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GB 2618454 B

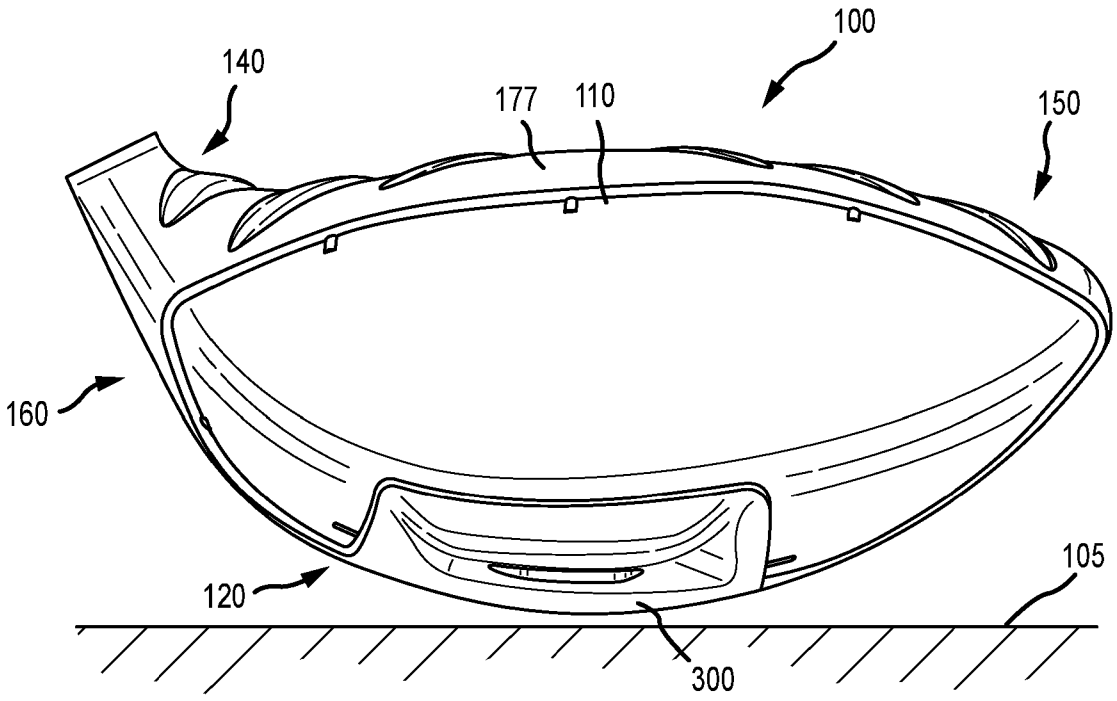


FIG.1A

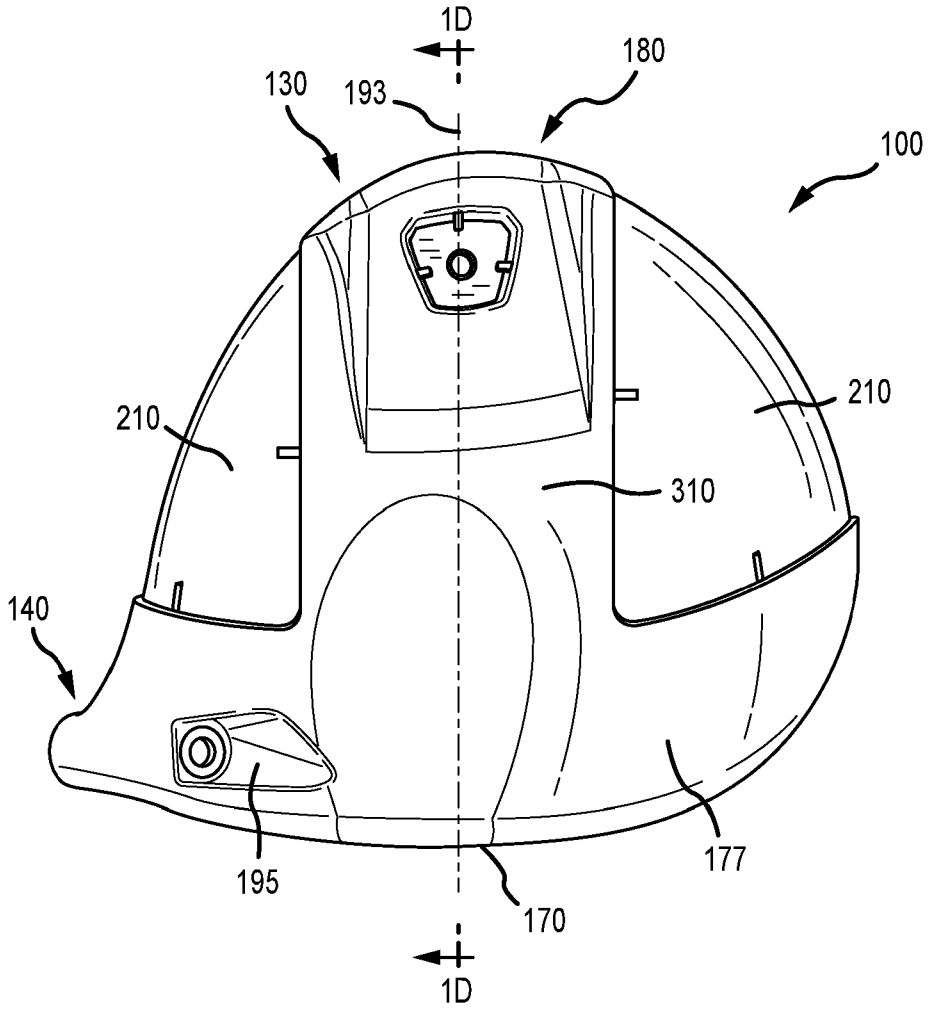


FIG.1B

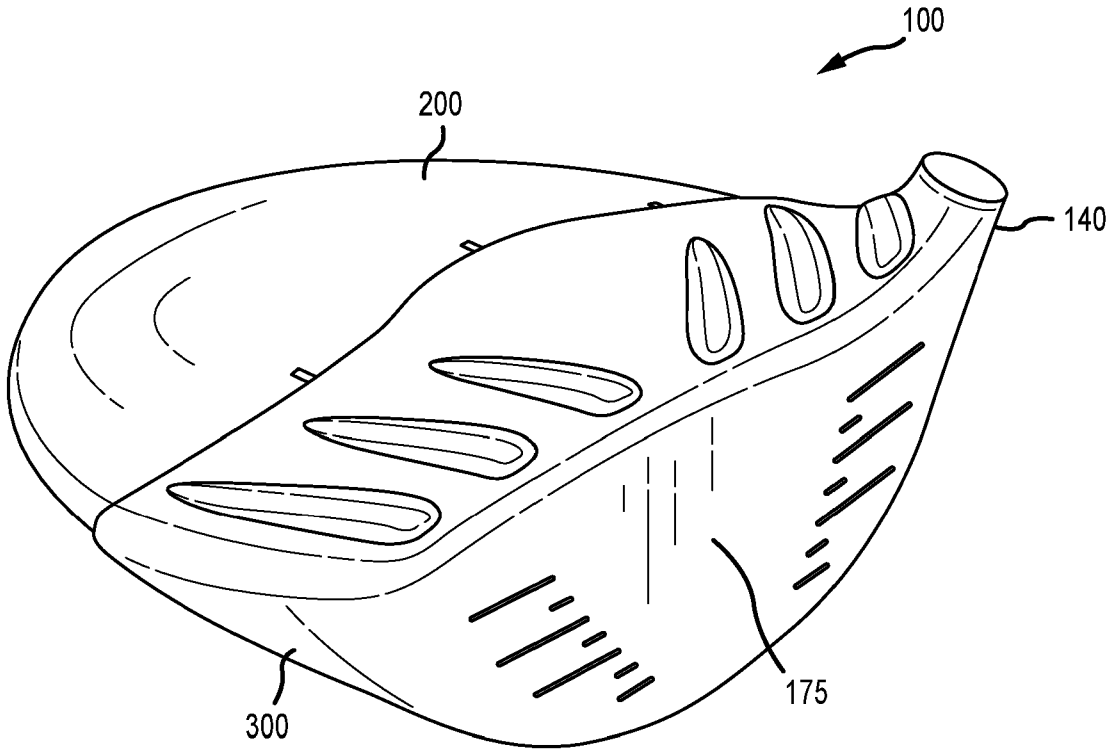


FIG.1C

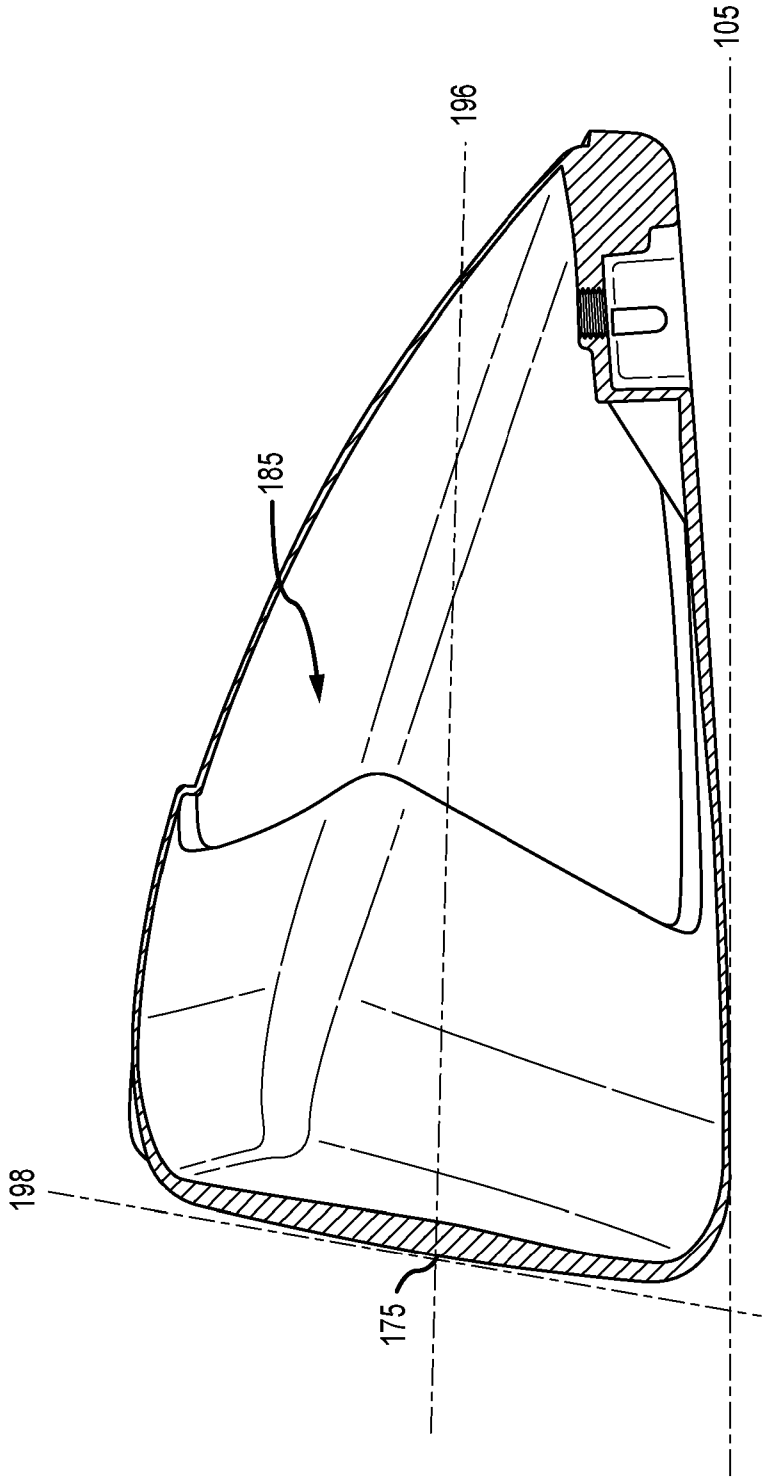


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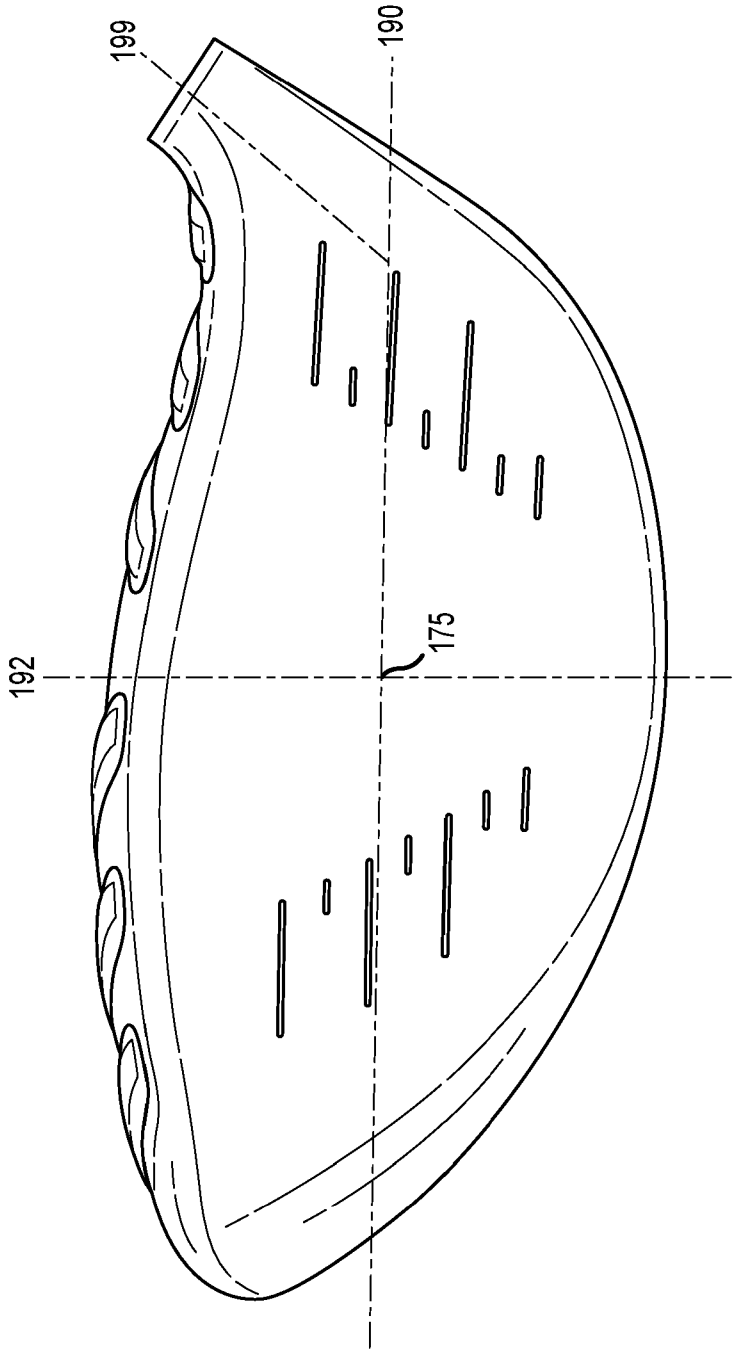


