US 20100267466A1

(19) **United States**

(12) **Patent Application Publication**

Stites

(10) **Pub. No.: US 2010/0267466 A1**

(43) **Pub. Date: Oct. 21, 2010**

(54) **GOLF CLUB HEAD OR OTHER BALL STRIKING DEVICE HAVING MULTIPLE FACE INSERTS**

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(21) Appl. No.: **12/424,344**

(22) Filed: **Apr. 15, 2009**

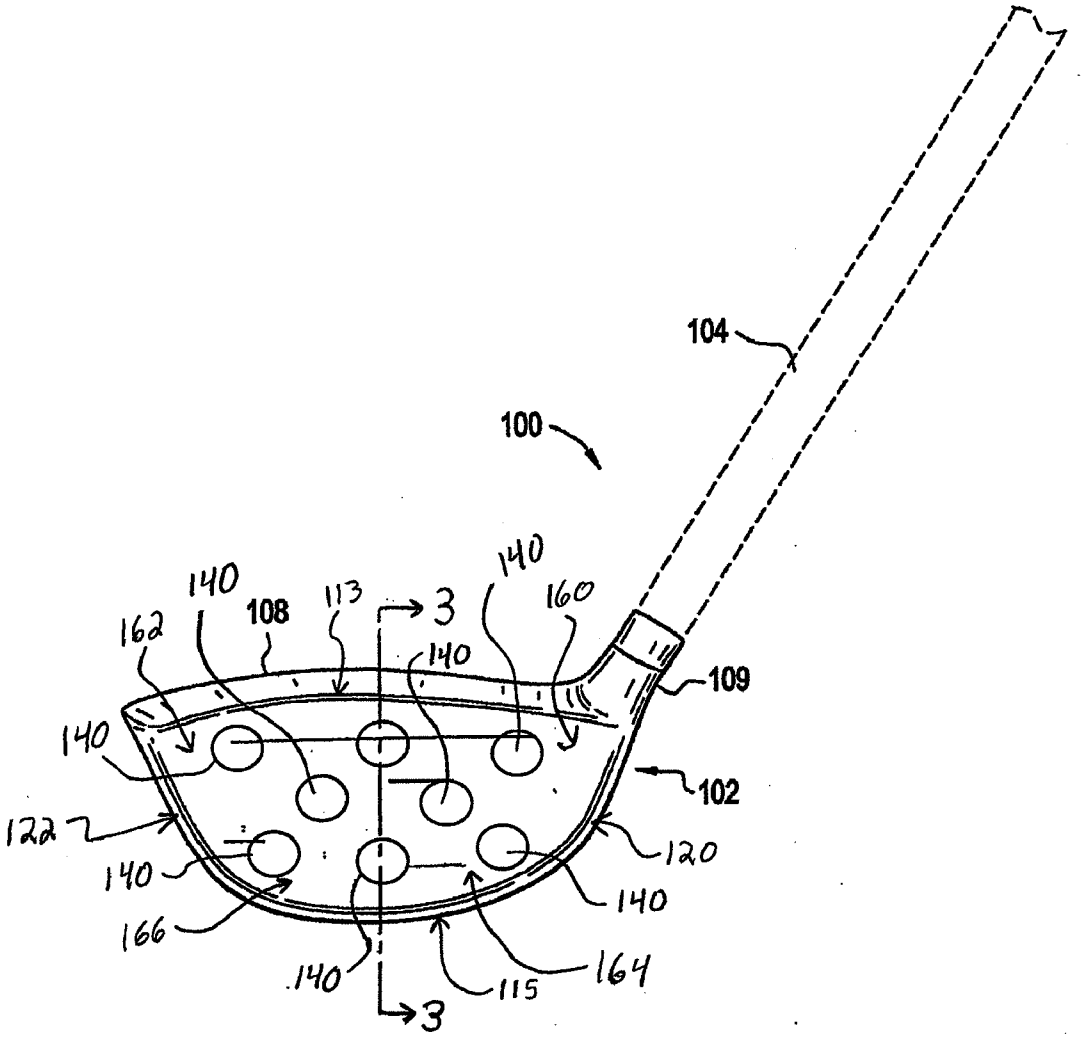
Publication Classification

(51) **Int. Cl.**
A63B 53/06 (2006.01)

(52) **U.S. Cl.** **473/335**; 473/342; 473/282; 473/409; 473/349

(57) **ABSTRACT**

A ball striking device, such as a golf club, includes a head with a face having an outer surface configured for striking a ball, a body connected to the face, and a plurality of cavities in the face, each cavity configured to receive an insert. The head may also include a plurality of inserts received within the cavities. The inserts may be made from one or more different materials having different densities. Different inserts having different densities can be connected to the face to customize the weighting of the face, such as to adjust the location of the center of gravity of the face or to change the moment of inertia of the head.



