickened portion 140.

[0038] Referring to FIG. 1 and to FIGS. 8A-8C, the lower rear surface region 116b may be generally demarcated from the upper rear surface region 116a at a transition region 121 (represented by contour lines). Typically, there will be no sharp boundary separating the lower rear surface region 116b and the upper rear surface region 116a, such as in the case of the embodiment shown in the figures, and the transition between the lower rear surface region 116b and the upper rear surface region 116a will be provided as a gradually curved surface. In such case, an interface line 121 a may be defined between the upper rear surface region 116a and the lower rear surface region 116b by the set of points where a line angled 45 degrees from the ball striking surface 114 tangentially contacts the surface in the transition region 121.

[0039] According to certain aspects, the transition region 121 on the toe-side of the club head 102 (and therefore, also, the interface line 121a) may be located in the middle third of the height dimension H (see FIG. 1) of the ball striking surface 114. Optionally, the transition region 121 on the toe-side of the club head 102 may be located in the middle quintile of the height dimension H of the ball striking surface 114. Even more preferably, the transition region 121 on the toe-side of the club head 102 may be located in the range between 45 to 55 percent of the height dimension H of the ball striking surface 114. According to some embodiments, the interface line 121 a defines the boundary between the upper blade-type portion 130 and the lower thickened portion 140 and, at the centerline L3, the interface line 121 a approximately bisects the height H of the ball striking surface 114. On the heel-side of the club head 102, the transition region 121 may become less defined that the transition region on the toe-side. Further, the transition region 121 on the heel-side of the club head 102 may dip down toward the sole surface 120.

[0040] According to some aspects, the interface line 121a on the toe-side of the club head 102 may be oriented at a slight angle to the horizontal (when the club is in the reference position). For example, the interface line 121a on the toe-side of the club head 102 may angle upward as it extends away from the heel 110 and toward the toe 112. Alternatively, the interface line 121 a on the toe-side of the club head 102 may be oriented substantially parallel to the horizontal (when the club is in the reference position). In certain embodiments, the transition region 121 and/or the interface line 121a may have a slight curvature. For example, the interface line may have a slight downwardly-facing concave curvature when the club head 102 is viewed from the rear. The curvature of the transition region 121 and of the interface line 121a may increase on the heel-side of the club head 120. In other embodiments, the transition region 121 and/or the interface line 121 may be substantially straight.

[0041] Thus, in accordance with aspects of this invention, the upper rear surface region 116a may be provided as a substantially flat area or a generally planar surface. A substantially flat area will be flat with the possible exception of relatively minor radii of curvature at perimeter transition regions. A generally planar surface may be provided with an overall gentle curvature or regions of gentle curvature such that the overall surface slightly departs from the planar as either a convexly curved or a concavely curved surface. Optionally, a generally planar surface may be provided as a smooth complexly-curved surface. In such instance, the generally planar surface may have regions of both very shallow convex curvature and very shallow concave curvature. The upper rear surface region 116a (in conjunction with the upper portion of the ball striking surface 114 defines a blade portion 130 of the club head 102. The upper rear surface region 116a (and the upper portion of the ball striking surface 114) extends across the entire length of the upper portion of the club head 102. According to certain embodiments, the upper rear surface region 116a and the upper portion of the ball striking surface 114 may be parallel or substantially parallel to each other (e.g., within 2 degrees).

[0042] Referring now to FIGS. 1 and 4, the lower rear surface region 116b will now be described. The lower rear surface region 116b is located adjacent the toe and extends a majority of the way toward a rear-surface heel-side edge 113. The rear-surface heel-side line 113 (shown dashed in FIGS. 1, 2 and 4) demarcates where the rear surface 116 transitions to the heel surface 110. Typically, there will be a curved transition region separating the rear surface 116 from the heel surface 110, such as in the embodiment shown in the figures. In such case, the rear-surface heel-side line 113 may be defined between the rear surface 116 and the heel surface 110 by the set of points where a line angled 45 degrees from the ball striking surface 114 tangentially contacts the surface in the heel-to-rear transition region.

[0043] In accordance with aspects of the invention, the lower rear surface region 116b has a more complex surface geometry than the upper rear surface region 116a. The lower rear surface region 116b may be apportioned into to portions: P1 and P2. Referring to FIGS. 1, 2, 4, 5, 8B and 8C, a first portion P1 of the lower rear surface region 116b may be formed as a substantially flat surface area and the second portion P2 may be formed as a complexly and smoothly curved indentation or hollow. The first portion P1 is located closer to the toe than is the second portion P2 and thus, the first portion P1 may be referred to as a toe-side portion and the second portion P2 may be referred to as a heel-side portion. According to certain embodiments, the first portion P1 of the lower rear surface region 116b may extend across approximately two-thirds of the length L of the club head 102 and the second portion P2 of the lower rear surface region 116b may extend approximately one-third of the length L of the club head 102.

[0044] The first portion P1 of the lower rear surface region 116b extends from the upper rear surface region 116a at

an angle A (see FIG. 8D). The first portion P1 is located adjacent to the toe 112 of the club head 102 and extends from the toe 112 toward the centerline L3. Further, the first portion P1 may extend from the toe 112 to the centerline L3 and/or beyond or past the centerline L3. Thus, the first portion P1 of the lower rear surface region 116 may extend across a majority of the length L of the club head 102. Further, the first portion P1 may extend across a majority of the length L_S of the ball striking area 114a.

[0045] The substantially flat area of the first portion P1 of the lower rear surface region 116b extends at an angle A to the substantially flat area of the upper rear surface region 116a. This is illustrated schematically in FIG. 8D, where line a_1 represents the substantially flat surface of upper rear surface region 116a and line a_2 represents the substantially flat surface of lower rear surface region 116b. Line a_1 may be determined as a least-squares fit of the contour of the upper rear surface region 116a and line a_2 may be determined as a least-squares fit of the contour of the lower rear surface region 116b.

[0046] According to certain aspects, the angle A between the upper rear surface region 116a and first portion P1 of the lower rear surface region 116b may be an obtuse angle (see FIGS. 8B and 8C). According to some embodiments, the angle A may equal to 130 degrees $\pm$ 30 degrees. Optionally, the angle A may be a function of the loft angle of the club head. For example, the angle A may generally equal to 180 degrees minus the loft angle ($\pm$ 20 degrees). According to certain embodiments, the line representing a least-squares fit of the contour of the lower rear surface region 116b at lines L2 and L3 may be substantially parallel ($\pm$ 10 degrees) to the longitudinal axis 106a of the shaft 106. Thus, when the club head 102 is in the reference position, the first portion P1 of the lower rear surface region 116b may be oriented substantially vertically. Further, the first portion P1 of the lower rear surface region 116b may extend parallel to the length of the club head 102.

[0047] Referring to FIGS. 1-5 and 8A, a second portion P2 of the lower rear surface region 116b may be formed as a complexly curved surface that smoothly and tangentially merges with the substantially flat or generally planar surface of the first portion P1 and with the substantially flat or generally planar surface of the upper rear surface region 116a. When merging with the first portion P1, the second portion P2 assumes a smooth, relatively shallow, convex curvature. When merging with the substantially flat or generally planar surface of the upper rear surface region 116a, the second portion P2 assumes a smooth, relatively shallow, concave curvature. For example, according to one embodiment, when viewed from below (see FIGS. 2 and 3), where the second portion P2 lies adjacent to the sole surface 120 (i.e., at perimeter edge 124), it has a relatively steep, approximately 45 degree slope as it extends away from the first portion P1 which then flattens to an approximately 0 degree slope as it merges with the heel 110. In some embodiments, this perimeter edge 124 may be slightly convex close to where it merges with the first portion P1 and slightly concave where it merges with the heel 110. Where the second portion P2 lies adjacent to the upper rear surface region 116a, it has a relatively constant slope of between 10 to 30 degrees. In some embodiments, the intersection 121 between the upper rear surface region 116a and the second portion P2 of the lower rear surface region 116b may be slightly convex as extends from the first portion P1 to the heel 110. Thus, the second portion P2 includes both convexly curved surfaces and concavely curved surfaces.

[0048] This second portion P2 is located adjacent the heel 110 of the club head 102 and extends from the heel 110 toward the centerline L3. According to some embodiments, the second portion P2 does not extend behind the centerline L3 of the ball striking area 114a. Thus, the second portion P2 may extend across a minority of the length L_S of the ball striking area 114a.

[0049] As shown in FIGS. 5 and FIGS. 8A-8C, the lower rear surface region 116b may include profile measurements T1, T2, and T3. These profile measurements T1, T2 and T3 are a measure of the distance between the ball striking surface 114 and a perimeter edge 124 of the lower rear surface region 116b. These profile measurements T1, T2, T3 are also a measure of the maximum thickness of the thickened portion 140. The perimeter edge 124 of the lower rear surface region 116b is defined as the intersection of the lower rear surface region 116b with the sole surface 120 and thus, may also be referred to as the sole trailing edge 124, as will be discussed further below. Profile dimension T1 is measured perpendicular to the ball striking surface 114 at the L1 cross-section (see FIG. 8A); profile dimension T2 is measured perpendicular to the ball striking surface 114 at the L2 cross-section (see FIG. 8B); and profile dimension T3 is measured perpendicular to the ball striking surface 114 at the L3 cross-section (see FIG. 5 and also FIGS. 8A-8C). T1 may define a maximum dimension of the thickened portion 140 at the L1 cross-section. T2 may define a maximum dimension of the thickened portion 140 at the L2 cross-section. T3 may define a maximum dimension of the thickened portion 140 at the centerline L3.

[0050] According to certain embodiments, T3 is greater than T2. Optionally, T2 may be within 30% of the value of T3, or even within 20% of the value of T3. For example, T3 may be approximately 20 mm ($\pm$ 3 mm), and T2 may be approximately 15 mm ($\pm$ 2 mm). According to some embodiments, T3 is considerably greater than T1. Optionally, T3 may be more than 100% greater than the value of T1, more than 200% greater than the value of T1, or even more than 300% greater than the value of T1. For example, T3 may be approximately 20 mm ($\pm$ 3 mm), and T1 may be approximately 7 mm ($\pm$ 1 mm).

[0051] Additionally, referring back to FIGS. 1-3, the club head 102 includes a sole or a sole surface 120. The sole

surface 120 is located at the bottom of the club head 102 and provides a lower surface of the thickened portion 140. The sole surface 120 extends from the heel 110 to the toe 112. Further, the sole surface 120 extends from a leading edge 122 to a trailing edge 124. The sole surface 120 may be complexly curved, for example, having a curvature along the length of the club head and also along the width of the club head 102.

[0052] According to aspects of the invention, as best illustrated in FIGS 2, 3 and 6 and FIGS. 8A-8C, the sole surface 120 may have a front-to-back width that is relatively thick in a first sole portion S1 and relatively thin in a second sole portion S2. First sole portion S1 may generally be associated with the first rear surface portion P1 and second sole portion S2 may generally be associated with the second rear surface portion P2. Thus, first sole portion S1 is located adjacent the toe 112 and extends toward the heel 100 beyond line L2, possibly beyond line L3, but not reaching line L1. Second sole portion S2 is located adjacent the heel 110 and extends toward the toe 112 beyond line L1, but generally does not reach line L3.

[0053] According to some embodiments, the combined sole portions S1 and S2 provide a smooth, unbroken, gently convexly curved sole surface 120. In other words, according to these embodiments, the surface of the sole surface 120 provides no demarcation between the sole portions S1, S2. However, the widths of the sole portions S1, S2 do provide a means for distinguishing the portions. Sole portion S1 has a relatively constant, relatively wide width. Sole portion S2 has a width that varies from the relatively wide width of sole portion S1 to a relatively thin width away from sole portion S1. According to some embodiments, sole portion S2 has an S-shaped edge that causes the width to substantially decrease as sole portion S2 extends from sole portion S1 toward the heel 110.