FIG.1E

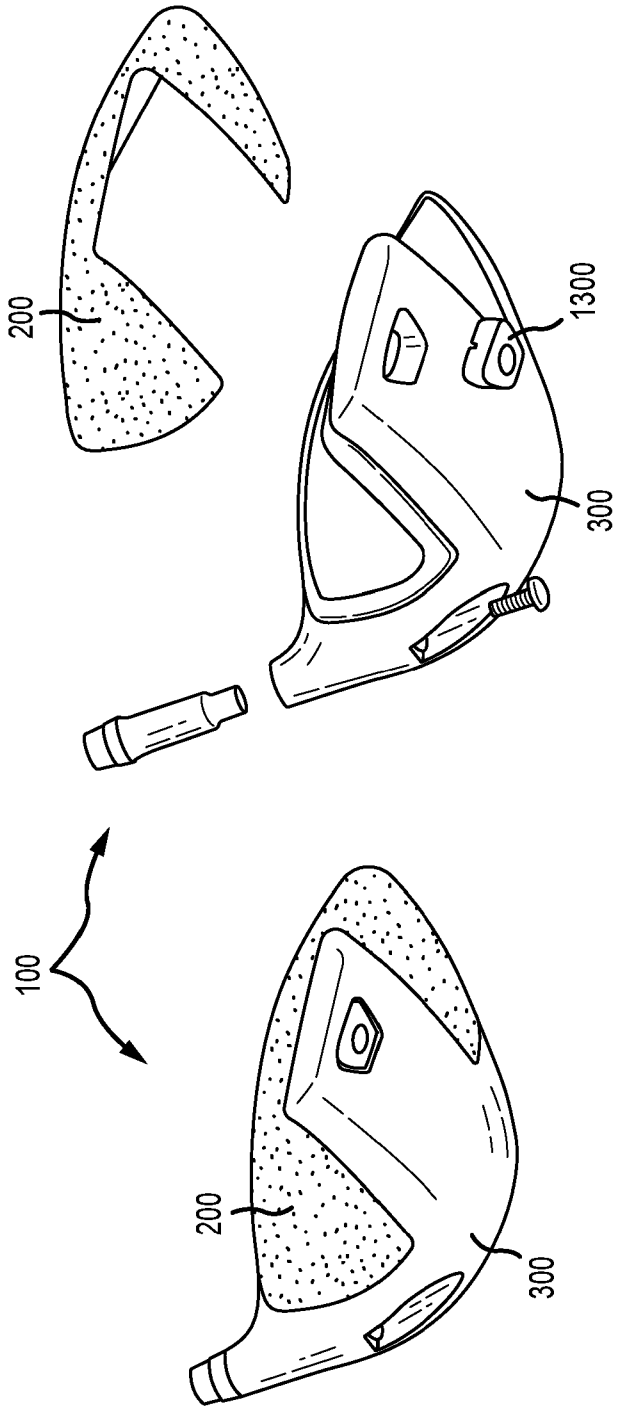


FIG.1F

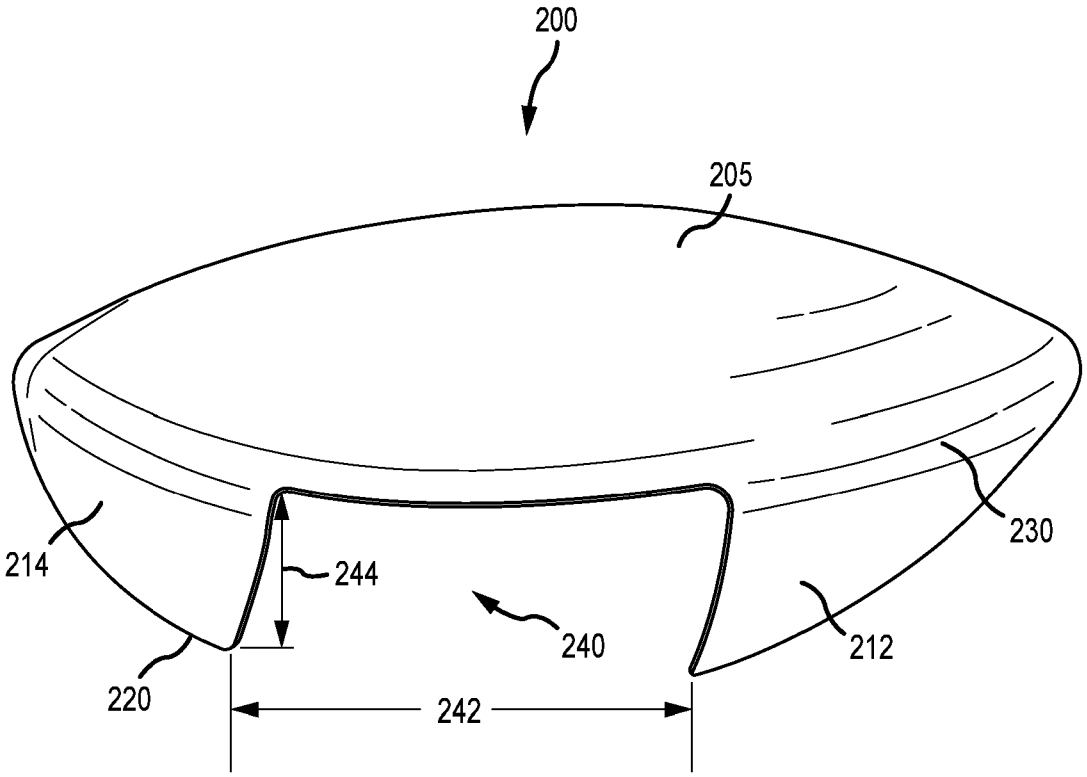


FIG.2

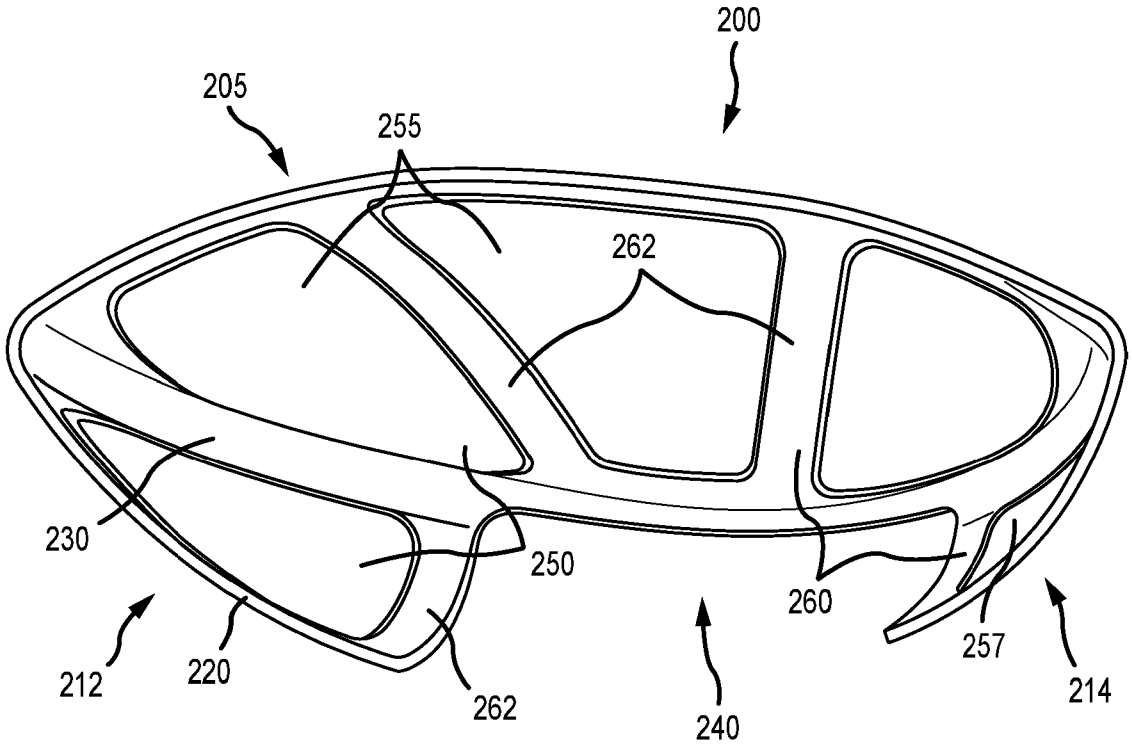


FIG.3A

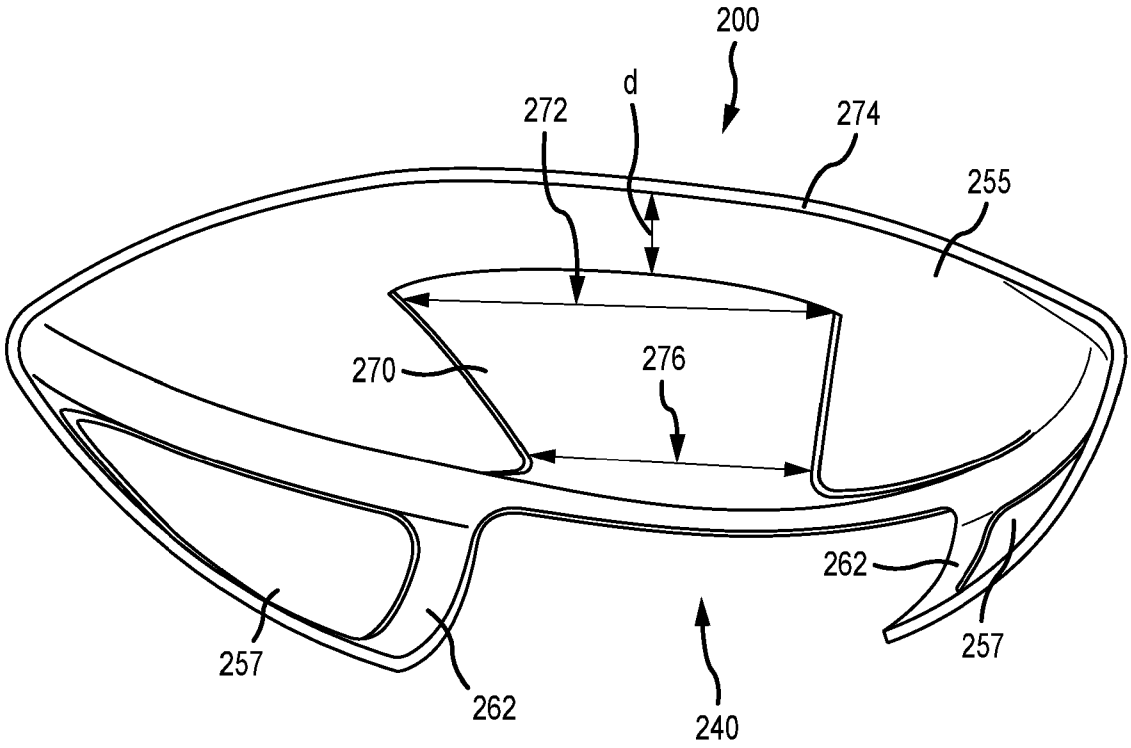


FIG.3B

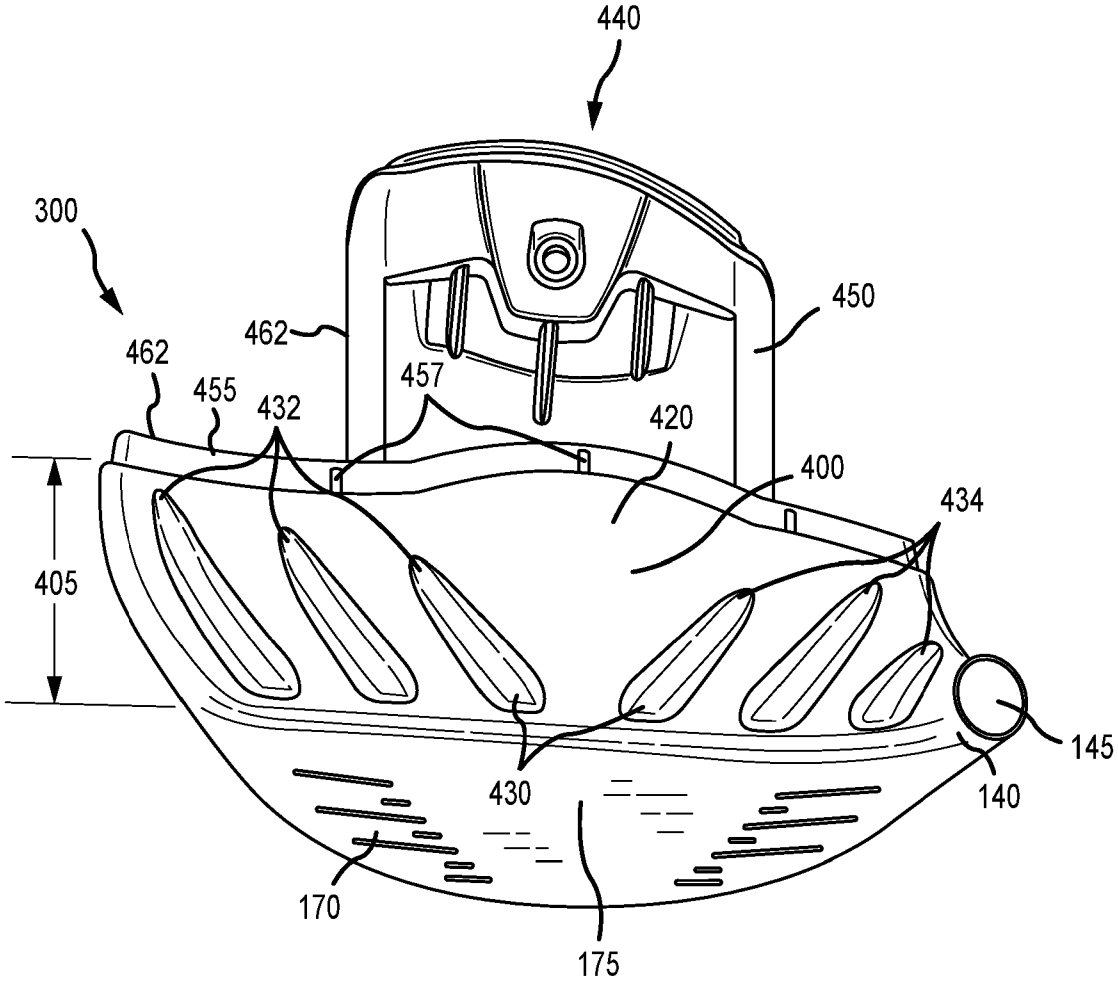

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FIG.4

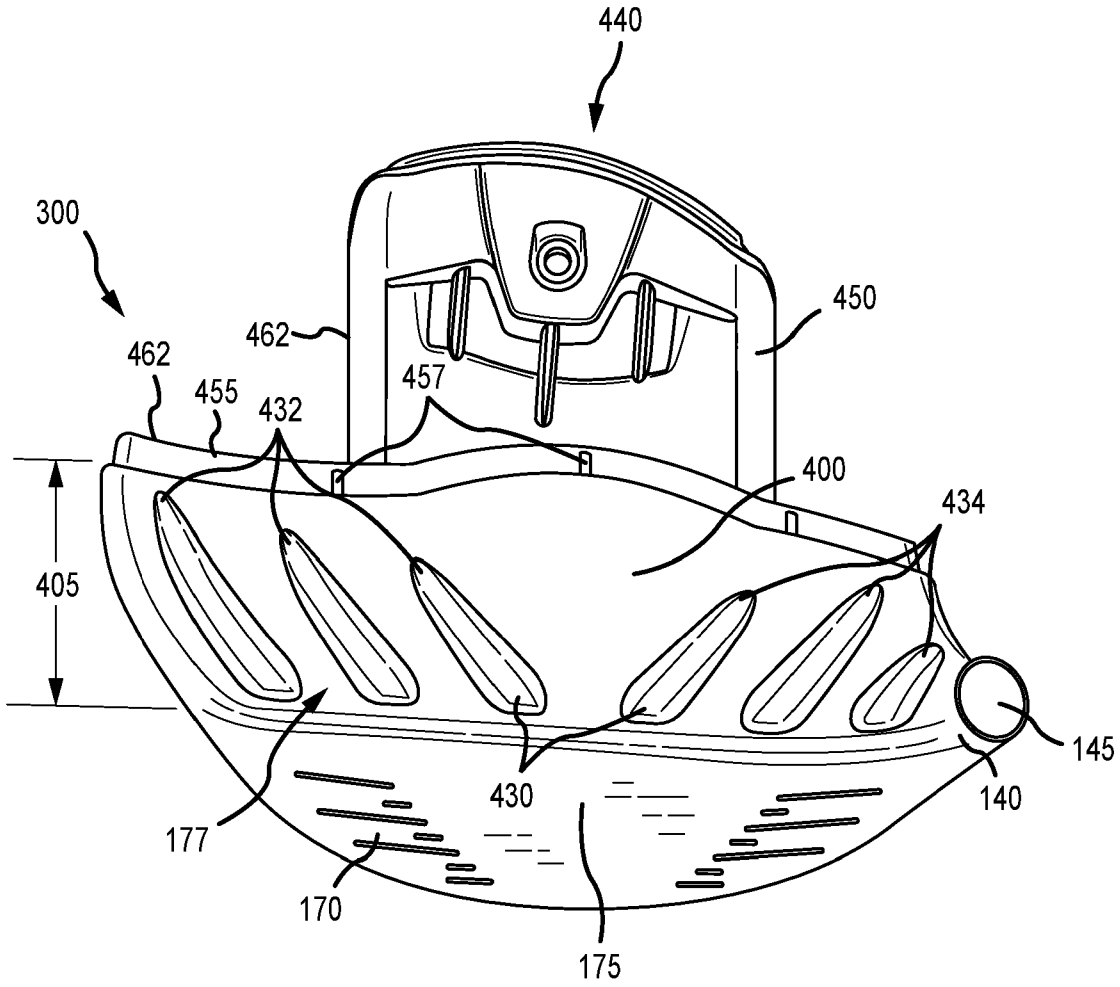

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FIG.5

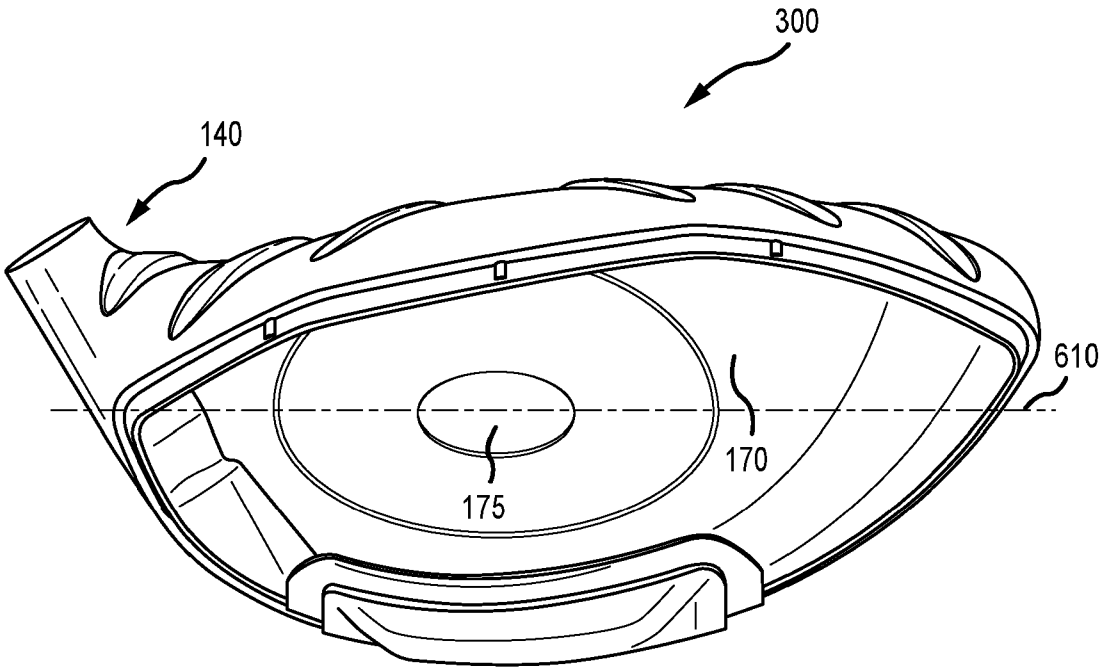


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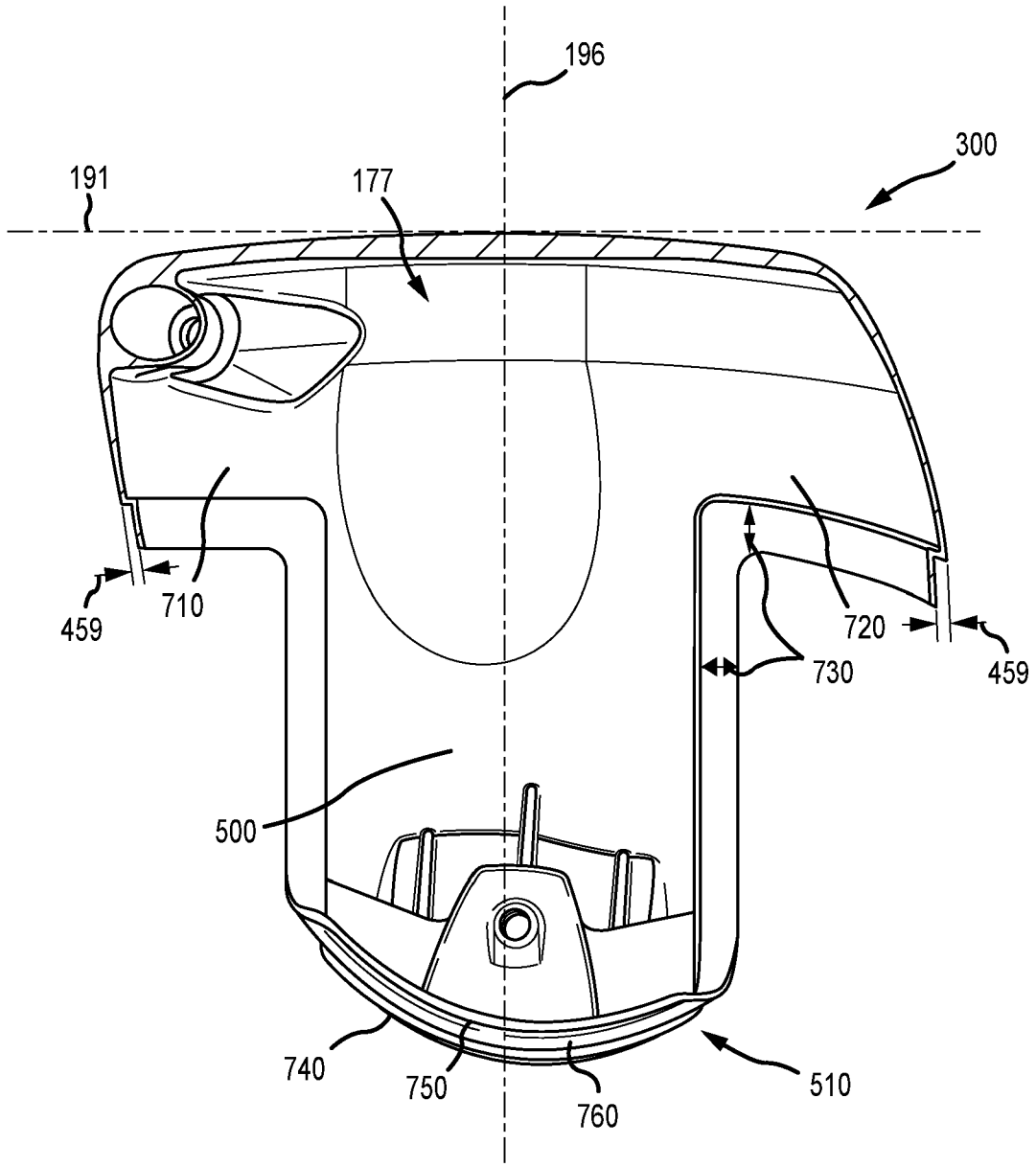


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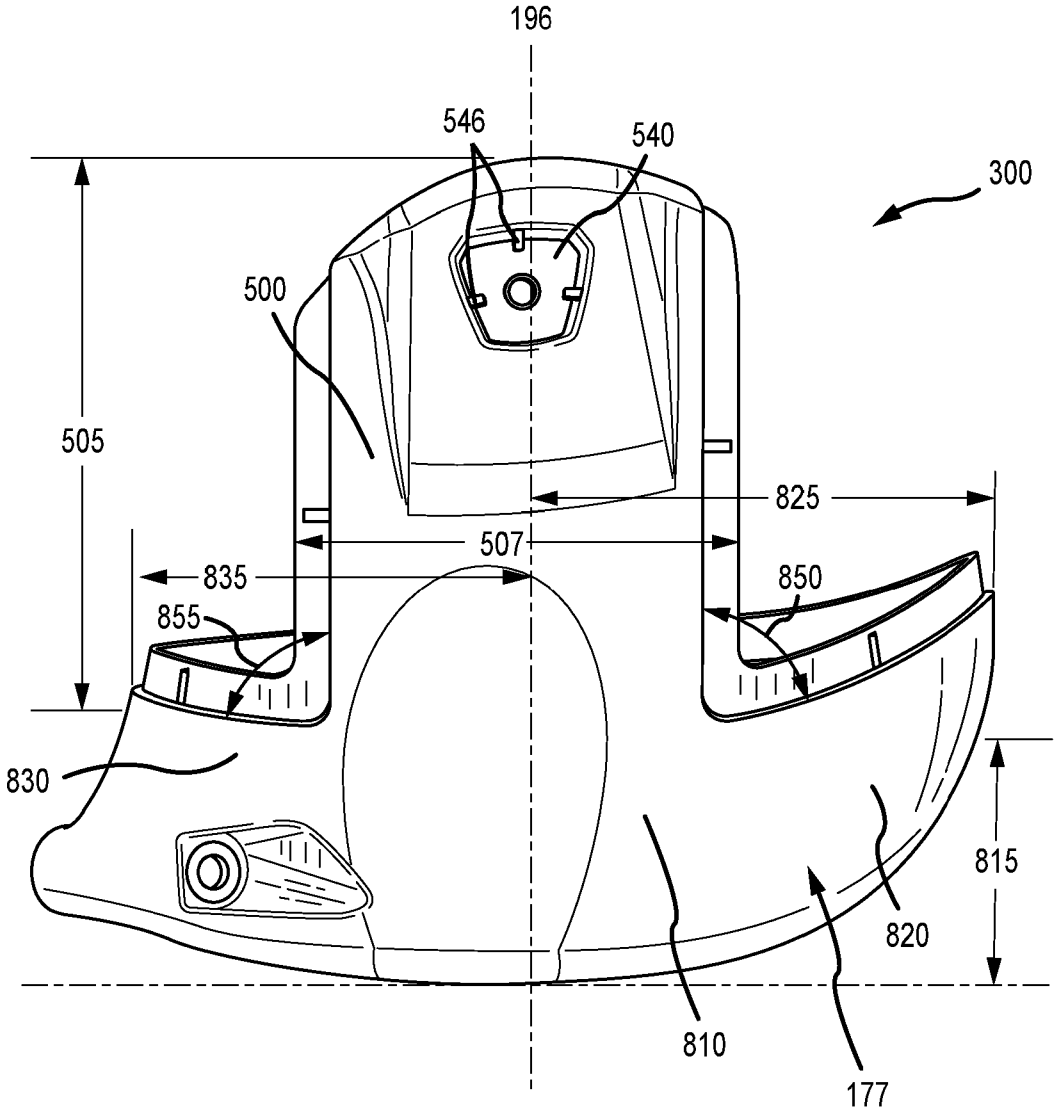


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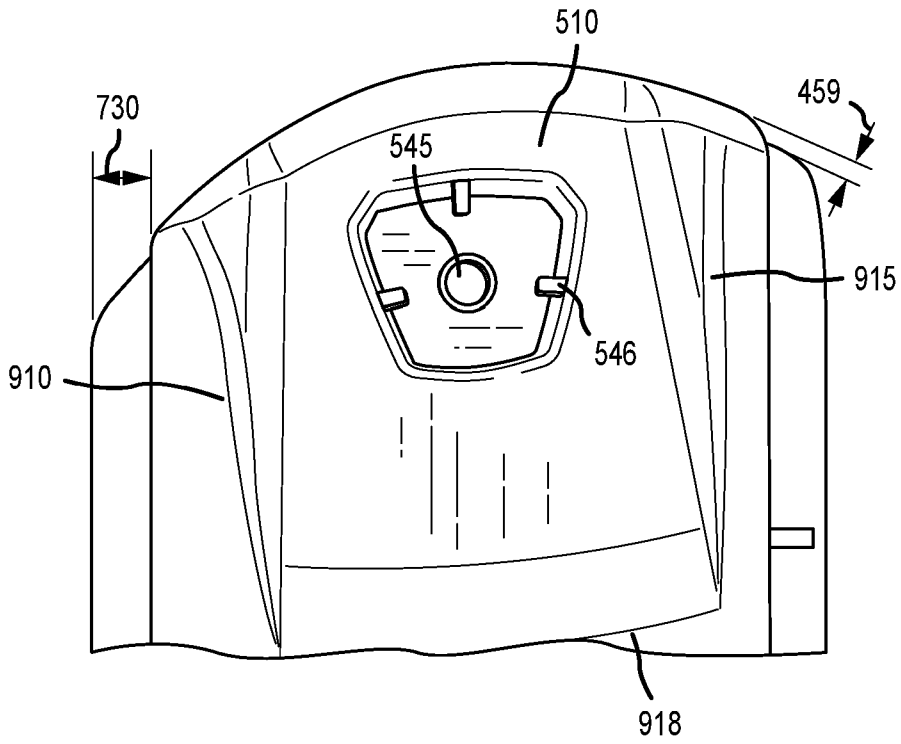


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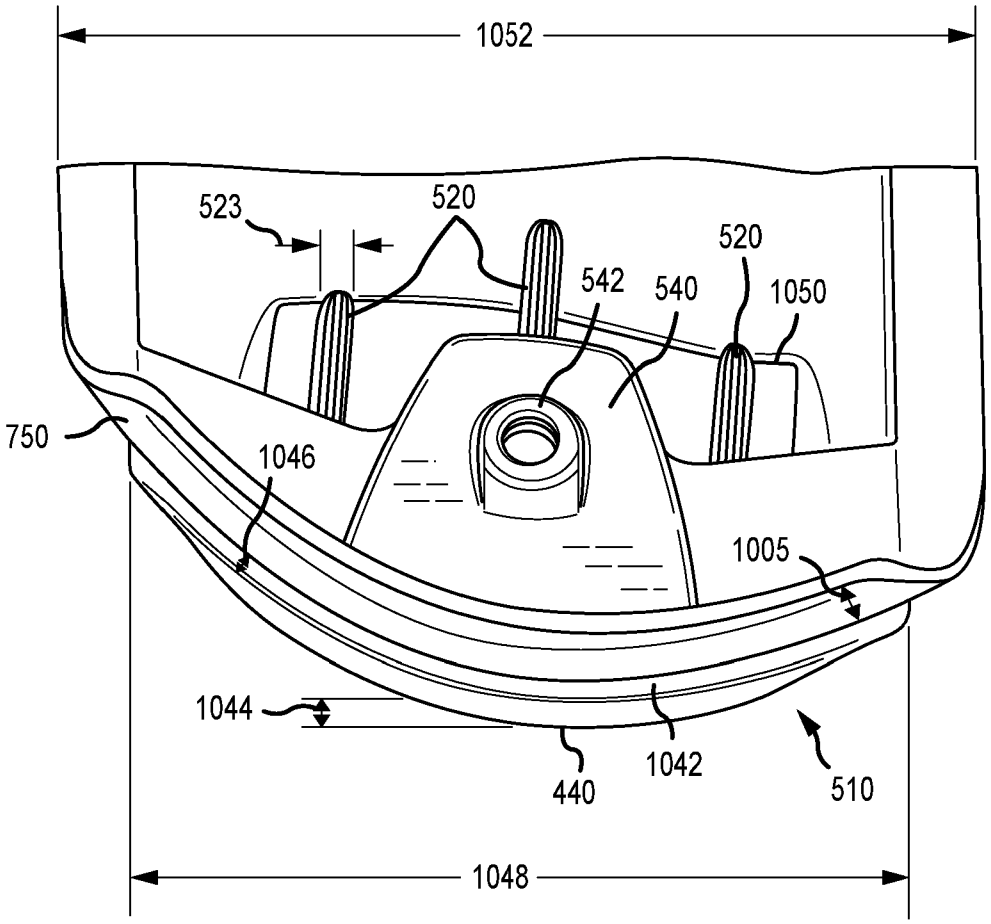