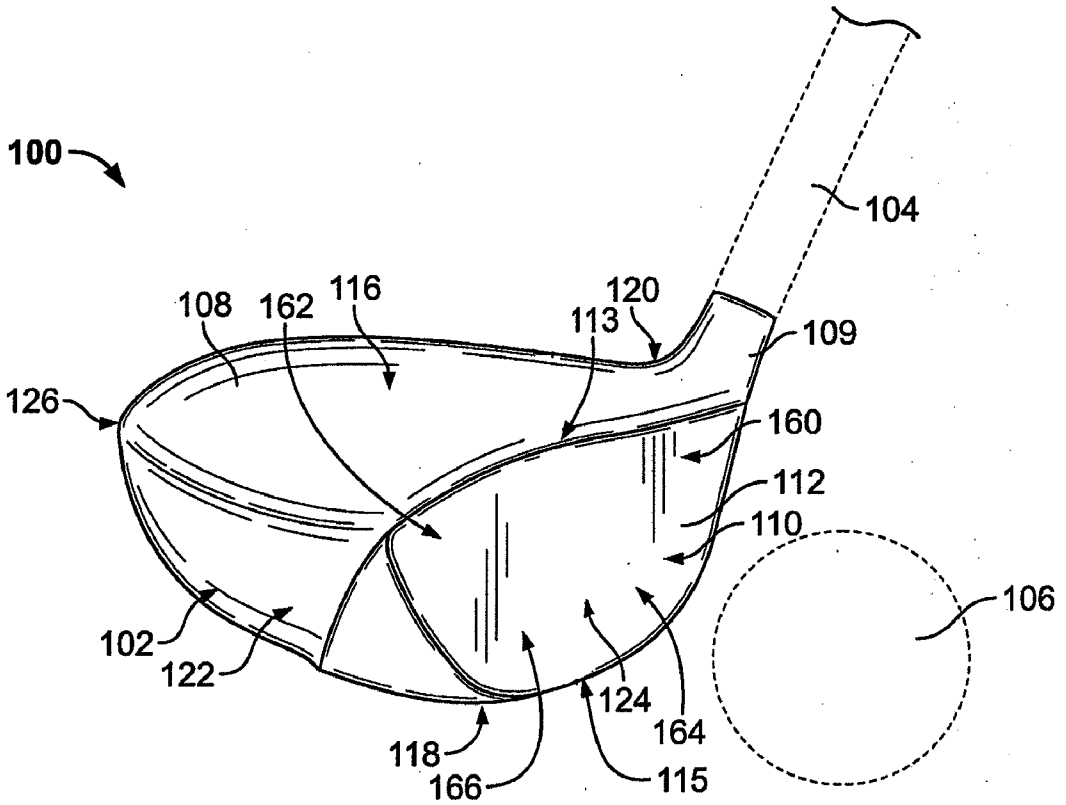

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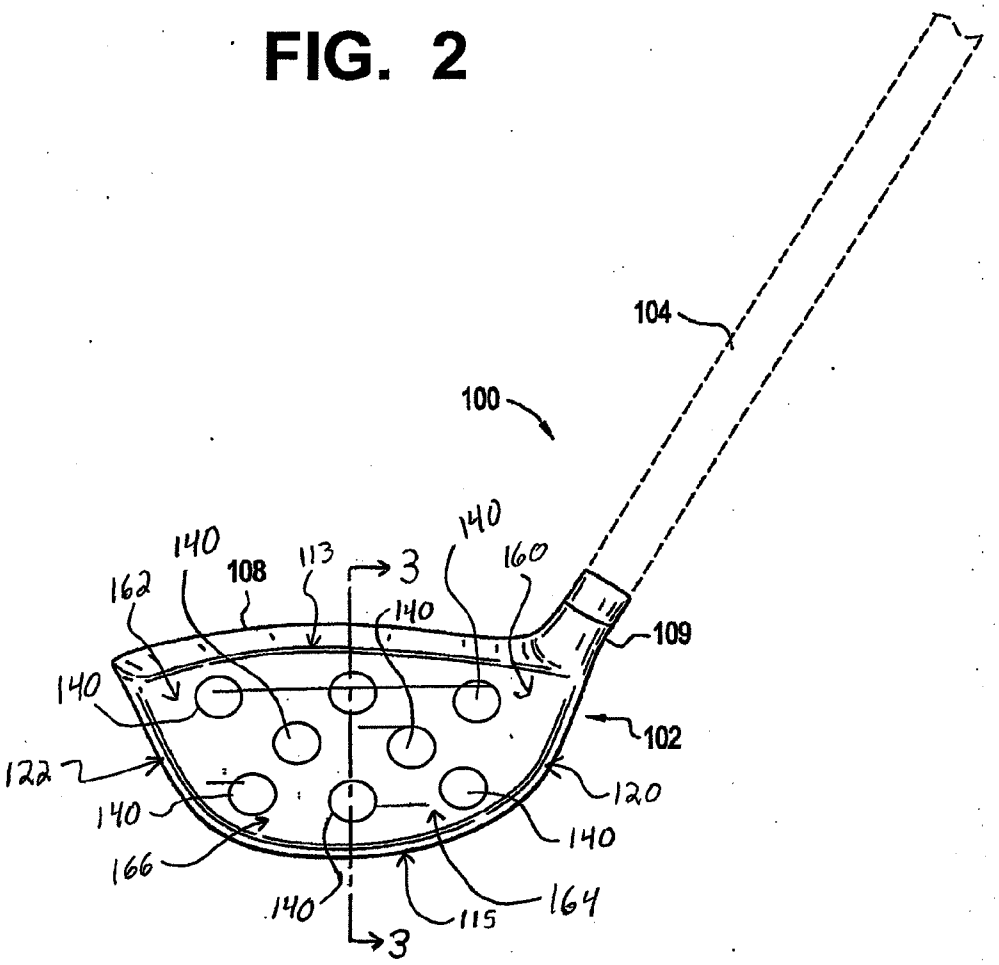
FIG. 1

FIG. 2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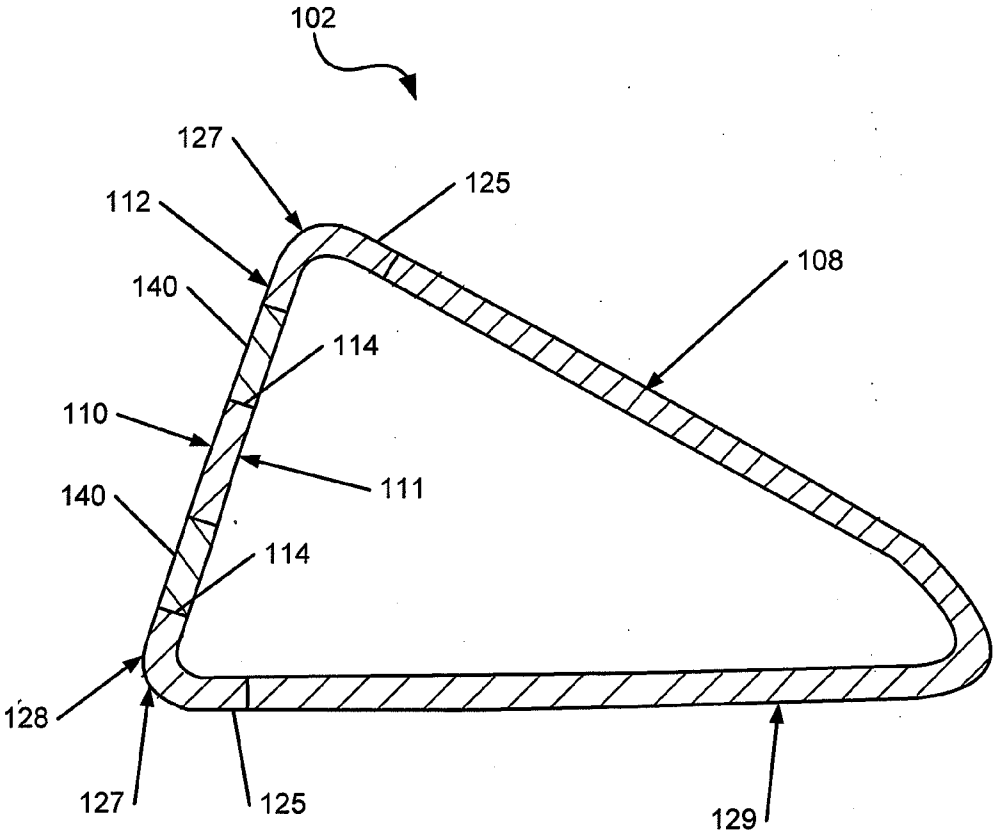

