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(71) Applicant *(for all designated States except US)*: **CALLAWAY GOLF COMPANY** [US/US]; A DELAWARE CORPORATION, 2180 RUTHERFORD ROAD, Carlsbad, CA 92008-7328 (US).

(72) Inventors: **EHLERS, Steven M.**; 17576 ST. ANDREWS, POWAY, CALIFORNIA 92064 (US). **ROLLINSON, Augustin w.**; 1350 LORING STREET, SAN DIEGO, CALIFORNIA 92109 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HELMSTETTER, Richard C.** [US/US]; P.O.BOX 3644, RANCHO SANTA FE, CALIFORNIA 92057 (US). **GALLOWAY, J. Andrew** [US/US]; 10197 QUAIL GLEN WAY, ESCONDIDO, CALIFORNIA 92029 (US). **HOCKNELL, Alan** [US/US]; 4587 ESSEX COURT, CARLSBAD, CALIFORNIA 92010 (US). **OLDKNOW, Andrew** [US/US]; 11 ST.ELIZABETH, LAGUNA NIGUEL, CALIFORNIA 92677 (US).

(74) Agent: **CATANIA, Michael A.**; CALLAWAY GOLF COMPANY, 2180 RUTHERFORD ROAD, Carlsbad, CA 92008-7328 (US).

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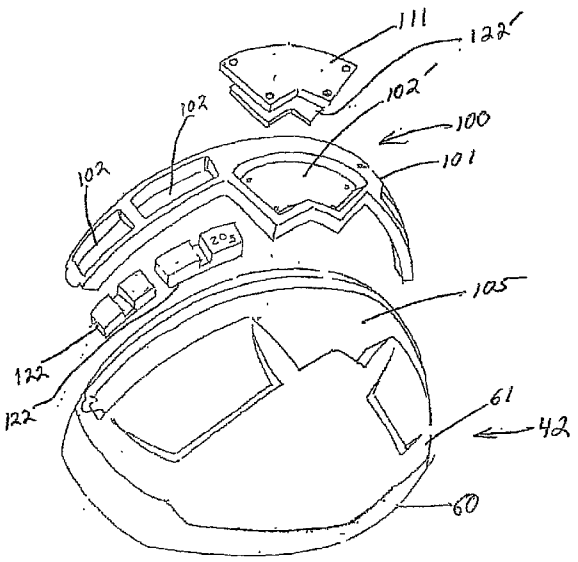
(54) Title: GOLF CLUB HEAD WITH CUSTOMIZABLE CENTER OF GRAVITY



(57) Abstract: A golf club (40) having a club head (42) with a face component (60), an aft body (61) and a removable weighting member (100) is disclosed herein. The face component (60) has a striking plate portion (72) and a return portion (74). The aft- body (61) is composed of a crown portion (62) and a sole portion (64) with a ribbon section (90) and a bottom section (91). The ribbon portion (91) has a recess (105) for placement of the weighting member (100) therein. The face component (60) is composed of a metal material, and the aft-body (61) is composed of a low-density material such as a composite material or a thermoplastic material. The club head (42) has a volume in the range of 290 cubic centimeters to 600 cubic centimeters, a weight in the range of 165 grams to 300 grams, and a moment of inertia, Izz, greater than 3000 grams-centimeter squared.

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Title

GOLF CLUB HEAD WITH CUSTOMIZABLE CENTER OF GRAVITY

(Corporate Docket Number PU2375-WO)

Technical Field

The present invention relates to a customizable golf club head and golf club. More specifically, the present invention relates to a method of customizing a golf club head with face component, an aft-body and a removable weight member that allow for multiple orientations of the center of gravity of the golf club head.

Background Art

When a golf club head strikes a golf ball, large impacts are produced that load the club head face and the golf ball. Most of the energy is transferred from the head to the golf ball, however, some energy is lost as a result of the collision. The golf ball is typically composed of polymer cover materials (such as ionomers) surrounding a rubber-like core. These softer polymer materials having damping (loss) properties that are strain and strain rate dependent which are on the order of 10-100 times larger than the damping properties of a metallic club face. Thus, during impact most of the energy is lost as a result of the high stresses and deformations of the golf ball (0.001 to 0.20 inch), as opposed to the small deformations of the metallic club face (0.025 to 0.050 inch). A more efficient energy transfer from the club head to the golf ball could lead to greater flight distances of the golf ball.

The generally accepted approach has been to increase the stiffness of the club head face to reduce metal or club head deformations. However, this leads to greater deformations in the golf ball, and thus increases in the energy transfer problem.

Some have recognized the problem and disclosed possible solutions. An example is Campau, U.S. Patent Number 4,398,965, for a Method Of Making Iron Golf Clubs With Flexible Impact Surface, which discloses a club having a flexible and

resilient face plate with a slot to allow for the flexing of the face plate. The face plate of Campau is composed of a ferrous material, such as stainless steel, and has a thickness in the range of 0.1 inches to 0.125 inches.

Another example is Eggiman, U.S. Patent Number 5,863,261, for a Golf Club Head With Elastically Deforming Face And Back Plates, which discloses the use of a plurality of plates that act in concert to create a spring-like effect on a golf ball during impact. A fluid is disposed between at least two of the plates to act as a viscous coupler.

Although not intended for flexing of the face plate, Viste, U.S. Patent Number 5,282,624 discloses a golf club head having a face plate composed of a forged stainless steel material and having a thickness of 3 mm. Anderson, U.S. Patent Number 5,344,140, for a Golf Club Head And Method Of Forming Same, also discloses use of a forged material for the face plate. The face plate of Anderson may be composed of several forged materials including steel, copper and titanium. The forged plate has a uniform thickness of between 0.090 and 0.130 inches.

U.S. Patent 6,146,571 to Vincent, *et.al.*, discloses a method of manufacturing a golf club head wherein the walls are obtained by injecting a material such as plastic over an insert affixed to a meltable core. The core has a melt point lower than that of the injectable plastic material so that once the core is removed, an inner volume is maintained to form the inner cavity. The insert may comprise a resistance element for reinforcing the internal portion of the front wall of the shell upon removal of the core where the reinforcement element is comprised of aluminum with a laterally extending portion comprised of steel.

U.S. Patent 6,149,534 to Peters, *et al.*, discloses a golf club head having upper and lower metal engagement surfaces formed along a single plane interface wherein the metal of the lower surface is heavier and more dense than the metal of the upper surface.

U.S. Patents 5,570,886 and 5,547,427 to Rigal, *et al.*, disclose a golf club head of molded thermoplastic having a striking face defined by an impact-resistant metallic

sealing element. The sealing element defines a front wall of the striking surface of the club head and extends upward and along the side of the impact surface to form a neck for attachment of the shaft to the club head. The sealing element preferably being between 2.5 and 5 mm in thickness.

U.S. Patent 5,425,538 to Vincent, *et al.*, discloses a hollow golf club head having a steel shell and a composite striking surface composed of a number of stacked woven webs of fiber.

U.S. Patent 5,624,331 to Lo, *et al.* discloses a hollow metal golf club head where the metal casing of the head is composed of at least two openings. The head also contains a composite material disposed within the head where a portion of the composite material is located in the openings of the golf club head casing.

U.S. Patent 1,167,387 to Daniel discloses a hollow golf club head wherein the shell body is comprised of metal such as aluminum alloy and the face plate is comprised of a hard wood such as beech, persimmon or the like. The face plate is aligned such that the wood grain presents endwise at the striking plate.

U.S. Patent 3,692,306 to Glover discloses a golf club head having a bracket with sole and striking plates formed integrally thereon. At least one of the plates has an embedded elongate tube for securing a removably adjustable weight means.

U.S. Patent 4,877,249 to Thompson discloses a wood golf club head embodying a laminated upper surface and metallic sole surface having a keel. In order to reinforce the laminations and to keep the body from delaminating upon impact with an unusually hard object, a bolt is inserted through the crown of the club head where it is connected to the sole plate at the keel and tightened to compress the laminations.

U.S. Patent 3,897,066 to Belmont discloses a wooden golf club head having removably inserted weight adjustment members. The members are parallel to a central vertical axis running from the face section to the rear section of the club head and perpendicular to the crown to toe axis. The weight adjustment members may be held in place by the use of capsules filled with polyurethane resin, which can also be used to form the faceplate. The capsules have openings on a rear surface of the club

head with covers to provide access to adjust the weight means.