[0054] Sole surface 120 may be defined, at least in part, by a sole leading edge 122 and a sole trailing edge 124. The sole leading edge 122 and the sole trailing edge 124 define opposite perimeter edges of the sole surface 120 and may generally extend from the heel 110 to the toe 112. The sole leading edge 122 is located at the intersection of a bottom edge of the ball striking surface 114 and the sole surface 120. When the ball striking surface 114 and the sole surface 120 are joined by a curved intersection, the sole leading edge 122 may be defined as the line where a 45 degree line relative to the horizontal ground plane is tangent to the curved intersection (in the vertical cross-section of the curved intersection). Similarly, the sole trailing edge 124 may be located generally opposite the sole leading edge 122 on the sole surface 120. When the rear surface 116 and the sole surface 120 are joined by a curved intersection, the sole trailing edge 124 may be defined as the line where a 45 degree line relative to the horizontal ground plane is tangent to the curved intersection (in the vertical cross-section of the curved intersection).

[0055] Additionally, referring particularly to FIGS. 1-3, the sole surface 120 may be further defined by a sole heel perimeter edge 126 and a sole toe perimeter edge 128. The sole heel edge 126 may be located generally near the heel side of the golf club head 102. The sole heel edge 126 may extend generally from the sole leading edge 122 to the sole trailing edge 124. Similarly, the sole toe edge 128 may be located generally near the toe side of the golf club head 102. The sole toe edge 128 may extend generally from the sole leading edge 122 to the sole trailing edge 124. As with the sole leading and trailing edges 122, 124, when the toe surface (or the heel surface) and the sole surface 120 are joined by a curved intersection, the sole toe edge 126 (or the sole heel edge 128) may be defined as the line where a 45 degree line relative to the horizontal ground plane is tangent to the curved intersection (in the vertical cross-section of the curved intersection).

[0056] The sole surface 120 of the present invention may be considered a contoured sole in comparison to the soles of conventional iron-type golf clubs and wedge-type golf club heads. Referring for example to FIGS. 2 and 3, viewed from below when the club head is in a reference position, the leading edge 122 of the sole surface 120 extends across both sole portions S1, S2 in a smooth, unbroken, very shallow convexly-curved line in a toe-to-heel direction. The trailing edge 124 of the sole surface 120 also extends in a smooth, unbroken, very shallow convexly-curved line in a toe-to-heel direction in the S1 sole portion. Further, the section of the trailing edge 124 in the first sole portion S1 may be generally oriented substantially parallel to the ball striking surface 114 and substantially parallel to the horizontal. However, the trailing edge 124 of the sole surface 120 in the second sole portion S2 assumes a complexly-curved shape, *i.e.*, having a convexly-curved portion and a concavely-curved portion. In the example embodiment shown, the trailing edge 124 assumes an S-shape profile in the S2 sole portion. For purposes of this disclosure, an S-shaped profile has a convex curvature and then a concave curvature with a point of inflection therebetween. The convex and concave curvatures need not be equal. The point of inflection need not be centered. Further, the curvatures may be shallow or deep. In the embodiment shown, the trailing edge 124 in the second sole portion S2 may be provided with a convex curvature that smoothly merges with the substantially linear section of the trailing edge 124 in the sole portion S1. As the trailing edge 124 extends further toward the heel its curvature smoothly and gradually changes to a concave curvature. The point of inflection may be approximately aligned with line L1.

[0057] Referring to FIG. 3 and as shown in FIGS. 8A-8C, the sole surface 120 may include three separate sole width measurements W1, W2 and W3. The sole widths W1, W2, W3 are measured as the horizontal distance between the sole leading edge 122 and the sole trailing edge 124, with the club head 102 at a reference position. Thus, the sole width measurements W1, W2, W3 may be defined as the horizontal distance on the regions of the sole surface 120 from the sole leading edge 122 to the sole trailing edge 124. W1 is associated with the L1 cross-section; W2 is associated

with the L2 cross-section; and W3 is associated with the L3 cross-section. W1 may be defined as a heel-side sole width measurement, measured at a location near or proximate to the sole heel edge 126. W2 may be defined as a toe-side sole width measurement, measured at a location near or proximate to the sole toe edge 128. W3 may be defined as a centerline sole width measurement, measured at the L3 cross-section, i.e., at a location approximately equidistant between W1 and W2.

[0058] Thus, according to certain aspects, the sole surface 120 may extend rearward from the sole leading edge 122 to the sole trailing edge 124 and may extend lengthwise from the sole heel edge 128 to the sole toe edge 128. The sole surface 120 may have a maximum width $W_{\max}$ and a minimum width $W_{\min}$ (see FIG. 3). The minimum width $W_{\min}$ may be located adjacent to the sole heel edge 126. Optionally, the minimum width $W_{\min}$ may be located between the heel-side boundary line L1 and the centerline L3. The maximum width $W_{\max}$ may be located between the ball striking centerline L3 and the sole toe edge 128. Optionally, the maximum width $W_{\max}$ may be located between the centerline L3 and the toe-side boundary line L2. The width of the sole surface 120 may monotonically increase from the minimum width $W_{\min}$ to the maximum width $W_{\max}$, from the sole heel edge 126 to the centerline L3, and/or from the heel-side boundary line L1 to the centerline L3. According to certain embodiments, the sole trailing edge 124 may have an S-shaped profile (i.e., a convex curvature and a concave curvature with a point of inflection therebetween) that extends between the maximum width $W_{\max}$ and the minimum width $W_{\min}$.

[0059] According to certain embodiments, W3 may be approximately equal to W2. Thus, the width of the sole surface 120 may be substantially constant (i.e., within 10%) from the centerline L3 to the toe-side boundary line L2 and/or from the centerline L3 to the sole toe edge 128.

[0060] According to other embodiments, W3 is greater than W2. Optionally, W2 may be within 20% of the value of W3, within 15% of the value of W3, or even within 10% of the value of W3. For example, W3 may be approximately 28 mm (± 3 mm), and W2 may be approximately 25 mm (± 3 mm). According to some embodiments, W3 is considerably greater than W1. Optionally, W3 may be more than 200% greater than the value of W1, more than 300% greater than the value of W1, or even more than 400% greater than the value of W1. For example, W3 may be approximately 28 mm (± 3 mm), and W1 may be approximately 6 mm (± 1 mm).

[0061] Thus, the thickened portion 140 of the club head may be considered to have two portions: a first portion 142 located adjacent to the toe 112 of the club head 102 and associated with the first portion P1 of the lower rear surface region 116b and the first portion S1 of the sole surface 120; and a second portion 144 located adjacent the heel 110 of the club head 102 and associated with the second portion P2 of the lower rear surface region 116b and the second portion S2 of the sole surface 120. According to aspects of the invention, the first portion 142 has a greater thickness than the second portion 144. The first portion 142 has a greater width of the sole surface 120 than the second portion 144. The first portion 142 has a greater volume than the second portion 144. The first portion 142 has a greater mass than the second portion 144. According to some embodiments, the second portion 142 may be shaped as a smooth depression that provides an ergonomically comfortable thumb-grip region when the club head 102 is gripped by a user's right hand, the pointer finger supports the ball striking surface 114 and the remaining three fingers of the user's right hand loosely curl around the hosel 104.

[0062] FIG. 8A illustrates a heel sole-to-ground measurement H1 between the sole surface 120 and the ground plane at the heel 110 of the club head 102. The heel sole-to-ground measurement H1 is associated with the L1 cross-section and the second portion S2 of the sole surface 120. The heel sole-to-ground measurement H1 may be defined as the vertical gap dimension between the sole surface 120 and the ground along the L1 cross-section at the lower heel surface 140 or heel edge when the club head 102 is oriented in the reference position. For a particular exemplary golf club head in accordance with the present invention, the H1 measurement may be approximately 5 mm. Other H1 dimensions may be applicable without departing from this invention.

[0063] FIG. 8C illustrates a toe sole-to-ground measurement H1 between the sole surface 120 and the ground plane at the toe 112 of the club head 102. The toe sole-to-ground measurement H3 is associated with the L3 cross-section and the second portion S1 of the sole surface 120. The toe sole-to-ground measurement H3 may be defined as the vertical gap dimension between the sole surface 120 and the ground along the L3 cross-section at the lower toe surface 144 or toe edge when the club head 102 is oriented in the reference position. For a particular exemplary golf club head in accordance with the present invention, the H3 measurement may be approximately 2.5 mm to 3 mm. Other H3 dimensions may be applicable without departing from this invention.

[0064] Table 1, below, provides dimensions for an exemplary 48-degree wedge club head in accordance with an embodiment of this invention.

Table 1 - Example Dimensions for a 48-Degree Loft Wedge Club Head

Lateral Position	Profile Dimension T1, T2 and T3 (mm)	Width W1, W2 and W3 (mm)
L1	7.0 ± 1.0	6.0 ± 1.0

(continued)

<u>Lateral Position</u>	<u>Profile Dimension T1, T2 and T3 (mm)</u>	<u>Width W1, W2 and W3 (mm)</u>
L2	15.0 ± 2.0	25.0 ± 3.0
L3	20.0 ± 3.0	28.0 ± 3.0

[0065] Table 1 describes a particular exemplary golf club heads in accordance with the present invention. Other golf club heads with different thickened portion profile dimensions T1, T2, T3, and/or different sole surface width measurements W1, W2, W3 may be provided in accordance with various aspect of the present invention, and or different sole-to-ground measurements H1, H3. For example, without departing from this invention, the profile dimension measurements T2 and T3 may be between approximately 20.0 mm and approximately 40.0 mm. Optionally, the profile dimension measurements T2 and T3 may be between approximately 25.0 mm and approximately 35.0 mm, or even between approximately 27.0 mm and approximately 32.0 mm.

[0066] Without departing from this invention, the sole width measurements W2 and W3 may be between approximately 20.0 mm and approximately 45.0 mm. Optionally, the sole width measurements W2 and W3 may be between approximately 25.0 mm and approximately 40.0 mm, or even between approximately 30.0 mm and approximately 35.0 mm.

[0067] A maximum sole width need not coincide with the sole widths at lines L2 or L3. According to some embodiments, the maximum sole width may be located between line L2 and L3 and may be slightly greater than the sole width measurements W2 and/or W3. Thus, by way of non-limiting example, a maximum sole width may be 0.5 mm to 2.0 mm greater than the sole width measurements W2 or W3. The maximum sole width may range from between approximately 25.0 mm and approximately 42.0 mm, between approximately 30.0 mm and approximately 37.0 mm, or even between approximately 32.0 mm and approximately 36.0 mm.

[0068] Without departing from this invention, the sole width measurement W1 may be between approximately 3.0 mm and approximately 15.0 mm. Optionally, the sole width measurement W1 may be between approximately 4.0 mm and approximately 10.0 mm, or even between approximately 5.0 mm and approximately 9.0 mm.

[0069] A minimum sole width need not coincide with the sole width at line L1. According to some embodiments, the minimum sole width may be slightly less than the sole width measurement W1. Thus, by way of non-limiting example, a minimum sole width may be 0.5 mm to 1.0 mm less than the sole width measurement W1. The minimum sole width may range from between approximately 3.0 mm and approximately 10.0 mm, between approximately 3.5 mm and approximately 9.0 mm, or even between approximately 3.0 mm and approximately 7.0 mm.

[0070] Additionally, the sole surface 120 may have a front-to-rear curvature radius, i.e., the radius of the curvature of the sole surface from the leading edge 122 to the trailing edge 124 (not shown). For example, for a particular exemplary 59-degree wedge, the front-to-rear curvature radius may be approximately 6.5 cm. Additionally, for the present invention, the sole surface 120 may have a front-to-rear curvature radius 130 ranging from between approximately 3.0 cm to approximately 10.0 cm, between approximately 4.0 cm to approximately 9.0 cm, between approximately 5.0 cm to approximately 8.0 cm, or even between approximately 6.0 cm to approximately 7.0 cm without departing from this invention. Such front-to-rear curvatures are described in U.S. Patent Application 13/047,625, "Iron-Type Golf Club Heads with a Wide Sole," filed March 14, 2011, to Knight et al., which is incorporated by reference in its entirety herein.