FIG. 3

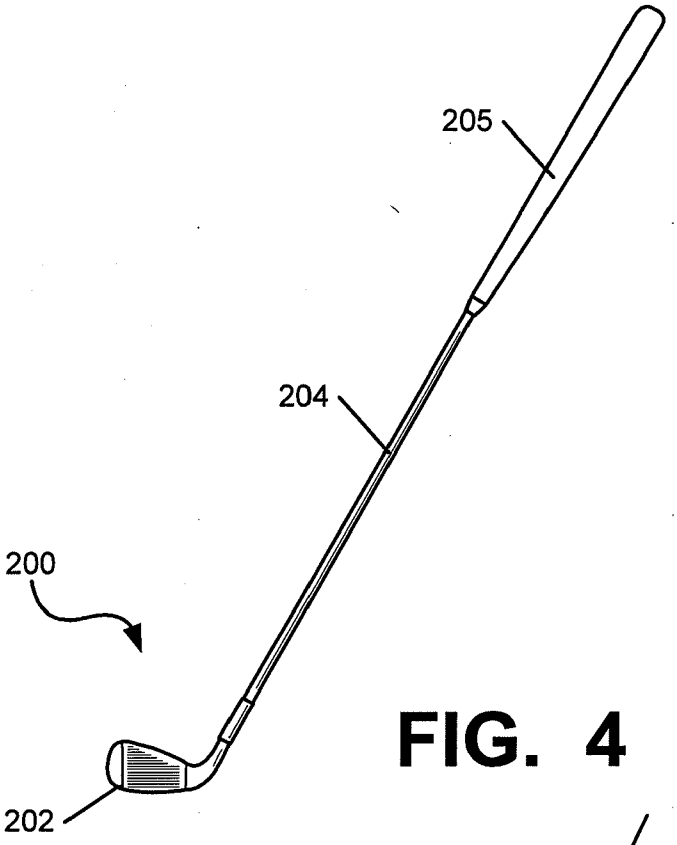
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FIG. 4

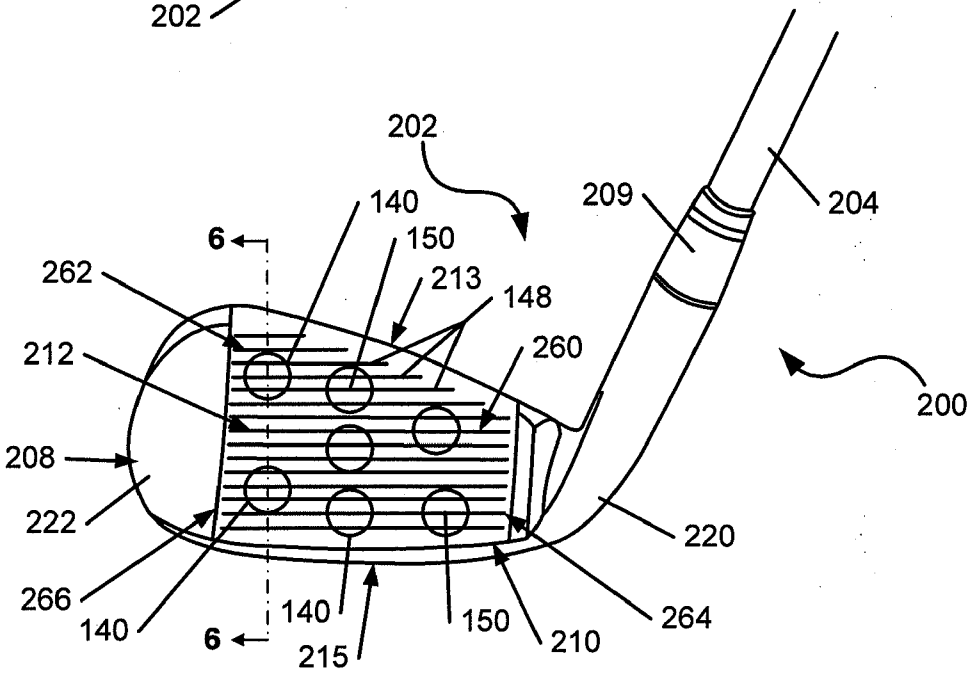
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FIG. 5