U.S. Patent 2,750,194 to Clark discloses a wooden golf club head with weight adjustment means. The golf club head includes a tray member with sides and bottom for holding the weight adjustment preferably cast or formed integrally with the heel plate. The heel plate with attached weight member is inserted into the head of the golf club via an opening.

U.S. Patent 4,872,685 to Sun discloses a wood type golf club head wherein a female unit is mated with a male unit to form a unitary golf club head. The female unit comprises the upper portion of the golf club head and is preferably composed of plastic, alloy, or wood. The male unit includes the structural portions of sole plate, a face insert consists of the striking plate and weighting elements. The male unit has a substantially greater weight being preferably composed of a light metal alloy. The units are mated or held together by bonding and or mechanical means.

U.S. Patent Number 1,780,625 to Mattern discloses a club head with a rear portion composed of a light-weight metal such as magnesium. U.S. Patent Number 1,638,916 to Butchart discloses a golf club with a balancing member composed of persimmon or a similar wood material, and a shell-like body composed of aluminum attached to the balancing member.

The Rules of Golf, established and interpreted by the United States Golf Association ("USGA") and The Royal and Ancient Golf Club of Saint Andrews, set forth certain requirements for a golf club head. The requirements for a golf club head are found in Rule 4 and Appendix II. A complete description of the Rules of Golf are available on the USGA web page at www.usga.org. Although the Rules of Golf do not expressly state specific parameters for a golf club face, Rule 4-1e prohibits the face from having the effect at impact of a spring with a golf ball. In 1998, the USGA adopted a test procedure pursuant to Rule 4-1e which measures club face COR. This USGA test procedure, as well as procedures like it, may be used to measure club face COR.

Existing large volume driver heads (>300cc) composed of conventional materials (titanium, steel) and conventional manufacturing methods (casting, forging, MIM, machining, etc.) are limited in the amount of discretionary material available for adjusting the center of gravity location of the golf club head. This limits the ability to customize the performance characteristics of the head to best suit a particular player or segment of players. Further, the center of gravity is not readily adjustable since the discretionary mass is in the form of parent metal or a discrete weight chip, both of which are established early in the head manufacturing process. Therefore, customizing the center of gravity of conventional head designs is generally difficult and ineffective.

Summary of the Invention

The present invention provides a means for locating a center of gravity of a golf club head that is selected to be appropriate for a specific player or player segment. The present invention preferably includes a removable weighting member which allows for post-manufacturing placement of the center of gravity location for a golf club head. The center of gravity location of the golf club head is preferably varied independently in the heel-toe and sole-crown directions to achieve desired levels of side spin and back spin for the specific player type. Golf club performance (trajectory and shot shape) is improved by adjusting the spin characteristics of the golf club head to better match the player type. A golf club having a tendency to provide a draw (left to right) shot shape can be provided to players who tend to hit a fade or slice (right to left). Also, a golf club having a tendency to provide a higher golf ball trajectory can be provided to players that tend to hit the golf ball lower than desired.

One aspect of the invention is a multi-material golf club head including a metallic face component, a non-metallic aft-body component that is bonded to the face component, and a removable weighting member removably attached to the aft-body.

The removable weighting member preferably comprises a plurality of mass inserts disposed within pockets of the weighting member. Each of the mass inserts is

preferably composed of a high-density material (greater than five grams per cubic centimeter) such as loaded urethane, copper or tin alloy material.

The mass inserts are preferably positioned on the weighting member to provide a desired center of gravity position for the golf club head. The preferred configuration consists of the minimum necessary quantity of mass inserts needed to achieve the desired range of center of gravity locations. Ideally, a single asymmetric placement of a mass insert on the weighting member would be used to achieve a range of center of gravity positions. More practically, a multiple set of mass inserts would be used to achieve such center of gravity positions, either by repositioning individual mass inserts or by replacing certain mass inserts with other elements having differing mass. The total mass of the golf club head is preferably held constant even though the center of gravity varies, although in some cases it may be desirable to also vary total golf club head mass as the center of gravity is varied in the golf club head.

In a preferred embodiment, the ribbon walls of the golf club head are near vertical so that as weight schemes are repositioned, the inertial properties Iyy and Izz are minimally affected. Also, vertical or near vertical ribbon walls in the golf club head de-couples the Ycg and Zcg properties from Xcg, enabling them to be adjusted independent of each other. In the case of golf club heads having sharply contoured (non-vertical) ribbon walls, changes in Ycg and Zcg are often accompanied by degradation in Iyy and Izz which results in reduced forgiveness and straightness of the golf club head. Also, in this case, changes in Ycg and Zcg are also accompanied by changes in Xcg.

Brief Description of the Drawings

FIG. 1 is a front view of a golf club.

FIG. 1A is a front view of a golf club illustrating the measurement for the aspect ratio.

FIG. 2 is a rear view of a golf club head.

FIG. 3 is toe side view of the golf club head of FIG. 2.

FIG. 4 is a heel side plan view of the golf club head of FIG. 2.

FIG. 5 is a top plan view of the golf club head of FIG. 2.

FIG. 6 is a bottom view of the golf club head of FIG. 2.

FIG. 7 is a heel side plan view of a golf club of the present invention illustrating the Z axis and X axis.

FIG. 8 is a front plan view of a golf club of the present invention illustrating the Z axis and Y axis.

FIG. 9 is a front plan view of a golf club illustrating the test frame coordinates X^T and Y^T and transformed head frame coordinates Y^H and Z^H.

FIG. 10 is a toe end view of the golf club illustrating the test frame coordinate Z^T and transformed head frame coordinates X^H and Z^H.

FIG. 11 is a rear perspective exploded view of a preferred embodiment of a golf club head.

FIG. 12 is a rear perspective exploded view of an alternative embodiment of a golf club head.

FIG. 13 is an isolated exploded view of a weighting member.

FIG. 14 is an isolated exploded view of a weighting member.

FIG. 15 is an isolated exploded view of a weighting member.

FIG. 16 is an isolated exploded view of a weighting member.

FIG. 17 is an isolated cross-sectional view of a mass screw.

FIG. 18 is an isolated cross-sectional view of a mass insert.

Best Mode(s) For Carrying Out The Invention

As shown in FIG. 1, a golf club is generally designated 40. The golf club 40 has a golf club head 42 with a hollow interior, not shown. Engaging the club head 42 is a shaft 48 that has a grip, not shown, at a butt end 52 and is inserted into a hosel 54 at a tip end 56.

In a preferred embodiment, the club head 42 is generally composed of three components, a face component 60, an aft-body 61 and a weighting member 100. The

aft-body 61 has a crown portion 62 and a sole portion 64. The club head 42 is preferably partitioned into a heel section 66 nearest the shaft 48, a toe section 68 opposite the heel section 66, and a rear section 70 opposite the face component 60.

The face component 60 is generally composed of a single piece of metal, and is preferably composed of a forged metal material. More preferably, the forged metal material is a forged titanium material. Such titanium materials include pure titanium and titanium alloys such as 6-4 titanium alloy, SP-700 titanium alloy (available from Nippon Steel of Tokyo, Japan), DAT 55G titanium alloy available from Diado Steel of Tokyo, Japan, Ti 10-2-3 Beta-C titanium alloy available from RTI International Metals of Ohio, and the like. Other metals for the face component 60 include stainless steel, other high strength steel alloy metals and amorphous metals. Alternatively, the face component 60 is manufactured through casting, forming, machining, powdered metal forming, metal-injection-molding, electro chemical milling, and the like.

The face component preferably comprises a striking plate portion 72 and a return portion 74. In a preferred embodiment, the return portion 74 generally includes an upper lateral section 76, a lower lateral section 78 with a sole extension 95, a heel lateral section 80 and a toe lateral section 82. Thus, the return 74 preferably encircles the striking plate portion 72 a full 360 degrees. However, those skilled in the pertinent art will recognize that the return portion 74 may only encompass a partial section of the striking plate portion 72, such as 270 degrees or 180 degrees, and may also be discontinuous.

The upper lateral section 76 extends inward, towards the aft-body 61, a predetermined distance, d, to engage the crown portion 62. In a preferred embodiment, the predetermined distance ranges from 0.2 inch to 1.0 inch, more preferably 0.40 inch to 0.75 inch, and most preferably 0.68 inch, as measured from the perimeter 73 of the striking plate portion 72 to the rearward edge of the upper lateral section 76. In a preferred embodiment, the upper lateral section 76 has a general curvature from the heel section 66 to the toe section 68. The upper lateral section 76 has a length from the perimeter 73 of the striking plate section 72 that is preferably a

minimal length near the center of the striking plate section 72, and increases toward the toe section 68 and the heel section 66.