[0071] In another embodiment, without departing from the invention, the front-to-rear curvature radius may include multiple radius sections, wherein each radius section may have different front-to-rear curvature radii. For example, the front-to-rear curvature radius may include a first radius section and a second radius section. For an exemplary 53-degree wedge, a first radius section may have an approximate 25 mm radius and a second radius section may have an approximate 50 mm radius. The first radius section may extend from the leading edge 122 to a convergence line approximately 7.0 mm from the front edge 122. The second radius section extends from convergence line to the rear edge 124. Such front-to-rear curvatures with multiple radius sections are described in U.S. Patent Application 13/047,625, "Iron-Type Golf Club Heads with a Wide Sole," filed March 14, 2011, to Knight et al., which is incorporated by reference in its entirety herein.

[0072] Additionally, the sole surface 120 may include a heel-to-toe curvature. A heel-to-toe curvature radius may be defined as the radius of the curvature of the sole surface 120 from the heel edge 126 to the toe edge 128. For an exemplary 59-degree wedge, the heel-to-toe radius may be approximately 18 cm. Additionally, as was described above for the front-to-rear curvature radius, the heel-to-toe curvature may also include multiple radius sections with each having different heel-to-toe radii. Such heel-to-toe curvature is also described in U.S. Patent Application 13/047,625, "Iron-Type Golf Club Heads with a Wide Sole," filed March 14, 2011, to Knight et al., which is incorporated by reference in its entirety herein.

[0073] A conventional ideal total weight of a golf club head 102 may be approximately 300 grams. In a particular exemplary wedge club head 102, the indentation in the thickened portion 140 in the toe region may remove approximately

eight to eleven grams of weight from the sole surface 120 and club head 102, or approximately 3-4% of the total weight of the golf club head 102 (as compared to a rear portion having constant thickness and width dimension across the entire length of the club head 102. Such weight may be re-distributed to other locations on the club head 102 to selectively control the center of gravity on the ball striking surface 114. Additionally, for the present invention, the indentation in the thickened portion 140 in the toe region may remove weight of approximately 6 grams, approximately 7 grams, approximately 8 grams, approximately 9 grams, approximately 10 grams, approximately 11 grams, approximately 12 grams, or approximately 13 grams or more without departing from this invention.

[0074] According to certain embodiments, the length of the thickened portion 140 may be defined as the distance from the heel edge 126 to the toe edge 128. In a particular exemplary club head 102, the length of the thickened portion 140 may be approximately 8.0 cm. Optionally, the thickened portion 140 may have a length ranging from approximately 6.5 cm to approximately 9.5 cm, from approximately 7.0 cm to approximately 9.0, or even from approximately 7.5 cm to approximately 8.5 cm without departing from this invention. According to some embodiments, the first portion 142 may extend at least two-thirds of the way from the toe 112 to the heel-side line 113. According to other embodiments, the first portion 142 of the thickened portion 140 may extend three-quarters of the way from the toe 112 to the heel-side line 113.

[0075] The contoured sole surface according to at least some examples of this disclosure may provide heel relief. FIGS. 9-12B best illustrate the features of the heel relief of the golf club head 102 of the present embodiment. Heel relief may be defined as the combination of the removal of material from the heel 110 of the sole 120 with smooth or soft transition edges. The heel relief may allow for the sole 120 of the club head 102 to lie at an angle and opens the face and increases lift. For example, heel relief may provide the ability for a consumer-type golfer to perform well in the bunker and in turf-type conditions. Heel relief generally provides and allows a wider, more stable sole surface 120 in the toe-side 112 of the club head 102.

[0076] FIGS. 9 and 10 illustrate top perspective views of a golf club head 102 showing a sole/ground contact area 170A 170B of the two different club heads 102A 102B. FIG. 9 illustrates a top perspective view of a prior art golf club head 102A and the sole/ground contact area 170A associated with the prior art club head 102A. FIG. 10 illustrates a top perspective view of a golf club head 102B in accordance with this invention and the sole/ground contact area 170B associated with the golf club head 102B. Both FIGS. 9 and 10 include a ground plane with the golf club head laying open along the ground plane at an angled striking position.

[0077] As illustrated in FIG. 9, the sole/ground contact area 170A of the prior art golf club head 102A is elongated across most of the length L of the club head 102A, from the toe to the heel. Additionally, the sole/ground contact area 170A of the prior art golf club head 102A is much thinner across the club head 102A and the sole 120 in the front to rear direction of the golf club head 102A.

[0078] In contrast to the prior art golf club head 102A, FIG. 10 illustrates a golf club head 102B in accordance with examples of this invention. As illustrated in FIG. 10, the sole/ground contact area 170B of the golf club head 102B is located towards or proximate to the toe 112 of the club head 102B. This golf club head 102B provides a wide toe-side 112 sole surface S 1 and sole/ground contact area 170B located at the toe 112 of the club head 102B. The sole/ground contact area 170B of the golf club head 102B is shorter, but more concentrated at the toe 112 of the golf club head 102B. Additionally, the sole/ground contact area 170B of the golf club head 102B is wider across the club head 102B and the sole 120 in the front to rear direction of the golf club head 102B. This sole/ground contact area 170B may help to provide a wider, more stable sole surface S1 in the toe-side 112 of the club head 102B, while providing good performance in the rough. This sole/ground contact area 170A may also provide a lack of heel/turf or ground interaction.

[0079] The heel relief of the golf club head 102 of the present invention also allows the center of gravity CG to be located closer to the face center Cs of the ball striking face 114. The face center C_s is illustrated and further described above with reference to FIG. 7. Moving the center of gravity CG closer to the face center Cs of the ball striking face 114 allows the visual center of gravity (or face center Cs) to be aligned more with the actual center of gravity CG. The center of gravity CG moves closer to the face center Cs because the club head 102 is much more center-biased as opposed to heel-biased, with the weight shifting from the heel 110 (with the heel relief) towards the toe 112. FIGS. 11A through 12B illustrate the movement of the center of gravity CG closer to and towards the face center C_s of the ball striking face 114.

[0080] FIGS. 11A and 11B illustrate an example prior art golf club head 102A. FIGS. 12A and 12B illustrate a golf club head 102B in accordance with this invention. FIGS. 11A and 12A illustrate front perspective views of the golf club head oriented in a reference position on the ground plane. FIGS. 11B and 12B illustrate cross-sectional views of the golf club head taken along Line 11B-11B in FIG. 11A or Line 12B-12B in FIG. 12A.

[0081] As illustrated in FIGS. 11A and 12A, each of the club heads include a face center Cs of the ball striking face 114 and a center of gravity CG location. FIGS. 11A and 12A also illustrate a distance or dimension in the X-direction (or heel-to-toe direction) from the face center Cs of the ball striking face 114A the center of gravity CG location, labeled "Cs to CG (X)". Additionally, FIGS. 11B and 12B illustrate club heads with the face center Cs of the ball striking face 114A and a center of gravity CG location. FIGS. 11B and 12B illustrate a distance or dimension of the location of the center of gravity location CG from the face center Cs of the ball striking face 114 in a direction normal to the ball striking face 114, or the distance from the center of gravity CG from the ball striking face 114, labeled "Cs to CG (Face)".

[0082] As was stated above, the heel relief of the golf club head 102B of the present invention allows the center of gravity CG to be located closer to the face center Cs of the ball striking face 114. The center of gravity CG of the golf club head 102B with heel relief of the present invention may move closer to the face center Cs of the ball striking face 114 in the X-direction or in the heel 110 to toe 112 direction. In one example, the Cs to CG (X) dimension for the prior art golf club head 102A in FIG. 11A may be approximately 6 millimeters, while the Cs to CG (X) dimension for the golf club head 102B in accordance with this invention and illustrated in FIG. 12A may be approximately 4.5 millimeters. The center of gravity CG for the golf club head 102B in accordance with this invention may be approximately 1.5 millimeters closer (or approximately 25% closer) to the face center Cs of the ball striking face 114 than the prior art golf club head 102A without the heel relief. In another example, the Cs to CG (X) dimension for the prior art golf club 102A in FIG. 11A may be approximately 6.37 millimeters, while the Cs to CG (X) dimension for the golf club head 102B in accordance with this invention and illustrated in FIG. 12A may be approximately 4.57 millimeters. The center of gravity CG for the golf club head 102B in accordance with this invention may be approximately 1.8 millimeters closer (or approximately 28% closer) to the face center Cs of the ball striking face 114 than the prior art golf club head 102A without the heel relief.

[0083] Additionally, the center of gravity CG of the golf club head 102B with heel relief of the present invention may move closer to the face center Cs of the ball striking face 114 in the direction normal to the face. In one example, the Cs to CG (Face) dimension for the prior art golf club head 102A in FIG. 11A may be approximately 1.3 millimeters, while the Cs to CG (Face) dimension for the golf club head 102B in accordance with this invention and illustrated in FIG. 12A may be approximately 0.1 millimeters. The center of gravity CG for the golf club head 102B in accordance with this invention may be approximately 1.2 millimeters closer (or approximately 90% closer) to the face center Cs of the ball striking face 114 than the prior art golf club head 102A without the heel relief. In another example, the Cs to CG (X) dimension for the prior art golf club head 102A in FIG. 11A may be approximately 1.32 millimeters, while the Cs to CG (X) dimension for the golf club head 102B in accordance with this invention and illustrated in FIG. 12A may be approximately 0.02 millimeters. The center of gravity CG for the golf club head 102B in accordance with this invention may be approximately 1.3 millimeters closer (or approximately 98% closer or almost exactly on the face center Cs) to the face center Cs of the ball striking face 114 than the prior art golf club head 102A without the heel relief.

[0084] A variety of club head 102 constructions are possible without departing from this disclosure. For example, if desired, some or all of the various individual parts of the club head 102 described above may be made from multiple pieces that are connected together (e.g., by adhesives or cements; by welding, soldering, brazing, or other fusing techniques; by mechanical connectors; etc.). Additionally, the club head 102 may also be a unitary piece that, if desired, includes some or all of the various individual parts of the club head 102 described above. The various parts (e.g., the heel 110, toe 112, ball striking surface 114, rear surface 116, and sole surface 120, etc.) may be made from any desired materials and combinations of different materials, including materials that are conventionally known and used in the art, such as metal materials, including lightweight metal materials, composite materials, polymer materials, steel, titanium, aluminum, tungsten, magnesium, beryllium, alloys including one or more of these metals, carbon-fiber reinforced materials, glass-fiber reinforced materials, graphite, etc.

[0085] Additionally, the club head 102 may be constructed in any suitable or desired manner without departing from this disclosure, including in conventional manners known and used in the art. The club head 102 and its various parts may be made by forging, casting, molding, stamping, pressing, machining, grinding, and/or using other techniques and processes, including techniques and processes that are conventional and known in the art.

[0086] A wide variety of overall club head constructions are possible without departing from this disclosure. For example, it is noted that the dimensions and/or other characteristics of a golf club head 102 according to examples of this disclosure may vary significantly without departing from the disclosure. For example, while the above described configuration may be particularly useful in wedges (e.g., pitching wedges, lob wedges, gap wedges, sand wedges, etc.), the features described above may be incorporated into any iron-type club head including, for example: iron-type hybrid clubs, driving irons, 0 through 10 irons, etc.