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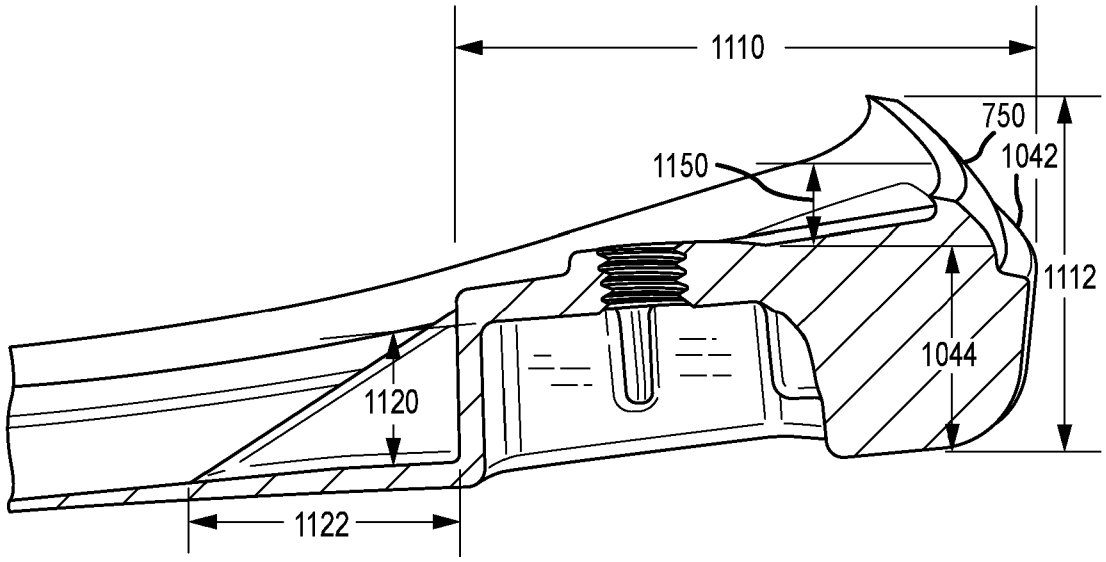


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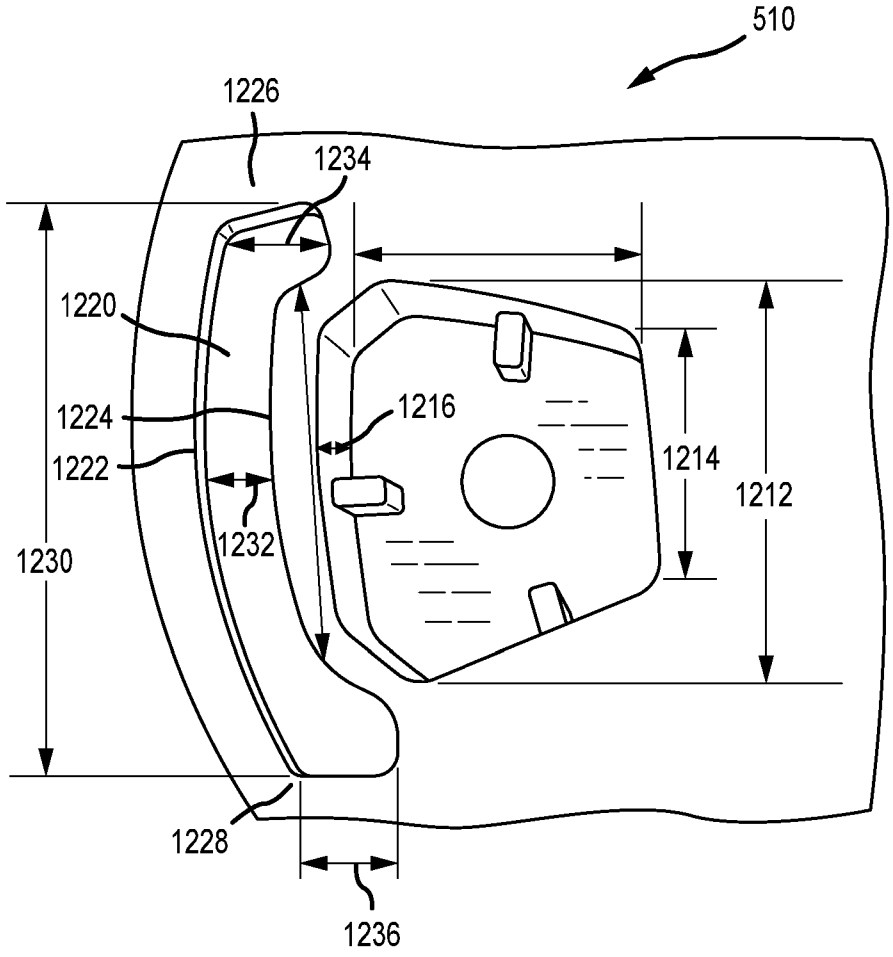

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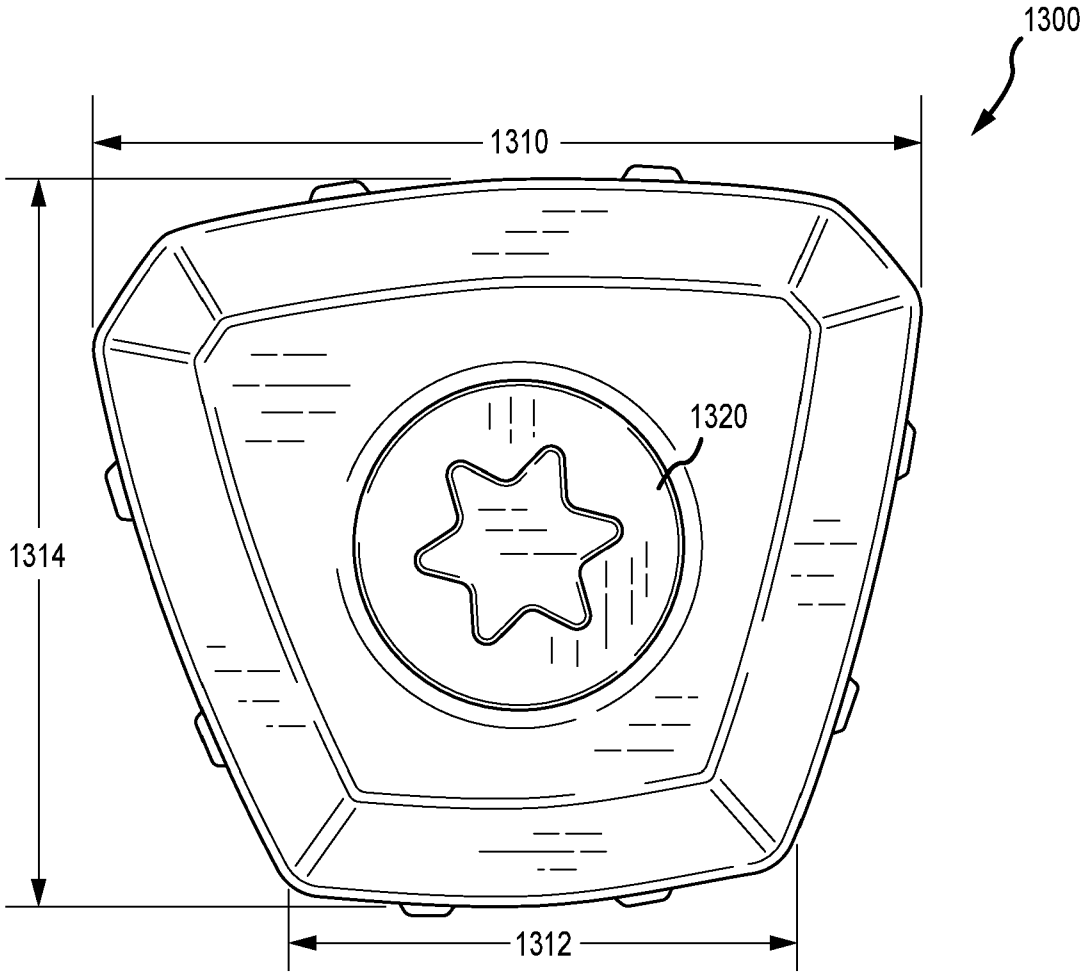


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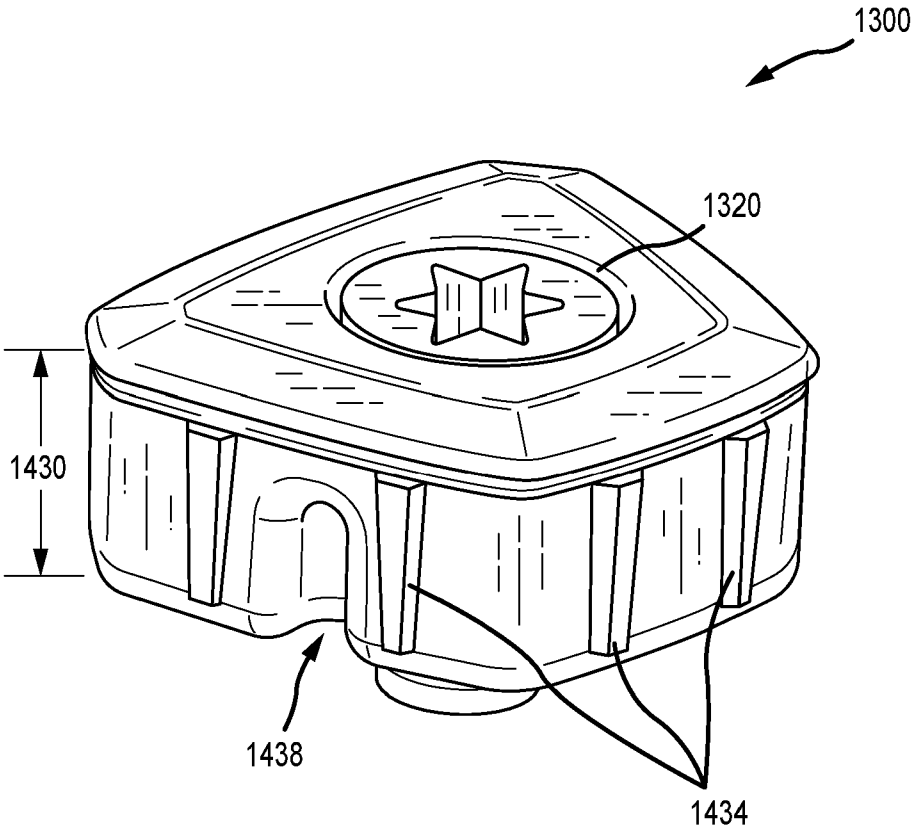


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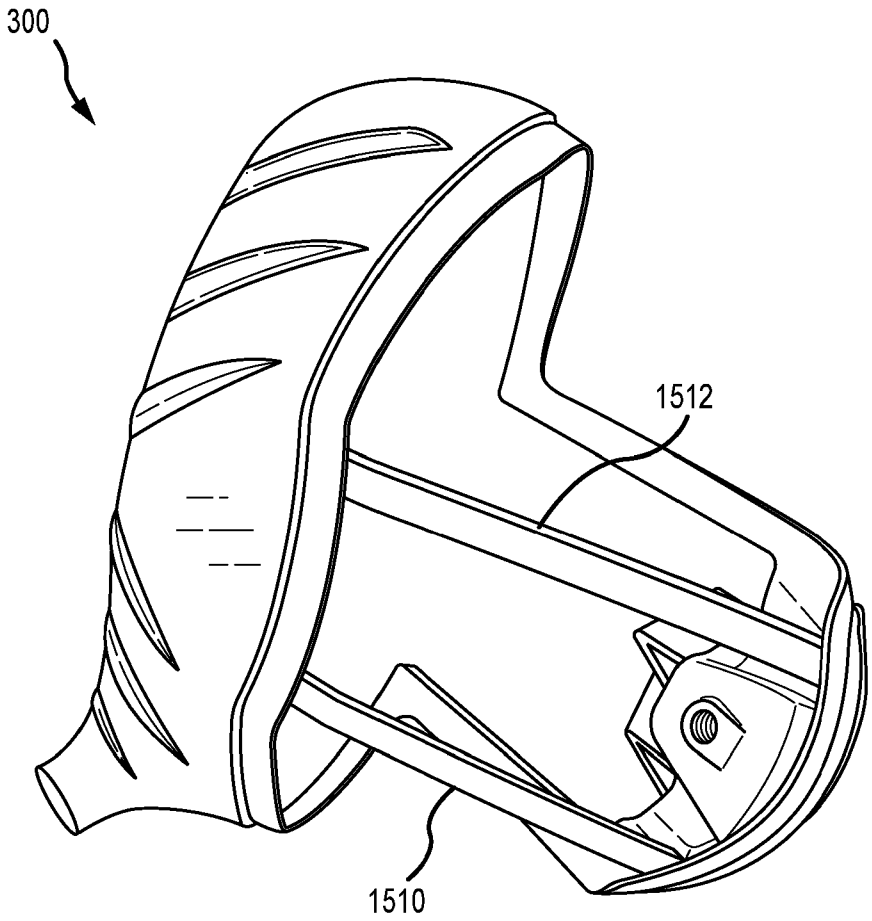


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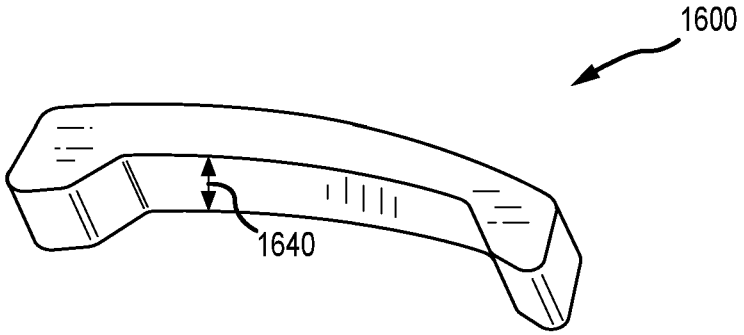


FIG.16A

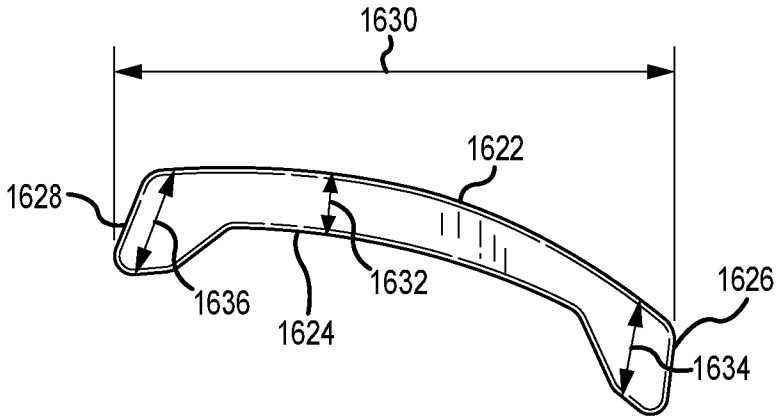


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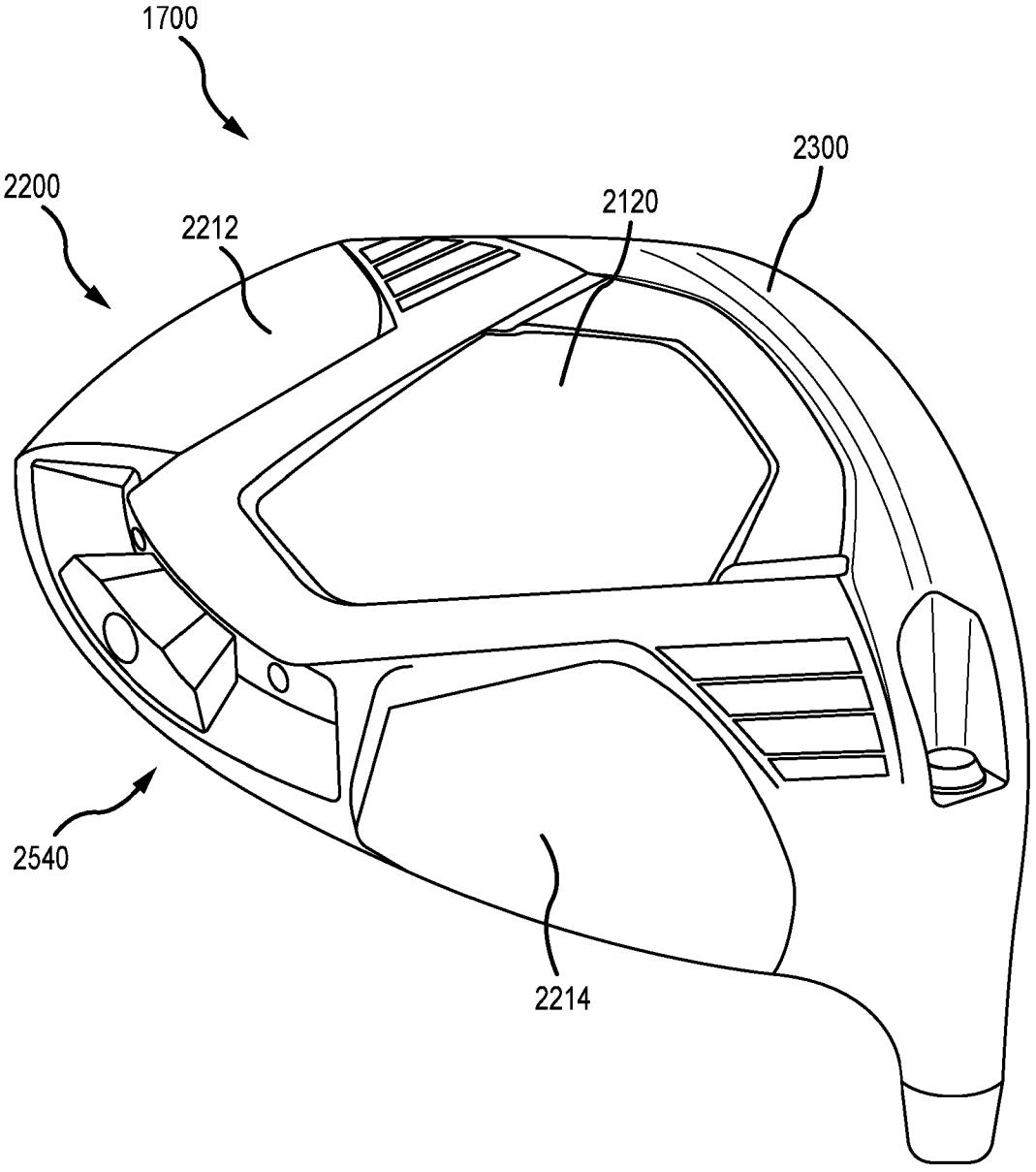


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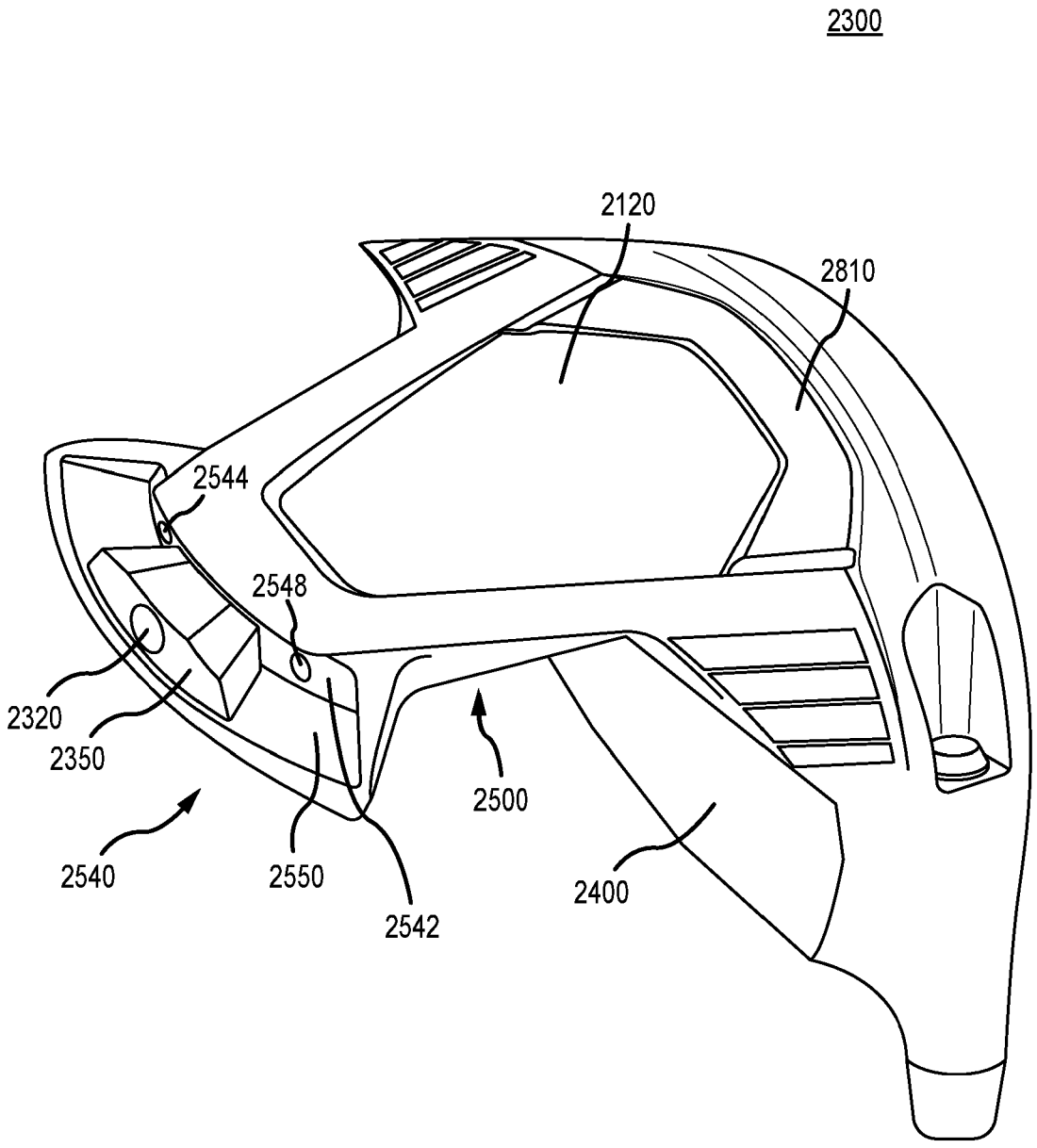


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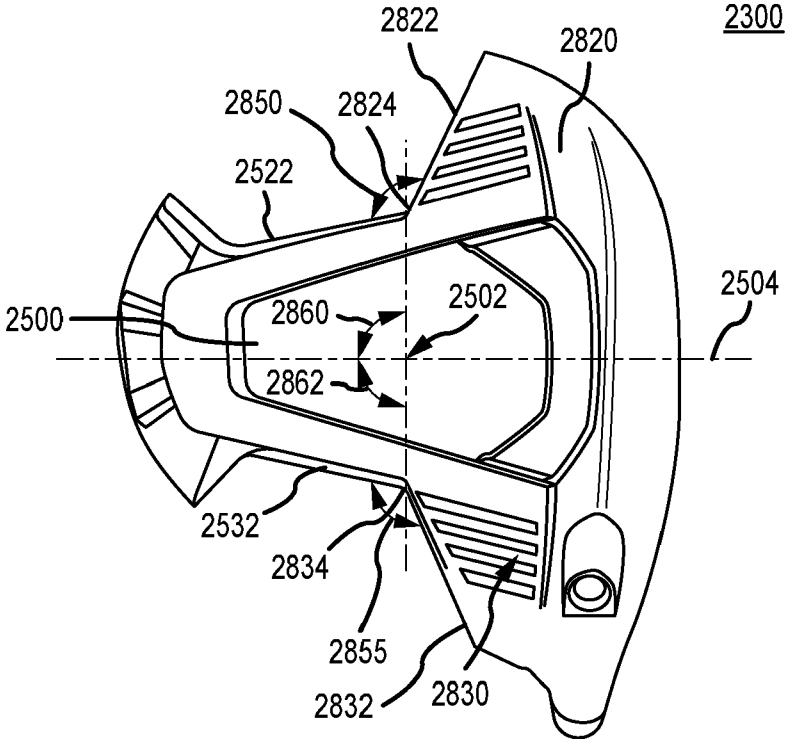