The perimeter 73 of the striking plate portion 74 is defined as the transition point where the face component 60 transitions from a plane substantially parallel to the striking plate portion 72 to a plane substantially perpendicular to the striking plate portion 72. Alternatively, one method for determining the transition point is to take a plane parallel to the striking plate portion 72 and a plane perpendicular to the striking plate portion, and then take a plane at an angle of forty-five degrees to the parallel plane and the perpendicular plane. Where the forty-five degrees plane contacts the face component is the transition point thereby defining the perimeter of the striking plate portion 72.

The present invention preferably has the face component 60 engage the crown portion 62 along a substantially horizontal plane. The crown portion 62 preferably has a crown undercut portion, which is placed under the return portion 74. Such an engagement enhances the flexibility of the striking plate portion 72 allowing for a greater coefficient of restitution. The crown portion 62 and the upper lateral section 76 are attached to each other as further explained below.

The heel lateral section 80 is substantially perpendicular to the striking plate portion 72, and the heel lateral section 80 covers the hosel 54 before engaging a ribbon section 90 and a bottom section 91 of the sole portion 64 of the aft-body 61. The heel lateral section 80 is attached to the sole portion 64, both the ribbon section 90 and the bottom section 91, as explained in greater detail below. The heel lateral section 80 extends inward a distance, d'', from the perimeter 73 a distance of 0.250 inch to 1.50 inches, more preferably 0.50 inch to 1.0 inch, and most preferably 0.950 inch. The heel lateral section 80 preferably has a general curvature at its edge.

At the other end of the face component 60 is the toe lateral section 82. The toe lateral section 82 is attached to the sole portion 64, both the ribbon section 90 and the bottom section 91, as explained in greater detail below. The toe lateral section 82 extends inward a distance, d''', from the perimeter 73 a distance of 0.250 inch to 1.50

inches, more preferably 0.75 inch to 1.30 inch, and most preferably 1.20 inch. The toe lateral section 80 preferably has a general curvature at its edge.

The lower lateral section 78 extends inward, toward the aft-body 61, a distance, d', to engage the sole portion 64, and a sole extension 95 extends further inward a distance d^s to preferably function as protection for the sole of the club head 42. In a preferred embodiment, the distance d' ranges from 0.2 inch to 1.25 inches, more preferably 0.50 inch to 1.10 inch, and most preferably 0.9 inch, as measured from the perimeter 73 of the striking plate portion 72 to the edge of the lower lateral section 78. In a preferred embodiment, the distance d^s ranges from 0.2 inch to 3.0 inches, more preferably 0.50 inch to 2.0 inches, and most preferably 1.50 inch, as measured from the edge of the lower lateral section 78 to an apex 97 of the sole extension 95.

The sole portion 64 has a sole undercut for placement under the return portion 74. The sole extension 95 is disposed within a sole undercut extension. The sole portion 64 and the lower lateral section 78, the heel lateral section 80 and the toe lateral section 82 are attached to each other as explained in greater detail below.

The aft-body 61 is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (including thermosetting materials or a thermoplastic materials for the resin). Other materials for the aft-body 61 include other thermosetting materials or other thermoplastic materials such as injectable plastics. Alternatively, the aft-body 61 is composed of low-density metal materials such as magnesium, magnesium alloys, aluminum alloys or aluminum.

The aft-body 61 is preferably manufactured through bladder-molding, resin transfer molding, resin infusion, injection molding, compression molding, or a similar process. In a preferred process, the face component 60, with an adhesive on the interior surface of the return portion 74, is placed within a mold with a preform of the aft-body 61 for bladder molding. The return portion 74 is placed and fitted into the undercut portions. Also, the adhesive may be placed on the undercut portions. Such

adhesives include thermosetting adhesives in a liquid or a film medium. A preferred adhesive is a two part liquid epoxy sold by 3M of Minneapolis Minnesota under the brand names DP420NS and DP460NS. Other alternative adhesives include modified acrylic liquid adhesives such as DP810NS, also sold by the 3M company. Alternatively, foam tapes such as Hysol Synspan may be utilized with the present invention.

A bladder is placed within the hollow interior of the preform and face component 60, and is pressurized within the mold, which is also subject to heating. The co-molding process secures the aft-body 61 to the face component 60. Alternatively, the aft-body 61 is bonded to the face component 60 using an adhesive, or mechanically secured to the return portion 74.

The crown portion 62 of the aft- body 61 is generally convex toward the sole portion 64, and engages the ribbon section 90 of sole portion 64 outside of the engagement with the face member 60. The crown portion 62 preferably has a thickness in the range of 0.010 to 0.100 inch, more preferably in the range of 0.025 inch to 0.070 inch, even more preferably in the range of 0.028 inch to 0.040 inch, and most preferably has a thickness of 0.033 inch. The sole portion 64, including the bottom section 91 and the ribbon section 90 which is substantially perpendicular to the bottom section 91, preferably has a thickness in the range of 0.010 to 0.100 inch, more preferably in the range of 0.025 inch to 0.070 inch, even more preferably in the range of 0.028 inch to 0.040 inch, and most preferably has a thickness of 0.033 inch. In a preferred embodiment, the aft-body 61 is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Patent Number 6,248,025, entitled *Composite Golf Head And Method Of Manufacturing*, which is hereby incorporated by reference in its entirety. The bottom section 91 is generally convex toward the crown portion 62.

As shown in FIGS. 11 and 12, a weighting member 100 is preferably disposed within a recess 105 of the ribbon section 90 of the aft-body 61. In a preferred embodiment, the weighting member 100 comprises a body 101, a plurality of pockets

102 and a plurality mass inserts 122. Each of the mass inserts 122 is disposed within a pocket 102. The location of the mass inserts 122 on the weighting member 100 will influence the center of gravity, moment of inertia, or other inherent properties of the golf club head 42. Each of the mass inserts 122 is preferably tungsten loaded film, tungsten doped polymers, or similar weighting mechanisms such as described in U.S. Patent Number 6,386,990, filed on December 29, 1999, entitled A Composite Golf Club Head With An Integral Weight Strip, and hereby incorporated by reference in its entirety. Those skilled in the pertinent art will recognize that other high density materials may be utilized as an optional weighting member without departing from the scope and spirit of the present invention.

In a preferred embodiment, each of the mass inserts 122 has a mass ranging from 10 grams to 30 grams, preferably from 14 grams to 25 grams, and more preferably from 15 grams to 20 grams. Each of the mass inserts 122 has a density ranging from 5 grams per cubic centimeters to 20 grams per cubic centimeters, more preferably from 7 grams per cubic centimeters to 12 grams per cubic centimeters, and most preferably 8.0 grams per cubic centimeters.

Each of the mass inserts 122 is preferably composed of a polymer material integrated with a metal material. The metal material is preferably selected from copper, tungsten, steel, aluminum, tin, silver, gold, platinum, or the like. A preferred metal is tungsten due to its high density. The polymer material is a thermoplastic or thermosetting polymer material. A preferred polymer material is polyurethane, epoxy, nylon, polyester, or similar materials. A most preferred polymer material is a thermoplastic polyurethane. A preferred mass insert 122 is an injection molded thermoplastic polyurethane integrated with tungsten to have a density of 8.0 grams per cubic centimeters. Alternatively, each mass insert 122 is composed of a nickel-tungsten-chromium alloy such as disclosed in U.S. Patent Application Number 10/604,518, filed on July 28, 2003 for a High Density Alloy For Improved Mass Properties In An Article, which is hereby incorporated by reference in its entirety.

The body 101 of the weighting member is preferably composed of a low-

density material. A preferred material is a polymer such as a thermoplastic polyurethane. Alternatively, the low-density material is a metal such as magnesium, magnesium alloys, aluminum or aluminum alloys. Preferably the mass of the body 101 of the weighting member 100 ranges from 5 grams to 50 grams, and more preferably 10 grams to 25 grams. The body 101 preferably has a plurality of pockets 102 for placement of the mass inserts 122 therein. Preferably the pockets allow for removable placement of the mass inserts 122 therein so that the center of gravity of the golf club head 42 may be adjusted. For example, if the mass inserts 122 were placed symmetrically on the body 101, then the golf club head should have a neutral bias. Placement of the mass inserts 122 asymmetrically will allow for a golf club with draw bias or a fade bias.

The recess 105 of the ribbon section 91is preferably arc-like extending from a heel end to a toe end of the aft-body 61. The recess 105 preferably has a height ranging from 1.0 centimeter to 4.0 centimeters, and a depth ranging from 0.2 centimeters to 2.0 centimeters, and an arc length ranging from 3.0 centimeters to 10 centimeters. The weighting member 100 is preferably placed within the recess 105 to form a smooth surface for the ribbon section 91.