[0087] Additional aspects of this disclosure relate to methods for producing and or manufacturing iron-type golf club heads and iron-type golf club structures in accordance with examples of this disclosure. Such methods may include, for example, one or more of the following steps in any desired order and/or combinations: (a) providing a golf club head body of the various types described above (including any or all of the various structures, features, and/or arrangements described above), e.g., by manufacturing or otherwise constructing the golf club head body, or by obtaining it from a third party source, etc.; (b) engaging a shaft member with the golf club head body; and (c) engaging a grip member with the shaft member.

[0088] The iron-type golf club and golf club head according to this invention provides many benefits over the current golf clubs and golf club heads. First, the sole surface 120 of the present invention may be considered a contoured sole as compared to conventional iron-type club heads. The contoured sole surface 120 may help create lift more efficiently to the golf club head 102 as it contacts and moves through the ground during golf ball contact thereby giving a user more room for swing-error when contacting the ground. Additionally, the contoured sole surface 120 may give the user more confidence with their golf swing and during the golf ball contact due to the wide nature of the sole.

[0089] The present disclosure is described above and in the accompanying drawings with reference to a variety of example structures, features, elements, and combinations of structures, features, and elements. The purpose served by the disclosure, however, is to provide examples of the various features and concepts related to the disclosure, not to limit the scope of the disclosure. One skilled in the relevant art will recognize that numerous variations and modifications may be made to the embodiments described above without departing from the scope of the present disclosure, as defined by the appended claims. For example, the various features and concepts described above in conjunction may be used individually and/or in any combination or subcombination without departing from this disclosure.

CLAUSES:

[0090]

1. An iron-type golf club head comprising:

a ball striking surface configured for striking a ball and having a ball striking area defining a heel-side boundary line, a toe-side boundary line and a ball striking centerline;

a rear surface opposite the ball striking surface; and

a sole surface extending rearward from a leading edge of the sole surface at an intersection with the ball striking surface to a trailing edge of the sole surface at an intersection with the rear surface and extending from a heel edge to a toe edge,

the sole surface having a maximum width and a minimum width, the widths measured horizontally when the club head is in a reference position,

wherein the minimum width is located adjacent to the heel edge,

wherein the maximum width is located between the ball striking centerline and the toe edge,

wherein the width of the sole surface monotonically increases from the minimum width to the maximum width, and

wherein the trailing edge of the sole surface has an S-shaped profile that extends between the maximum width and the minimum width.

2. The iron-type golf club head of clause 1, wherein the minimum width is between approximately 3.5 mm and approximately 9.0 mm.

3. The iron-type golf club head of clause 1, wherein the maximum width is between approximately 25.0 mm and approximately 31.0 mm

4. The iron-type golf club head of clause 1, wherein the maximum width is at least three times the minimum width.

5. The iron-type golf club head of clause 1, wherein the S-shaped portion of the trailing edge extends from the toe edge to the ball striking centerline.

6. The iron-type golf club head of clause 1, wherein the width of the sole surface is substantially constant from the centerline to the toe edge.

7. The iron-type golf club head of clause 1, wherein the minimum width is located between the heel-side boundary line and the centerline.

8. The iron-type golf club head of clause 1, wherein the maximum width is located between the ball striking centerline and the toe-side boundary line.

9. The iron-type golf club head of clause 1, wherein the width of the sole surface monotonically increases from the heel-side boundary line to the centerline.

10. The iron-type golf club head of clause 1, wherein the width of the sole surface is substantially constant from the centerline to the toe-side boundary line.

11. The iron-type golf club head of clause 1, wherein an upper portion of the club head is configured as a blade-type club head and a lower portion of the club head includes a thickened portion that extends from the heel to the toe.

12. The iron-type golf club head of clause 11, wherein an interface line defines the boundary between the upper portion and the lower portion and, at the ball striking centerline the interface line approximately bisects the height of the ball striking surface.

13. The iron-type golf club head of clause 11, wherein a heel vertical gap dimension between the ground plane and the heel edge when the club is oriented in the reference position is approximately 5 mm.

14. The iron-type golf club head of clause 11, wherein a toe vertical gap dimension between the ground plane and the toe edge when the club is oriented in the reference position is approximately 3 mm.

15. An iron-type golf club head comprising:

a ball striking surface configured for striking a ball, wherein the ball striking surfaces defines a heel-side boundary line, a toe-side boundary line and a ball striking centerline;

a rear surface opposite the ball striking surface, the rear surface having an upper rear surface region, a lower rear surface region and an interface line defining the boundary therebetween; and

wherein the upper rear surface region is oriented substantially parallel to the ball striking surface and is bounded by the upper edge and the interface line,

wherein the lower rear surface region has a toe-side portion that extends at least from the ball striking centerline to the toe-side boundary line, and wherein the toe-side portion is oriented substantially vertically when the club head is in a reference position, and

wherein the lower rear surface region has a heel-side portion that extends from the toe-side portion to the heel, the heel-side portion having a rear profile dimension measured perpendicular to the ball striking surface, that monotonically decreases as it approaches the heel.

16. The iron-type golf club head of clause 13, where the toe-side portion of the lower rear surface portion extends substantially parallel to the length direction of the club head.

17. The iron-type golf club head of clause 13, wherein, at the ball striking centerline, the interface line is located in the middle quintile of the height of the ball striking surface.

18. The iron-type golf club head of clause 13, wherein, when viewed from above and parallel to the ball striking surface, the toe-side portion of the lower rear surface region has a convexly-curved rear profile.

19. The iron-type golf club head of clause 13, wherein, when viewed from above and parallel to the ball striking surface, the heel-side portion of the lower rear surface region includes a concavely-curved rear profile portion.

20. The iron-type golf club head of clause 13, wherein the maximum rear profile dimension of the lower rear surface region is nearer the toe than the heel.

21. An iron-type golf club head comprising:

a ball striking surface configured for striking a ball and having a grip-enhancing area defining a heel-side boundary line, a toe-side boundary line and a ball striking centerline;

a rear surface opposite the ball striking surface, the rear surface having an upper rear surface region, a lower rear surface region and an interface line defining the boundary therebetween; and

a sole surface extending rearward from the ball striking surface to the rear surface and extending from a heel edge to a toe edge,

wherein the sole surface has a maximum width and a minimum width, the widths measured horizontally when the club head is in a reference position, and wherein the width of the sole surface monotonically increases from the heel edge to the centerline, and

wherein, when viewed from above and parallel to the ball striking surface, the lower rear surface region has a complexly-curved rear profile that monotonically increases as it extends from the heel to the centerline and a convexly-curved rear profile between the centerline and the toe.

22. The iron-type golf club head of clause 19, wherein the complexly-curved rear profile of the lower rear surface region extending between the heel to the centerline has a concave portion near the heel and a convex portion near the centerline.

23. The iron-type golf club head of clause 19, wherein, when viewed from below, the trailing edge of the sole surface has an S-shaped profile that extends between the maximum width and the minimum width.

24. The iron-type golf club head of clause 19, wherein the lower rear surface region has a toe-side portion that extends at least from the ball striking centerline to the toe-side boundary line and wherein the toe-side portion is oriented substantially vertically when the club head is in a reference position.

25. The iron-type golf club head of clause 22, wherein the lower rear surface region is oriented substantially parallel to the length dimension of the club head.

26. The iron-type golf club head of clause 19, wherein the upper rear surface region is oriented substantially parallel to the ball striking surface.

Claims

1. An iron-type golf club head comprising:

a ball striking surface configured for striking a ball and having a ball striking area defining a heel-side boundary line, a toe-side boundary line and a ball striking centerline;
 a rear surface opposite the ball striking surface; and
 a sole surface extending rearward from a leading edge of the sole surface at an intersection with the ball striking surface to a trailing edge of the sole surface at an intersection with the rear surface and extending from a heel edge to a toe edge,
 the sole surface having a maximum width and a minimum width, the widths measured horizontally when the club head is in a reference position,
 wherein the minimum width is located adjacent to the heel edge,
 wherein the maximum width is located between the ball striking centerline and the toe edge,
 wherein the width of the sole surface monotonically increases from the minimum width to the maximum width, and
 wherein the trailing edge of the sole surface has an S-shaped profile that extends between the maximum width and the minimum width.

2. The iron-type golf club head of claim 1, wherein:

- i) the minimum width is between approximately 3.5 mm and approximately 9.0 mm;
- ii) the maximum width is between approximately 25.0 mm and approximately 31.0 mm; or
- iii) the maximum width is at least three times the minimum width.

3. The iron-type golf club head of claim 1, wherein:

- i) the S-shaped portion of the trailing edge extends from the toe edge to the ball striking centerline; or
- ii) the width of the sole surface is substantially constant from the centerline to the toe edge.

4. The iron-type golf club head of claim 1, wherein:

- i) the minimum width is located between the heel-side boundary line and the centerline;
- ii) the maximum width is located between the ball striking centerline and the toe-side boundary line;
- iii) the width of the sole surface monotonically increases from the heel-side boundary line to the centerline; or
- iv) the width of the sole surface is substantially constant from the centerline to the toe-side boundary line.

5. The iron-type golf club head of claim 1, wherein an upper portion of the club head is configured as a blade-type club head and a lower portion of the club head includes a thickened portion that extends from the heel to the toe.

6. The iron-type golf club head of claim 5, wherein an interface line defines the boundary between the upper portion and the lower portion and, at the ball striking centerline the interface line approximately bisects the height of the ball striking surface.

7. The iron-type golf club head of claim 5, wherein a heel vertical gap dimension between the ground plane and the heel edge when the club is oriented in the reference position is approximately 5 mm.

8. The iron-type golf club head of claim 5, wherein a toe vertical gap dimension between the ground plane and the toe edge when the club is oriented in the reference position is approximately 3 mm.

9. An iron-type golf club head comprising:

a ball striking surface configured for striking a ball, wherein the ball striking surfaces defines a heel-side boundary line, a toe-side boundary line and a ball striking centerline;

a rear surface opposite the ball striking surface, the rear surface having an upper rear surface region, a lower rear surface region and an interface line defining the boundary therebetween; and

wherein the upper rear surface region is oriented substantially parallel to the ball striking surface and is bounded by the upper edge and the interface line,

wherein the lower rear surface region has a toe-side portion that extends at least from the ball striking centerline to the toe-side boundary line, and wherein the toe-side portion is oriented substantially vertically when the club head is in a reference position, and

wherein the lower rear surface region has a heel-side portion that extends from the toe-side portion to the heel, the heel-side portion having a rear profile dimension measured perpendicular to the ball striking surface, that monotonically decreases as it approaches the heel.

10. The iron-type golf club head of claim 7, wherein:

- i) the toe-side portion of the lower rear surface portion extends substantially parallel to the length direction of the club head;
- ii) at the ball striking centerline, the interface line is located in the middle quintile of the height of the ball striking surface;
- iii) when viewed from above and parallel to the ball striking surface, the toe-side portion of the lower rear surface region has a convexly-curved rear profile; or
- iv) the maximum rear profile dimension of the lower rear surface region is nearer the toe than the heel.

11. The iron-type golf club head of claim 7, wherein, when viewed from above and parallel to the ball striking surface, the heel-side portion of the lower rear surface region includes a concavely-curved rear profile portion.

12. An iron-type golf club head comprising:

a ball striking surface configured for striking a ball and having a grip-enhancing area defining a heel-side boundary line, a toe-side boundary line and a ball striking centerline;

a rear surface opposite the ball striking surface, the rear surface having an upper rear surface region, a lower rear surface region and an interface line defining the boundary therebetween; and

a sole surface extending rearward from the ball striking surface to the rear surface and extending from a heel edge to a toe edge,

wherein the sole surface has a maximum width and a minimum width, the widths measured horizontally when the club head is in a reference position, and wherein the width of the sole surface monotonically increases from

the heel edge to the centerline, and

wherein, when viewed from above and parallel to the ball striking surface, the lower rear surface region has a complexly-curved rear profile that monotonically increases as it extends from the heel to the centerline and a convexly-curved rear profile between the centerline and the toe.