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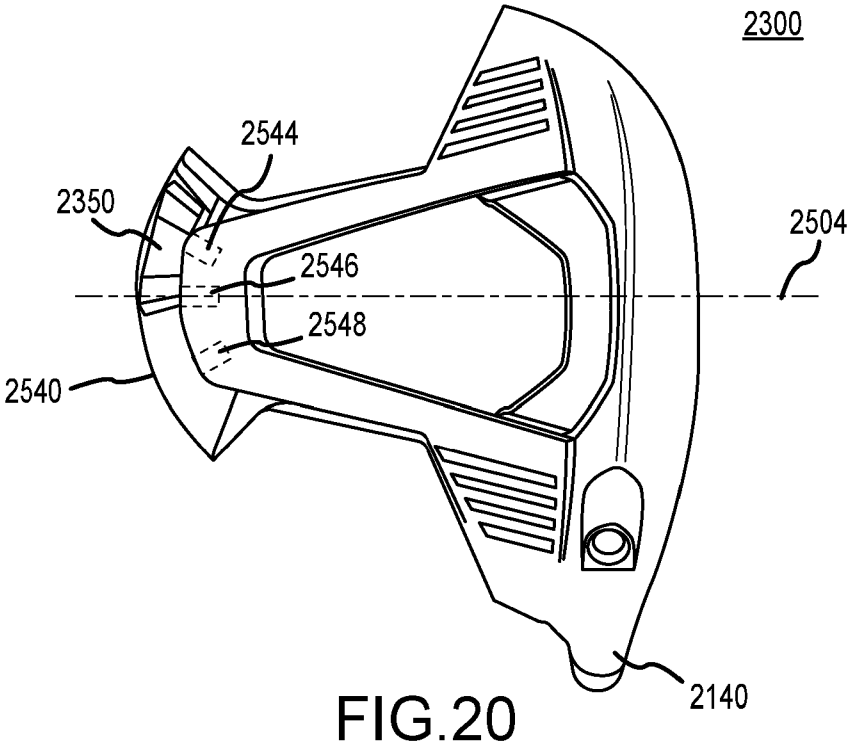

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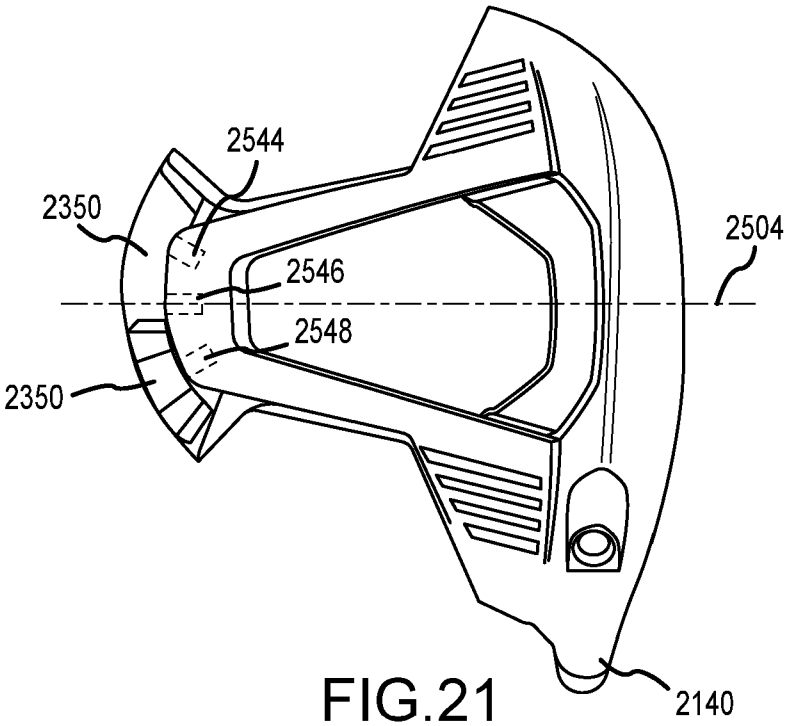

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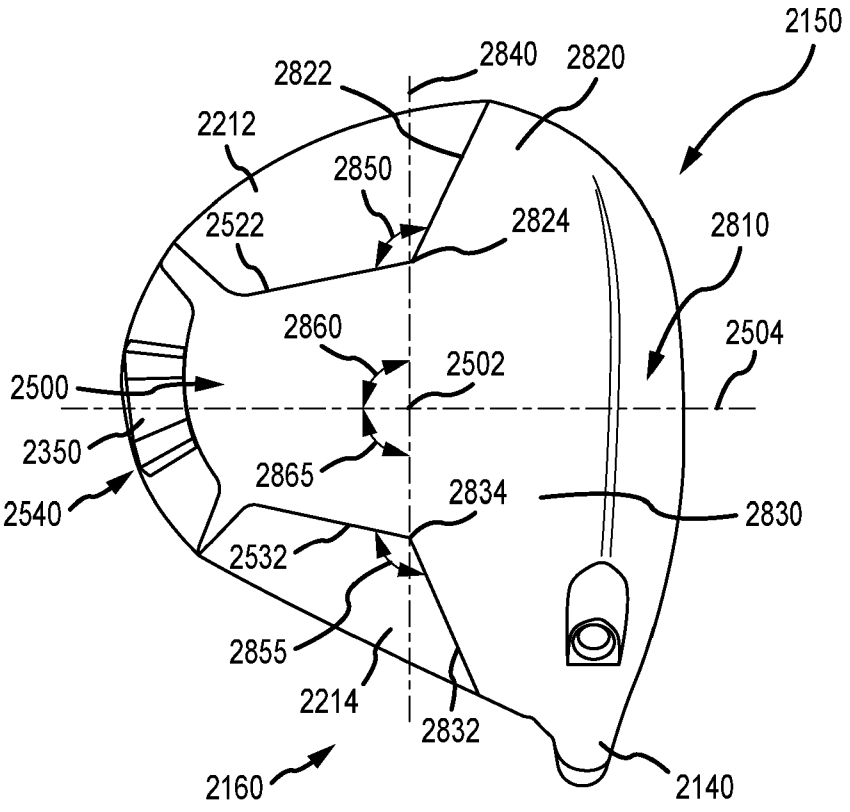

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FIG.22

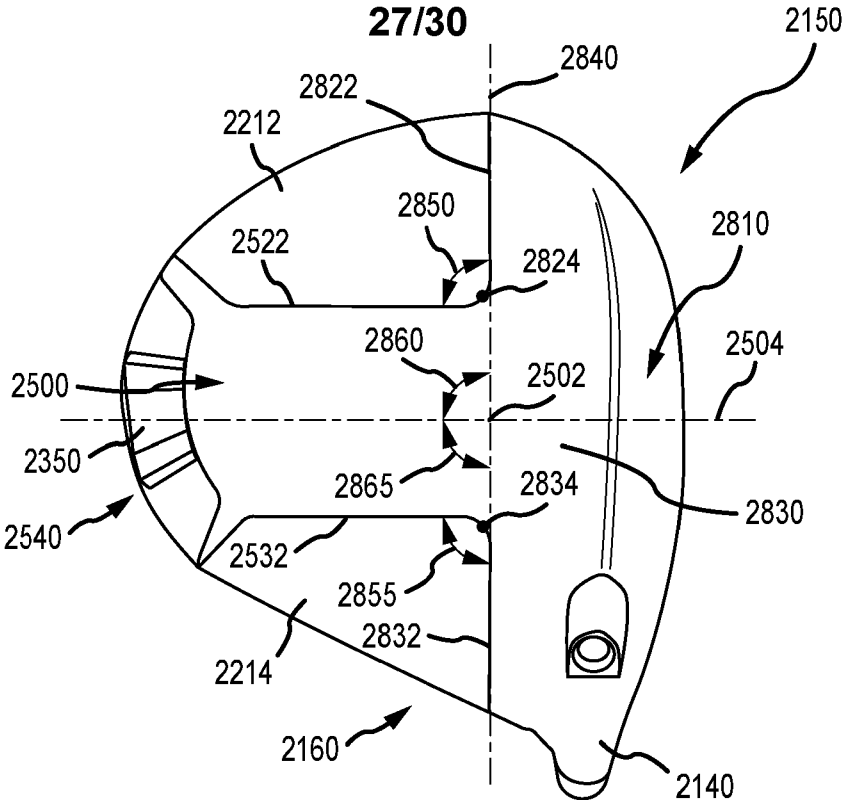

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FIG.23

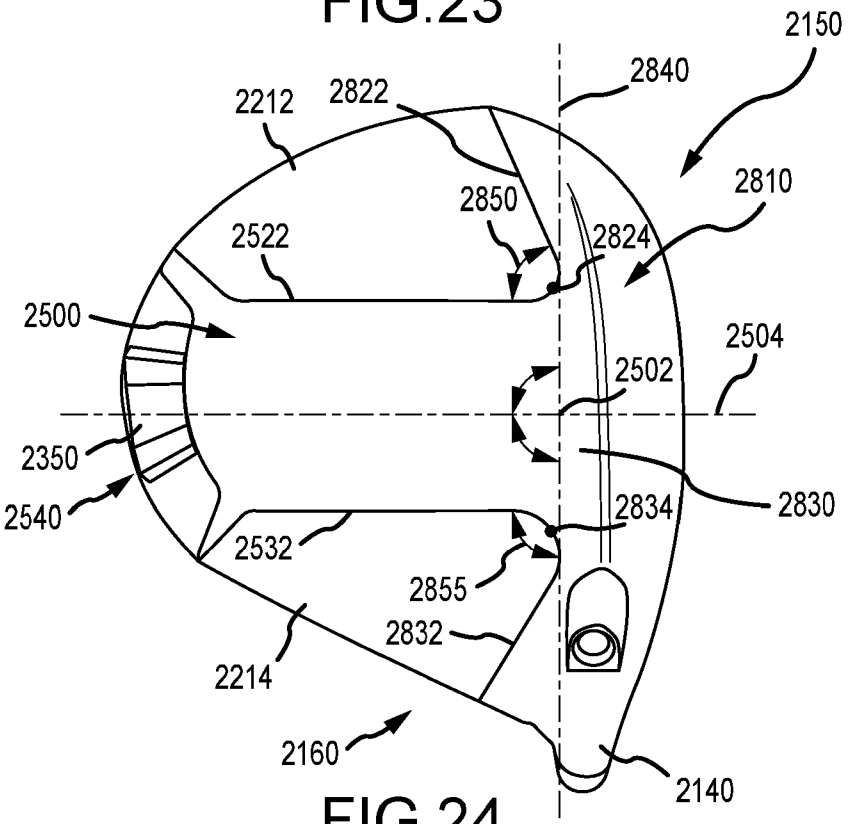

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FIG.24

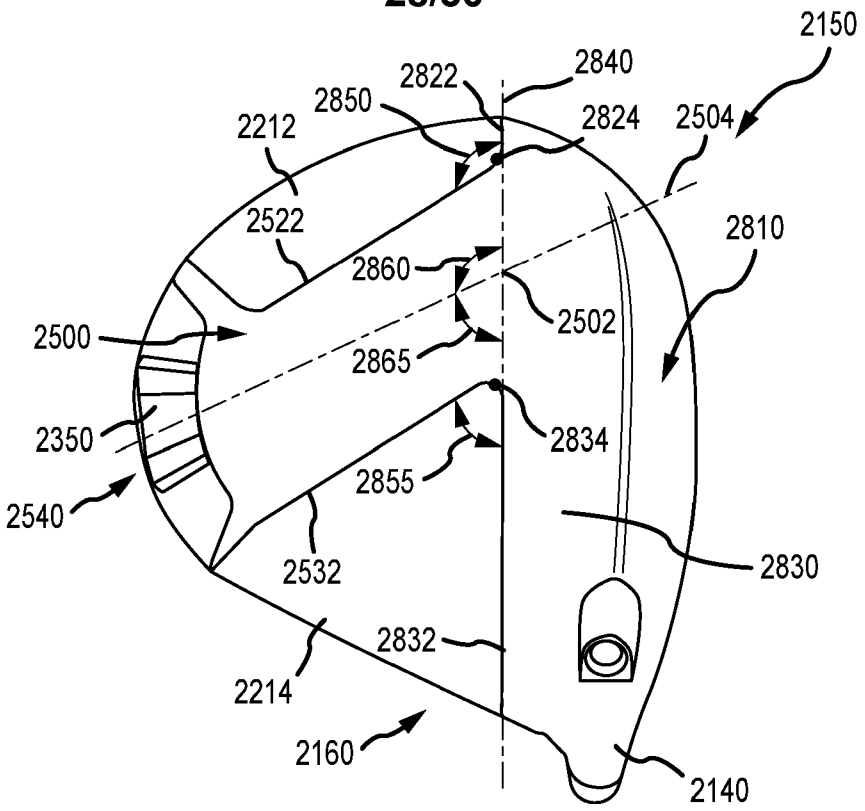

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FIG.25

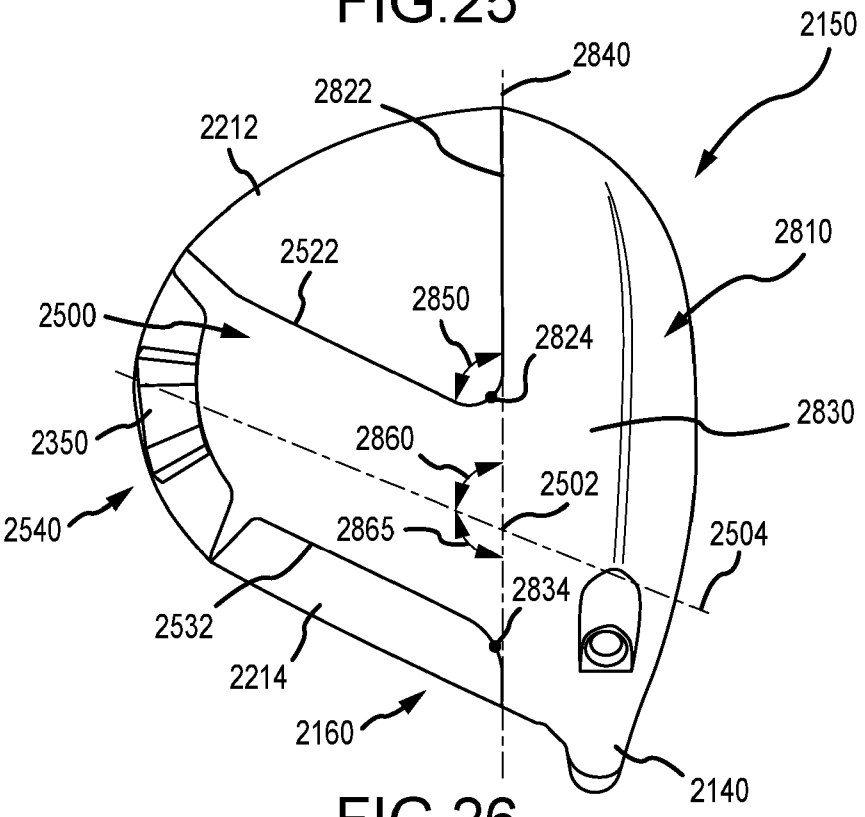

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FIG.26

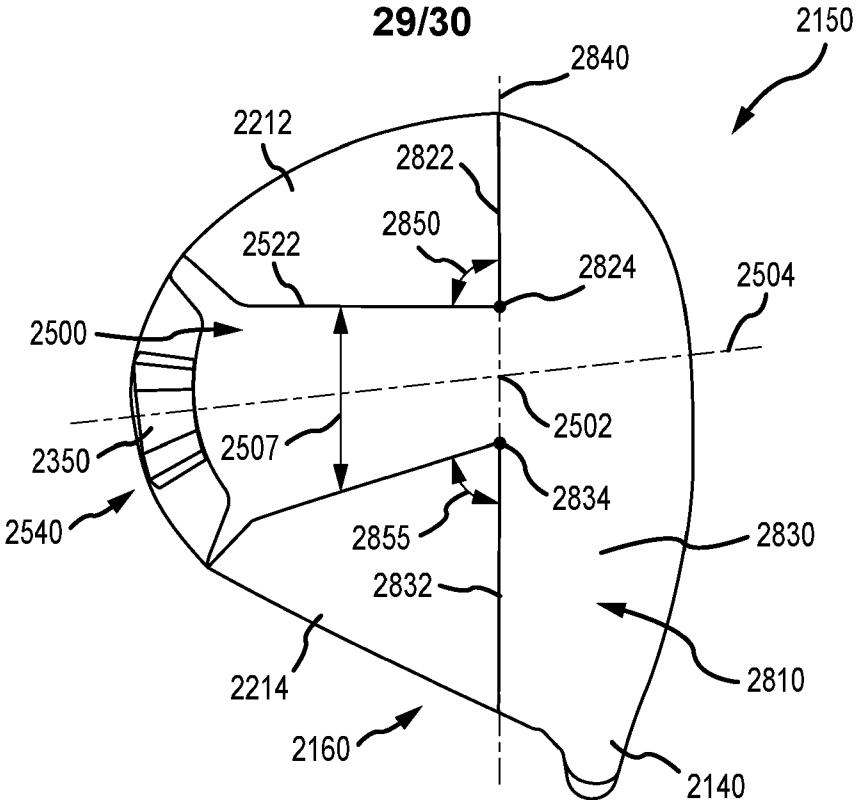

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FIG.27

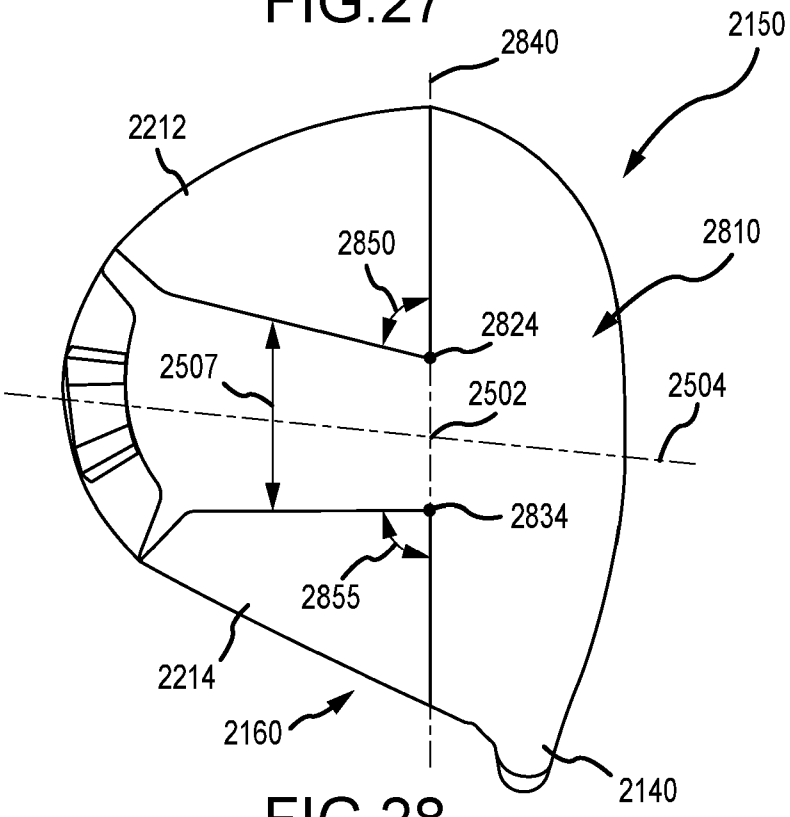

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FIG.28

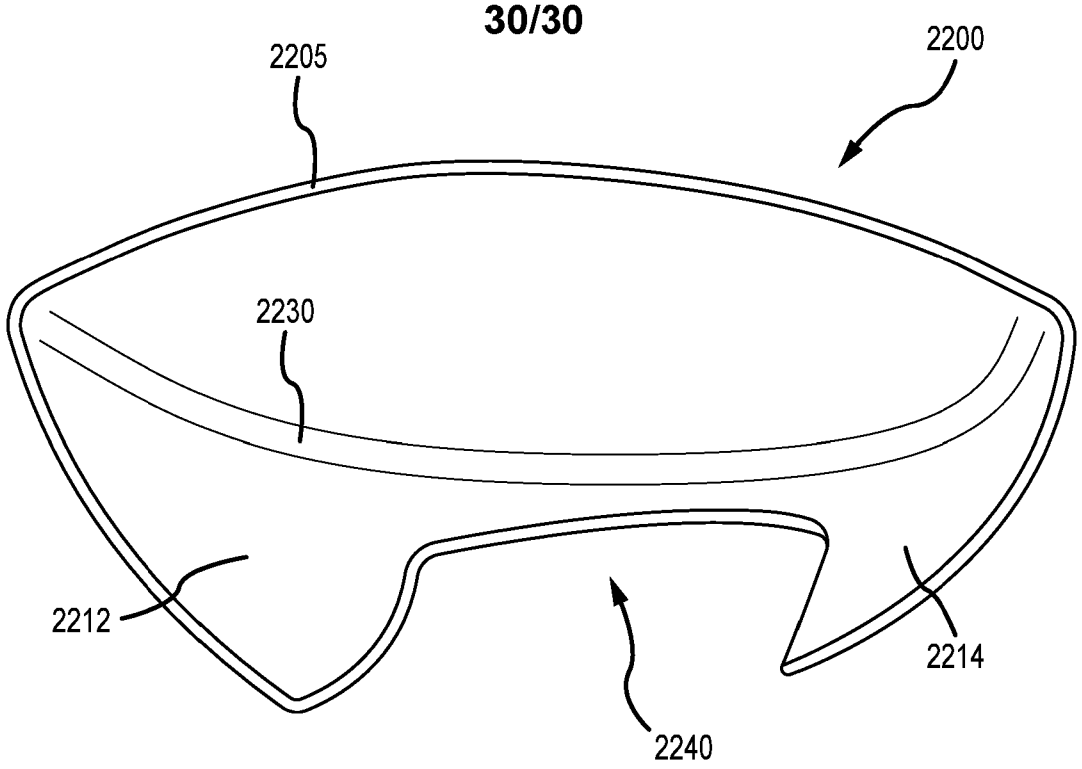


FIG.29

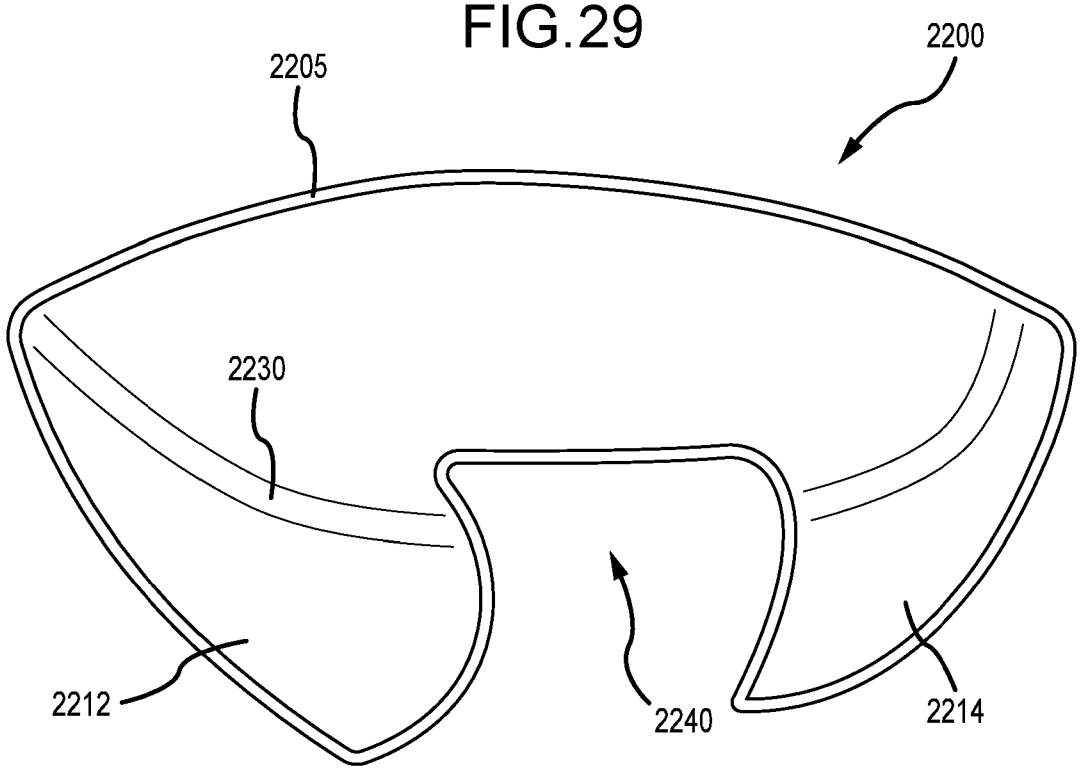


FIG.30

MULTI-COMPONENT GOLF CLUB HEAD

FIELD

[0001] The disclosure relates generally to golf equipment, and more particularly, to multi-component golf club heads and methods to manufacture multi-component golf club heads.