The club head 42 also preferably includes means for removably attaching the weighting member 100 to the aft-body 61. The attachment means 110 is preferably a plurality of attachment screws 110'. In a preferred embodiment, three attachment screws 110' removably attach the weighting member 100 to the aft-body 61. In this manner, the placement of mass on the weighting member 100 may be changed, or a substitute weighting member 100 with a different mass placement or amount may be utilized to affect the mass properties of the club head 42 and in particular the location of the center of gravity of the club head 42.

As shown in FIG. 11, a mass insert 122' is placed within a central pocket 102' which is covered with a cover plate 111.

As shown in FIG. 12, a sole plate 95' is adhesively attached to the bottom section 90 of the sole portion 64. In this embodiment, three mass inserts 122 are

placed in a heel bias position within pockets 102 of the body 101. As shown in FIG. 18, a mass insert 122 is placed flush within a pocket 102.

As shown in FIG. 13, a single mass insert 122 is placed within a central pocket 102' and covered with a cover plate 111. the cover plate 111 is attached with a multitude of screws 117. The weighting member 100 is attached to the aft-body 61 with screws 110 placed through apertures 113. Similar threaded sockets are located on the aft-body to receive the screws 110.

As shown in FIG. 14, a plurality of mass screws 123 are substituted for the mass inserts 122. In this embodiment, the mass screws 123 act as weighting means and attachment means for the weighting member 100. The mass screws 123 are preferably composed of tungsten or a tungsten alloy. The mass screws 123 are placed through the apertures 113 in the body 101 and into threaded sockets on the aft-body 61. As shown in FIG. 17, the mass screw 123 is threaded through the aperture 113 of the body 101.

As shown in FIG. 15, the weighting member 100 has mass screws 123 and a mass insert 122.

As shown in FIG. 16, the weighting member 100 has two mass inserts 122 placed within pockets 102 on the body 101. A screw 110 attaches the weighting member 100 to the aft-body 61.

As mentioned previously, the face component 60 is preferably forged from a rod of metal material. One preferred forging process for manufacturing the face component is set forth in U.S. Patent Number 6,440,011, filed on April 13, 2000, entitled Method For Processing A Striking Plate For A Golf Club Head, and hereby incorporated by reference in its entirety. Alternatively, the face component 60 is cast from molten metal in a method such as the well-known lost-wax casting method. The metal for forging or casting is preferably titanium or a titanium alloy such as 6-4 titanium alloy, alpha-beta titanium alloy or beta titanium alloy for forging, and 6-4 titanium for casting.

Additional methods for manufacturing the face component 60 include forming

the face component 60 from a flat sheet of metal, super-plastic forming the face component 60 from a flat sheet of metal, machining the face component 60 from a solid block of metal, electrochemical milling the face from a forged pre-form, and like manufacturing methods. Yet further methods include diffusion bonding titanium sheets to yield a variable face thickness face and then superplastic forming.

Alternatively, the face component 60 is composed of an amorphous metal material such as disclosed in U.S. Patent Number 6,471,604, which was filed on April 4, 2002 and is hereby incorporated by reference in its entirety.

The present invention is directed at a golf club head that has a high coefficient of restitution thereby enabling for greater distance of a golf ball hit with the golf club head of the present invention. The coefficient of restitution (also referred to herein as "COR") is determined by the following equation:

$$e = \frac{v_2 - v_1}{U_1 - U_2}$$

wherein U_1 is the club head velocity prior to impact; U_2 is the golf ball velocity prior to impact which is zero; v_1 is the club head velocity just after separation of the golf ball from the face of the club head; v_2 is the golf ball velocity just after separation of the golf ball from the face of the club head; and e is the coefficient of restitution between the golf ball and the club face.

The values of e are limited between zero and 1.0 for systems with no energy addition. The coefficient of restitution, e, for a material such as a soft clay or putty would be near zero, while for a perfectly elastic material, where no energy is lost as a result of deformation, the value of e would be 1.0. The present invention provides a club head having a coefficient of restitution ranging from 0.81 to 0.94, as measured under conventional test conditions.

The coefficient of restitution of the club head 42 of the present invention under standard USGA test conditions with a given ball ranges from approximately 0.81 to 0.94, preferably ranges from 0.83 to 0.883 and is most preferably 0.87.

Additionally, the striking plate portion 72 of the face component 60 has a smaller aspect ratio than face plates of the prior art. The aspect ratio as used herein is defined as the width, "w", of the face divided by the height, "h", of the face, as shown in FIG. 1A. In one preferred embodiment, the width w is 78 millimeters and the height h is 48 millimeters giving an aspect ratio of 1.625. The striking plate portion 72 of the present invention has an aspect ratio that is no greater than 1.7. The aspect ratio of the present invention preferably ranges from 1.0 to 1.7. One embodiment has an aspect ratio of 1.3. The striking plate portion 72 of the present invention is more circular than faces of the prior art. The face area of the striking plate portion 72 of the present invention ranges from 4.00 square inches to 7.50 square inches, more preferably from 5.00 square inches to 6.5 square inches, and most preferably from 5.8 square inches to 6.0 square inches.

The club head 42 of the present invention also has a greater volume than a club head of the prior art while maintaining a weight that is substantially equivalent to that of the prior art. The volume of the club head 42 of the present invention ranges from 290 cubic centimeters to 600 cubic centimeters, and more preferably ranges from 350 cubic centimeters to 510 cubic centimeters, even preferably 420 cubic centimeters to 475 cubic centimeters, and most preferably 460 cubic centimeters.

The mass of the club head 42 of the present invention ranges from 165 grams to 225 grams, preferably ranges from 175 grams to 205 grams, and most preferably from 190 grams to 200 grams. Preferably, the face component 60 has a mass ranging from 50 grams to 110 grams, more preferably ranging from 65 grams to 95 grams, yet more preferably from 70 grams to 90 grams, and most preferably 78 grams. The aft-body 61 (without weighting) has a mass preferably ranging from 10 grams to 60 grams, more preferably from 15 grams to 50 grams, and most preferably 35 grams to 40 grams. The weighting member 100, with mass inserts 122, preferably has a mass preferably ranging from 30 grams to 120 grams, more preferably from 50 grams to 80 grams, and most preferably 60 grams. An interior hosel 54 preferably a mass preferably ranging from 3 grams to 20 grams, more preferably from 5 grams to 15

grams, and most preferably 12 grams. Additionally, epoxy, or other like flowable materials, in an amount ranging from 0.5 grams to 5 grams, may be injected into the hollow interior of the golf club head 42 for selective weighting thereof.

FIGS. 7 and 8 illustrate the axes of inertia through the center of gravity of the golf club head. The axes of inertia are designated X, Y and Z. The X axis extends from the striking plate portion 72 through the center of gravity, CG, and to the rear of the golf club head 42. The Y axis extends from the toe section 68 of the golf club head 42 through the center of gravity, CG, and to the heel section 66 of the golf club head 42. The Z axis extends from the crown portion 62 through the center of gravity, CG, and to the sole portion 64.

As defined in *Golf Club Design, Fitting, Alteration & Repair*, 4th Edition, by Ralph Maltby, the center of gravity, or center of mass, of the golf club head is a point inside of the club head determined by the vertical intersection of two or more points where the club head balances when suspended. A more thorough explanation of this definition of the center of gravity is provided in *Golf Club Design, Fitting, Alteration & Repair*.

The center of gravity and the moment of inertia of a golf club head 42 are preferably measured using a test frame (X^T, Y^T, Z^T), and then transformed to a head frame (X^H, Y^H, Z^H), as shown in FIGS. 9 and 10. The center of gravity of a golf club head may be obtained using a center of gravity table having two weight scales thereon, as disclosed in U.S. Patent Number 6,607,452, entitled High Moment Of Inertia Composite Golf Club, and hereby incorporated by reference in its entirety. If a shaft is present, it is removed and replaced with a hosel cube that has a multitude of faces normal to the axes of the golf club head. Given the weight of the golf club head, the scales allow one to determine the weight distribution of the golf club head when the golf club head is placed on both scales simultaneously and weighed along a particular direction, the X, Y or Z direction.