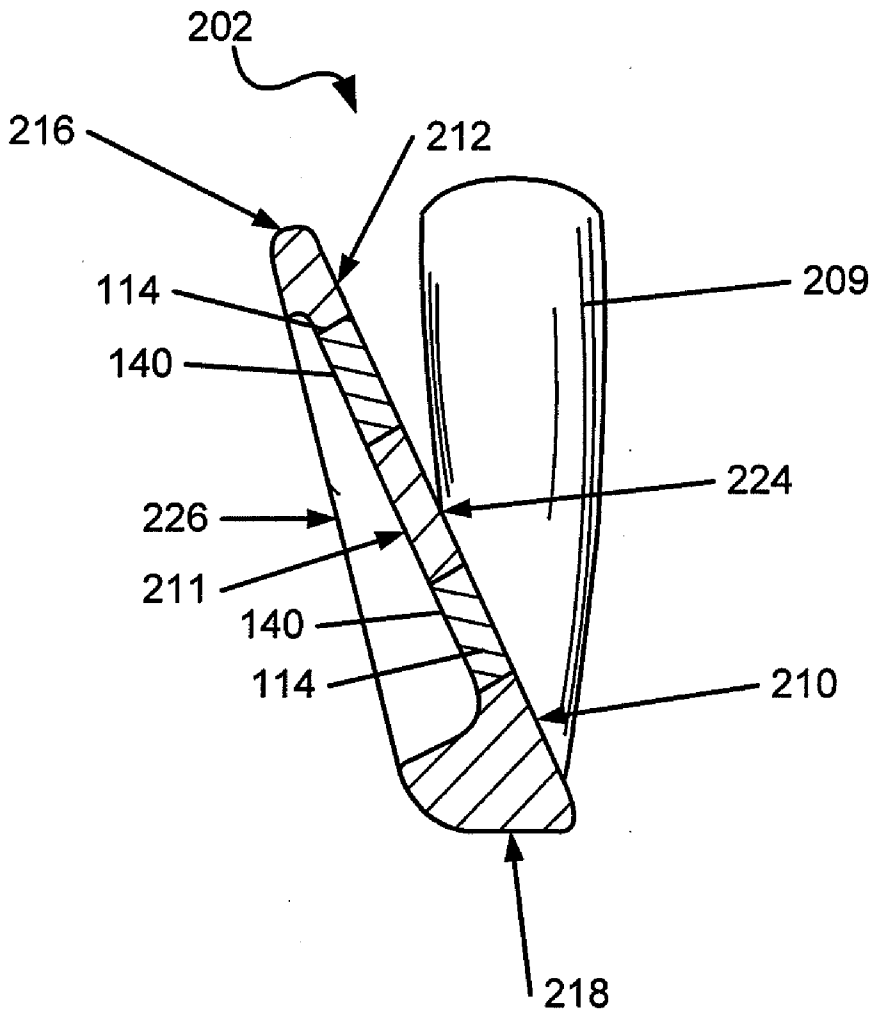

FIG. 6

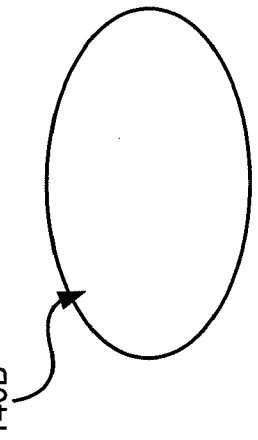

FIG. 8

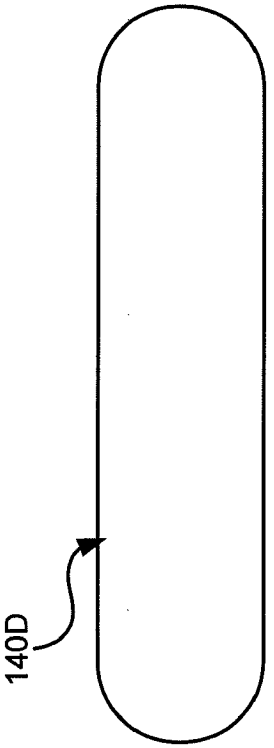

FIG. 10

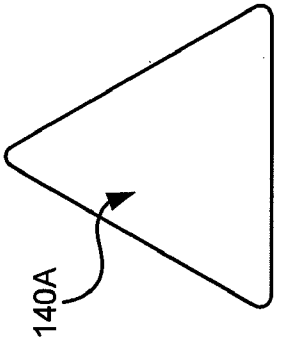

FIG. 7

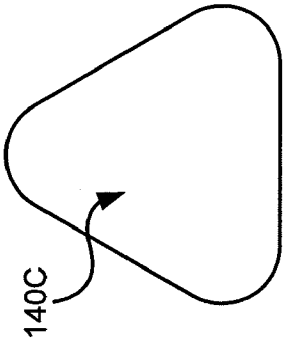

FIG. 9

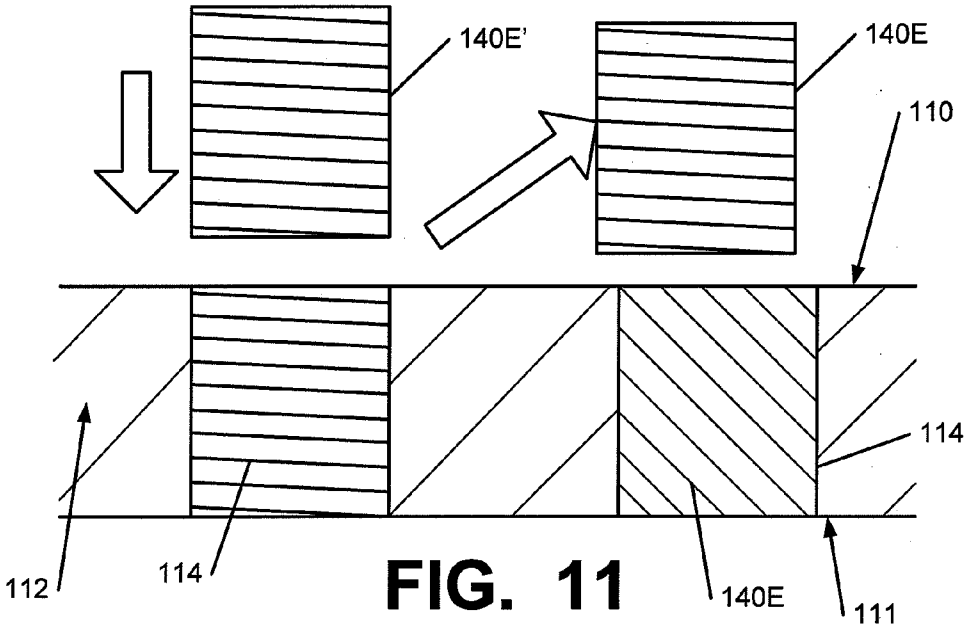
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FIG. 11

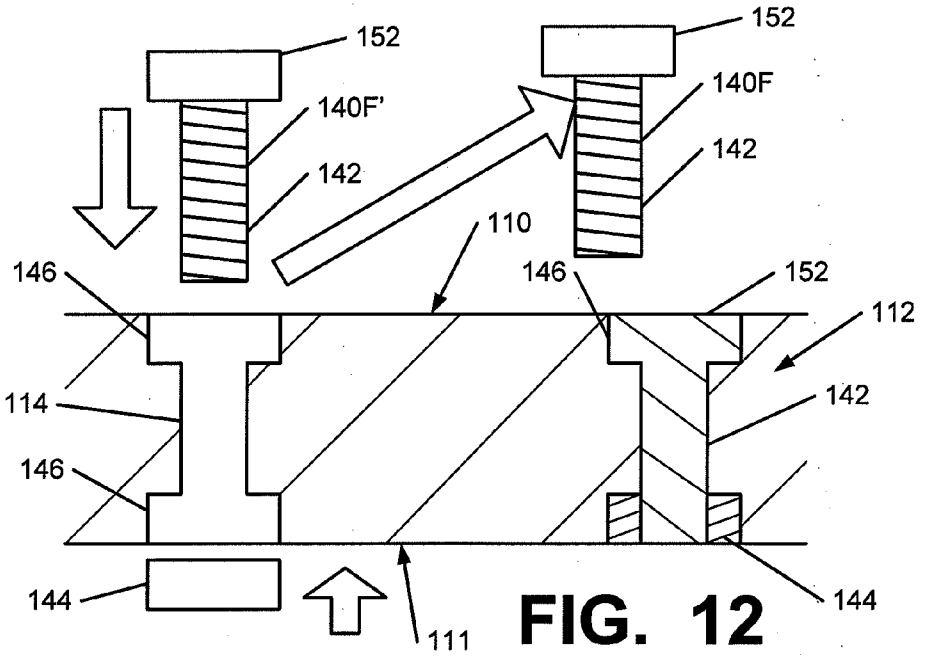
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FIG. 12

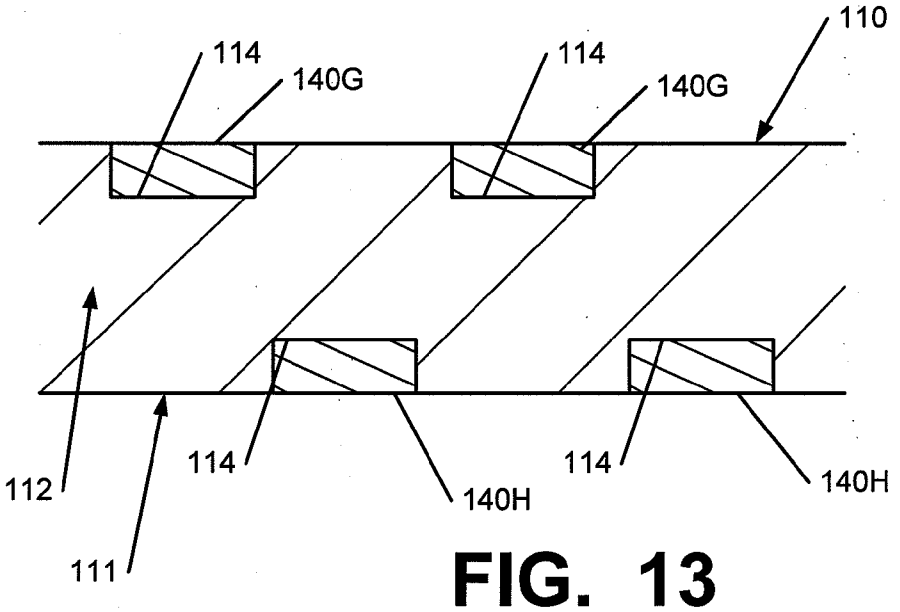
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FIG. 13