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- 13.** The iron-type golf club head of claim 11, wherein the complexly-curved rear profile of the lower rear surface region extending between the heel to the centerline has a concave portion near the heel and a convex portion near the centerline.

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- 14.** The iron-type golf club head of claim 11, wherein:

i) when viewed from below, the trailing edge of the sole surface has an S-shaped profile that extends between the maximum width and the minimum width;

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ii) the lower rear surface region has a toe-side portion that extends at least from the ball striking centerline to the toe-side boundary line and wherein the toe-side portion is oriented substantially vertically when the club head is in a reference position; or

iii) the upper rear surface region is oriented substantially parallel to the ball striking surface.

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- 15.** The iron-type golf club head of claim 13, wherein the lower rear surface region is oriented substantially parallel to the length dimension of the club head.

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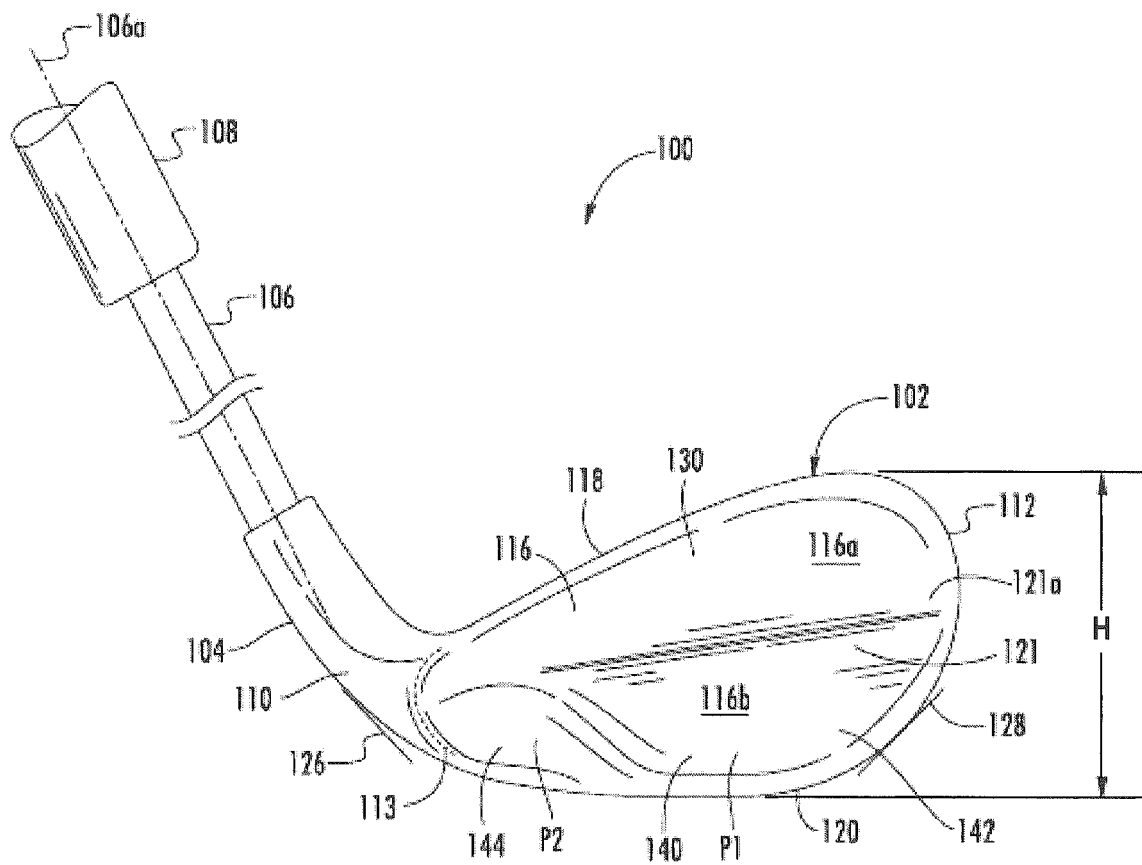