In general, the moment of inertia, Izz, about the Z axis for the golf club head 42 of the present invention will range from 2800g-cm^2 to 5000g-cm^2, preferably from

3000g-cm^2 to 4500g-cm^2, and most preferably from 3750g-cm^2 to 4250g-cm^2. The moment of inertia, Iyy, about the Y axis for the golf club head 42 of the present invention will range from 1500g-cm^2 to 2750g-cm^2, preferably from 2000g-cm^2 to 2400g-cm^2, and most preferably from 2100g-cm^2 to 2300g-cm^2.

In general, the golf club head 42 has products of inertia such as disclosed in U.S. Patent Number 6,425,832, which was filed on July 26, 2001 and is hereby incorporated by reference in its entirety. Preferably, each of the products of inertia, Ixy, Ixz and Iyz, of the golf club head 42 have an absolute value less than 100 grams-centimeter squared.

Those skilled in the pertinent art will recognize that other variations with more weight members of varying masses may be used to control the center of gravity of the golf club head without departing from the scope and spirit of the present invention.

Claims

1. A golf club head comprising:

a body having a crown portion, a sole portion, a face portion and a ribbon portion, the ribbon portion having a recess therein extending from a heel end to an aft end to a toe end;

a weighting member having a body composed of a first material, the body having a plurality of pockets therein, the weighting member also comprising a plurality of mass inserts, each of the plurality of mass inserts disposed within each of the plurality of pockets, each of the plurality of mass inserts composed of a second material having a density greater than the first material, the weighting member removably attached within the recess of the ribbon portion; and

attachment means for attaching the weighting member to the body.

2. The golf club head according to claim 1 wherein the body of the weighting member is composed of a thermoplastic polyurethane material.

3. The golf club head according to claim 1 wherein the weighting member has a mass ranging from 20 grams to 120 grams.

4. The golf club head according to claim 1 wherein the weighting member has 10% to 40% of the mass of the golf club head, the aft-body has 10% to 20% of the mass of the golf club head, and the face component 10% to 50% of the mass of the golf club head.

5. The golf club head according to claim 1 wherein the attachment means is a plurality of screws.

6. The golf club head according to claim 1 wherein the golf club head has a volume ranging from 420 to 470 cubic centimeters.

7. The golf club head according to claim 1 wherein the golf club head has a mass ranging from 180 grams to 250 grams.

8. A golf club head comprising:

a face component composed of a metal material, the face component having striking plate portion and a return portion, the striking plate portion having a thickness in the range of 0.010 inch to 0.250 inch; and

an aft-body attached to the return portion of the face component, the aft body having a crown portion and a sole portion with a bottom section and a ribbon portion, the ribbon portion having a recess therein;

a weighting member having a body composed of a first material, the body having a plurality of pockets therein, the weighting member also comprising a plurality of mass inserts, each of the plurality of mass inserts disposed within each of the plurality of pockets, each of the plurality of mass inserts composed of a second material having a density greater than the first material, the weighting member removably attached within the recess of the ribbon portion;

wherein the golf club head has a coefficient of restitution of 0.81 to 0.94.

9. The golf club head according to claim 8 wherein the face component is composed of a material selected from the group consisting of titanium, titanium alloys, steel and steel alloys.

10. The golf club head according to claim 8 wherein the moment of inertia about the Izz axis is greater than 3000 grams- centimeter squared.

11. The golf club head according to claim 8 wherein the face component has a mass

ranging from 65 grams to 95 grams.

12. The golf club head according to claim 8 wherein the aft-body is composed of a plurality of plies of pre-preg material.

13. The golf club head according to claim 8 wherein the aft-body has a mass ranging from 15 grams to 50 grams.

14. The golf club head according to claim 8 wherein the golf club head has a volume ranging from 350 cubic centimeters to 510 cubic centimeters.

15. The golf club head according to claim 8 wherein each of the mass inserts is composed of a material selected from the group consisting of tungsten, tungsten alloys, polymers doped with tungsten, nickel-chromium-tungsten alloys and stainless steel.

16. A golf club head comprising:

a face component composed of a metal material, the face component having striking plate portion and a return portion, the striking plate portion having a thickness in the range of 0.010 inch to 0.250 inch; and

an aft-body attached to the return portion of the face component, the aft body having a crown portion and a sole portion with a bottom section and a ribbon section, the ribbon section having a recess therein;

a weighting member having a body composed of a first material, the body having a plurality of pockets therein, the weighting member also comprising at least one mass insert disposed within one of the plurality of pockets, the at least one mass insert composed of a second material having a density greater than the first material, the weighting member removably attached within the recess of the ribbon portion;

wherein the moment of inertia about the Izz axis through the center of gravity is greater than 3000 grams- centimeter squared, and the moment of inertia about the Iyy axis through the center of gravity is greater than 1900 grams- centimeter squared.

17. A golf club head comprising:

a face component composed of a metal material, the face component having striking plate portion and a return portion, the striking plate portion having a thickness in the range of 0.010 inch to 0.250 inch; and

an aft-body attached to the return portion of the face component, the aft body having a crown portion and a sole portion with a bottom section and a ribbon section, the ribbon section having a recess therein;

a weighting member having a body composed of a first material, the weighting member also comprising at least one mass insert or a plurality of mass screws disposed within the body, the at least one mass insert or plurality of mass screws composed of a second material having a density greater than the first material, the weighting member removably attached within the recess of the ribbon portion;

wherein the golf club head has a volume ranging from 400 cubic centimeters to 525 cubic centimeters and a mass ranging from 175 grams to 225 grams.