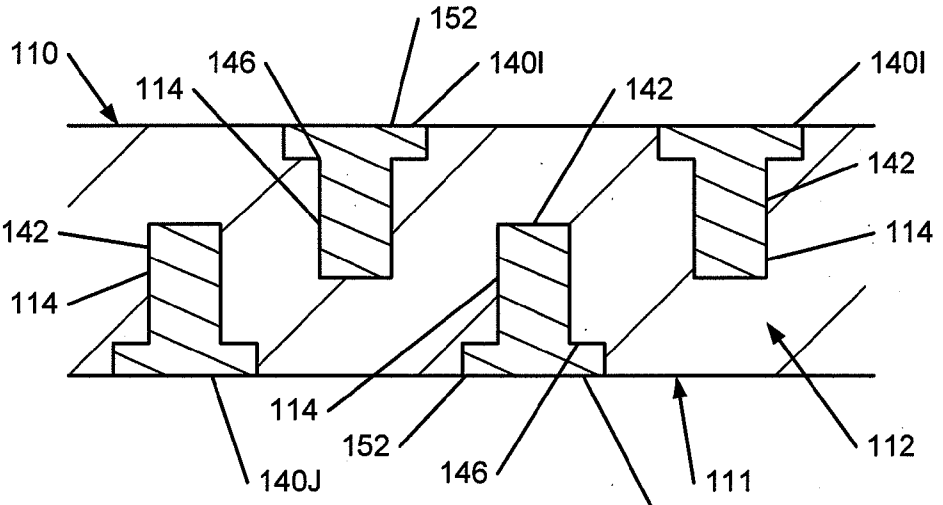
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FIG. 14

GOLF CLUB HEAD OR OTHER BALL STRIKING DEVICE HAVING MULTIPLE FACE INSERTS

TECHNICAL FIELD

[0001] The invention relates generally to ball striking devices, such as golf club heads, having multiple face inserts. Certain aspects of this invention relate to golf club heads having a plurality of cavities, each configured to receive an insert made from a material having desired properties.

BACKGROUND

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

[0003] Golfers at all skill levels seek to improve their performance, lower their golf scores, and reach that next performance "level." Manufacturers of all types of golf equipment have responded to these demands, and recent years have seen dramatic changes and improvements in golf equipment. For example, a wide range of different golf ball models now are available, with some balls designed to fly farther and straighter, provide higher or flatter trajectory, provide more spin, control, and feel (particularly around the greens), etc.

[0004] Being the sole instrument that sets a golf ball in motion during play, the golf club also has been the subject of much technological research and advancement in recent years. For example, the market has seen improvements in golf club heads, shafts, and grips in recent years. Additionally, other technological advancements have been made in an effort to better match the various elements of the golf club and characteristics of a golf ball to a particular user's swing features or characteristics (e.g., club fitting technology, ball launch angle measurement technology, etc.).

[0005] Despite the various technological improvements, golf remains a difficult game to play at a high level. For a golf ball to reliably fly straight and in the desired direction, a golf club must meet the golf ball square (or substantially square) to the desired target path. Moreover, the golf club must meet the golf ball at or close to a desired location on the club head face (i.e., on or near a "desired" or "optimal" ball contact location) to reliably fly straight, in the desired direction, and for a desired distance. Off-center hits may tend to "twist" the club face when it contacts the ball, thereby sending the ball in the wrong direction, imparting undesired hook or slice spin, and/or robbing the shot of distance. Club face/ball contact that deviates from squared contact and/or is located away from the club's desired ball contact location, even by a relatively minor amount, also can launch the golf ball in the wrong direction, often with undesired hook or slice spin, and/or can rob the shot of distance. Accordingly, club head features that can help a user keep the club face square with the ball would tend to help the ball fly straighter and truer, in the desired direction, and often with improved and/or reliable distance.

[0006] Golf clubs must make square contact with the golf ball, in the desired direction or path, in order to produce straight and true shots in the desired direction. Even small deviations from squareness between the club head and the golf ball at the point of contact can cause inaccuracy. Various golf club heads have been designed to improve a golfer's accuracy by assisting the golfer in squaring the club head face at impact with a golf ball. A number of golf club heads reposition the weight of the golf club head in order to alter the location of the club head's center of gravity. The location of the center of gravity of the golf club head is one factor that determines whether a golf ball is propelled in the intended direction. When the center of gravity is positioned behind the point of engagement on the contact surface, the golf ball follows a generally straight route. When the center of gravity is spaced to a side of the point of engagement, however, the golf ball may fly in an unintended direction and/or may follow a route that curves left or right, ball flights that are often referred to as "pulls," "pushes," "draws," "fades," "hooks," or "slices". Similarly, when the center of gravity is spaced above or below the point of engagement, the route of the golf ball may exhibit more boring or climbing trajectories, respectively.

[0007] The degree of twisting of the club head upon off-center impacts can also be dependent upon the moment of inertia of the club head. Generally, a higher moment of inertia results in less twisting of the club head on impact. The moment of inertia can be increased by distributing the weight of the club head proportionally more toward the edges of the head and away from the center.

[0008] Many off-center golf hits are caused by common errors in swinging the golf club that are committed repeatedly by the golfer, and which may be similarly committed by many other golfers. As a result, patterns can often be detected, where a large percentage of off-center hits occur in certain areas of the club face. For example, one such pattern that has been detected is that many high handicap golfers tend to hit the ball on the low-heel area of the club face and/or on the high-toe area of the club face. Other golfers may tend to miss in other areas of the club face. Because golf clubs are typically designed to contact the ball at or around the center of the face, such off-center hits may result in less energy being transferred to the ball, decreasing the distance of the shot. The energy or velocity transferred to the ball by a golf club also may be related, at least in part, to the flexibility of the club face at the point of contact, and can be expressed using a measurement called "coefficient of restitution" (or "COR"). The maximum COR for golf club heads is currently limited by the USGA at 0.83. Also, as described above, the direction of ball flight and the degree of twisting of the club head during impact, may also be related, at least in part, to the moment of inertia of the club head and the location of the center of gravity of the club head with relation to the point of impact. The energy or velocity transferred to the ball by the golf club may also be related to the moment of inertia and/or the location of the center of gravity of the club head. Accordingly, a need exists to customize or adjust the moment of inertia and/or the location of the center of gravity of a golf club face to provide maximum energy transfer and minimum twisting for impacts in the areas of the face where off-center hits tend to occur most.

[0009] The present device and method are provided to address the problems discussed above and other problems, and to provide advantages and aspects not provided by prior ball striking devices of this type. A full discussion of certain of the features and advantages of the present invention is deferred to the following detailed description, which proceeds with reference to the accompanying drawings.