BACKGROUND

[0002] In general, the club head mass is the total amount of structural mass and the amount of discretionary mass. In an ideal club design, having a constant total swing weight, structural mass would be minimized (without sacrificing resiliency) to provide a designer with sufficient discretionary mass for optional placement to customize and maximize club performance. Structural mass generally refers to the mass of the materials required to provide the club head with the structural resilience to withstand repeated impacts. Structural mass is highly design-dependent, and provides a designer with a relatively low amount of control over specific mass distribution. Conversely, discretionary mass is any additional mass (beyond the minimum structural requirements) that may be added to the club head design solely to customize the performance and/or forgiveness of the club. There is a need in the art for alternative designs to all metal golf club heads to provide a means for maximizing discretionary weight to maximize club head moment of inertia (MOI) and lower/back center of gravity (CG), and provide options for golf ball flight manipulation.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1A illustrates a back view of an assembled golf club head.

[0004] FIG. 1B illustrates a bottom view of an assembled golf club head.

[0005] FIG. 1C illustrates a front perspective view of an assembled golf club head.

[0006] FIG. 1D illustrates a cross-sectional view of a golf club head with a loft plane, a ground plane, and a Z axis.

[0007] FIG. 1E illustrates a front view of an assembled golf club head with X, Y, and hosel axes.

[0008] FIG. 1F illustrates an assembled and exploded view of a golf club head.

[0009] FIG. 2 illustrates a golf club head second component rear exterior view.

[0010] FIG. 3 illustrates a golf club head second component front interior view.

[0011] FIG. 4 illustrates a golf club head first component front top view.

[0012] FIG. 5 illustrates a golf club head first component top view.

[0013] FIG. 6 illustrates a golf club head first component rear view showing a mid-plane through a strike face center parallel to the ground plane.

[0014] FIG. 7 illustrates a cross section of the first golf club component of Figure 6 along reference line XI.

[0015] FIG. 8 illustrates a golf club head first component bottom view.

[0016] FIG. 9 illustrates a golf club head first component sole portion rear extension mass portion bottom view.

[0017] FIG. 10 illustrates a golf club head first component sole portion rear extension mass portion close rear view.

[0018] FIG. 11 illustrates a cross section of a golf club head first component sole portion rear extension mass portion.

[0019] FIG. 12 illustrates a golf club head first component sole portion rear extension mass portion with a detachable weight recess and an embedded weight recess.

[0020] FIG. 13 illustrates a top view of a detachable weight with a threaded fastener.

[0021] FIG. 14 illustrates side perspective view of a detachable weight with a threaded fastener.

[0022] FIG. 15 illustrates a golf club head first component showing casting support bars.

[0023] FIG. 16A illustrates a side view of an embedded weight for fitting in the embedded weight recess of FIG. 12.

[0024] FIG. 16B illustrated a top view of an embedded weight.

[0025] FIG. 17 illustrates a perspective view of a golf club head, according to a second embodiment.

[0026] FIG. 18 illustrates a perspective view of a first component of the club head of FIG. 17.

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[0027] FIG. 19 illustrates a sole view of the first component of FIG. 18.

[0028] FIG. 20 illustrates a sole view of the first component of FIG. 18, with the movable weight in a toe-side position.

[0029] FIG. 21 illustrates a sole view of the first component of FIG. 18, with the movable weight in a heel-side position.

[0030] FIG. 22 illustrates a sole view of a golf club head, with a straight rear sole extension, according to an embodiment.

[0031] FIG. 23 illustrates a sole view of a golf club head, with a straight rear sole extension, according to an embodiment.

[0032] FIG. 24 illustrates a sole view of a golf club head, with a straight rear sole extension, according to an embodiment.

[0033] FIG. 25 illustrates a sole view of a golf club head, with an angled rear sole extension, according to an embodiment.

[0034] FIG. 26 illustrates a sole view of a golf club head, with an angled rear sole extension, according to an embodiment.

[0035] FIG. 27 illustrates a sole view of a golf club head, with a varying width sole extension, according to an embodiment.

[0036] FIG. 28 illustrates a sole view of a golf club head, with a varying width sole extension, according to an embodiment.

[0037] FIG. 29 illustrates a front view the second component of a golf club head, according to an embodiment.

[0038] FIG. 30 illustrates a front view the second component of a golf club head, according to an embodiment.

DETAILED DESCRIPTION

[0039] Described herein is a hollow golf club head comprising two major components. The first component is metallic. The second component is non-metallic. The metallic, first component

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comprises the striking portion and a sole extension. The non-metallic, second component comprises the rear portion of the crown, and wraps around to also comprise a portion of the sole. The first component comprises the load bearing, or structural area of the golf club head, and also comprises most of the mass of the golf club head. The first component comprises a rearwardly extending sole portion with a significant portion of the golf club mass at the most rearward portion of the extension, causing the first part to form a "T" shape when viewed from above. This arrangement provides discretionary mass available to be redistributed to improve the center of gravity (CG) location and moment of inertia (MOI). The improved CG and MOI provide for a more precise ball flight compared to traditional, all metallic golf club heads. The golf club head discussed herein may comprise a driver-type golf club head, a fairway-type golf club head, or a hybrid-type golf club head.

[0040] The more dense "T" shaped sole of the first component, coupled to the less dense crown wrapped around second component can optimize mass properties by reducing the crown mass, and shifting the golf club head center of gravity (CG) lower. The saved weight from the second component can be redistributed to other locations of the golf club head to further optimize the CG and increase the MOI. The CG of the golf club head can move lower and toward the rear of the golf club head comprising the first component and the second component, wherein the second component comprises a second material with a second density that is lower than the first material density, compared to an alternate golf club head comprising only the first material with a constant density.

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[0041] "A," "an," "the," "at least one," and "one or more" are used interchangeably to indicate that at least one of the item is present; a plurality of such items may be present unless the context clearly indicates otherwise. All numerical values of parameters (e.g., of quantities or conditions) in this specification, including the appended claims, are to be understood as being modified in all instances by the term "about" whether or not "about" actually appears before the numerical value. "About" indicates that the stated numerical value allows some slight imprecision (with some approach to exactness in the value; about or reasonably close to the value; nearly). If the imprecision provided by "about" is not otherwise understood in the art with this ordinary meaning, then "about" as used herein indicates at least variations that may arise from ordinary methods of measuring and using such parameters. In addition, disclosure of ranges includes disclosure of all values and further divided ranges within the entire range. Each value within a range and the endpoints of a range are hereby all disclosed as separate embodiment. The terms "comprises," "comprising," "including," and "having,"

are inclusive and therefore specify the presence of stated items, but do not preclude the presence of other items. As used in this specification, the term "or" includes any and all combinations of one or more of the listed items. When the terms first, second, third, etc. are used to differentiate various items from each other, these designations are merely for convenience and do not limit the items.

[0042] The terms "first," "second," "third," "fourth," and the like in the description and in the claims, if any, are used for distinguishing between similar elements and not necessarily for describing a particular sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances such that the embodiments described herein are, for example, capable of operation in sequences other than those illustrated or otherwise described herein. Furthermore, the terms "include," and "have," and any variations thereof, are intended to cover a non-exclusive inclusion, such that a process, method, system, article, device, or apparatus that comprises a list of elements is not necessarily limited to those elements, but may include other elements not expressly listed or inherent to such process, method, system, article, device, or apparatus.

[0043] The terms "left," "right," "front," "back," "top," "bottom," "over," "under," and the like in the description and in the claims, if any, are used for descriptive purposes and not necessarily for describing permanent relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances such that the embodiments of the apparatus, methods, and/or articles of manufacture described herein are, for example, capable of operation in other orientations than those illustrated or otherwise described herein.

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[0044] Other features and aspects will become apparent by consideration of the following detailed description and accompanying drawings. Before any embodiments of the disclosure are explained in detail, it should be understood that the disclosure is not limited in its application to the details or construction and the arrangement of components as set forth in the following description or as illustrated in the drawings. The disclosure is capable of supporting other embodiments and of being practiced or of being carried out in various ways. It should be understood that the description of specific embodiments is not intended to limit the disclosure from covering all modifications, equivalents and alternatives falling within the spirit and scope of the disclosure. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

I) First Embodiment of Golf Club Head

[0045] Described herein is an embodiment of a golf club head (100) comprising two components, a first component and a second component. The golf club head forms a striking face (170), a striking face return (177), a hosel (140), a crown (110), a sole (120), a heel end (160), a toe end (150), a trailing edge (130) at a rear-most portion of a rear end (180), a hosel (140), and a sole portion hosel adaptor attachment recess (195).

[0046] The golf club head (100) further defines a loft plane (198) tangent to the striking face center (175) of the striking face (170). A face height can be measured parallel to the loft plane between a top end of the striking face perimeter near the crown (110) and a bottom end of the striking face perimeter near the sole (120). In these embodiments, the striking face perimeter can be located along the outer edge of the striking face (170) where the curvature deviates from the bulge and/or roll of the striking face (170).

[0047] Referring to FIGS 1D and 1E, the striking face center (175) further defines a coordinate system having an origin at the striking face center (175) of the striking face (170), the coordinate system having an X axis, a Y axis, and a Z axis. The X axis (190) extends through the striking face center (175) of the striking face (170) in a direction from the heel end (160) to the toe end (150) of the golf club head (100), and parallel to a ground plane (105) when the club head (100) is at address. The Y axis (192) extends through the striking face center (175) of the striking face (170) in a direction from the crown (110) to the sole (120) of the golf club head (100), and perpendicular to the X axis (190), and the Z axis (196) extends through the striking face center (175) of the striking face (170) in a direction from the striking face (170) to the rear end (180) of the golf club head (100) and perpendicular to the X axis (190) and the Y axis (192).

[0048] The coordinate system defines an XY plane extending through the X axis (190) and the Y axis (192), an XZ plane extending through the X axis (190) and the Z axis (196), and a YZ plane extending through the Y axis (192) and the Z axis (196), wherein the XY plane, the XZ plane, and the YZ plane are all perpendicular to one another and intersect at the origin of the coordinate system at the striking face center (175) of the striking face (170). The XY plane extends parallel to a hosel axis and is positioned at an angle corresponding to the loft angle of the golf club head (100) from the loft plane. Further the X axis (190) is positioned at a 60 degree angle to the hosel axis (199) when viewed from a direction perpendicular to the XY plane.

A) First Component

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[0049] As illustrated in FIGS. 1A-1F, and 4-8, a first component (300) can comprise the striking face (170) having a return portion (177) that forms a portion of the crown (400), the hosel (140), a portion of the heel end (160), a portion of the toe end (150), a portion of the trailing edge (130), a recessed lip (450) (also referred to as a joint extension surface), and a portion of the sole (120). The striking face return portion (177) comprises a rearward extension positioned approximately perpendicular to the striking face (170) and extending from another perimeter of the striking face (170). The striking face return (177) forms a rearward profile in a heel end to toe end direction. In other embodiments, the rearward profile of the first component (300) can extend from the heel end (160) toward the toe end (150) in a straight-lined profile, in a positive parabolic profile, in a bell shaped profile, or any other profiles relative to the striking face (170). As illustrated in FIGS. 2 and 3, the second component (200) can comprise at least a portion of the crown (110), the sole (120), the trailing edge (130), and a rear cutout (240).

[0050] The first component (300) comprises a first material having a first density. The first material comprises a metallic material. The second component (200) comprises a second material comprising a second density. The second component (200) comprises a second component mass.

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[0051] The first material density of the first component (300) is greater than the second material density of the second component (200). The mass percentage of the first component (300) can range from 85% to 96% of the mass of golf club head (100). For example, the first component percentage of the mass of the golf club head may be 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, or 96%. The mass percentage of the second component (200) can range from 4% to 15% of the mass of golf club head (100). The first component (300) comprises a sole portion rear extension (500) having a mass portion (510) at an extreme rear position of the rear extension (500). The mass portion (510) can comprise between 20% and 35% of the mass of the hollow multi-component golf club head (100). Placing so much of the mass of the golf club head at an extreme rear position of the golf club head provides mass characteristics that are functionally desirable. For example, the extreme rear position of the mass portion (510) can lower the CG of the golf club head, which improves launch characteristics.

[0052] The first component (300) may be integrally formed as a single piece, so the first component comprises a single material. Alternately, first component (300) may comprise a separately formed striking face insert comprising a different material (i.e. a third material) than the remainder of the first component (300).

[0053] The first, metallic component (300) is coupled to the second, non-metallic component (200) wrapped around the first component (300) to form the hollow golf club head (100). The second component trailing edge portion (230) connects the second component crown portion (205) and the second component sole portions (212) and (214) as they wrap around the first component (300).

[0054] Referring to FIG. 1F, the golf club head (100) comprises a first component (300) and a second component (200) configured to be coupled together to form a hollow golf club head. Wherein the first component is T-shaped, and comprises a metallic material. The sole of the first component (300) has a rear sole extension with a mass member at the extreme rear end of the sole extension. This configuration lowers the CG of the assembled golf club head, and moves the CG towards the rear of the assembled golf club head.

[0055] Referring to FIGS 1E and 4, the first component (300) comprises a hosel bore (145) defining a hosel axis (199), a striking face center (175), a striking face crown portion (420), a striking face return crown portion (400) having a striking face return crown portion width (405), and a first component trailing edge (440). Some embodiments may further comprise first component crown portion turbulators (430) having a first component crown portion turbulators toe portion (432) and a first component crown portion turbulators heel portion (434).

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[0056] The first component can comprise a recessed lip (also referred to as a joint extension surface) configured to overlap with a portion of the second component, and together form the golf club head. The first component (300) can comprise a first component lip (450) bordering the first component perimeter edge (462) having a first component crown portion lip (455), and first component tabs (457). The first component tabs (457), and matching grooves in the second component, align the first component (300) to the second component (200) during assembly, and also add mechanical support to prevent sideways movement between the first component (300) and the second component (200).

[0057] The first component lip is recessed from an outer surface of the golf club head to accommodate the combined thickness of the overlapping lip of the second component, and any adhesive securing the two components together. Referring to FIG. 5, the first component (300) comprises a first component lip recessed offset (459), a first component sole portion lip (460), a first component sole portion rear extension (500), a first component sole portion rear extension mass portion (510) having a mass portion interior forward edge (502), one or more mass portion interior

ribs (520), and a detachable weight recess (540) having a threaded fastener receiver boss (542) and a detachable weight recess interior forward edge (544). Referring also to FIG. 1F, a first component lip (455) is configured to be covered by a portion of the second component (200) when the first component (300) is coupled to the second component (200) to form the golf club (100). The first component (300) may preferably be coupled to the second component (200) with an adhesive placed between the overlapping surfaces of the first component and the second component.

[0058] Referring to FIG. 7, the first component lip has a width (730), which can range from 3.17 mm to 9.98 mm (0.125 inch to 0.275 inch). For example, the first component lip width (730) may be 3.17 mm (0.125 inch), 3.81 mm (0.150 inch), 4.44 mm (0.175 inch), 5.08 mm (0.200 inch), 5.58 mm (0.22 inch), 5.71 mm (0.225 inch), 6.35 mm (0.250 inch), or 6.98 mm (0.275 inch).

[0059] The first component recessed offset (459) is an offset distance of the lip (455) from the outer surface of the first component (300) toward the interior of the golf club head. The recessed offset (459) can range from 1.52 mm to 4.06 mm (0.060 inch to 0.160 inch) toward the interior of the golf club head (100). In other embodiments, the recessed offset (459) can range from 1.52 mm to 3.81 mm (0.060 inch to 0.150 inch), 1.52 mm to 3.56 mm (0.060 inch to 0.140 inch), 2.03 mm to 4.06 mm (0.080 inch to 0.160 inch), 2.29 mm to 3.81 mm (0.090 to 0.150 inch), or 2.29 mm to 4.06 mm (0.090 inch to 0.160 inch). For example, the recessed offset (459) can be 1.52 mm (0.060 inch), 1.78 mm (0.070 inch), 2.03 mm (0.080 inch), 2.29 mm (0.090 inch), 2.54 mm (0.100 inch), 2.79 mm (0.110 inch), 3.05 mm (0.120 inch), 3.30 mm (0.130 inch), 3.56 mm (0.140 inch), 3.81 mm (0.150 inch), or 4.06 mm (0.160 inch).

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[0060] The first component lip (450) can comprise a thickness. The thickness of the first component lip (450) can range between 0.178 mm to 0.76 mm (0.007 inch and 0.030 inch). In some embodiments, the thickness of the first component lip (450) can be between about 0.178 mm and 0.23 mm (0.007 inch and 0.009 inch), 0.23 mm and 0.28 mm (0.009 inch and 0.011 inch), 0.28 mm and 0.33 mm (0.011 inch and 0.013 inch), 0.33 mm and 0.38 mm (0.013 inch and 0.015 inch), 0.38 mm and 0.43 mm (0.015 inch and 0.017 inch), 0.43 mm and 0.48 mm (0.017 inch and 0.019 inch), 0.48 mm and 0.53 mm (0.019 inch and 0.021 inch), 0.53 mm and 0.58 mm (0.021 inch and 0.023 inch), 0.58 mm and 0.64 mm (0.023 inch and 0.025 inch), 0.64 mm and 0.68 mm (0.025 inch and 0.027 inch), or 0.68 mm and 0.76 mm (0.027 inch and 0.030 inch).

[0061] Still referring to FIG. 5, the first component has a rear extension on the sole, which allows a larger portion of the mass of the assembled golf club head to be moved down to the sole and towards the rear of the assembled golf club head. The rear extension (500) extends from and is integral with the striking face return, allowing impact stresses to propagate all the way to the rear of the sole, helping to balance the distribution of impact stress in the golf club head.

[0062] Still referring to FIG. 5, the first component lip (450) comprises the first component crown portion lip (455), the first component sole portion lip (460). The first component lip (450) may have other portions.

[0063] Referring to FIG. 6, a plane (610) parallel to the ground plane (105), and intersecting the strike face center (175) defines a view of the lower portion of the first component (300) as show in FIG. 7. Referring to FIGS. 7 and 8, the rear extension (500) extends from a rear perimeter of striking face return sole portion (810) toward the rear end (180) of the golf club head (100).

[0064] Referring to FIG. 7, the first component (300) comprises a first component sole portion heel extension (710), a first component sole portion toe extension (720), a first component lip (460) having a first component lip width (730), a first component trailing edge portion (740), and a first component sole portion rear extension mass portion (510) having a vertical lip (750), and a mass portion trailing edge shelf (760).

[0065] The rear extension (510) has a larger mass at a rear most position of the extension. Placing the mass at the rear most position allows for the manipulation of the rear sole extension position to greatly affect the mass properties of the assembled golf club head. Referring to FIG. 8, the first component (300) comprises a first component sole portion rear extension (500) having a first component sole portion rear extension length (505) and a first component sole portion rear extension width (507). The first component (300) comprises a striking face return sole portion (810), having a striking face return sole portion width (815), a first component sole portion toe extension (820) having a first component sole portion toe extension length (825), and a first component sole portion heel extension (830) having a first component sole portion heel extension length (835). The rear extension length (505) is measured from a rear perimeter of the striking face return portion (810), towards the rear end (180). The return sole portion width (815) is measured from the loft plane (198) rearwardly to a rear perimeter of the striking face return portion, which is a sole portion of a first component perimeter edge (462). The rear extension length (505) and the return sole portion width (815) together comprise a total sole length of the golf club head (100) measured from the loft plane (198) to the rear end (180) along the sole (120). The rear extension width (507) is the width of the rear extension (500). The rear extension width (507) is measured in a heel to toe direction rearward of a rear perimeter of the striking face return sole portion (810), which is a sole portion of a first component perimeter edge (462). The rear extension width (507) is less than an entire width of the sole (120) of the golf club (100). The rear extension width (507) can range from 25% to 85% of an entire width of the sole (120). The rear extension width (507) may be 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80% or 85% of an entire width of the sole (120).

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[0066] Referring to FIGS 7 and 8, the first component sole portion rear extension (500), toe extension (720), and heel extension (710) together form a T-like structure. The first component sole portion rear extension (500) forms a toe-ward angle (850) with the toe extension (720), and a heel-ward angle (855) with the heel extension (710). The first component (300) further comprises a detachable weight recess (540) having a plurality of detachable weight recess tabs (546).

[0067] Referring to FIGS 5, 7, and 8, the striking face return (177) extends rearwardly from a striking face perimeter, essentially perpendicular to the striking face (170). The striking face (170) and striking face return (177) comprise a forward section of the assembled golf club head. The striking face return (177) comprises a striking face return crown portion (400) having a striking face return crown portion width (405), and a striking face return sole portion (810) having a striking face return sole portion width (815). The striking face return crown portion (400) comprises a rearward perimeter that forms a profile on the crown (110) from the heel end (160) of the crown (110) to a toe end (150) of the crown (110). The striking face return crown portion width measured from the striking face (170) toward the rear end (180) may vary. The striking face return crown portion maximum width (405) may be smaller at the toe end (150) and at the heel end (160), and larger in a middle region between the toe end (150) and the heel end (160). The striking face return crown portion width (405) can be at least 20.32 mm (0.8 inch), at least 25.4 mm (1.0 inch), at least 30.48 mm (1.2 inches), or at least 35.56 mm (1.4 inches). In some embodiments, the striking face return crown portion maximum width (405) can range from 25.4 mm to 38.1 mm (1.0 inch to 1.5 inches). For example, the striking face return crown portion maximum width (405) may be 25.4 mm (1.0 inch), 27.94 mm (1.1 inches), 30.48 mm (1.2 inches), 33.02 mm (1.3 inches), 35.56 mm (1.4 inches), or 38.1 mm (1.5 inches). The second component crown portion width (405) can be similar to the crown portion as described in U.S. Appl. No. 11/693,490, now U.S. Patent No. 7,601,078.

[0068] Manipulating the position of the rear sole extension provides a means of manipulating the mass properties of the assembled golf club head. Referring to FIGS. 4, 5, 7, and 8, the sole portion of the first component can extend from a center near the striking face toward the toe end forming a first component sole portion toe end extension (720), toward the heel end forming a first component sole portion heel end extension (710), and toward the rear end forming a first component sole portion rear extension (500). The first component sole portion toe extension (720), first component sole portion heel extension (710), and first component sole portion rear extension (500) can form a "T" shaped profile. In some embodiments, the toe extension can have a first component sole portion toe end extension length (825) in a range of 38.1 mm to 50.8 mm (1.50 inch to 2.00 inch) from the YZ plane toward the toe end

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(150). For example, the first component sole portion toe extension (720) can have first component sole portion toe end extension length (825) of 38.1 mm (1.50 inch), 40.64 mm (1.60 inch), 43.18 mm (1.70 inch), 45.72 mm (1.80 inch), 48.26 mm (1.90 inch), or 50.80 mm (2.00 inch) toward the toe end (150). In some embodiments, the first component sole portion heel end extension (710) can have a first component sole portion heel extension length (835) in a range of 22.86 mm to 35.56 mm (0.90 inch to 1.40 inch) from the YZ plane toward the heel end (160). For example, the first component sole portion heel end extension (710) can extend 22.86 mm (0.90 inch), 27.94 mm (1.10 inch), 30.48 mm (1.20 inch), 33.02 mm (1.30 inch), or 35.56 mm (1.40 inch). The first component sole portion rear extension (500) can be 58.42 mm to 73.66 mm (2.30 inch to 2.90 inch) measured from the striking face return (177). For example, the first component sole portion rear extension (500) can extend from the striking face return (177) by a distance of 58.42 mm (2.30 inch), 60.96 mm (2.40 inch), 63.50 mm (2.50 inch), 66.04 mm (2.60 inch), 68.58 mm (2.70 inch), 71.12 mm (2.80 inch), or 73.66 mm (2.90 inch).