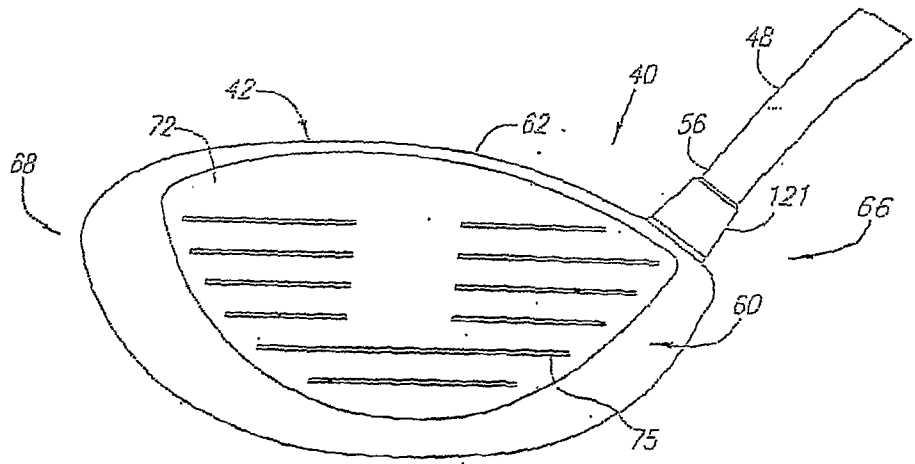


FIG. 1

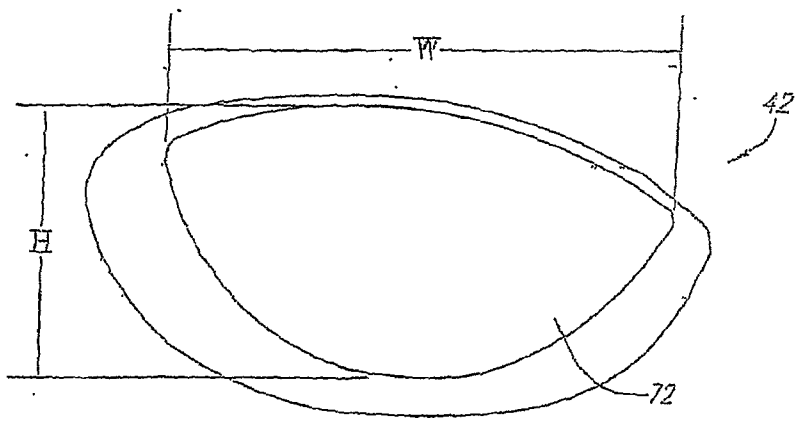


FIG. 1A

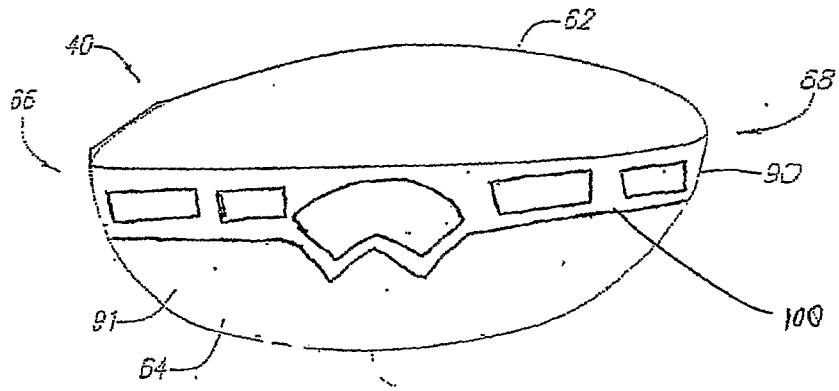


FIG. 2

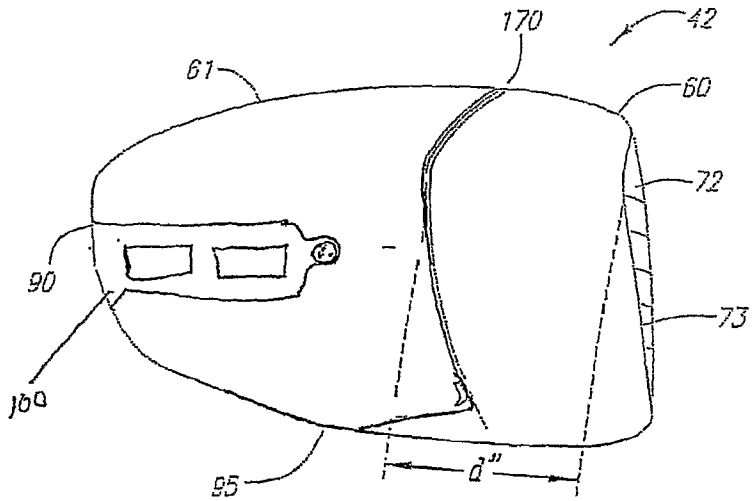


FIG. 3

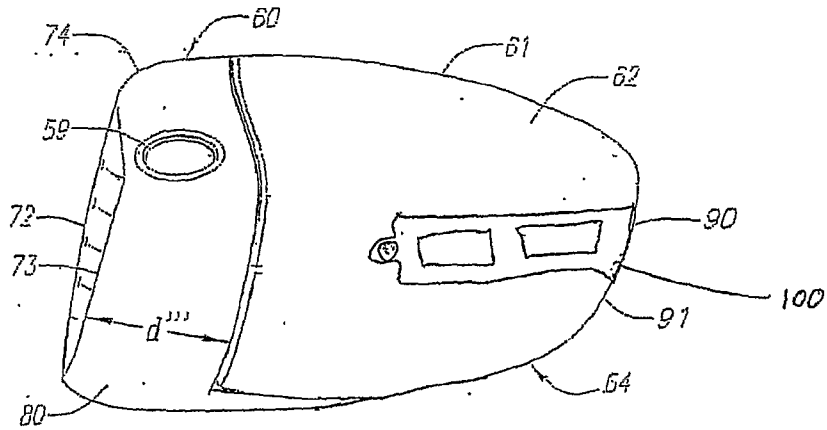


FIG. 4

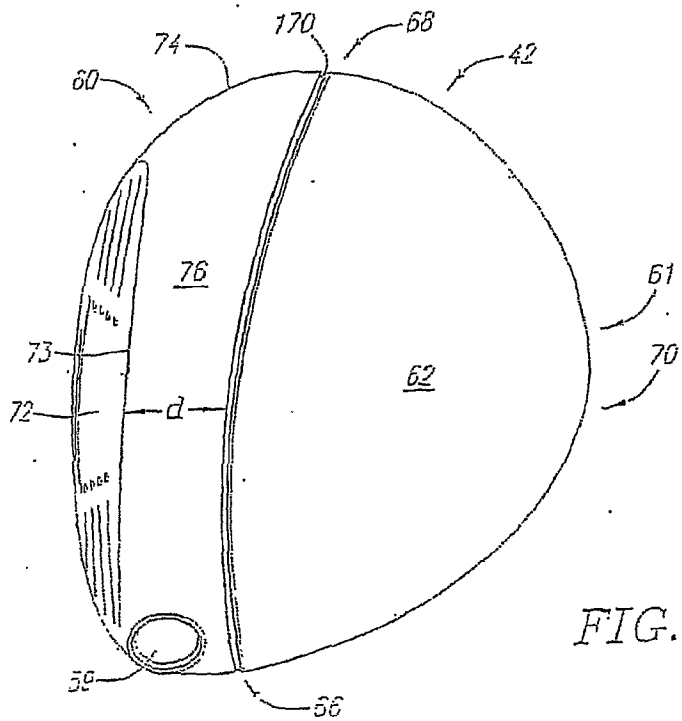


FIG. 5

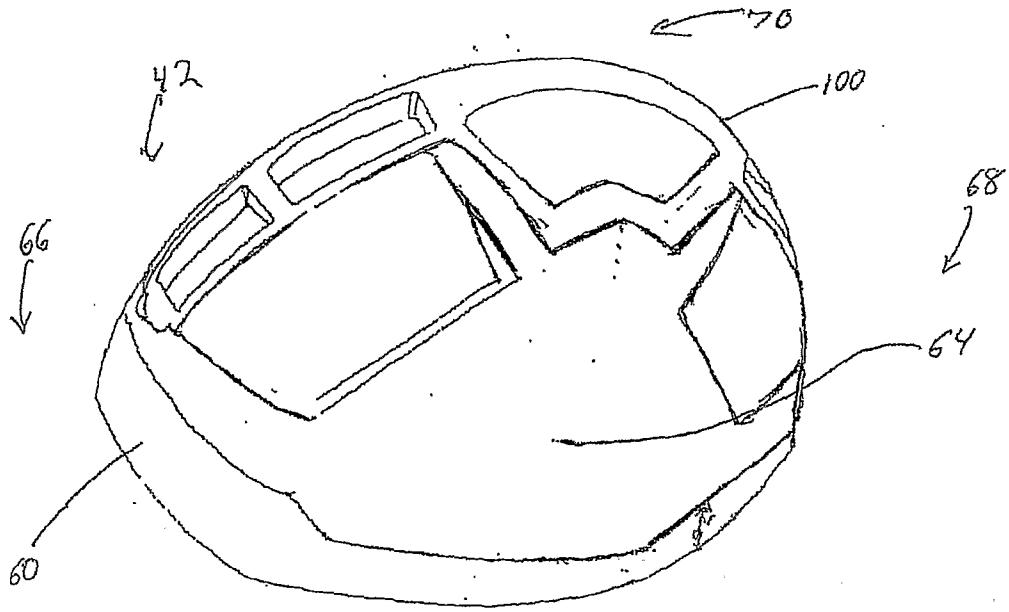