BRIEF SUMMARY

[0010] The following presents a general summary of aspects of the invention in order to provide a basic understanding of the invention. This summary is not an extensive overview of the invention. It is not intended to identify key or critical elements of the invention or to delineate the scope of the invention. The following summary merely presents some concepts of the invention in a general form as a prelude to the more detailed description provided below.

[0011] Aspects of the invention relate to ball striking devices, such as golf clubs, with a head that includes a face configured for striking a ball and a body connected to the face, the body being adapted for connection of a shaft thereto. Various example structures of heads described herein include a plurality of cavities in the face, each cavity configured to receive an insert. By strategically weighting the face to provide increased moment of inertia and/or to shift the center of gravity based on locations on the face where a golfer tends to hit the ball, the golf shot may experience increased "kick" off the face and straighter ball flight on off-center hits (provided the off-center hits impact the face at the locations of increased flexibility and at a sufficient velocity), e.g., due to decreased twisting of the face during impacts at these locations.

[0012] According to one aspect, the head includes cavities located in various locations on the face. For example, in one embodiment, at least one of the cavities is located on a heel side of the face and at least one of the cavities is located on a toe side of the face. In another embodiment, at least one of the cavities is located on a vertical centerline of the face. In a further embodiment, at least one of the cavities is located on a top side of the face and at least one of the cavities is located on a bottom side of the face. In yet another embodiment, at least one of the cavities is located on a horizontal centerline of the face.

[0013] According to another aspect, the face includes four quadrants extending from the geometric center of the face, and at least one cavity is located entirely in a high-heel quadrant, at least one cavity is located entirely in a high-toe quadrant, at least one cavity is located entirely in a low-heel quadrant, and at least one cavity is located entirely in a low-toe quadrant.

[0014] According to another aspect, the cavities extend to at least one of the outer surface of the face and the inner surface of the face. Additionally, the cavities may extend completely through the face.

[0015] Additional aspects of the invention relate to a face as described above, also including a plurality of inserts received in the plurality of cavities. The inserts may be permanently connected to the face, or may be removable and interchangeable

[0016] According to one aspect, the inserts extend to the outer surface of the face and each insert has an outer surface that is flush with the outer surface of the face.

[0017] According to another aspect, one or more of the inserts may have a density that is different from a density of the face, and/or may have a density that is different from a density of one or more other inserts.

[0018] According to another aspect, one or more of the inserts may be made of a material that is different from a material of the face, and/or may be made of a material that is different from a material of one or more other inserts.

[0019] According to a further aspect, the outer surface of the face has grooves and at least one of the inserts has an outer surface with grooves that are contiguous with the grooves of the face.

[0020] Other aspects of this invention relate to face members for use in a ball striking device, including a face, a wall extending rearward from an outer periphery of the face, and a plurality of cavities in the face, each cavity configured to receive an insert, as described above. The face has an outer surface configured for striking a ball and an inner surface located rearward and opposite of the outer surface. The face may also further include a plurality of inserts received in the plurality of cavities, as described above.

[0021] Further aspects of the invention relate to methods that can be used for manufacturing or customizing a golf club head, which is provided with a face configured for striking a ball with an outer surface thereof and a body connected to the face. The method includes inserting inserts into the cavities, such as the inserts and cavities as described above. The method may also include removing at least one of the inserts and replacing the removed insert with a second insert having a density different from the removed insert.

[0022] Still further aspects of the invention relate to golf clubs that include a golf club head as described above and a shaft connected to the head.

[0023] Other features and advantages of the invention will be apparent from the following description taken in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] To allow for a more full understanding of the present invention, it will now be described by way of example, with reference to the accompanying drawings in which:

[0025] FIG. **1** is a perspective view of an illustrative embodiment of a head of a ball striking device according to the present invention, shown with a ball;

[0026] FIG. **2** is a front view of the head of FIG. **1**, illustrating a plurality of inserts received in a plurality of cavities in a face of the head;

[0027] FIG. **3** is a cross-section view of the head of FIG. **1**, taken along lines **3-3** of FIG. **2**;

[0028] FIG. **4** is a perspective view of a second illustrative embodiment of a ball striking device according to the present invention;

[0029] FIG. **5** is a front view of a head of the ball striking device of FIG. **3**, illustrating a plurality of inserts received in a plurality of cavities in a face of the head;

[0030] FIG. **6** is a cross-section view of the head of FIG. **4**, taken along lines **6-6** of FIG. **5**;

[0031] FIG. **7** is a plan view of one illustrative embodiment of an insert suitable for connection to a face of a ball striking device according to the present invention;

[0032] FIG. **8** is a plan view of a second illustrative embodiment of an insert suitable for connection to a face of a ball striking device according to the present invention;

[0033] FIG. **9** is a plan view of a third illustrative embodiment of an insert suitable for connection to a face of a ball striking device according to the present invention;.

[0034] FIG. **10** is a plan view of a fourth illustrative embodiment of an insert suitable for connection to a face of a ball striking device according to the present invention;

[0035] FIG. **11** is a cross-section view of one illustrative embodiment of a face having a plurality of inserts and being suitable for use with a head of a ball striking device according to the present invention;

[0036] FIG. **12** is a cross-section view of a second illustrative embodiment of a face having a plurality of inserts and being suitable for use with a head of a ball striking device according to the present invention;

[0037] FIG. **13** is a cross-section view of a third illustrative embodiment of a face having a plurality of inserts and being suitable for use with a head of a ball striking device according to the present invention; and

[0038] FIG. **14** is a cross-section view of a fourth illustrative embodiment of a face having a plurality of inserts and being suitable for use with a head of a ball striking device according to the present invention.

DETAILED DESCRIPTION

[0039] In the following description of various example structures according to the invention, reference is made to the accompanying drawings, which form a part hereof, and in which are shown by way of illustration various example devices, systems, and environments in which aspects of the invention may be practiced. It is to be understood that other specific arrangements of parts, example devices, systems, and environments may be utilized and structural and functional modifications may be made without departing from the scope of the present invention. Also, while the terms "top," "bottom," "front," "back," "side," "rear," and the like may be used in this specification to describe various example features and elements of the invention, these terms are used herein as a matter of convenience, e.g., based on the example orientations shown in the figures or the orientation during typical use. Additionally, the term "plurality," as used herein, indicates any number greater than one, either disjunctively or conjunctively, as necessary, up to an infinite number. Nothing in this specification should be construed as requiring a specific three dimensional orientation of structures in order to fall within the scope of this invention. Also, the reader is advised that the attached drawings are not necessarily drawn to scale.

[0040] The following terms are used in this specification, and unless otherwise noted or clear from the context, these terms have the meanings provided below.

[0041] "Ball striking device" means any device constructed and designed to strike a ball or other similar objects (such as a hockey puck). In addition to generically encompassing "ball striking heads," which are described in more detail below, examples of "ball striking devices" include, but are not limited to: golf clubs, putters, croquet mallets, polo mallets, baseball or softball bats, cricket bats, tennis rackets, badminton rackets, field hockey sticks, ice hockey sticks, and the like.