FIG. 1

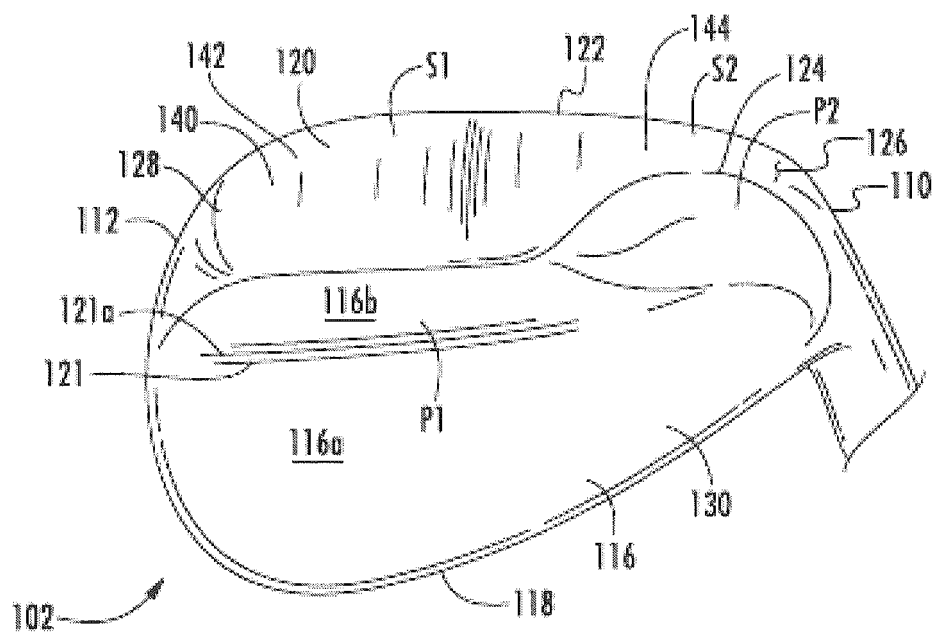


FIG. 2

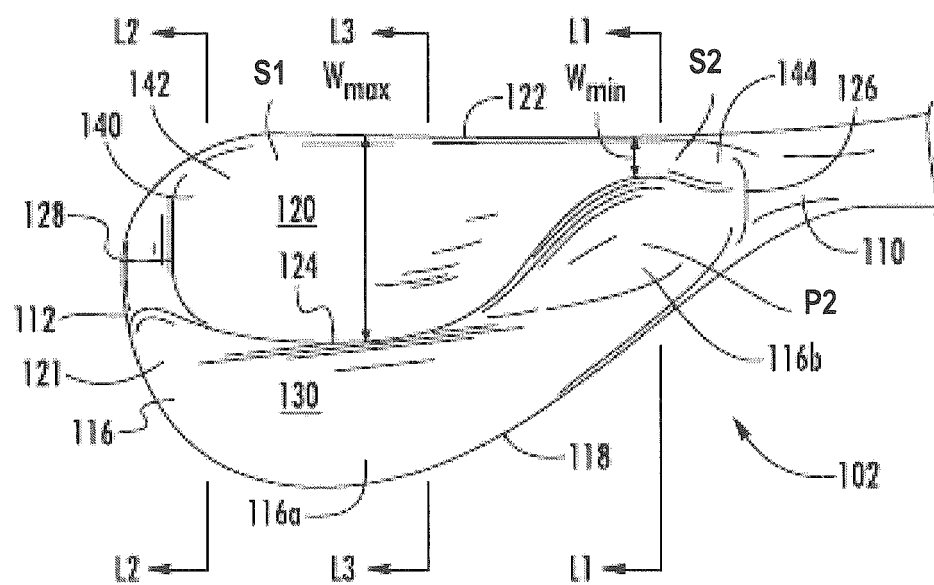


FIG. 3

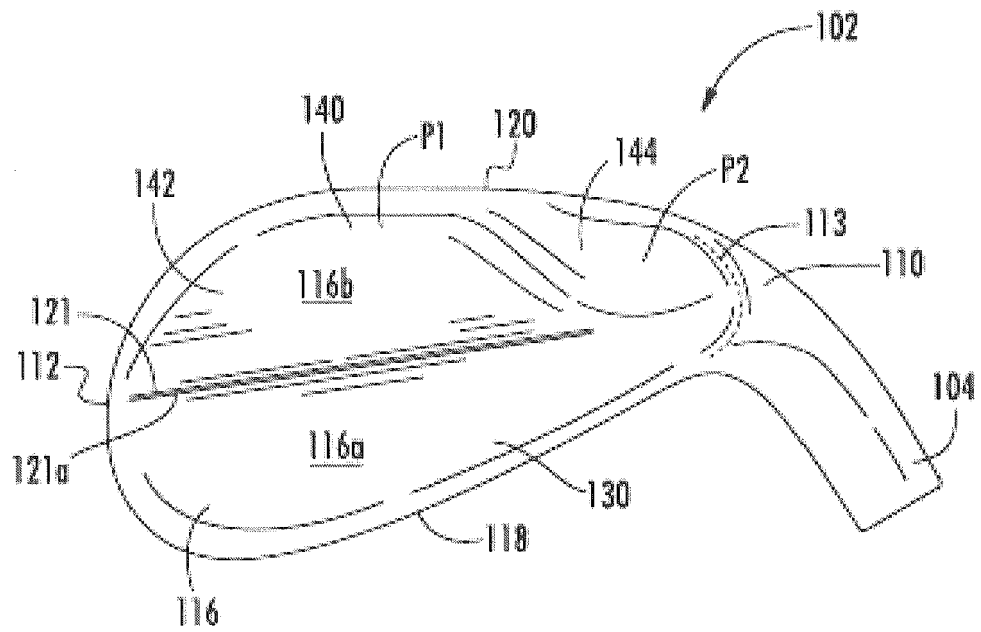


FIG. 4

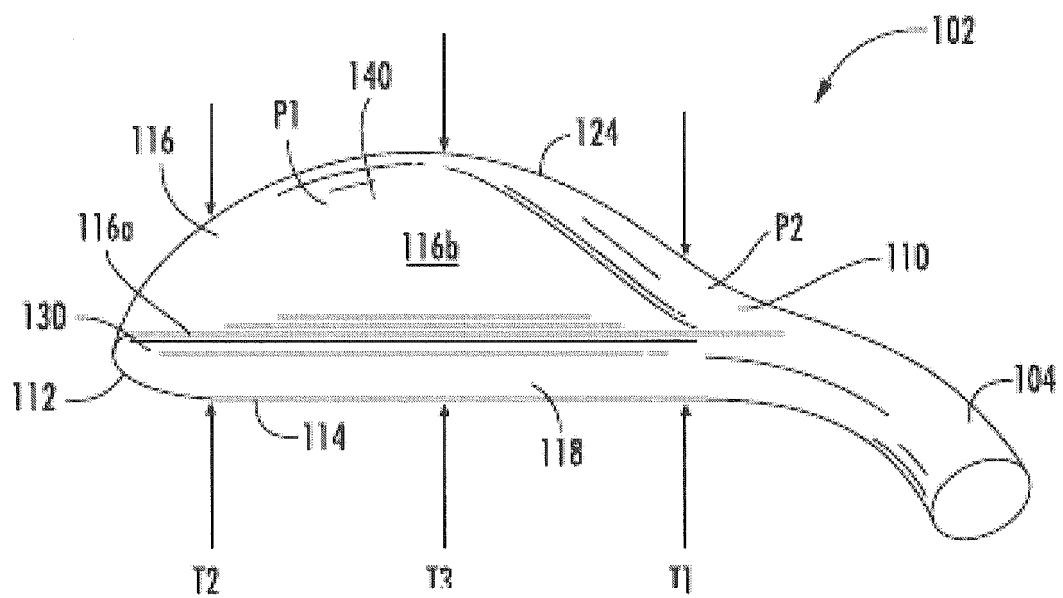


FIG. 5

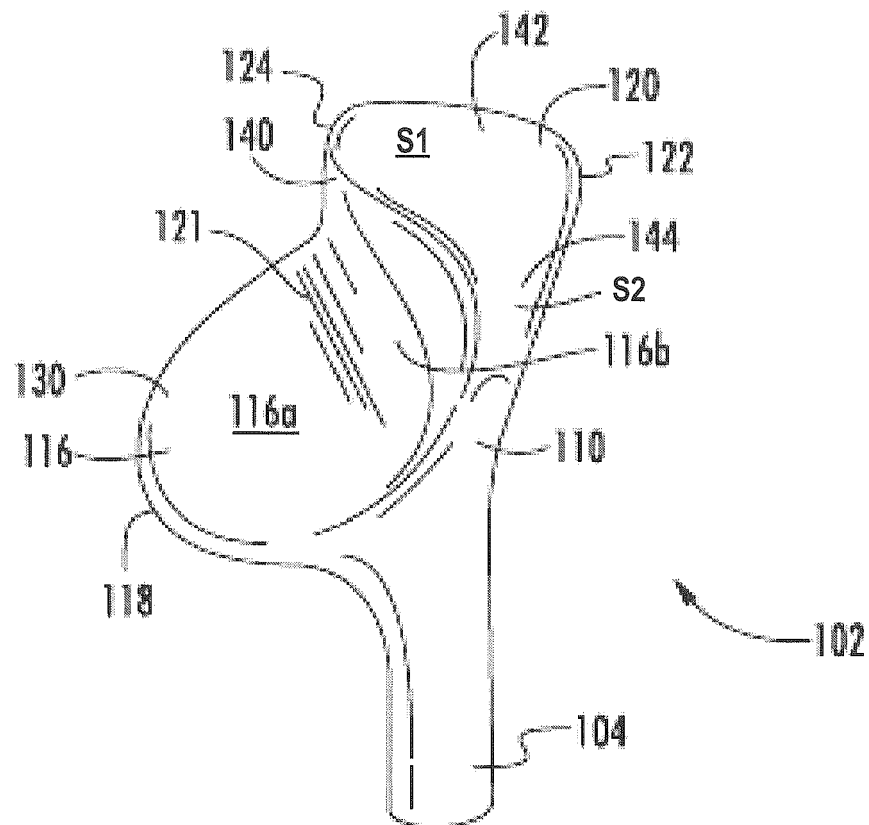


FIG. 6

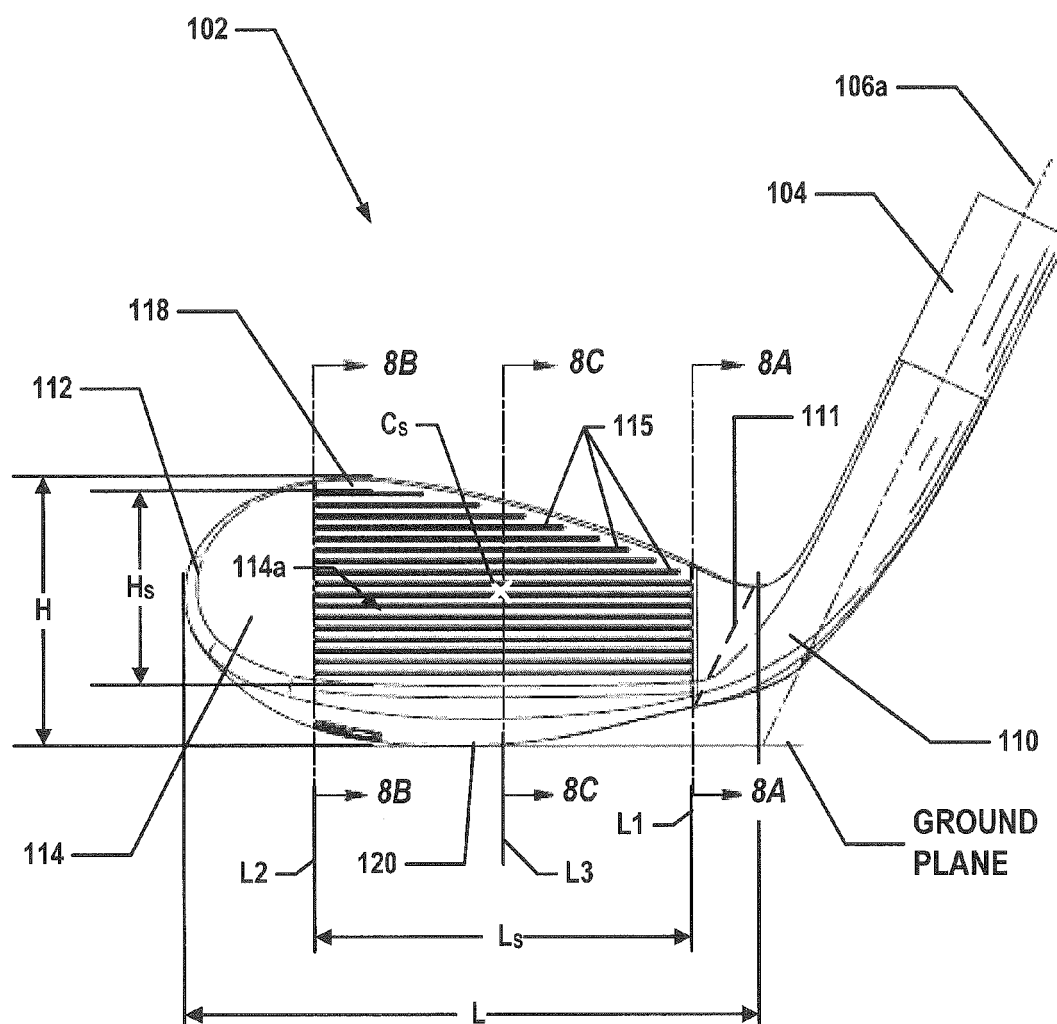