FIG. 6

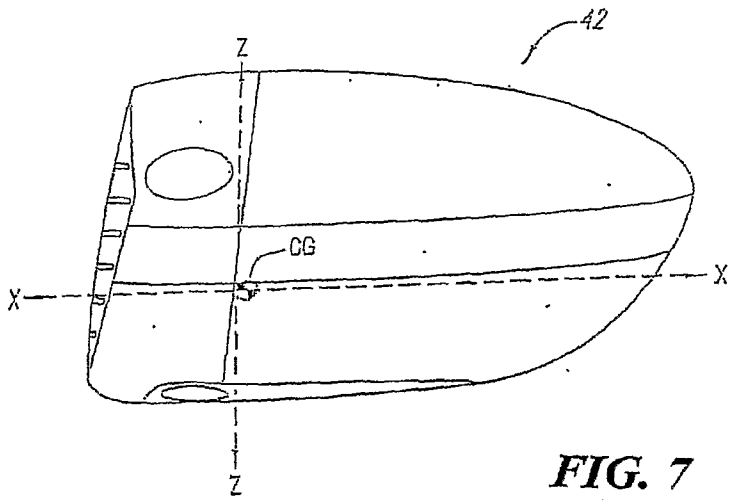


FIG. 7

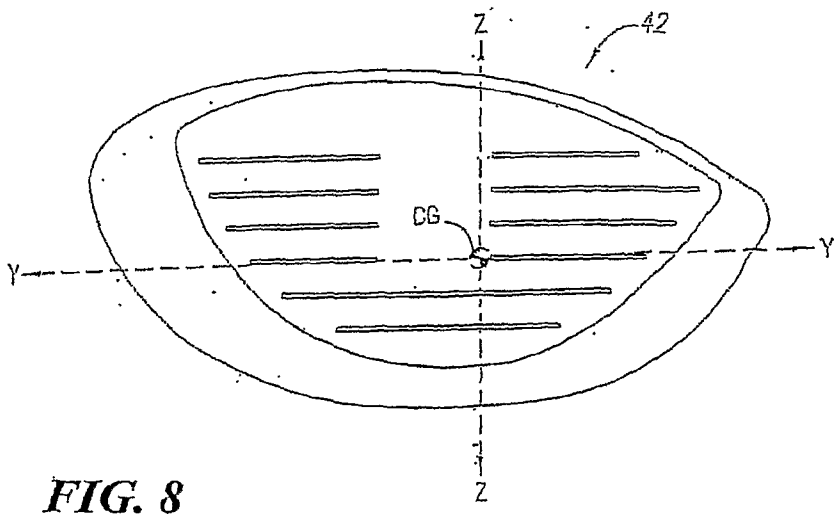


FIG. 8

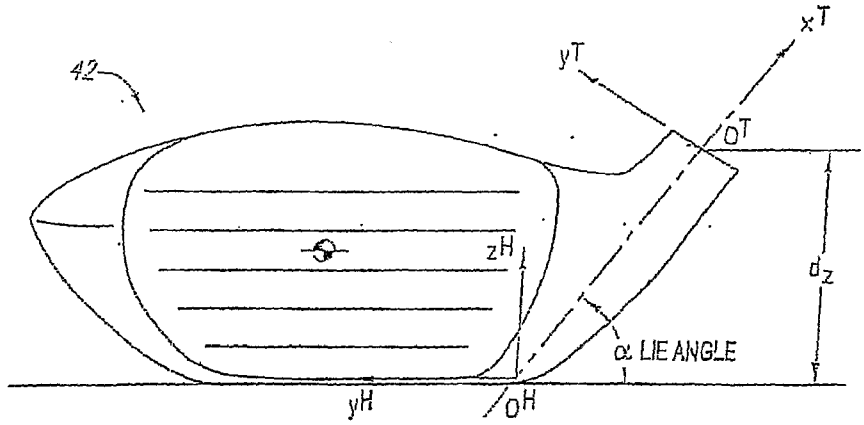

42
xT
yT
OT
zH
dz
α LIE ANGLE
yH
OH

FIG. 9

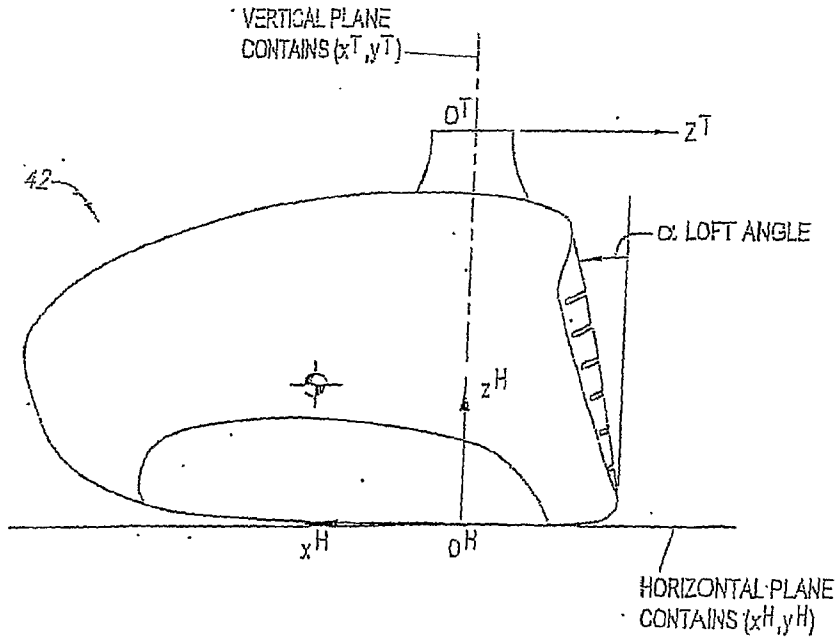

VERTICAL PLANE
CONTAINS (xT, yT)
OT
zT
42
α LOFT ANGLE
zH
xH
OH
HORIZONTAL PLANE
CONTAINS (xH, yH)