[0069] Shifting the first component sole portion rear extension closer to the toe end (150) or the heel end (160) of the golf club head (100) provides one means of manipulating the mass properties of the assembled golf club head, and changing the ball flight. When manufacturing the first component (300), moving the first component sole portion rear extension (500) toward the toe end (150) or toward the heel end (160) of the golf club (100) will change mass properties of the assembled golf club head. If the first component sole portion rear extension (500) is moved toward the toe end (150) by decreasing the first component sole portion toe end extension length (825) the center of gravity of the golf club head (100) will also be moved towards the toe end (150). If the first component sole portion rear extension (500) is moved toward the heel end (160) of the golf club head (100), the center of gravity of the golf club head (100) will also be moved towards the heel end (160).

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[0070] The return portion of the first component (300) can comprise a thickness extending between the outer surface and the inner surface of the return portion. The thickness of the first component can range from 0.38 mm to 1.02 mm (0.015 inch to 0.040 inch). In other embodiments, the thickness of the first component can range from 0.25 mm to 1.02 mm (0.010 inch to 0.040 inch), 0.25 mm to 0.51 mm (0.010 inch to 0.020 inch), 0.38 mm to 0.63 mm (0.015 inch to 0.025 inch), 0.51 mm to 0.76 mm (0.020 inch to 0.030 inch), 0.63 mm to 0.89 mm (0.025 inch to 0.035 inch), 0.76 mm to 1.02 mm (0.030 inch to 0.040 inch), 1.02 mm to 2.54 mm (0.040 inch to 0.10 inch), or 2.54 mm to 6.35 mm (0.10 inch to 0.25 inch). For example, the thickness of the first component can be 0.25 mm (0.010 inch), 0.38 mm (0.015 inch), 0.51 mm (0.020 inch), 0.63 mm (0.025 inch), 0.76 mm (0.030 inch), 0.89 mm (0.035 inch), or 1.02 mm (0.040 inch). The thickness of the first component can further vary at the striking face (170), the first component crown portion (420), the first component sole portion (310), the first component sole portion heel extension (710), the first component sole portion toe extension (720), and the first component sole portion rear extension mass portion (510).

[0071] The first component (300) comprises a surface area ranging from 17419 mm^2 to 26452 mm^2 (27 $inch^2$ to 41 $inch^2$) out of the entire surface area of the golf club head (100). In some embodiments, the surface area of the first component (300) can range from 16129 mm^2 to 27742 mm^2 (25 $inch^2$ to 43 $inch^2$), 16129 mm^2 to 18064 mm^2 (25 $inch^2$ to 28 $inch^2$), 18064 mm^2 to 20000 mm^2 (28 $inch^2$ to 31 $inch^2$), 20000 mm^2 to 21935 mm^2 (31 $inch^2$ to 34 $inch^2$), 21935 mm^2 to 23871 mm^2 (34 $inch^2$ to 37 $inch^2$), 23871 mm^2 to 25806 mm^2 (37 $inch^2$ to 40 $inch^2$), or 25806 mm^2 to 27741 mm^2 (40 $inch^2$ to 43 $inch^2$). For example, the 16129 mm^2 (25 $inch^2$), 17419 mm^2 (27 $inch^2$), 18710 mm^2 (29 $inch^2$), 20000 mm^2 (31 $inch^2$), 21290 mm^2 (33 $inch^2$), 22581 mm^2 (35 $inch^2$), 23871 mm^2 (37 $inch^2$), 25161 mm^2 (39 $inch^2$), 26452 mm^2 (41 $inch^2$), or 27742 mm^2 (43 $inch^2$).

[0072] The first component (300) can comprise a material such as steel, tungsten, aluminum, titanium, vanadium, chromium, cobalt, nickel, other metals, or metal alloys. In some embodiments, the first component (300) can comprise a Ti-8Al-1Mo-1V alloy. In many embodiments wherein the golf club head (100) is a driver-type club head, the first component (300) can comprise a titanium material. In many embodiments wherein the golf club head (100) is a fairway wood-type club head, the first component (300) can comprise a steel material.

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[0073] In many embodiments, the first component (300) can be casted. In other embodiments, the first component (300) can be forged, pressed, rolled, extruded, machined, electroformed, 3-D printed, or any appropriate forming technique. Referring FIG. 15, in embodiments wherein the first component (300) is cast, the first component (300) may further comprise a plurality of casting support bars, including one or more heel end casting support bars (1510), and one or more toe end casting support bars (1512).

1) First Component Rear Sole Extension

[0074] As discussed above, the first component comprises the striking face and striking face return. These portions of the golf club head receive and distribute the impact forces when the golf club strikes a ball. The rear extension (500) is integrally formed with the rest of the first component, and extends from the sole portion of the striking face return (810). Further, the mass of the rear extension (500), resists torquing forces caused by off center hits on the striking face. In many embodiments, the first component sole portion toe end extension (720), and the first component sole portion heel end extension (710) can be parallel with the striking face (170), comprising a constant width from front to back. In other embodiments, the toe end extension (720), and heel end extension (710) can increase and/or decrease in width from toward the toe end (150) and heel end (160), comprising a varying width. In some embodiments, the first component sole portion toe (720) and heel end (710) extensions can comprise a width ranging from 25.4 mm to 38.1 mm (1.0 inch to 1.5 inches). For example, the

toe (720) and heel end (710) extensions can be 25.4 mm (1.00 inch), 27.94 mm (1.10 inches), 30.48 mm (1.20 inches), 33.02 mm (1.30 inches), 35.56 mm (1.40 inches), or 38.1 mm (1.50 inches).

[0075] In many embodiments, the first component sole portion rear extension (500) can increase in width, decrease in width, and/or comprise a consistent width (507) from a rear boundary of the striking face return sole portion (810) toward the rear end (180). In some embodiments, the rear end extension (500) can comprise a width (507) ranging from 25.4 mm to 88.9 mm (1.0 inch to 3.5 inches). For example, the rear end extension can be 25.4 mm (1.0 inch), 31.75 mm (1.25 inches), 38.1 mm (1.50 inches), 44.45 mm (1.75 inches), 50.8 mm (2.00 inches), 57.15 mm (2.25 inches), 63.5 mm (2.50 inches), 69.85 mm (2.75 inches), 76.2 mm (3.0 inches), 82.55 mm (3.25 inches), or 88.9 mm (3.50 inches). In some embodiments, the rear extension (500) comprises a varying width in a front to rear direction. Specifically, the rear extension (500) can comprise a width that increases in a front to rear direction. In these embodiments, the width of the rear extension (500) has a minimum value adjacent the striking face return sole portion (810), an a maximum value adjacent the rear of the club head. Increasing the width of the rear extension (500) towards the rear of the club head allows the rear extension (500) to support a weight or weight system. Varying the width of the rear extension (500), so that the minimum width is adjacent the striking face return sole portion (810), reduces mass adjacent the face return and allows this saved weight to be redistributed to the perimeter of the club head. In other embodiments, the rear extension (500) can comprise a width that decreasing in a front to rear direction. Decreasing the width of the rear extension towards the rear of the club head can provide additional structural support for the weight or weight systems attached to the rear extension (500).

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[0076] In some embodiments as illustrated in FIG. 2, the first component sole portion rear extension (500) can extend in a perpendicular orientation relative to the striking face (170), centered between the toe end (150) and the heel end (160). In other embodiments, the rear extension (500) can extend in an orientation closer to the toe end (150), or closer to the heel end (160). The rear extension (500) can be offset towards the heel end (160) from 1.27 mm to 25.4 mm (0.05 inch to 1.0 inch). For example, the rear extension (500) can be offset towards the heel end (160) 2.54 mm (0.1 inch), 5.08 mm (0.2 inch), 7.63 mm (0.3 inch), 10.16 mm (0.4 inch), 12.7 mm (0.5 inch), 15.24 mm (0.6 inch), 17.78 mm (0.7 inch), 20.32 mm (0.8 inch), 22.86 mm (0.9 inch), or 25.4 mm (1.0 inch). The first component sole portion rear end extension (500) can be offset towards the toe end (150) from 1.27 mm to 25.4 mm (0.05 inch to 1.0 inch). For example, the rear extension (500) can be offset towards the toe end (160) 2.54 mm (0.1 inch), 5.08 mm (0.2 inch), 7.62 mm (0.3 inch), 10.16 mm (0.4 inch), 12.7 mm (0.5 inch), 15.24 mm (0.6 inch), 17.78 mm (0.7 inch), 20.32 mm (0.8 inch), 22.86 mm (0.9 inch), or 25.4 mm (1.0 inch).

[0077] If the first component sole portion rear end extension (500) is offset towards the toe end (150), the center of gravity of the golf club head (100) can be offset towards the toe end (150) up to

0.150 inch. For example, the center of gravity may be offset towards the toe end (150) 0.25 mm (0.010 inch), 0.51 mm (0.020 inch), 0.76 mm (0.030 inch), 1.02 mm (0.040 inch), 1.27 mm (0.050 inch), 1.52 mm (0.060 inch), 1.78 mm (0.070 inch), 2.03 mm (0.080 inch), 2.29 mm (0.090 inch), 2.54 mm (0.100 inch), 2.79 mm (0.110 inch), 3.05 mm (0.120 inch), 3.30 mm (0.130 inch), 3.56 mm (0.140 inch), or 3.81 mm (0.150 inch). If the first component sole portion rear end extension (500) is offset towards the heel end (160), the center of gravity of the golf club head (100) can be offset towards the heel end (160) up to 3.81 mm (0.150 inch). For example, the center of gravity may be offset towards the heel end (160) 0.25 mm (0.010 inch), 0.51 mm (0.020 inch), 0.76 mm (0.030 inch), 1.02 mm (0.040 inch), 1.27 mm (0.050 inch), 1.52 mm (0.060 inch), 1.78 mm (0.070 inch), 2.03 mm (0.080 inch), 2.29 mm (0.090 inch), 2.54 mm (0.100 inch), 2.79 mm (0.110 inch), 3.05 mm (0.120 inch), 3.30 mm (0.130 inch), 3.56 mm (0.140 inch), or 3.81 mm (0.150 inch).

[0078] Another means of manipulating the mass properties of the golf club head is to change the angle the rear sole extension relative to striking face of the first component. The first component sole portion rear extension toe-ward angle (850) and the first component sole portion rear extension heel-ward angle (855) are supplementary angles (i.e. the two angles add up to 180 degrees). In one embodiment, the toe-ward angle (850) and the heel-ward angle (855) are each 90 degrees, so the rear extension (500) is essentially perpendicular to the striking face (170). In alternate embodiments, the toe-ward angle (850) and the heel-ward angle (855) can each vary between 45 degrees and 135 degrees, as long as the two angles continue to be supplementary angles. For example, the toe-ward angle (850) can be 100 degrees, while the heel-ward angle (855) is the supplementary 80 degrees. In this example, the mass portion (510) is angularly offset towards the heel end (180) of the golf club head (100). Other combination of toe-ward angle (850) and heel-ward angle (855) may be 110 degrees and 70 degrees, 120 degrees and 60 degrees, 130 degrees and 50 degrees, or 135 degrees and 45 degrees. The center of gravity of the golf club head would be offset toward the rear mass portion (510) position. For example, the center of gravity may be offset towards the heel end (160) 0.25 mm (0.010 inch), 0.51 mm (0.020 inch), 0.76 mm (0.030 inch), 1.02 mm (0.040 inch), 1.27 mm (0.050 inch), 1.52 mm (0.060 inch), 1.78 mm (0.070 inch), 2.03 mm (0.080 inch), 2.29 mm (0.090 inch), 2.54 mm (0.100 inch), 2.79 mm (0.110 inch), 3.05 mm (0.120 inch), 3.30 mm (0.130 inch), 3.56 mm (0.140 inch), or 3.81 mm (0.150 inch). In a similar fashion, the toe-ward angle may decrease while the heel-ward angle increases. For example, the combination of toe-ward angle (850) and heel-ward angle may be 80 degrees and 100 degrees, 70 degrees and 110 degrees, 60 degrees and 120 degrees, 50 degrees and 130 degrees, or 45 degrees and 135 degrees. For example, the center of gravity may be offset towards the toe end (160) by 0.25 mm (0.010 inch), 0.51 mm (0.020 inch), 0.76 mm (0.030 inch), 1.02 mm (0.040 inch), 1.27 mm (0.050 inch), 1.52 mm (0.060 inch), 1.78 mm (0.070 inch), 2.03 mm (0.080 inch), 2.29 mm (0.090 inch), 2.54 mm (0.100 inch), 2.79 mm (0.110 inch), 3.05 mm (0.120 inch), 3.30 mm (0.130 inch), 3.56 mm (0.140 inch), or 3.81 mm (0.150 inch). This angular offset may be desirable to place a rear mass more toward the rear, heel-ward portion or rear toe-ward portion to position a club head center of gravity in that

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direction to influence ball flight characteristics. Other angular offsets in different embodiments may differently combine the first component sole portion rear extension toe-ward angle (850) and the first component sole portion rear extension heel-ward angle (855), which can produce different club head center of gravity positions and different ball flight characteristics.

2) First Component Rear Sole Extension Rear Mass

[0079] As discussed above, the first component comprises most of the mass of the assembled golf club head. The rear extension (500) allows for some of the golf club mass to be positioned away toward the rear of the club head, and in the sole of the club head. The rear extension (500) comprises a mass portion at the rear of the golf club head, allowing the mass there to further influence the CG and MOI of the golf club head. The first component sole portion rear extension mass portion (510) alone can comprise between 20% to 35% of the total mass of the golf club head (100). Placing this mass at the rear most portion of the rear extension (500) is an important aspect to controlling the mass properties of the golf club head (100) during manufacturing the first component (300).

[0080] Referring to FIG. 9, the first component sole portion rear extension mass portion (510) comprises a threaded receiver (545), one or more weight recess tabs (546), and the mass portion (510) having a heel side external boundary (910), a toe side external boundary (915), and a forward external boundary (918).

[0081] Referring to FIG. 10, the mass portion (510) further comprises a plurality of internal ribs (520) having an internal rib width (523). The plurality of internal ribs (520) may comprise two ribs, three ribs, four ribs, five ribs, or more than five ribs. The plurality of internal ribs (520) mate with, or attach to the interior surface of the rear extension mass portion detachable weight recess (540). The internal ribs (520) can reduce unwanted vibration at the mass portion (510), which is desirable because so much of the mass of the golf club head (100) is located so far to the rear of the golf club head. The mass portion (510) further comprises a vertical lip (750) having a vertical lip height (1150), a mass portion trailing edge shelf (1042) having a shelf length (1048), a shelf height (1044), and a shelf width (1046). The shelf length (1048) is approximately the same as a rear extension width (507), and varies as the width of the mass portion (510) varies.

[0082] The shelf (1042) provides a mating surface for a portion of the second component when the first and second components are coupled to form the assembled golf club head. The mass portion (510) further comprises an interior forward boundary (1050), and a vertical lip length (1052).

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[0083] Referring to FIG. 8, the view of the rear mass (510) is bisected by the YZ plane (800). Referring to FIG. 11, the mass portion (510) further comprises an internal length (1110), a mass portion maximum height (1112), and a vertical lip height (1150). The internal ribs further comprises a rib height (1120) and a rib length (1122).

[0084] The internal rib width (523) can range from 0.63 mm to 2.54 mm (0.025 inch to 0.100 inch). For example, the internal rib width (523) may be 0.63 mm (0.025 inch), 1.27 mm (0.050 inch), 1.90 mm (0.075 inch), or 2.54 mm (0.100 inch). The internal rib height (1120) ranges from 25% to 100 % of a detachable weight recess depth (1216). The internal rib length (1122) can range from 2.54 mm to 38.1 mm (0.100 inch to 1.500 inch). For example, the internal rib length (1122) may be 2.54 mm (0.100 inch), 5.08 mm (0.200 inch), 7.63 mm (0.300 inch), 10.16 mm (0.400 inch), 12.7 mm (0.500 inch), 15.24 mm (0.600 inch), 17.78 mm (0.700 inch), 20.32 mm (0.800 inch), 22.86 mm (0.900 inch), 25.4 mm (1.000 inch), 27.94 mm (1.100 inches), 30.48 mm (1.200 inches), 33.02 mm (1.300 inches), 35.56 mm (1.400 inches), or 38.1 mm (1.500 inches).

[0085] The mass portion (510) has a mass portion maximum height (1112) located approximately along the most upper portion of the mass portion vertical lip (750). The mass portion (510) decreases in thickness as it approaches the heel side external boundary (910), the toe side external boundary (915), and the forward external boundary (918). The mass portion maximum height (1112) comprises the maximum thickness of the mass portion (510). The maximum thickness of the mass portion (510) can range from 10.2 mm to 17.78 mm (0.40 inch to 0.70 inch). For example, the maximum thickness of the mass portion (510) may be 10.2 mm (0.40 inch), 12.7 mm (0.50 inch), 15.24 mm (0.60 inch), or 17.78 mm (0.70 inch).

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3) First Component Detachable and Embedded Weights

[0086] To allow further control of the mass properties of the assembled golf club head, a detachable weight recess and a detachable weight are provided, wherein the detachable weight mass can fine tune the mass properties of the golf club head at the point of assembly. The detachable weight recess (540) further comprises a plurality of detachable weight recess tabs. The plurality of detachable weight recess tabs may be two tabs, three tabs, four tabs, five tabs, or more than five tabs.

[0087] Referring to FIG. 12, it may be desirable to further increase the mass placed in the rear most portion of the golf club head. The mass portion (510) further comprises an embedded weight recess (1220). Therefore, an embedded weight recess (1220) and an embedded weight (1600) (configured to be received with the embedded weight recess (1220)) comprising an embedded weight material having a density that is higher than the first density of the first component (300) first material may be provided.

[0088] Referring to FIG. 13, the detachable weight (1300) can comprise a material such as steel, tungsten, aluminum, titanium, vanadium, chromium, cobalt, nickel, other metals, metal alloys, composite polymer materials or any combination thereof. In many embodiments, the sole weight can be tungsten. The detachable weight (1300) has a mass.

[0089] The detachable weight (1300) mass can range from 1.0 gram to 20.0 grams. For example, the detachable weight (1300) mass may be 1.0 gram, 1.5 grams, 2.0 grams, 3.0 grams, 4.0 grams, 5.0 grams, 6.0 grams, 7.0 grams, 8.0 grams, 9.0 grams, 10.0 grams, 11.0 grams, 12.0 grams, 13.0 grams, 14.0 grams, 15.0 grams, 16.0 grams, 17.0 grams, 18.0 grams, 19.0 grams, or 20.0 grams.

[0090] Referring to FIGS 8 and 13, the detachable weight (1300) is configured to be received within the detachable weight recess (540). The detachable weight (1300) further comprises a through hole approximately in the center of the detachable weight (1300). The through hole is configured to receive a detachable weight threaded fastener (1320), allowing the threaded fastener (1320) to be threadably received in the threaded receiver boss (544) to secure the detachable weight (1300) into the detachable weight recess (540).

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[0091] Referring to FIG. 14, the detachable weight (1300) further comprises a thickness (1430), a plurality of detachable weight offsets (1434), and a plurality of detachable weight side grooves (1438). The plurality of detachable weight offsets (1434) may be two offsets, three offsets, four offsets, five offsets, or more than five offsets. The plurality of detachable weight side grooves (1438) may be two grooves, three grooves, four grooves, five grooves, or more than five grooves. The offsets (1434) are configured to cause the detachable weight (1300) to be slightly offset from the walls of the detachable weight recess (540) when the detachable weight (1300) is received within the detachable weight recess (540). The detachable weight side grooves (1438) are configured to receive the detachable weight recess tabs when the detachable weight (1300) is received within the detachable weight recess (540).

[0092] Referring to FIGS. 16A and 16B, an embedded weight (1600) has a mass. The embedded weight (1600) mass can range from 1.0 gram to 20.0 grams. For example, the embedded weight (1600) mass may be 1.0 gram, 2.0 grams, 3.0 grams, 4.0 grams, 5.0 grams, 6.0 grams, 7.0 grams, 8.0 grams, 9.0 grams,10.0 grams, 11.0 grams, 12.0 grams, 13.0 grams, 14.0 grams, 15.0 grams, 16.0 grams, 17.0 grams, 18.0 grams, 19.0 grams, or 20.0 grams.

[0093] The embedded weight (1600) comprises a tungsten material, a tungsten alloy material, a polymer matrix embedded with tungsten particles, or any other suitable material having a density

greater than the first material density. The embedded weight (1600) is configured to fit within and be permanently affixed in the embedded weight recess (1220). The embedded weight (1600) may be permanently affixed using an adhesive, by swedging or other press fit methods, or by using an appropriate mechanical attachment means.

B) Second Component

[0094] The golf club head (100) comprises a first component (300) and a non-metallic, lightweight second component (200) configured to be coupled together to form the hollow golf club head (100). Referring to FIGS. 1F and 2, the second component (200) comprises a second component crown portion (205), a second component sole portion heel portion (214), a second component sole portion toe portion (212), a second component perimeter edge (220), a second component sole portion rear cutout (240) having a second component sole portion rear cutout width (242) and a second component sole portion rear cutout height (244), and a second component trailing edge portion (230). In some embodiments, not shown, the second component can comprise only a portion of the crown. In these embodiments, the sole portion rear cutout (240) can wrap around into the crown (205).

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[0095] As illustrated in FIGS. 1-4, the second component crown portion (205) wraps over the trailing edge (130), integrally forming the portions of the sole complementary to the first component. The second component heel and toe sole portions (214) (212) formed by the second component (200) can comprise a triangular shape positioned between the toe end extension and rear end extension, and rear end extension and heel end extension of the first component. In other embodiments, the sole portions formed by the second component (200) can comprise a circular shape, square shape, oval shape, any other polygonal shape, or a shape with at least one curved surface, complementary to the sole portions of the first component (100).The second component (200) may comprise a single monolithic piece, entirely formed together with no further joining necessary. For example, the second component (200) can be formed by injection molding a single monolithic piece comprising a single material.

[0096] Alternately, the second component (200) may comprise a plurality of separately formed portions subsequently permanently joined by adhesives, sonic welding, fusion bonding, or other permanent joining methodologies appropriate to the materials used in forming the plurality of separately formed portions. For example, the second component crown portion (205), toe portion (212), and heel portion (214) may be formed separately from the same or different materials. The

second component portions may then be adhesively joined to form the complete second component (200). Such forming of separate portions later joined may be advantageous when using materials such as bi-directional carbon fiber prepreg materials. Bi-directional carbon fiber prepreg does not easily accommodate certain small curvatures, and cannot be easily formed in a single piece to arrive at the desired second component (200) geometry. Using such a material may produce a need to form separate sole portions (212) and (214), which are later joined by adhesives or other methods to the rest of the second component (200).

[0097] The second component of the golf club head (100) can comprise a thickness. The thickness of the second component can range from 1.14 mm to 1.52 mm (0.045 inch to 0.500 inch). In some embodiments, the thickness of the second component can range from 1.14 mm to 1.40 mm (0.045 inch to 0.055 inch), 1.14 mm to 1.65 mm (0.045 inch to 0.65 inch), 1.27 mm to 1.52 mm (0.050 inch to 0.060 inch), 1.40 mm to 1.65 mm (0.055 inch to 0.065 inch), 1,52 mm to 1.78 mm (0.060 inch to 0.070 inch), 1.65 mm to 1.90 mm (0.065 inch to 0.075 inch), 1.78 mm to 2.03 mm (0.070 inch to 0.080 inch), 1.90 mm to 2.16 mm (0.075 inch to 0.085 inch), 2.03 mm to 2.29 mm (0.080 inch to 0.090 inch), 2.16 mm to 2.41 mm (0.085 inch to 0.095 inch), 2.03 mm to 2.29 mm (0.080 inch to 0.090 inch), 2.16 mm to 2.41 mm (0.085 inch to 0.095 inch), 2.41 mm to 2.54 mm (0.090 inch to 0.100 inch), 2.54 mm to 5.08 mm (0.100 inch to 0.200 inch), 5.08 mm to 7.62 mm (0.200 inch to 0.300 inch), 7.62 mm to 10.16 mm (0.300 inch to 0.400 inch), or 10.16 mm to 12.7 mm (0.400 inch to 0.500 inch). For example, the thickness of the second component can be 0.20 mm (0.008 inch), 0.25 mm (0.010 inch), 0.38 mm (0.015 inch), 0.51 mm (0.020 inch), 0.63 mm (0.025 inch), 0.76 mm (0.030 inch), 0.89 mm (0.035 inch), 1.02 mm (0.040 inch), 1.14 mm (0.045 inch), 1.27 mm (0.050 inch), 1.40 mm (0.055 inch), 1.52 mm (0.060 inch), or 1.65 mm (0.065 inch). The thickness of the second component can further vary from the crown, the sole, the heel end, the toe end, and the trailing edge. For example, in a single embodiment, the thickness of the second component may differ across the crown, sole, heel end, toe end, and trailing edge portions of the second component. In some embodiments, the second component further comprises internal ribs. The thickness of the second component internal ribs may be the same as the rest of the second component or may be up to 0.25 mm (0.010 inch) thicker than other portions of the second component (200).