[0042] "Ball striking head" means the portion of a "ball striking device" that includes and is located immediately adjacent (optionally surrounding) the portion of the ball striking device designed to contact the ball (or other object) in use. In some examples, such as many golf clubs and putters, the ball striking head may be a separate and independent entity from any shaft or handle member, and it may be attached to the shaft or handle in some manner.

[0043] The terms "shaft" and "handle" are used synonymously and interchangeably in this specification, and they include the portion of a ball striking device (if any) that the user holds during a swing of a ball striking device.

[0044] "Integral joining technique" means a technique for joining two pieces so that the two pieces effectively become a single, integral piece, including, but not limited to, irreversible joining techniques, such as adhesively joining, cementing, welding, brazing, soldering, or the like, where separation of the joined pieces cannot be accomplished without structural damage thereto.

[0045] In general, aspects of this invention relate to ball striking devices, such as golf club heads, golf clubs, putter heads, putters, and the like. Such ball striking devices, according to at least some examples of the invention, may include a ball striking head and a ball striking surface. In the case of a golf club, the ball striking surface is a substantially flat surface on one face of the ball striking head. Some more specific aspects of this invention relate to wood-type golf clubs and golf club heads, including drivers, fairway woods, wood-type hybrid clubs, and the like, although aspects of this invention also may be practiced on irons, iron-type hybrid clubs, and the like.

[0046] According to various aspects of this invention, the ball striking device may be formed of one or more of a variety of materials, such as metals (including metal alloys), ceramics, polymers, composites (including fiber-reinforced composites), and wood, and may be formed in one of a variety of configurations, without departing from the scope of the invention. In one illustrative embodiment, some or all components of the head, including the face and at least a portion of the body of the head, are made of metal. It is understood that the head may contain components made of several different materials, including carbon-fiber and other components. Additionally, the components may be formed by various forming methods. For example, metal components (such as titanium, aluminum, titanium alloys, aluminum alloys, steels (including stainless steels), and the like) may be formed by forging, molding, casting, stamping, machining, and/or other known techniques. In another example, composite components, such as carbon fiber-polymer composites, can be manufactured by a variety of composite processing techniques, such as prepreg processing, powder-based techniques, mold infiltration, and/or other known techniques.

[0047] The various figures in this application illustrate examples of ball striking devices according to this invention. When the same reference number appears in more than one drawing, that reference number is used consistently in this specification and the drawings refer to the same or similar parts throughout.

[0048] At least some examples of ball striking devices according to this invention relate to golf club head structures, including heads for wood-type golf clubs, such as drivers, as well as long iron clubs (e.g., driving irons, zero irons through five irons, and hybrid type golf clubs), short iron clubs (e.g., six irons through pitching wedges, as well as sand wedges, lob wedges, gap wedges, and/or other wedges), and putters. Such devices may include a one-piece construction or a multiple-piece construction. Example structures of ball striking devices according to this invention will be described in detail below in conjunction with FIG. **1**, which illustrates an example of a ball striking device **100** in the form of a golf driver, and FIG. **4**, which illustrates an example of a ball striking device **200** in the form of an iron-type golf club, in accordance with at least some examples of this invention.

[0049] FIGS. **1-3** illustrate a ball striking device **100** in the form of a golf driver, in accordance with at least some examples of this invention. As shown in FIG. **1**, the ball striking device **100** includes a ball striking head **102** and a shaft **104** connected to the ball striking head **102** and extending therefrom. A ball **106** in use is also schematically shown in FIG. **1**, in a position to be struck by the ball striking device **100**. The ball striking head **102** of the ball striking device **100** of FIG. **1** has a face **112** connected to a body **108**, with a hosel **109** extending therefrom. Any desired hosel and/or head/shaft interconnection structure may be used without departing from this invention, including conventional hosel and/or head/shaft interconnection structures as are known and used in the art. For reference, the head **102** generally has a top **116**, a bottom or sole **118**, a heel **120** proximate the hosel **109**, a toe **122** distal from the hosel **109**, a front **124**, and a back or rear **126**. The shape and design of the head **102** may be partially dictated by the intended use of the device **100**. In the club **100** shown in FIG. **1**, the head **102** has a relatively large volume, as the club **100** is designed for use as a driver or wood-type club, intended to hit the ball accurately over long distances. In other applications, such as for a different type of golf club, the head may be designed to have different dimensions and configurations. When configured as a driver, the club head may have a volume of at least 400 cc, and in some structures, at least 450 cc, or even at least 460 cc. Other appropriate sizes for other club heads may be readily determined by those skilled in the art.

[0050] In the illustrative embodiment illustrated in FIGS. **1-3**, the head **102** has a hollow structure defining an inner cavity (e.g., defined by the face **112** and the body **108**). Thus, the head **102** has a plurality of inner surfaces defined therein. In one embodiment, the hollow center cavity may be filled with air. However, in other embodiments, the head **102** could be filled with another material, such as a foam. In still further embodiments, the solid materials of the head may occupy a greater proportion of the volume, and the head may have a smaller cavity or no inner cavity at all. It is understood that the inner cavity may not be completely enclosed in some embodiments.

[0051] The face **112** is located at the front **124** of the head **102**, and has a ball striking surface **110** located thereon and an inner surface **111** opposite the ball striking surface **110**. The ball striking surface **110** is typically an outer surface of the face **112** configured to face a ball **106** in use, and is adapted to strike the ball **106** when the device **100** is set in motion, such as by swinging. As shown, the ball striking surface **110** is relatively flat, occupying most of the face **112**. For reference purposes, the portion of the face **112** nearest the top face edge **113** and the heel **120** of the head **102** is referred to as the "high-heel area" **160**; the portion of the face **112** nearest the top face edge **113** and toe **122** of the head **102** is referred to as the "high-toe area" **162**; the portion of the face **112** nearest the bottom face edge **115** and heel **120** of the head **102** is referred to as the "low-heel area" **164**; and the portion of the face **112** nearest the bottom face edge **115** and toe **122** of the head **102** is referred to as the "low-toe area" **166**. Conceptually, these areas **160-166** may be recognized and referred to as quadrants of substantially equal size (and/or quadrants extending from a geometric center of the face **112**), though not necessarily with symmetrical dimensions. The face **112** may include some curvature in the top to bottom and/or heel to toe directions (e.g., bulge and roll characteristics), as is known and is conventional in the art. In other embodiments, the surface **110** may occupy a different proportion of the face **112**, or the body **108** may have multiple ball striking surfaces **110** thereon. In the illustrative embodiment shown in FIG. **1**, the ball striking surface **110** is inclined slightly (i.e., at a loft angle), to give the ball **106** slight lift and spin when struck. In other illustrative embodiments, the ball striking surface **110** may have a different incline or loft angle, to affect the trajectory of the ball **106**. Additionally, the face **112** may have a variable thickness and/or may have one or more internal or external inserts in some embodiments.