FIG. 10

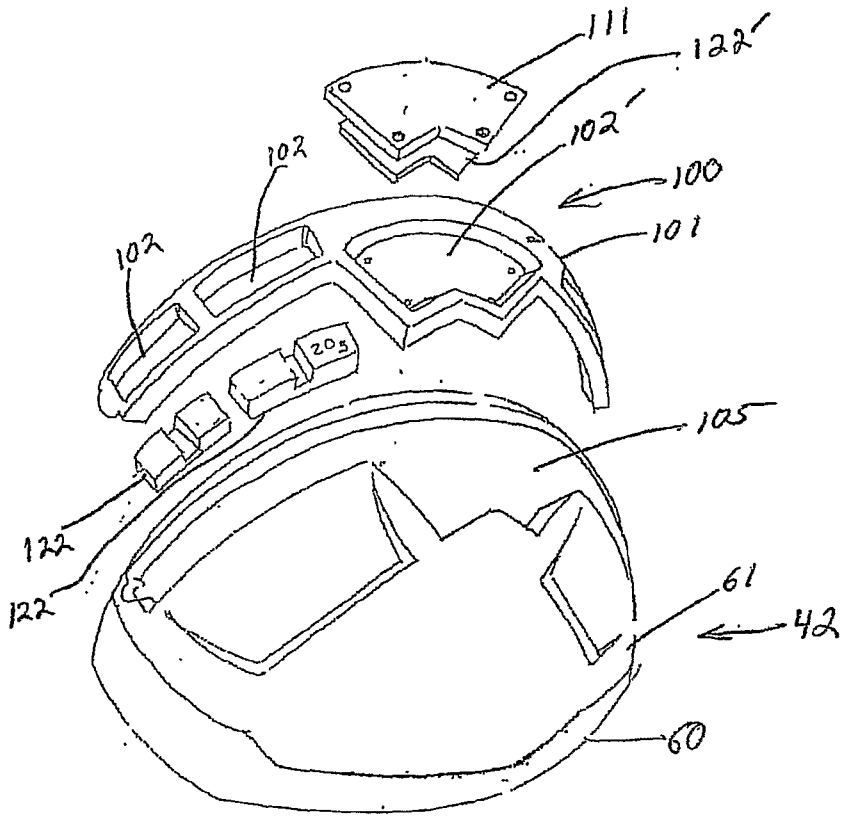


FIG. 11

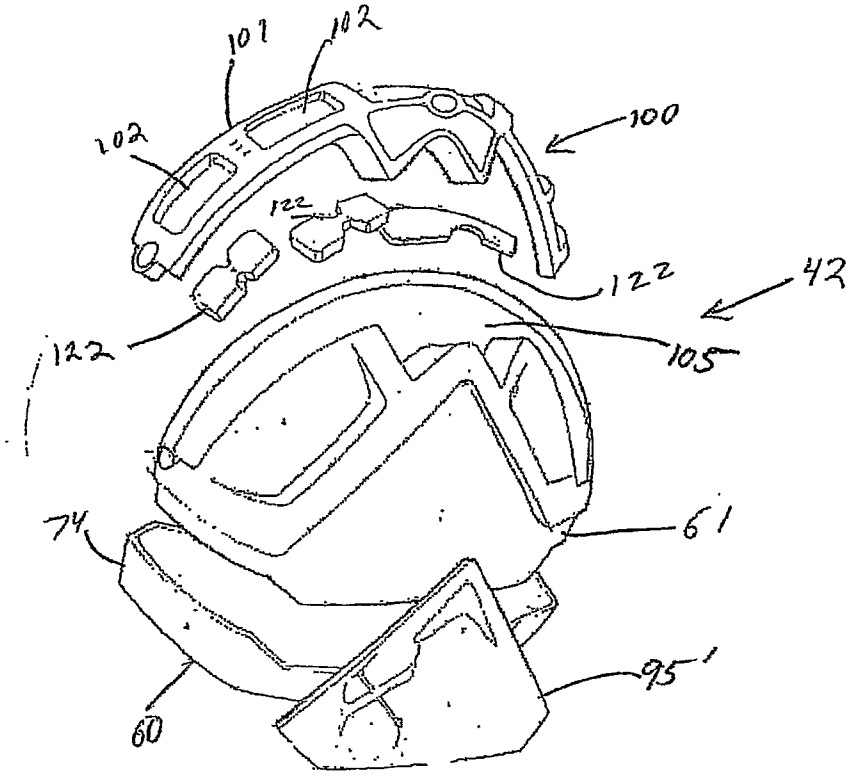


FIG. 12

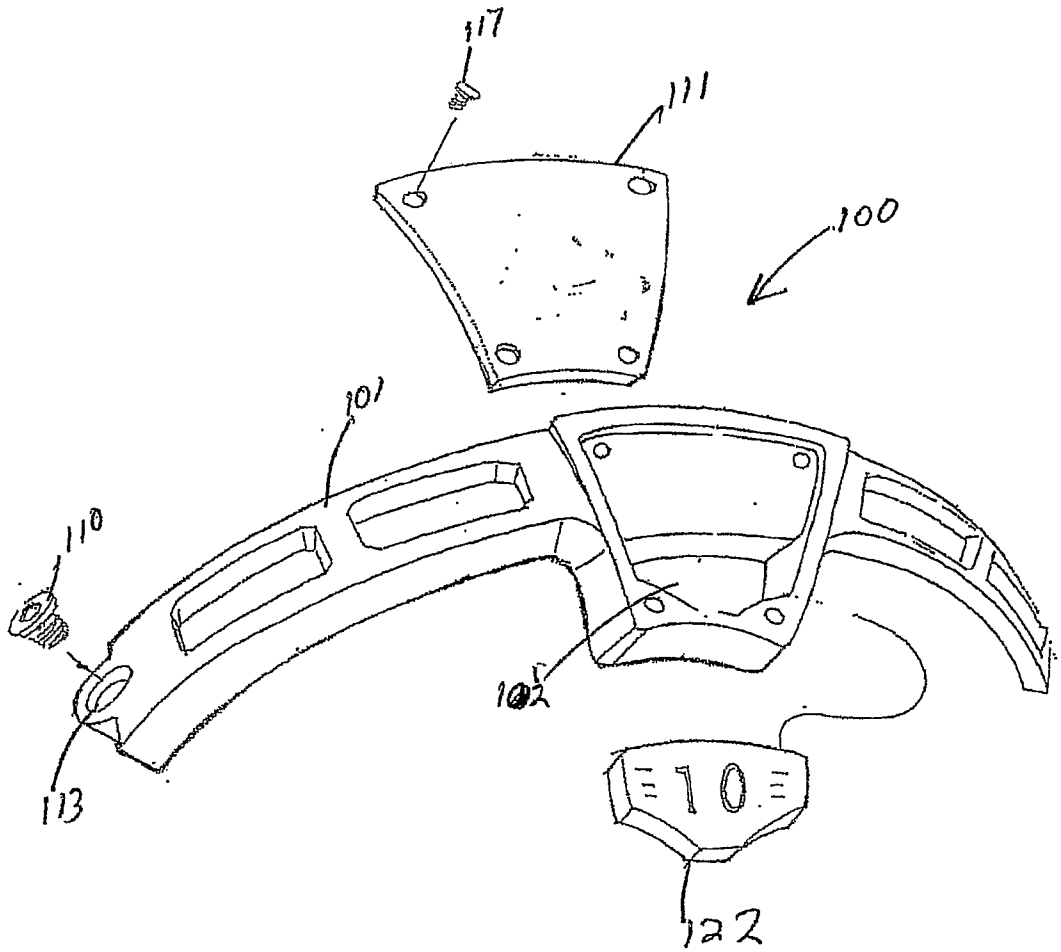
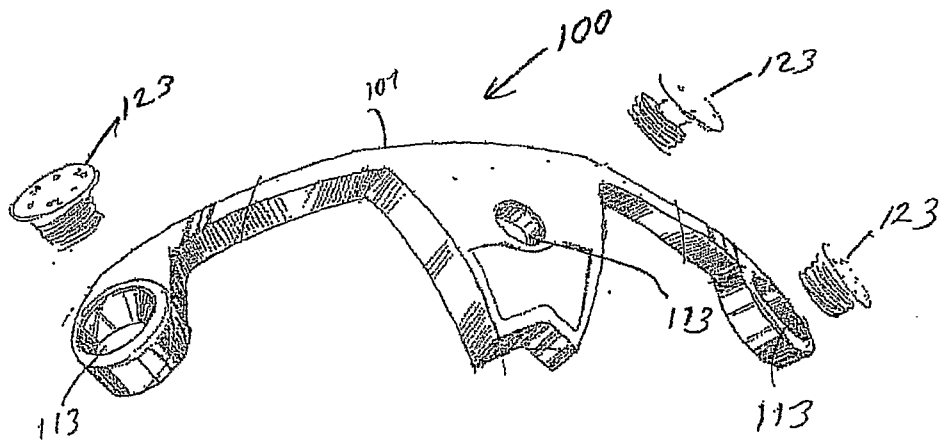


FIG. 13


100
123
101
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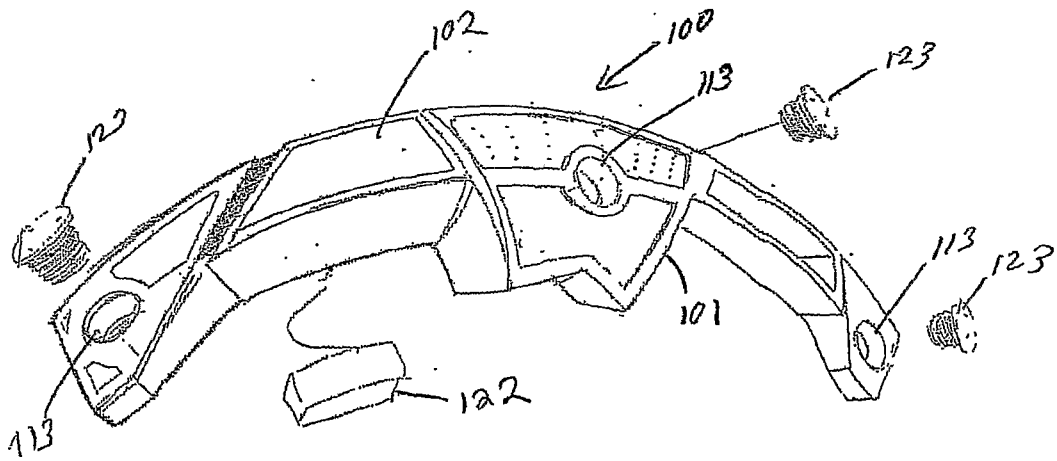
123
113
113

FIG. 14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113
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101
122
113

FIG. 15

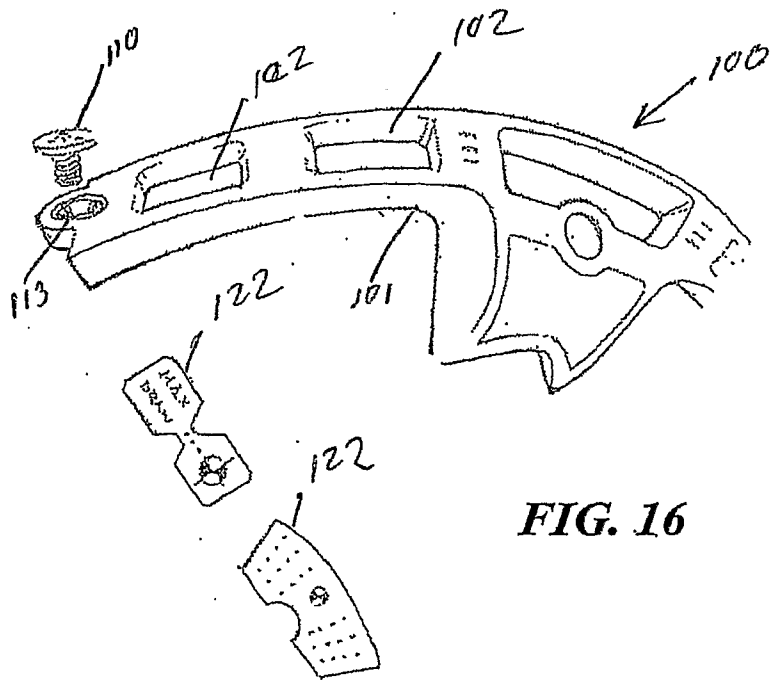

FIG. 16

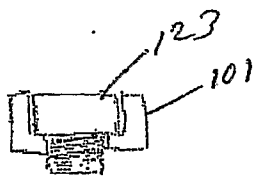

FIG. 17

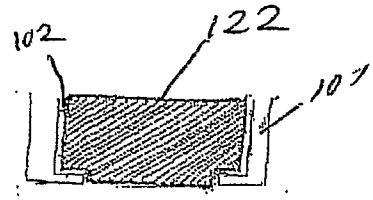

FIG. 18