[0098] In some embodiments, such as the embodiment of FIG. 3, the second component (200) further comprises a plurality of second component reduced thickness sections (250) having one or more crown portion reduced thickness sections (255) and one or more sole portion reduced thickness sections (257). The second component (200) further comprises a plurality of second component internal ribs (260) having one or more crown portion internal ribs (262) and one or more sole portion internal ribs (264). The plurality of internal ribs (260) may be two ribs, three ribs, four ribs, five ribs, or more than five ribs. The crown portion (262) and sole portion (264) internal ribs are between the second component reduced thickness sections (250). The crown portion (262) and sole portion (264) internal ribs may comprise the greatest thickness of the second component (200). In some

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embodiments, the second component internal ribs (260) can be similar to the ribs as described in U.S. Appl. No. 15/076,511, now U.S. Patent No. 9,700,768. The second component internal ribs (260) can reduce stress on the golf club head (100) and improve sound during an impact.

[0099] The plurality of second component reduced thickness sections (250) comprise a thickness. The thickness of the plurality of second component reduced thickness sections (250) can range from 0.20 mm to 0.89 mm (0.008 inch to 0.035 inch). In other embodiments, the thickness of the reduced thickness sections (250) can range from 0.20 mm to 0.38 mm (0.008 inch to 0.015 inch), 0.25 mm to 0.51 mm (0.010 inch to 0.020 inch), 0.38 mm to 0.63 mm (0.015 inch to 0.025 inch), 0.51 mm to 0.76 mm (0.020 inch to 0.030 inch), or 0.63 mm to 0.89 mm (0.025 inch to 0.035 inch). For example, the thickness of the reduced thickness sections (250) can be 0.20 mm (0.008 inch), 0.25 mm (0.010 inch), 0.38 mm (0.015 inch), 0.51 mm (0.020 inch), 0.63 mm (0.025 inch), 0.76 mm (0.030 inch), or 0.89 mm (0.035 inch). In some embodiments, the second component is devoid of internal ribs and reduced thickness sections.

[00100] The second component comprises a mass percentage of the overall mass of the golf club head (100). The mass percentage of the second component can range from 4% to 15% of the overall mass of the golf club head (100), or can be approximately 10 grams to 25 grams. In other embodiments, the mass percentage of the second component can range from 4% to 15%. For example, the mass percentage of the second component may be 4%, 5%, 6%, 7%. 8%, 9%, 10%, 11%, 12%, 13%, 14%, or 15% of the overall mass of the golf club head (100).

[00101] The second component comprises a outer surface area ranging from 10968 mm^2 to 16129 mm^2 (17 $inch^2$ to 25 $inch^2$). In some embodiments, the surface area of the second component can range from 9677 mm^2 to 17419 mm^2 (15 $inch^2$ to 27 $inch^2$), 17419 mm^2 to 11613 mm^2 (15 $inch^2$ to 18 $inch^2$), 11613 mm^2 to 13548 mm^2 (18 $inch^2$ to 21 $inch^2$), 13548 mm^2 to 16129 mm^2 (21 $inch^2$ to 25 $inch^2$). For example, the surface area of the second component can be 17419 mm^2 (15 $inch^2$), 10968 mm^2 (17 $inch^2$), 12258 mm^2 (19 $inch^2$), 13548 mm^2 (21 $inch^2$), 14839 mm^2 (23 $inch^2$), or 16129 mm^2 (25 $inch^2$).

1) Second Component Materials

[00102] The second component (200) comprises a less dense material than the material of the first component. In some embodiments, the second component can comprise a composite formed from polymer resin and reinforcing fiber. The polymer resin can comprise a thermoset or a thermoplastic. More specifically, in embodiments with a thermoplastic resin, the resin can comprise a thermoplastic polyurethane (TPU) or a thermoplastic elastomer (TPE). For example, the resin can comprise polyphenylene sulfide (PPS), polyetheretheretherketone (PEEK), polyimides, polyamides such as PA6 or PA66, polyamide-imides, olyphenylene sulfides (PPS), polycarbonates, engineering polyurethanes, and/or other similar materials. The reinforcing fiber can comprise carbon fibers (or chopped carbon

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fibers), glass fibers (or chopped glass fibers), graphine fibers (or chopped graphite fibers), or any other suitable filler material. In other embodiments, the second component composite material can comprise beads (e.g. glass beads, metal beads) or powders (e.g., tungsten powder) for weighting. In other embodiments, the composite material may comprise any reinforcing filler that adds strength, durability, and/or weighting.

[00103] The polymer resin should preferably incorporate one or more polymers that have sufficiently high material strengths and/or strength/weight ratio properties to withstand typical use while providing a weight savings benefit to the design. Specifically, it is important for the design and materials to efficiently withstand the stresses imparted during an impact between the strike face and a golf ball, while not contributing substantially to the total weight of the golf club head. In general, the polymers can be characterized by a tensile strength at yield of greater than about 60 MPa (neat). When the polymer resin is combined with the reinforcing fiber, the resulting composite material can have a tensile strength at yield of greater than about 110 MPa, greater than about 180 MPa, greater than about 220 MPa, greater than about 260 MPa, greater than about 280 MPa, or greater than about 290 MPa. In some embodiments, suitable composite materials may have a tensile strength at yield of from about 60 MPa to about 350 MPa.

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[00104] In some embodiments, the reinforcing fiber comprises a plurality of distributed discontinuous fibers (i.e. "chopped fibers"). In some embodiments, the reinforcing fiber comprises a discontinuous "long fibers," having a designed fiber length of from about 3 mm to 14 mm. For example, in some embodiments, the fiber length is about 12.7 mm (0.5 inch) prior to the molding process. In another embodiment, the reinforcing fiber comprises discontinuous "short fibers," having a designed fiber length of from about 0.01 mm to 3 mm. In either case (short or long fiber), it should be noted that the given lengths are the pre-mixed lengths, and due to breakage during the molding process, some fibers may actually be shorter than the described range in the final component. In some configurations, the discontinuous chopped fibers may be characterized by an aspect ratio (e.g., length/diameter of the fiber) of greater than about 10, or more preferably greater than about 50, and less than about 1500. Regardless of the specific type of discontinuous chopped fibers used, in certain configurations, the composite material may have a fiber length of from about 0.01 mm to about 14 mm.

[00105] The composite material may have a polymer resin content of from about 40% to about 90% by weight, or from about 55% to about 70% by weight. The composite material of the

second component can have a fiber content between about 10% to about 60% by weight. In some embodiments, the composite material has a fiber content between about 20% to about 50% by weight, between 30% to 40% by weight. In some embodiments, the composite material has a fiber content of between about 10% and about 15%, between about 15% and about 20%, between about 20% and about 25 %, between about 25% and about 30%, between about 30% and about 35%, between about 35% and about 40%, between about 40% and about 45%, between about 45% and about 50%, between about 50% and about 55%, or between about 55% and about 60% by weight.

[00106] The density of the composite material, which forms the second component, can range from about 1.15 g/cc to about 2.02 g/cc. In some embodiments, the composite material density ranges between about 1.30 g/cc and about 1.40 g/cc, or between about 1.40 g/cc to about 1.45 g/cc. The composite material can have a melting temperature of between about 210 °C to about 280 °C. In some embodiments, the composite material can have a melting temperature of between about 250 °C and about 270 °C.

[00107] In some embodiments, the composite material comprises a long fiber reinforced TPU. The long fiber TPU can comprise about 40% long carbon fiber by weight. The long fiber TPU can exhibit a high elastic modulus, greater than that of short carbon fiber compounds. The long fiber TPU can withstand high temperatures, making it suitable for use in a golf club head that is used and/or stored in a hot climate. The long fiber TPU further exhibits a high toughness, allowing it to serve well as a replacement for traditionally metal components. In some embodiments, the long fiber TPU comprises a tensile modulus between about 26,000 MPa and about 30,000 MPa or between about 27,000 MPa and about 29,000 MPa. In some embodiments, the long fiber TPU comprises a flexural modulus between about 21,000 MPa and about 26,000 MPa or between about 22,000 MPa and 25,000 MPa. The long fiber TPU material can exhibit an tensile elongation (at break) of between about 0.5% and about 2.5%. In some embodiments, the tensile elongation of the composite TPU material can be between about 1.0% and about 2.0%, between about 1.2% and about 1.4%, between about 1.4% and about 1.6%, between about 1.6% and about 1.8%, between about 1.8% and about 2.0%.

[00108] Although strength and weight are the two main properties under consideration for the composite material, a suitable composite material may also exhibit secondary benefits. For example, PPS and PEEK are two exemplary thermoplastic polymers that meet the strength and weight requirements of the present design. Unlike many other polymers, however, the use of PPS or PEEK is further advantageous due to their unique acoustic properties. Specifically, in many circumstances,

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PPS and PEEK emit a generally metallic-sounding acoustic response when impacted. As such, by using a PPS or PEEK polymer, the present design can leverage the strength/weight benefits of the polymer, while not compromising the desirable metallic club head sound at impact.

[00109] In many embodiments, the second component (200) of the golf club head (100) can be injection molded. The second component (200) can be injection molded out of one composite material comprising both the polymer resin and the reinforcing fibers. The reinforcing fibers can be embedded within the resin prior to molding the second component. The composite material including both the resin and the fibers can be provided in pellet form. The pellets can be melted and injected into an empty mold to form the second component. In other embodiments, the second component can be extruded, injection blow molded, 3-D printed, or any other appropriate forming means.

[00110] In embodiments that employ injection molding, the temperature of the mold used for forming the second component from the composite material can ideally be held between about 60 °C and 90 °C. For example, the temperature of the mold can be about 75 °C.In alternate embodiments, the second component (200) may comprise fiber reinforced composite (FRC) materials. FRC materials generally include one or more layers of a uni- or multi-directional fiber fabric that extend across a larger portion of the polymer. Unlike the reinforcing fibers that may be used in filled thermoplastic (FT) materials, the maximum dimension of fibers used in FRCs may be substantially larger/longer than those used in FT materials, and may have sufficient size and characteristics so they may be provided as a continuous fabric separate from the polymer. When formed with a thermoplastic polymer, even if the polymer is freely flowable when melted, the included continuous fibers are generally not.

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[00111] FRC materials are generally formed by arranging the fiber into a desired arrangement, and then impregnating the fiber material with a sufficient amount of a polymeric material to provide rigidity. In this manner, while FT materials may have a resin content of greater than about 45% by volume or more preferably greater than about 55% by volume, FRC materials desirably have a resin content of less than about 45% by volume, or more preferably less than about 35% by volume. FRC materials traditionally use two-part thermoset epoxies as the polymeric matrix, however, it is possible to also use thermoplastic polymers as the matrix. In many instances, FRC materials are pre-prepared prior to final manufacturing, and such intermediate material is often referred to as a prepreg. When a thermoset polymer is used, the prepreg is partially cured in intermediate form, and final curing occurs once the prepreg is formed into the final shape. When a thermoplastic polymer is used, the

prepreg may include a cooled thermoplastic matrix that can subsequently be heated and molded into final shape.

[00112] The second component (200) may be substantially formed from a formed fiber reinforced composite material that comprises a woven glass or carbon fiber reinforcing layer embedded in a polymeric matrix. In such an embodiment, the polymeric matrix is preferably a thermoplastic material such as, for example, polyphenylene sulfide (PPS), polyether ether ketone (PEEK), or a polyamide such as PA6 or PA66. In other embodiments, the second component (200) may instead be formed from a filled thermoplastic material that comprises a glass bead or discontinuous glass, carbon, or aramid polymer fiber filler embedded throughout the thermoplastic material such as, for example, polyphenylene sulfide (PPS), polyether ether ketone (PEEK), or polyamide. In still other embodiments, the second component (200) may have a mixed-material construction that includes both a filled thermoplastic material and a formed fiber reinforced composite material.

[00113] The second component (200) may have a mixed-material construction that includes both a fiber reinforced thermoplastic composite resilient layer (not shown) and a molded thermoplastic structural layer (not shown). In some preferred embodiments, the molded thermoplastic structural layer may be formed from a filled thermoplastic material that comprises a glass bead or discontinuous glass, carbon, or aramid polymer fiber filler embedded throughout a thermoplastic material such as, for example, polyphenylene sulfide (PPS), polyether ether ketone (PEEK), or a polyamide such as PA6 or PA66. The resilient layer may then comprise a woven glass, carbon fiber, or aramid polymer fiber reinforcing layer embedded in a thermoplastic polymeric matrix that includes, for example, a polyphenylene sulfide (PPS), a polyether ether ketone (PEEK), or a polyamide such as PA6 or PA66. In one particular embodiment, the second component (200) resilient layer may comprise a woven carbon fiber fabric embedded in a polyphenylene sulfide (PPS), and the second component (200) structural layer may comprise a filled polyphenylene sulfide (PPS) polymer.

[00114] In alternate embodiments, the second component (200) may have one or more interior cross connecting members (not shown). The cross connecting members may provide additional structural stiffness or sound control. The interior cross connecting members can comprise members that connect non-adjacent portions of the interior of the second component (200). For example, the cross connecting members may connect the interior surface of the second component crown portion (205) to one of the second component sole portion heel portion (214), or the second component sole portion toe portion (212). The interior cross connecting members may comprise a length that extends

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entirely from an interior surface of a front most edge of the second component (200) to the second component trailing edge portion (230) interior surface, or the interior cross connect members may comprise a length that does not extend entirely from an interior surface of a front most edge of the second component (200) to the second component trailing edge portion (230) interior surface. The interior cross connecting members comprise a thickness. The thickness of interior cross connecting members can range from 0.25 mm to 6.35 mm (0.01 inch to 0.25 inch). For example, the thickness of interior cross connecting members may be 0.25 mm (0.01 inch), 1.27 mm (0.05 inch), 2.54 mm (0.10 inch), 3.81 mm (0.15 inch), 5.08 mm (0.20 inch), or 6.35 mm (0.25 inch).

I) Second Embodiment of Golf Club Head

[00115] A second embodiment of a golf club head (2100), illustrated in FIG. 17, comprises a first component (2300) with a weight channel and a second component (2200) that joins onto the first component (2300). The first component (2300) of golf club head (2100) can be similar to the first component (300) of golf club head (100), with the exception of the weight system. The second component (2200) of golf club head (2100) can be similar to the second component of golf club head (100), described above. The golf club head (2100) forms a striking face (2170), a striking face return (2177), a hosel (2140), a crown (2110), a sole (2120), a heel end (2160), a toe end (2150), a trailing edge (2130) at a rear-most portion of a rear end (2180), a hosel (2140), and a sole portion hosel adaptor attachment recess (2195).

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[00116] As illustrated in FIG. 18, the first component (2300) can comprise a rear extension (2500). The rear extension (2500) can comprise a portion of the sole (2120). The rear extension (2500) comprises a weight channel (2540). The weight channel (2540) is exposed at the rear end (2180) and sole (2120) of the club head (2300).

[00117] The weight channel (2540) is configured to receive a movable weight (2350) in one of three positions. The weight (2350) can be secured to the weight channel (2540) by a threaded fastener (2320). The weight (2350) can be placed in a toe-side position, a central position, or a heel-side position. The weight channel (2540) comprises a mounting wall (2542) and a sole wall (2550). The mounting wall (2542) can be oriented approximately perpendicular to the sole (2120). The sole wall (2550) can be oriented approximately parallel to the main sole (2120), but inset by a distance equal to a height of the mounting wall (2542). The movable weight (2350) can comprise an elongate, trapezoidal shape, or any other suitable weight. The movable weight (2350) can comprise a inward wall and a connecting wall. The inward wall lies flush against the sole wall (2550) of the weight channel

(2540). The connecting wall lies flush with the mounting wall (2542) when the weight (2350) is attached in one of the three positions.

[00118] The mounting wall (2542) of the weight channel (2540) comprises three threaded apertures that correspond to the three weight positions. The mounting wall (2542) comprises a toe-side threaded aperture (2544), a center threaded aperture (2546), and a heel-side threaded aperture (2548). The movable weight (2350) is positioned in the toe-side position by placing the connecting wall of the weight (2350) flush against the mounting wall (2542) of the channel (2540) and securing the fastener (2320) into the toe-side threaded aperture (2544). The movable weight (2350) is positioned in the central position by placing the connecting wall of the weight (2350) flush against the mounting wall (2542) of the channel (2540) and securing the fastener (2320) into the center threaded aperture (2546). The movable weight (2350) is positioned in the heel-side position by placing the connecting wall of the weight (2350) flush against the mounting wall (2542) of the channel (2540) and securing the fastener (2320) into the heel-side threaded aperture (2548).

[00119] When the movable weight (2350) is positioned in the central position, as illustrated in the sole view of FIG. 19, the golf club (2100) is configured to offer no draw or fade bias. When the weight (2350) is positioned in the toe-side position, as illustrated in FIG. 20, the weight (2350) gives the club head a fade bias. When the weight (2350) is positioned in the heel-side position, as illustrated in FIG. 21, the weight (2350) gives the club head a draw bias.

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[00120] The first component (2300) comprises a sole portion rear extension (2500), a striking face return crown portion (2400), and a striking face return sole portion (2810). The striking face return sole portion (2810) comprises a heel extension (2830) and a toe extension (2820). The heel extension (2830) comprises a rear wall (2832). The toe extension (2820) comprises a rear wall (2822).

[00121] The first component rear extension (2500) comprises a toe-side wall (2522) and a heel-side wall (2532) that connect the weight channel (2540) to the striking face sole return (2810). The rear extension toe-side wall (2522) and the toe extension rear wall (2822) can form a toe-side wall angle (2850). The toe-side wall angle (2850) can range between 45 degrees and 180 degrees. The rear extension heel-side wall (2532) and the heel extension rear wall (2832) can form a heel-side wall angle (2855). The heel-side wall angel (2855) can range between 45 degrees and 180 degrees. In some embodiments, the toe-side wall angle (2850) is roughly equal to the heel-side wall angle (2855). In other embodiments, the toe-side wall angle (2850) and the heel-side wall angle (2855) are different. In

some embodiments, the toe-side wall angle (2850) and the heel-side wall angle (2855) are supplementary angles (their sum equals roughly 180 degrees). In these embodiments, the toe extension rear wall (2822) and the heel extension rear wall (2832) are located roughly within the same plane (the toe rear wall (2822) and the heel rear wall (2832) are roughly parallel when viewed from the sole). For example, the toe-side wall angle (2850) can be a acute angle, while the heel-side wall angle (2855) is a supplementary obtuse angle.

[00122] Referring to FIGS. 19 and 22, some embodiments comprise obtuse toe-side and heel-side wall angles (2850 and 2855). Referring to FIG. 23, some embodiments comprise approximately 90 degree toe-side and heel-side wall angles (2850 and 2855). Referring to FIG. 24, some embodiments comprise acute toe-side and heel-side wall angles (2850 and 2855). Embodiments with obtuse toe-side and heel-side wall angles (2850 and 2855) can distribute stress smoothly, rearward into the sole (2120). The obtuse angles can increase the strength of the sole (2120) and support the sole rear extension (2500). However, embodiments with acute angles can comprise a first component with a smaller mass than embodiments with obtuse or 90 degree angles. Therefore, the embodiments with acute toe-side and heel-side wall angles (2850 and 2855) can allow for improved weighting properties, such as a high MOI.

[00123] The weight channel (2540) can fan outward beyond a main section of the rear sole extension (2500), as shown in the embodiment of FIGS. 19-21. In these embodiments, where the weight channel (2540) extends toe-ward and heel-ward, the rear extension toe-side wall (2522) and heel-side wall (2532) each have a bend adjacent the weight channel (2540). In other embodiments, such as is illustrated in FIG. 22, the rear extension toe-side wall (2522) and heel-side wall (2532) can be straight. In some embodiments, the rear extension toe-side wall (2522) can be parallel to the rear extension heel-side wall (2532). In some embodiments, the rear extension toe-side wall (2522) can be non-parallel to the rear extension heel-side wall (2532).

[00124] The rear extension (2500) can be attached to the striking face return (2810) at different locations. This shift of the attachment point can affect how the rear extension (2500) is angled with respect to the striking face return (2810). A rear extension axis (2504) approximates a center of the rear extension (2500). The rear extension axis (2504) extends between a front midpoint (2502) of the rear extension and the center threaded aperture (2546) of the weight channel (2540). The rear extension axis (2504) may be coincident with and aligned along the YZ plane. The rear extension axis (2504) may form an angle with the YZ plane, and therefore not align with the YZ plane. The rear

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extension axis (2504) may be offset from the YZ plane and parallel to the YZ plane. The front midpoint (2502) is located half way between a toe-side intersection point (2824) and a heel-side intersection point (2834). The toe-side intersection point (2824) is the point at which the toe extension rear wall (2822) intersects and connects to the rear extension toe-side wall (2522). Similarly, a heel-side intersection point (2834) is the point at which the heel extension rear wall (2832) intersects and connects to the rear extension heel-side wall (2532). The toe-side and heel-side intersection points (2824 and 2834) can be located anywhere along a rear edge of the striking face return sole portion (2810). In some embodiments, the connection between the toe/heel extension rear wall (2822/2832) and the rear extension toe/heel-side wall (2522/2532), respectively, is filleted, beveled, or chamfered.

[00125] The weight channel (2540) may be centered with respect to the rear extension axis (2504). The weight channel (2540) may be centered with respect to the YZ plane. The weight channel may be centered with respect to both the rear extension axis (2504) and the YZ plane simultaneously. The weight channel may be centered with respect to both the rear extension axis (2504) and the YZ plane even if the rear extension axis (2504) is not coincident with the YZ plane. In such a case, the rear extension axis (2504) intersects the YZ plane at or approximately at a mid point of the weight channel (2504) mounting wall (2542). The weight channel may be centered with respect to the rear end (2180) of the golf club head (2100).

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[00126] The toe-side intersection point and the heel-side intersection point are located at a distance rearward of the striking face. The toe toe-side intersection point and the heel-side intersection point may be located at the same distance rearward of the striking face. The toe-side intersection point and the heel-side intersection point may be located at distances rearward of the striking face that are different. The toe-side intersection point may be located further towards the rear than the heel-side instersection point. The heel-side intersection point may be located further towards the rear than the toe-side instersection point. The toe-side intersection point and the heel-side intersection point distance rearward of the striking face may be in a range of 2.54 mm to 50.8 mm (0.1 inches to 2.0 inches). The toe-side intersection point and the heel-side intersection point distance rearward of the striking face may be 2.54 mm (0.1 inch), 5.08 mm (0.2 inch), 7.62 mm (0.3 inch), 10.16 mm (0.4 inch), 12.7 mm (0.5 inch), 15.24 mm (0.6 inch), 17.78 mm (0.7 inch), 20.32 mm (0.8 inch), 22.86 mm (0.9 inch), 25.4 mm (1.0 inch), 27.94 mm (1.1 inches), 30.48 mm (1.2 inches), 33.02 mm (1.3 inches), 35.56 mm (1.4 inches), 38.1 mm (1.5 inches), 40.64 mm (1.6 inches), 43.18 mm (1.7 inches), 45.72 mm (1.8 inches), 48.26 mm (1.9 inches), 50.8 mm (2.0 inches).