FIG. 7

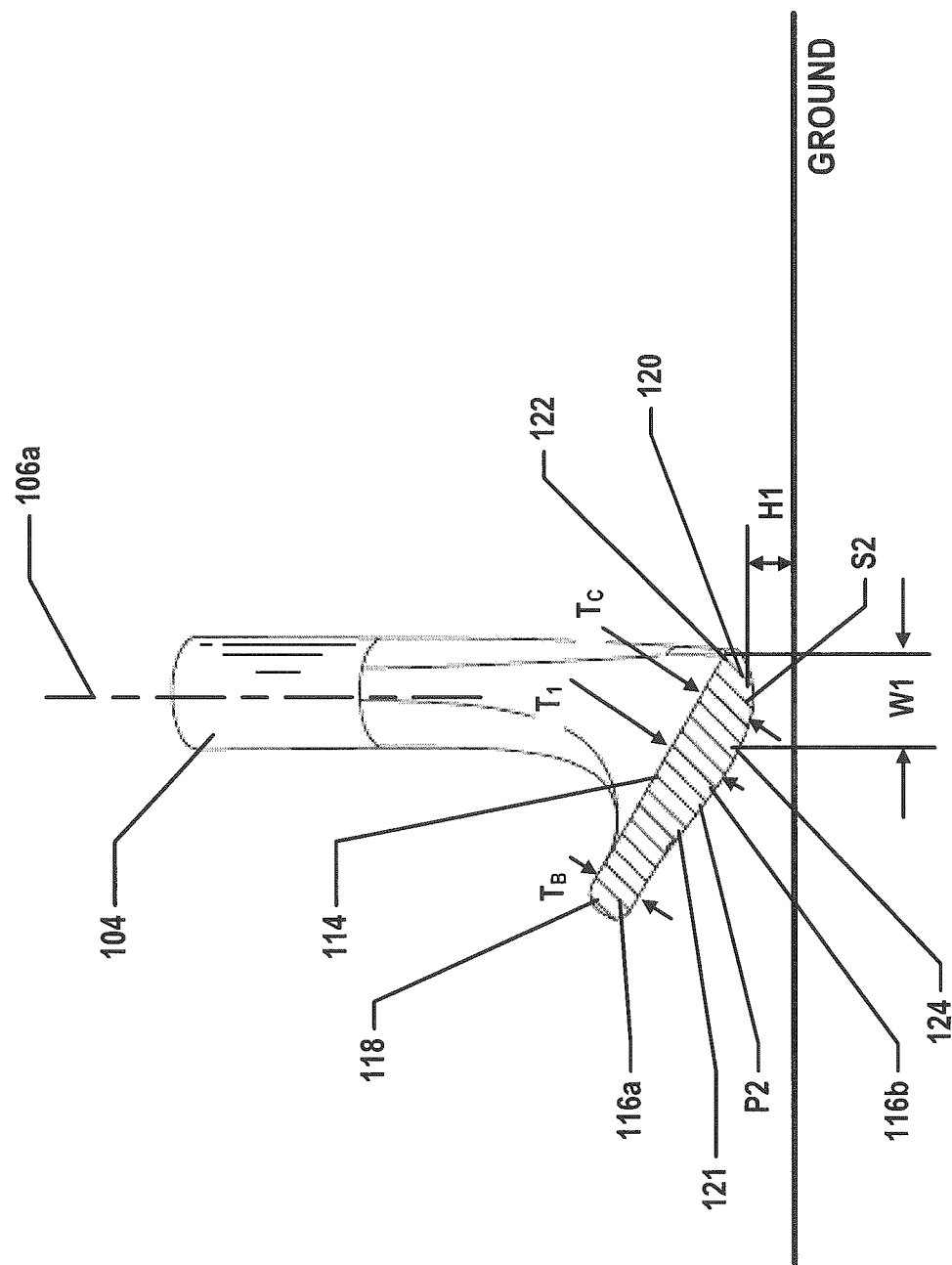


FIG. 8A

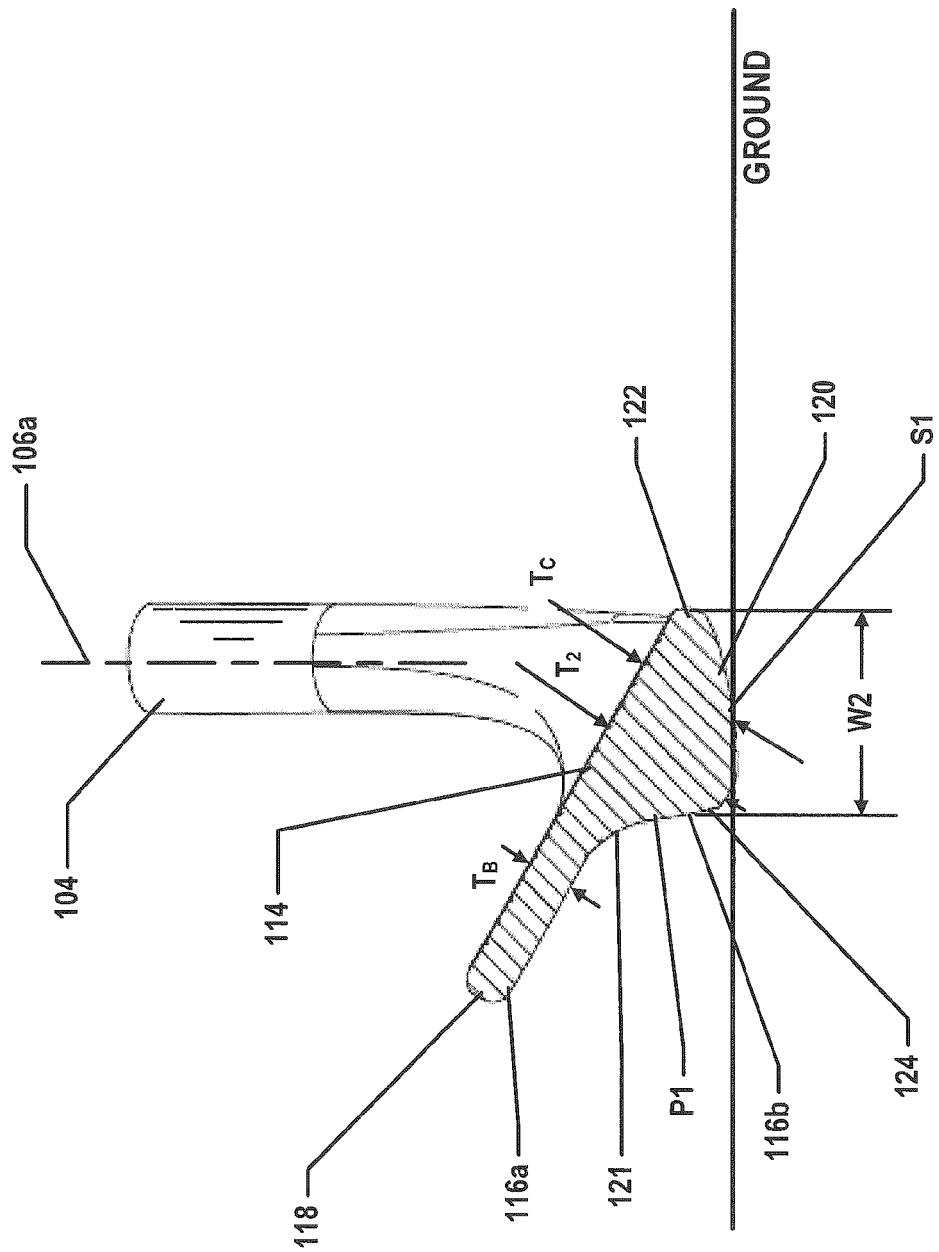


FIG. 8B

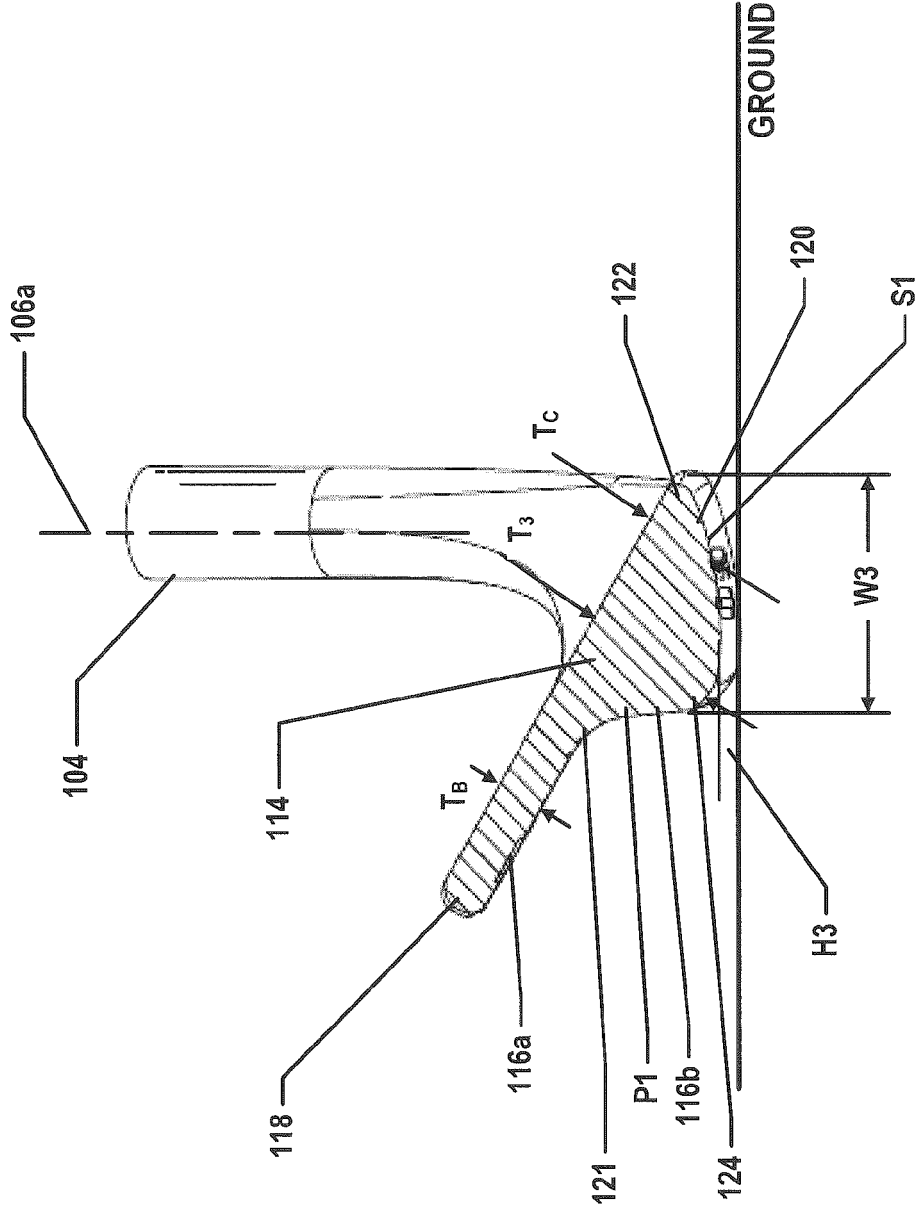


FIG. 8C

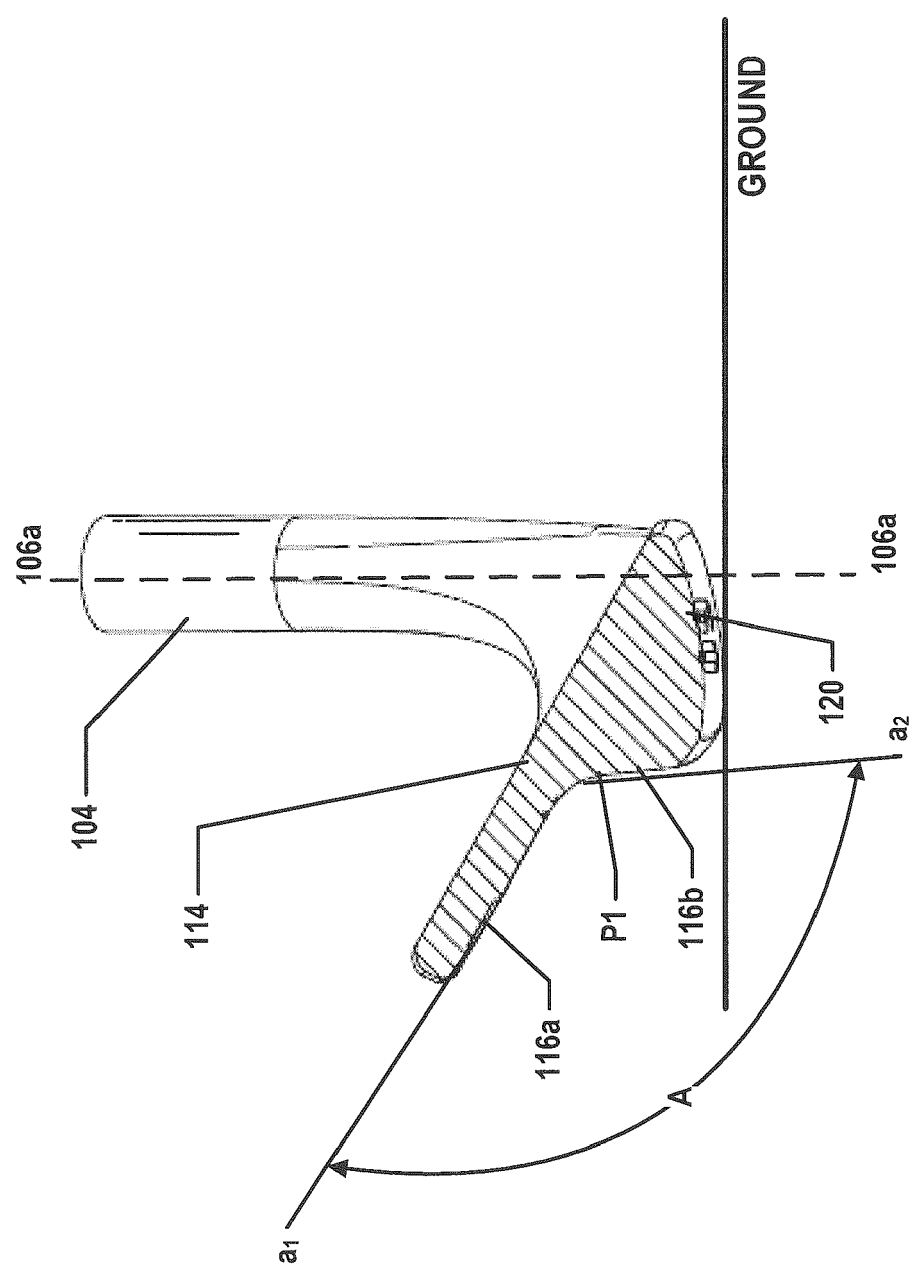


FIG. 8D

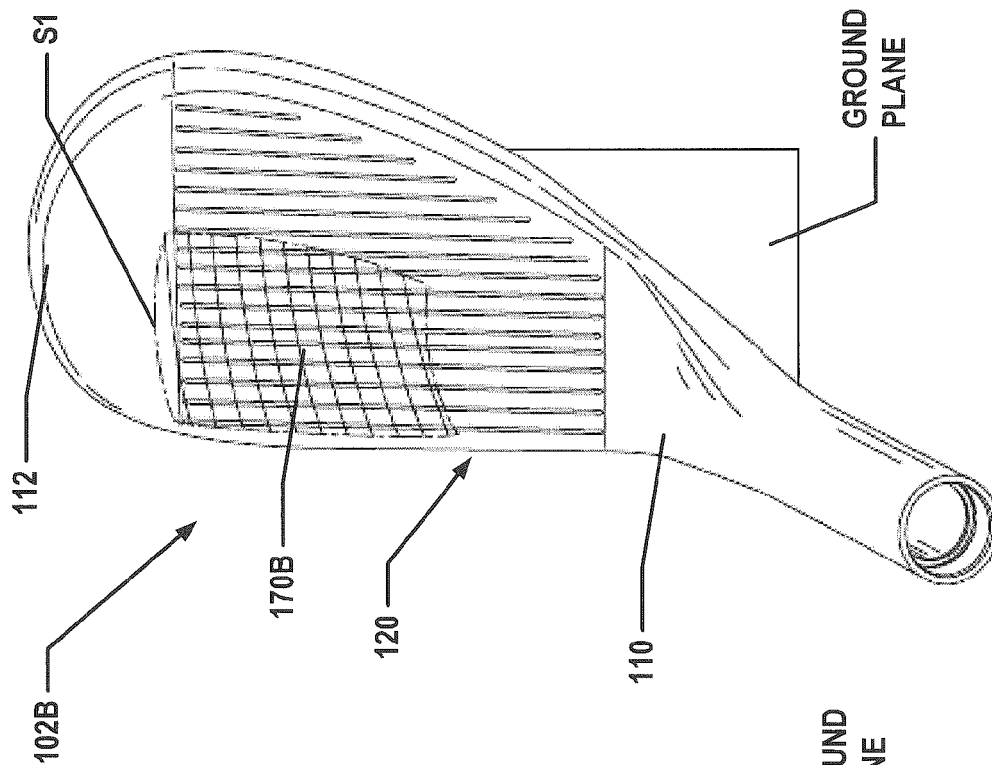


FIG. 10

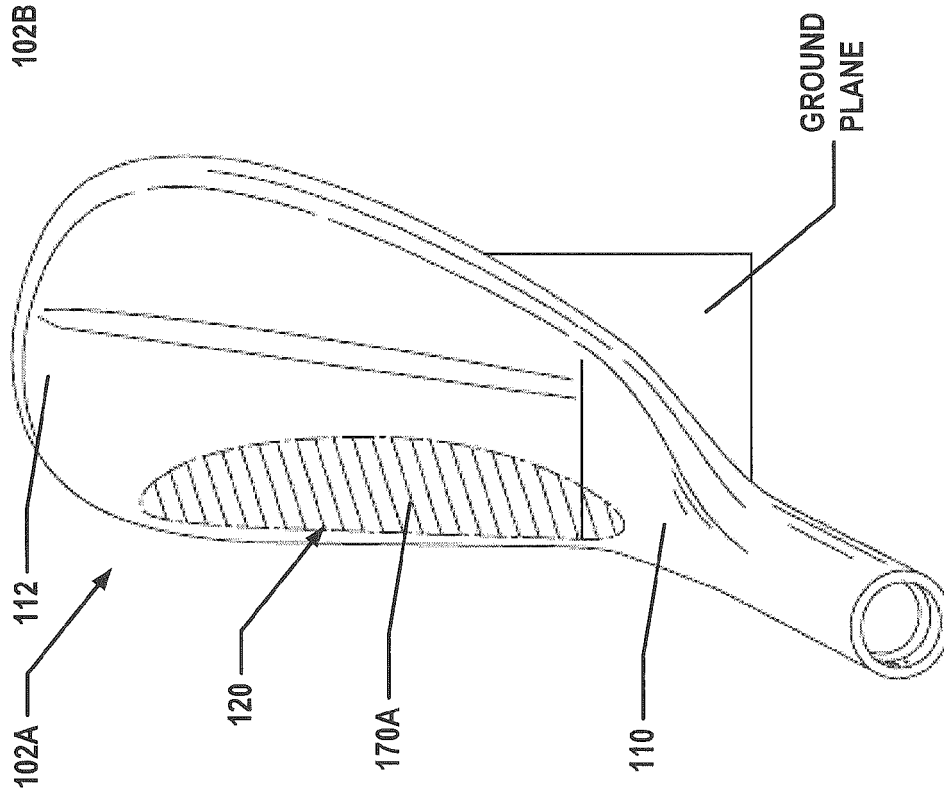