[00127] The sole rear extension (2500) of the first component (2300) can be angled with respect to an intersection plane (2840). As illustrated in FIGS. 19 and 22-28 the intersection plane (2840) can extend parallel to the XY plane. The intersection plane (2840) may extend such that it forms an angle

with respect to the XY plane. The intersection plane (2840) is coincident with the toe-side intersection point (2824) and the heel-side intersection point (2834). In some embodiments, such as those of FIGS. 19-24, the rear extension (2500) extends straight rearward, such that the intersection plane (2840) and the rear extension axis (2504) form an approximately 90 degree angle when viewed from a sole view. In some embodiments, such as that of FIGS. 25-28, the intersection plane (2840) and the rear extension axis (2504) intersect at an angle that is not 90 degrees.

[00128] A toe-side axis angle (2860) is measured (in the sole view) from the intersection plane (2840) to the rear extension axis (2504) on the toe-side of the rear extension axis (2504). A heel-side axis angle (2865) is measured (in the sole view) from the intersection plane (2840) to the rear extension axis (2504) on the heel-side of the rear extension axis (2504). The toe-side axis angle (2860) and the heel-side axis angle (2865) are supplementary angles (adding to 180 degrees).

[00129] Referring to FIG. 25, in some embodiments, the rear extension is attached to the striking face return sole portion (2810) closer to the toe end (2150) of the club head (2100) than the heel end (2160) of the club head (2100). In these embodiments, the toe-side axis angle (2860) is greater than 90 degrees, and the heel-side axis angle (2865) is less than 90 degrees. The weight channel (2540) remains centrally located in the rear end (2180) of the golf club head (2100). Because of the location of the first component rear extension (2500), the second component (2200) can occupy a greater portion of the heel side of the sole (2120). More specifically, a second component heel sole portion (2214) can be greater than a second component toe sole portion (2212).

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[00130] Referring to FIG. 26, in some embodiments, the rear extension is attached to the striking face return sole portion (2810) closer to the heel end (2160) of the club head (2100) than the toe end (2150) of the club head (2100). In this embodiment, the toe-side axis angle (2860) is greater than 90 degrees, and the heel-side axis angle (2865) is less than 90 degrees. The weight channel (2540) remains centrally located in the rear end (2180) of the golf club head (2100). Because of the location of the first component (2300) rear extension (2500), the second component (2200) can occupy a greater portion of the toe side of the sole (2120). More specifically, the second component toe sole portion (2212) can be greater than the second component heel sole portion (2214). The attachment position of the rear extension can alter the weighting and launch characteristics of the golf club head (2100).

[00131] Referring to FIGS. 27 and 28, in some embodiments, the rear extension can have a varying width. In these embodiments, the toe-side wall angle (2850) and the heel-side wall angle (2855) may

not be supplementary angles (may not sum to 180 degrees). In some embodiments, both the toe-side and the heel side wall angels (2850 and 2855) may be acute angles, reducing the weight of the first component and allowing greater perimeter weighting in the club head. In other embodiments, both the toe-side and the heel side wall angels (2850 and 2855) may be obtuse angles, increasing the durability of the sole and simplifying manufacturing assembly of the golf club head (2100).

[00132] The rear extension width (2507) is measured in a heel to toe direction rearward of a rear perimeter of the striking face return sole portion (2810). The rear extension width (2507) is less than an entire width of the sole (2120) of the golf club (2100). The rear extension width (2507) can range from 25% to 85% of an entire width of the sole (2120). The rear extension width (2507) may be 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80% or 85% of an entire width of the sole (2120). The width of the rear extension adjacent the weight channel (2540) can range between 25.4 mm to 63.5 mm (1 inch to 2.5 inches). The rear extension width (2507) between the toe-side intersection point (2824) and the heel-side intersection point (2834) can range between 25.4 mm and 127 mm (1 inch and 5 inches). The rear extension width (2507) can be greater adjacent the weight channel (2540), as illustrated in FIGS. 27 and 28, or greater adjacent the striking face return (2810) as illustrated in FIGS. 18-22.

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[00133] As illustrated in FIGS. 29 and 30, the second component can comprise a crown portion (2205), a trailing edge portion (2230), a sole toe portion (2212), and a sole heel portion (2214). The crown portion (2205) connects the sole toe portion (2212) and the sole heel portion (2214). The trailing edge portion (2230) connects the crown portion (2205) to the sole toe and heel portions (2212 and 2214). The crown portion (2205), sole toe portion (2212) and sole heel portion (2214) define a rear cutout (2240) in the sole side of the second component (2200). In some embodiments, such as the one illustrated in FIG. 29, the rear cutout 2240 cuts into the sole only. In other embodiments, such as the one illustrated in FIG. 30, the rear cutout 2240 cuts into both the sole and the crown portion (2205). The embodiment that cuts into both the sole and the crown portion (2205) allows more room in the rear end (2180) of the club head (2100) for the weight channel (2540) of the first component (2300).

[00134] The second component sole toe portion (2212) and sole heel portion (2214) can be dimensioned to correspond to the dimensions of the first component (2300), as illustrated in FIGS. 22-28. For example, the second component sole toe portion (2212) can be roughly the same size as the sole heel portion (2214) when the rear extension (2500) is centrally located, such as in the embodiments of FIG. 22-24. In embodiments where the rear extension axis (2504) is angled with

respect to the intersection plane (2840), the sole toe portion (2212) can be either smaller or larger than the sole heel portion (2214), as illustrated in the embodiments of FIGS. 25 and 26.

[00135] The second component (2200) can be secure to the first component (2300) in a way similar to that described above for the first golf club head (100) embodiment. The materials of the first (2300) and second (2200) components can also be similar to those described above for the first golf club head (100) embodiments.

II) Method of Manufacture

[00136] A first embodiment of a method of manufacturing the golf club head (100) comprises forming the first component (300), forming the second component (200), applying an adhesive to a first component lip (450), aligning the second component (200) to the first component (300), fitting the second component (200) to the first component (300) so the second component (200) overlays the lip (450), and allowing the adhesive to set, permanently affixing the second component (200) to the first component (300) to form the hollow golf club head (100).

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[00137] Referring to FIG. 15, as discussed above, the first component (300) may further comprise a plurality of casting support bars, including one or more heel end casting support bars (1510), and one or more toe end casting support bars (1512). The casting support bars stabilize the cast part of the first component (300) while the metal cools after casting. The stabilization provided by the casting support bars prevents the front portion of the cast part from folding towards or away from the first component sole portion rear extension (500) while the part cools after casting. The casing support bars are removed from the as cast first component (300) and are not present in the finished golf club head (100).

[00138] An alternative method of manufacturing the golf club head (100) comprises casting the first component (300), molding a wax pattern of the first component (300), adding wax support bars to the wax pattern, investing the modified wax pattern, casting the investment, trimming the metal casting support bars (1510) and (1512), forming the first component (300), forming the second component (200), applying an adhesive to a first component lip (450), aligning the second component (200) to the first component (300), fitting the second component (200) to the first component (300) so the second component (200) overlays the lip (450), and allowing the adhesive to set, permanently affixing the second component (200) to the first component (300) to form the hollow golf club head (100). When adding the support bars to the wax pattern, the attachment points for the support bars

are an interior surface of the first component (300) wax pattern, to avoid any marring or distortion of an outer surface of the first component (300) The advantage of adding the support bars is that the casting of the first component is supported against distortion while in a cooling phase after casting.

[00139] The first component (300) can be coupled to the second component (200) at the first component lip (450) to form the body of the golf club head (100). The first component lip (450), including the crown portion lip (455), the sole portion lip (460), and the mass portion vertical lip (750) are entirely covered by the second component (200) when the first component (300) is coupled to the second component (200) to form the body of the golf club head (100). The second component sole portion rear cutout (240) comprises a portion of perimeter edge (220) at the trailing edge portion (230). When the first component (300) is coupled to second component (200) at the first component lip (450) (to form the body of the golf club head (100)), the portion of perimeter edge (220) at the trailing edge portion (230) is joined along the mass portion trailing edge shelf (1042).

[00140] The first component (300) may be coupled to the second component (200) by means of an adhesive. In many embodiments, an adhesive such as glue, epoxy, epoxy gasket, tape (e.g., VHB tape), or any other adhesive materials can be disposed at the junction of the second component (200) and the first component lip (450). In some embodiments, the first component tabs (457) on the first component lip (450 and 455) can abut the second component (200), leaving a clearance gap between the first component lip (450 and 455) and the second component (200). This clearance gap can house the adhesive. The clearance gap can have a uniform height or thickness due to the first component tabs (457) having uniform heights. This uniform height of the clearance gap can create an even bond between the first and second components. In other embodiments, the second component (200) can be coupled to the first component (300) by fasteners, clips, press fit, or any other appropriate mechanical means of attachment (not shown). In other embodiments, the first component (300) may be coupled to the second component (200) by an adhesive in conjunction with an appropriate mechanical means of attachment. In other embodiments, the first component (300) may be coupled to the second component (200) using laser welding to heat the second component (200) material to cause it to adhere to the first component (300) material.

[00141] In some embodiments, when the first component is coupled to the second component to form the golf club head 100), the surface of the first component (300) is not offset from the surface of the second component (200). When the first component (300) is coupled to the second component (200) to form the golf club head (100), a nominal outer surface of the first component is not offset

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above or below a nominal outer surface of the second component at the juncture of the coupling (i.e. the outer surfaces of the first component (300) and the second component (200) are flush).A second method of manufacturing the golf club head (100) comprises the following steps: (1) forming the first component (300), (2) providing the second component (200), (3) securing the first component (300) to the second component (200), and (4) polishing and finishing the club head. The first step can comprise casting an unifinished first component, laser cutting out unwanted portions of the unfinished first component, and optionally welding a faceplate to the first component to form the finished first component.

[00142] Forming the first component (300) in the first step can start with casting an unfinished version of the first component. The first component can be cast as a full club head, with a reduced thickness region. A majority of the reduced thickness region can be located approximately where the second component will later be attached. A peripheral section around an edge of the reduced thickness region will eventually form the lip of the first component. The unfinished first component is cast with the reduced thickness region because the reduced thickness region helps the first component hold its desired shape during the casting process. Casting the first component without the reduced thinkess region could result in warping of the part or other casting quality issues. Therefore, casting with the reduced thickness region, which is later removed, ensures that the first component maintains its desired shape so that the second component will fit on it correctly during step three.

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[00143] After the unfinished first component is removed from the mold in which it was cast, a laser is used to cut out the unwanted portion of the reduced thickness region, leaving only the peripheral section, which forms the lip of the second component. The lip can be ground down or polished, as necessary. In some embodiments, the strikeface of the club head is integrally cast as part of the first component. In other embodiments, the first component can be cast without a strikeface (with an opening or void in the front of the first component). In these embodiments, a faceplate is provided separately by either casting or forging the faceplate from a metallic material. The faceplate can be conventionally welded, laser welded, or swedged (swagged) into the front opening of the first component.

[00144] The second step can comprise injection molding the second component. providing a composite material (typically in pellet form), melting the composite material, injecting the melted composite material into a mold to form an unfinished second component, cutting off the spruce, and polishing the gate area to finish the second component. As describe above, the composite material

can comprise a polymer resin and a reinforcing fiber. The composite material can be provided in pellets that comprise both resin and fiber. The composite pellets are melted and injected into a mold to form the unfinished second component.

[00145] The third step can comprise applying an adhesive (such as a two-part liquid epoxy) to the first component lip, aligning and placing the second component (200) over the first component lip (450), and allowing the adhesive to dry. One or more first component tabs (457) on the lip (450) and (455) can provide a clearance gap between the first component lip (450) and the second component. This clearance gap can house the adhesive. The clearance gap can have a uniform height or thickness due to the first component tabs (457) having uniform heights. This uniform height of the clearance gap can create an even bond between the first component (300) and the second component (200).

[00146] In some embodiments of this second method, a functionalized bonding film or layer can be used instead of an adhesive. The functionalized bonding film can be provided in one or more strip sections that correspond to the shape and side of the first component lip (450) and (455). The functionalized bonding film comprises a first and second side. The film can be configured to bond with the material of the first component on the first side and with the material of the second component on the second side. The bonding film can bond the first and second components together when placed under the necessary temperature and pressure conditions for a set amount of time.

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[00147] After the adhesive is applied to the first component lip (450) and (455), the second component (200) can be placed or slid over the first component lip (450) and (455). The second component (200) can be slid over the first component lip (450) and (455) until an outer edge of the second component (200) comes into contact with the remainder of the first component (300). As illustrated in FIG. 5, the first component lip comprises a recessed offset (459), which the second component (200) fills when the club head is assembled. The third step can further comprise allowing the adhesive to dry and bond the first component (200) to the second component (300).

[00148] The fourth step can comprise polishing, cleaning, coating, and/or painting the club head. In some embodiments, the fourth step can further comprise placing a detachable weight within the weight recess (540) and securing the weight using a fastener.

III) T-Shaped Design Functions

[00149] As discussed above, the embodiment of a hollow golf club head (100) described herein can comprise two major components. The metallic, first component (300) comprises the striking

portion and a sole extension (500) forming a "T" shape. The non-metallic, second component (200) comprises the rear portion of the crown (110), and wraps around the first component to also comprise a portion of the sole (120). The more dense "T" shaped sole of the first component (300), coupled to the less dense crown wrapped around second component (200) can optimize mass properties by reducing the crown mass, and shifting the golf club head center of gravity (CG) lower. The saved weight from the second component (200) can be redistributed to other locations of the golf club head (100) to further optimize the CG, increase the MOI, and manipulate the shape of the shot trajectory.

[00150] The CG of the golf club head (100) can move lower and toward the rear of the golf club head (100) comprising the first component (300) and the second component (200), wherein the second component (200) comprises a second material with a second density that is lower than the first material density, compared to an alternate golf club head comprising only the first material with a constant density.

EXAMPLE

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[00151] A comparative club head and an exemplary club head of the instant application are compared in Table 1. The comparative club is entirely metallic, but has similar total mass and total volume as the exemplary club head. The exemplary club head is an embodiment of the golf club head of the instant application.

Table 1

	CG_y	CG_z	I_{XX}	I_{YY}	Mass	Volume
Comparative Golf Club Head	0.895	1.913	584.45	834.3	205.7 g	445_{CC}
Exemplary Golf Club Head	0.887	1.986	652.71	875.94	205.8 g	445_{CC}
Exemplary Golf Club Head with Embedded Weight	0.89	2.013	678.31	901.78	205.2 g	445_{CC}

[00152] The comparative club head and an exemplary club head have equal volumes of approximately 445 cm3. The comparison club, constructed entirely of a metallic material has a CG_y, which is the height of the CG above the ground plane (105), of 22.73 mm (0.895 inch). The exemplary golf club head has a CG_y of 22.53 mm (0.887 inch). It is desirable to have a lower value for CG_y. The CG_y of the exemplary golf club head is lower than that of the comparison club by 0.20 mm (0.008 inch).

[00153] As described above, CG_z is measured as a distance the CG is located toward the rear end of the golf club head from the strike face center (175) in a direction perpendicular to the loft plane of the (198). A greater CG_z, located further to the rear of the golf club, is beneficial for ball flight control. The comparison club, has a CG_z of 45.59 mm (1.913 inches). The exemplary golf club head has a CG_z of 50.44 mm (1.986 inches). The CG_z of the exemplary golf club head is 1.85 mm (0.073 inch) further back than the CG_z of the comparison club.

[00154] The position of the CG helps determine the launch characteristics of a ball (*e.g.*, ball trajectory, ball spin, and ball speed), moment of inertia (MOI), and performance characteristics (*e.g.*, swing speed, squaring the face during impact). A high MOI prevents rotation of the golf club head during a swing, and helps square the striking face during impact with the ball. Striking the ball with a squared striking face helps ensure a straight ball path and optimal height/trajectory, compared to slicing or hooking the ball when the striking face is not squared. Further, with a lower CG, the speed and spin of the ball are improved, which can add distance and prevent the ball rolling backwards upon landing.

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[00155] The MOI of the exemplary golf club head (is greater than the MOI of the comparison golf club. MOI values I_{XX} and I_{YY} are the MOI values about the X axis (190) and Y axis, (192) respectively. Larger MOI is desirable, as a high MOI helps prevent rotation of the golf club head during a swing, and helps square the striking face during impact with the ball. The comparative club has I_{XX} and I_{YY} values of 584.45 and 834.30, respectively. The exemplary golf club head has I_{XX} and I_{YY} values of 652.71 and 875.94, respectively. The exemplary golf club head has a quite large11.7% improvement of I_{XX}, and a 5.0% improvement of I_{YY} over the comparative club.

[00156] The ball flight of a golf ball struck by the exemplary golf club head has improved CG_y, and CG_z values, directly leading to improved I_{XX} and I_{YY} values. The improved CG values leads to lower ball spin at impact, which leads to a longer carry for the ball flight. The improved MOI values lead directly to more forgiveness for off center hits.

[00157] In an alternate embodiment, an embedded high density weight was added to the exemplary golf club head. The exemplary golf club head with weight has a CG_y of 22.6 mm (0.890 inch) and a CG_z of 51.13 mm (2.013 inches). The exemplary golf club head with weight CG_y is less than the CG_y of the comparative golf club head by 0.127 mm (0.005 inch), but the CG_z of the exemplary golf with weight is greater than the CG_z of the comparative golf club head by 2.54 mm (0.100 inch). The exemplary golf club head with weight has an I_{XX} value

of 678.31, and I_{YY} value of 901.78. These MOI values are both greater than the I_{XX} and I_{YY} of the comparative golf club head by 16% and 8.1%, respectively.

[00158] Replacement of one or more claimed elements constitutes reconstruction and not repair. Additionally, benefits, other advantages, and solutions to problems have been described with regard to specific embodiments. The benefits, advantages, solutions to problems, and any element or elements that may cause any benefit, advantage, or solution to occur or become more pronounced, however, are not to be construed as critical, required, or essential features or elements of any or all of the claims, unless such benefits, advantages, solutions, or elements are expressly stated in such claims.

[00159] As the rules to golf may change from time to time (e.g., new regulations may be adopted or old rules may be eliminated or modified by golf standard organizations and/or governing bodies such as the United States Golf Association (USGA), the Royal and Ancient Golf Club of St. Andrews (R&A), etc.), golf equipment related to the apparatus, methods, and articles of manufacture described herein may be conforming or non-conforming to the rules of golf at any particular time. Accordingly, golf equipment related to the apparatus, methods, and articles of manufacture described herein may be advertised, offered for sale, and/or sold as conforming or non-conforming golf equipment. The apparatus, methods, and articles of manufacture described herein are not limited in this regard.

[00160] Custom within the industry, rules set by golf organizations such as the United States Golf Association (USGA) or The R&A, and naming convention may augment this description of terminology without departing from the scope of the present application.

[00161] While the above examples may be described in connection with a hollow body golf club, the apparatus, methods, and articles of manufacture described herein may be applicable to other types of golf club such as an iron-type golf club, a wedge-type golf club, or a putter-type golf club. Alternatively, the apparatus, methods, and articles of manufacture described herein may be applicable to other types of sports equipment such as a hockey stick, a tennis racket, a fishing pole, a ski pole, etc.

[00162] Moreover, embodiments and limitations disclosed herein are not dedicated to the public under the doctrine of dedication if the embodiments and/or limitations: (1) are not expressly claimed in the claims; and (2) are or are potentially equivalents of express elements and/or limitations in the claims under the doctrine of equivalents.

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CLAIMS

1. A golf club head comprising a body:

the body comprising:

a striking face, a rear end, a toe end, a heel end, a crown, a sole, and a trailing edge,

the body further comprising:

a first component comprising the striking face, a striking face return, and a rear extension further comprising a weight channel;

and a second component comprising at least a portion of the rear end;

wherein the second component is configured to be coupled to the first component to form an enclosed hollow interior of the golf club head;

wherein:

the weight channel is centrally located in the rear end of the golf club head and is exposed at the rear end and sole of the body;

the weight channel is configured to receive a moveable weight in one of three positions;

wherein the striking face comprises a striking face center, and

an X-axis extends through the striking face center in a direction from the heel end to the toe end of the golf club head, and parallel to a ground plane when the club head is at an address position,

a Y-axis extending through the striking face center in a direction from the crown to the sole of the golf club head, and perpendicular to the X-axis,

a Z-axis extending through the striking face center in a direction from the striking face to the rear end and perpendicular to the X-axis and the Y-axis,

a loft plane approximately parallel to the striking face and tangent to the striking face center forming a loft angle with the ground plane,

an XY plane extending through the X-axis and the Y-axis,

and

a YZ plane extending through the Y-axis and the Z-axis,

wherein:

the first component comprises a first material having a first density;

the second component comprises a second material having a second density;

wherein the first density is greater than the second density;

wherein the striking face return of the first component extends rearwardly from the striking face, and comprises a first component crown portion and a first component sole portion;

wherein the rear extension extends from the first component sole portion of the striking face return toward the rear end,

wherein the rear extension comprises a toe-side wall and heel-side wall connecting the weight channel to the striking face return,

wherein the rear extension comprises a rear extension width measured in a heel to toe direction rearward of a rear perimeter of the striking face return sole portion; and

wherein the rear extension width varies along a striking face to rear end direction.

2. The golf club head of claim 1, wherein a first component mass is 85% to 96% of a mass of the golf club head.
3. The golf club head of claim 1, wherein the second component further comprises a crown portion, a sole toe portion, and a sole heel portion;

   wherein the crown portion, sole toe portion, and sole heel portion make a rear cutout.
4. The golf club head of claim 1, wherein the first component sole portion further comprises a toe extension and a heel extension on a toe side of the rear extension and heel side of the rear extension respectively,

   wherein the toe extension comprises a toe extension rear wall, and the heel extension comprises a heel extension rear wall.
5. The golf club head of claim 4, the rear extension toe-side wall and the toe extension rear wall form a toe-side wall angle, and wherein the rear extension heel-side wall and the heel extension rear wall form a heel-side wall angle.
6. The golf club head of claim 5, wherein the toe-side wall angle and the heel-side angle add up to a sum of the angles that is not 180 degrees.
7. The golf club head of claim 1, wherein the moveable weight is secured by a threaded fastener.
8. The golf club head of claim 1, wherein the weight channel further comprises a sole wall, and wherein a mounting wall is oriented approximately perpendicular to the sole.

9. The golf club head of claim 8, wherein the mounting wall comprises three threaded apertures,

wherein the three threaded apertures comprise a toe-side threaded aperture, a center threaded aperture, and a heel-side threaded aperture,

wherein the center threaded aperture is located at center point of a length of the mounting wall.

10. The golf club head of claim 1, wherein the rear extension width adjacent the weight channel can range between 25.4 mm (1 inch) and 63.5 mm (2.5 inches).

11. The golf club head of claim 1, wherein the rear extension width is in a range of 25% to 85% of an entire width of the sole.

12. The golf club head of claim 5, wherein the rear extension toe-side wall and the toe extension rear wall connect at a toe-side intersection point, and the rear extension heel-side wall and the heel extension connect at a heel-side intersection point, wherein an intersection plane is coincident with the toe-side intersection point and the heel-side intersection point, and extends parallel with the XY plane.

13. The golf club head of claim 12, wherein the rear extension comprises a rear extension axis extending between a rear extension front midpoint and a center of a mounting wall center aperture, wherein the rear extension front midpoint is located halfway between the toe-side intersection point and the heel-side intersection point.

14. The golf club head of claim 13, wherein the rear extension axis is perpendicular to the intersection plane.

15. The golf club head of claim 13, wherein the rear extension axis is not perpendicular to the intersection plane.

16. The golf club head of claim 13, wherein a toe-side axis angle comprises an angle between the intersection plane and the rear extension axis measured from a sole view of the golf club head on a toe-side of rear extension axis,

a heel-side axis angle comprises an angle between the intersection plane and the rear extension axis measured from a sole view of the golf club head on a heel-side of rear extension axis,

wherein the toe-side axis angle and the heel-side axis angle are angles that add to 180 degrees.

17. The golf club head of claim 16, wherein the rear extension is attached to the striking face return sole portion closer to the toe end of the golf club head than the heel end, wherein the toe-side axis angle is greater than 90 degrees and the heel-side axis angle is less than 90 degrees.
18. The golf club head of claim 16, wherein the rear extension is attached to the striking face return sole portion closer to the heel end of the golf club head than the toe end, wherein the heel-side axis angle is greater than 90 degrees and the toe-side axis angle is less than 90 degrees.