FIG. 9
[PRIOR ART]

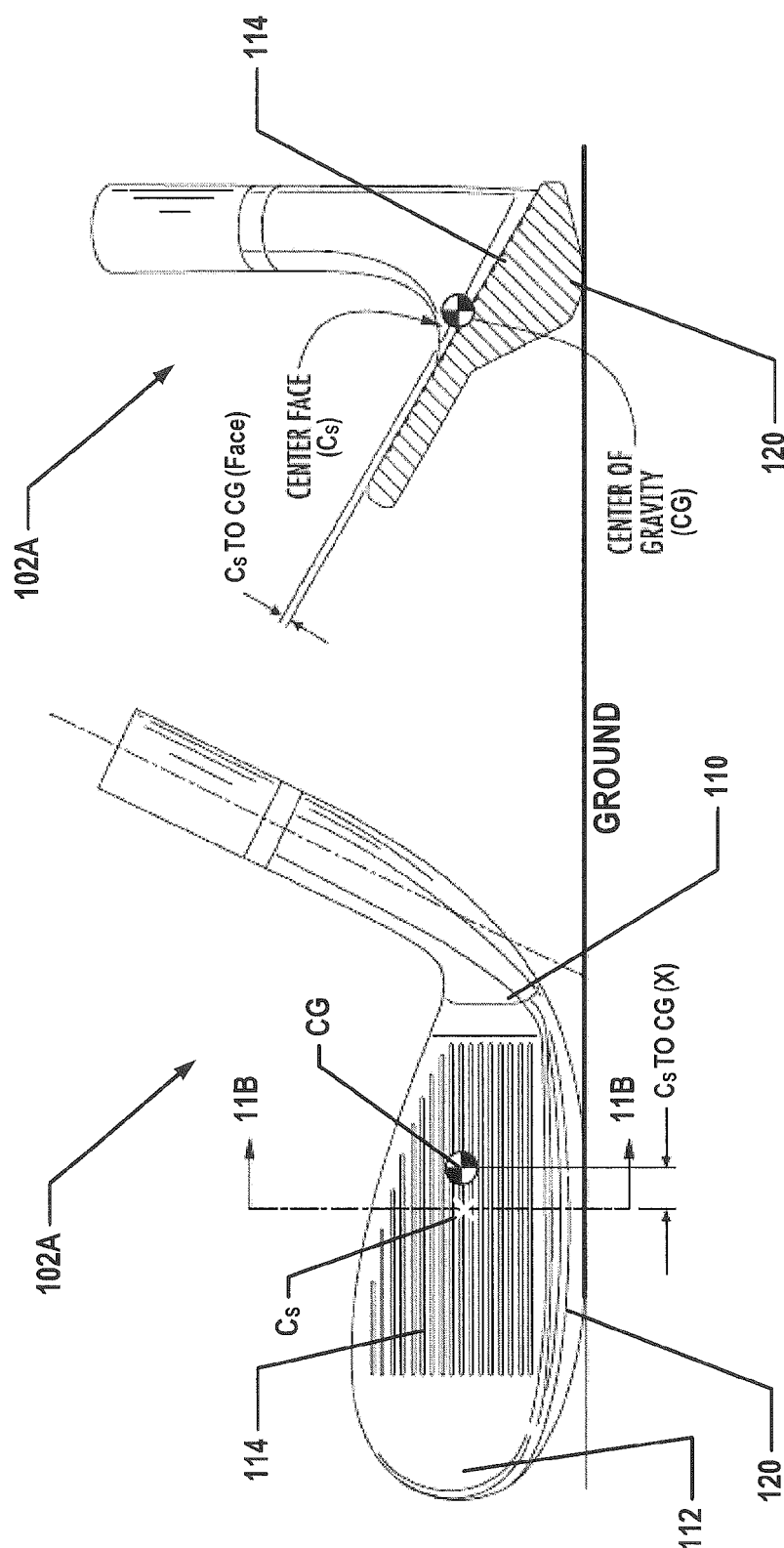


FIG. 11A
[PRIOR ART]

FIG. 11B
[PRIOR ART]

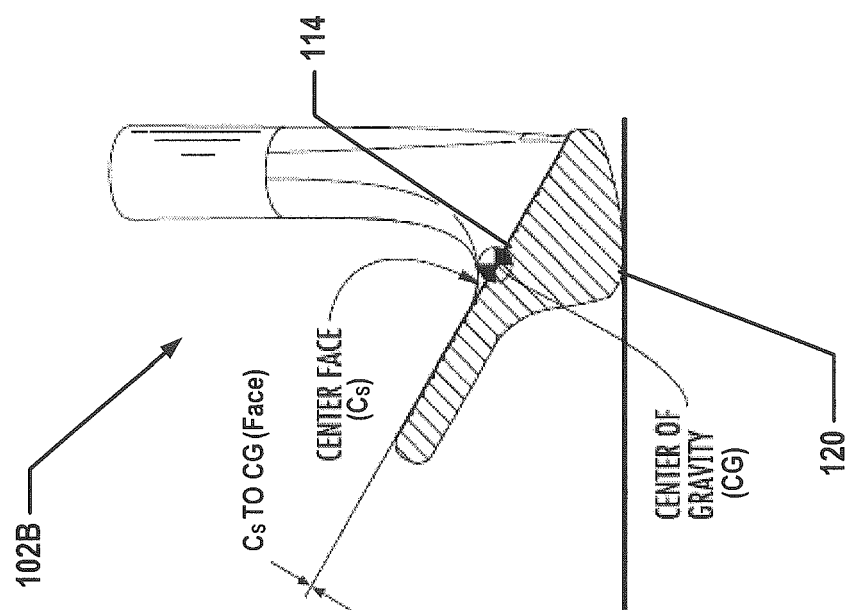
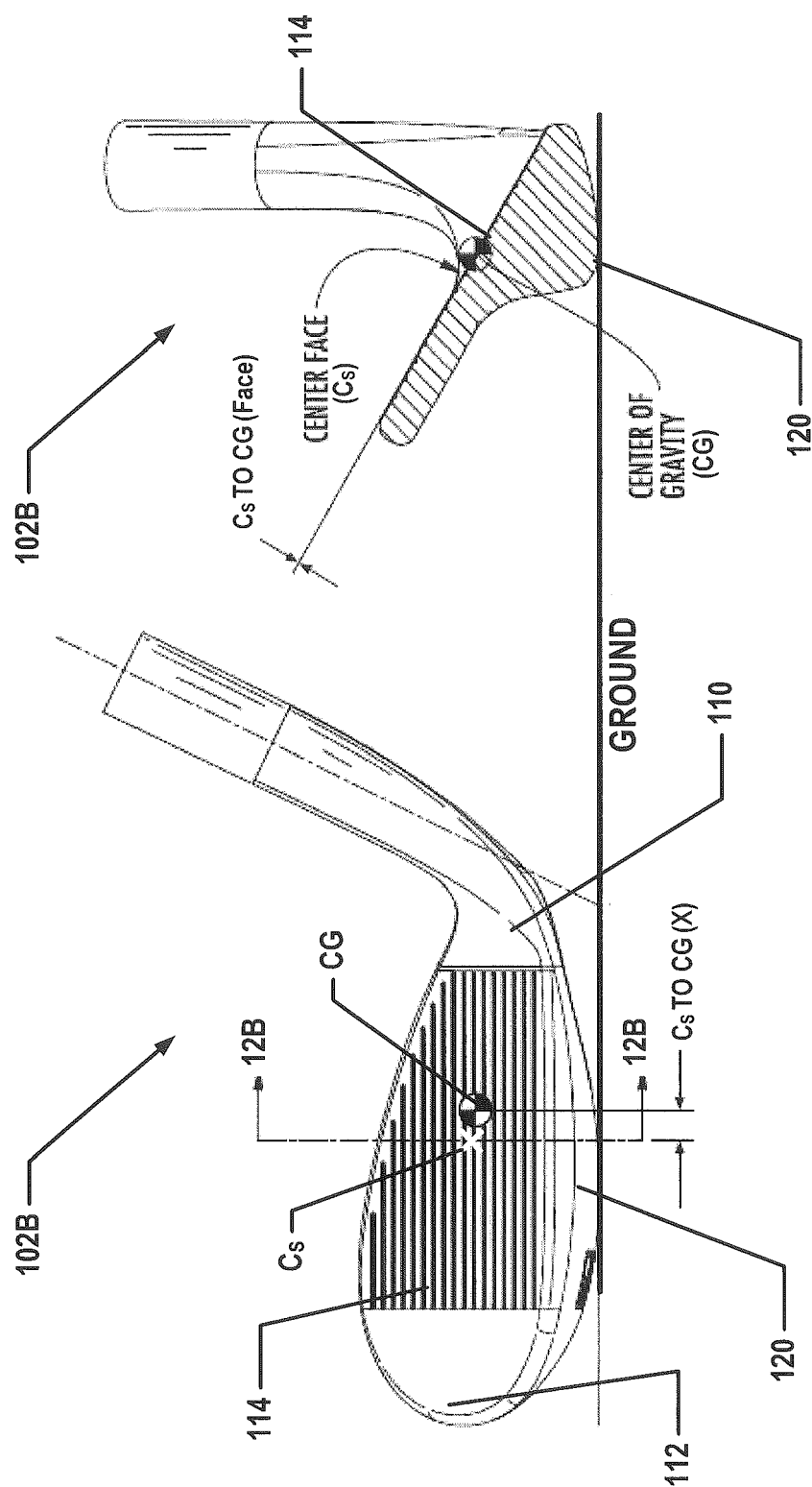


FIG. 12A

FIG. 12B

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 04762511 A [0070] [0071] [0072]