[0052] It is understood that the face **112**, the body **108**, and/or the hosel **109** can be formed as a single piece or as separate pieces that are joined together. In the illustrative embodiment shown in FIG. **3**, the face **112** is formed as part of a face frame member **128**, with a wall or walls **125** extending rearward from the edges **127** of the face **112**. This configuration is also known as a cup face structure. The body **108** can be formed as a separate piece or pieces joined to the walls **125** of the face frame member **128**. In the illustrative embodiment shown in FIG. **3**, the body **108** is partially formed by a backbody member **129**, which may be a single piece or multiple pieces. The walls **125** of the face frame member **128** combine with the backbody member **129** to form the body **108** of the head **102**. These pieces may be connected by an integral joining technique, such as welding, cementing, or adhesively joining. Other known techniques for joining these parts can be used as well, including many mechanical joining techniques, including releasable mechanical engagement techniques. If desired, the hosel **109** may be integrally formed as part of the face frame member **128**. Further, a gasket (not shown) may be included between the face frame member **128** and the backbody member **129**.

[0053] FIGS. **4-6** illustrate a ball striking device **200** in the form of a golf iron, in accordance with at least some examples of this invention. Many common components between the ball striking device **100** of FIGS. **1-3** and the ball striking device **200** of FIGS. **4-6** are referred to using similar reference numerals in the description that follows, using the "200" series of reference numerals. The ball striking device **200** includes a shaft **204** and a golf club head **202** attached to the shaft **204**. The golf club head **202** of FIG. **4** may be representative of any iron or hybrid type golf club head in accordance with examples of the present invention.

[0054] As shown in FIGS. **5-6**, the golf club head **202** includes a body member **208** having a face **202** and a hosel **209** extending from the body **208** for attachment of the shaft **204**. For reference, the head **202** generally has a top **216**, a bottom or sole **218**, a heel **220** proximate the hosel **209**, a toe **222** distal from the hosel **209**, a front **224**, and a back or rear **226**. The shape and design of the head **202** may be partially dictated by the intended use of the device **200**. The heel portion **220** is attached to and/or extends from a hosel **209** (e.g., as a unitary or integral one piece construction, as separate connected elements, etc.).

[0055] The face **212** is located at the front **224** of the head **202**, and has a ball striking surface **210** located thereon and an inner surface **211** opposite the ball striking surface **210**. The ball striking surface **210** is typically an outer surface of the face **212** configured to face a ball (not shown) in use, and is adapted to strike the ball when the device **200** is set in motion, such as by swinging. As shown, the ball striking surface **210** is relatively flat, occupying most of the face **212**. The ball striking surface **210** may include grooves **148** (e.g., generally horizontal grooves **148** extending across the face **212** in the

illustrated example) for the removal of water and grass from the face **212** during a ball strike. Of course, any number of grooves, desired groove patterns, and/or groove constructions may be provided (or even no groove pattern, if desired), including conventional groove patterns and/or constructions, without departing from this invention.

[0056] For reference purposes, the portion of the face **212** nearest the top face edge **213** and the heel **220** of the head **202** is referred to as the "high-heel area" **260**; the portion of the face **212** nearest the top face edge **213** and toe **222** of the head **202** is referred to as the "high-toe area" **262**; the portion of the face **212** nearest the bottom face edge **215** and heel **220** of the head **202** is referred to as the "low-heel area" **264**; and the portion of the face **212** nearest the bottom face edge **215** and toe **222** of the head **202** is referred to as the "low-toe area" **266**. Conceptually, these areas **260-266** may be recognized and referred to as quadrants of substantially equal size (and/or quadrants extending from a geometric center of the face **212**), though not necessarily with symmetrical dimensions. The face **212** may include some curvature in the top to bottom and/or heel to toe directions (e.g., bulge and roll characteristics), as is known and is conventional in the art. In other embodiments, the surface **210** may occupy a different proportion of the face **212**, or the body **208** may have multiple ball striking surfaces **210** thereon. In the illustrative embodiment shown in FIG. **4**, the ball striking surface **210** is inclined (i.e., at a loft angle), to give the ball an appreciable degree of lift and spin when struck. In other illustrative embodiments, the ball striking surface **210** may have a different incline or loft angle, to affect the trajectory of the ball. Additionally, the face **212** may have a variable thickness and/or may have one or more internal or external inserts in some embodiments. It is understood that the face **212**, the body **208**, and/or the hosel **209** can be formed as a single piece or as separate pieces that are joined together.

[0057] The body member **208** of the golf club head **202** may be constructed from a wide variety of different materials, including materials conventionally known and used in the art, such as steel, titanium, aluminum, tungsten, graphite, polymers, or composites, or combinations thereof. Also, if desired, the club head **202** may be made from any number of pieces (e.g., having a separate face plate, etc.) and/or by any construction technique, including, for example, casting, forging, welding, and/or other methods known and used in the art.

[0058] The ball striking device **100**, **200** may include a shaft **104**, **204** connected to or otherwise engaged with the ball striking head **102**, **202**, as shown schematically in FIGS. **1** and **4**. The shaft **104**, **204** is adapted to be gripped by a user to swing the ball striking device **100**, **200** to strike the ball **106**. The shaft **104**, **204** can be formed as a separate piece connected to the head **102**, **202**, such as by connecting to the hosel **109**, **209**, as shown in FIGS. **1** and **4**. In other illustrative embodiments, at least a portion of the shaft **104**, **204** may be an integral piece with the head **102**, **202**, and/or the head **102**, **202** may not contain a hosel **109**, **209** or may contain an internal hosel structure. Still further embodiments are contemplated without departing from the scope of the invention. The shaft **104**, **204** may be constructed from one or more of a variety of materials, including metals, ceramics, polymers, composites, or wood. In some illustrative embodiments, the shaft **104**, **204**, or at least portions thereof, may be constructed of a metal, such as stainless steel or titanium, or a composite, such as a carbon/graphite fiber-polymer composite. However, it is contemplated that the shaft **104**, **204** may be constructed of different materials without departing from the scope of the invention, including conventional materials that are known and used in the art. A grip element **205** may be positioned on the shaft **104**, **204** to provide a golfer with a slip resistant surface with which to grasp golf club shaft **104**, **204**, as shown in FIG. **4**. The grip element **205** may be attached to the shaft **104**, **204** in any desired manner, including in conventional manners known and used in the art (e.g., via adhesives or cements, threads or other mechanical connectors, swedging/swaging, etc.).

[0059] FIGS. **11-14**, described in greater detail below, show a general cross-section of a face **112** for a ball striking device, having an outer (ball striking) surface **110** and an opposed inner surface **111**. It is understood that while the reference numerals "**112**," "**110**," and "**111**" are used to describe the features of FIGS. **11-14**, the features of the faces **112** shown in FIGS. **11-13** can be incorporated into the head **102** of the ball striking device **100** of FIGS. **1-3** and the head **202** of the ball striking device **200** of FIGS. **4-6**, as well as any other ball striking device in accordance with aspects of this invention.

[0060] In general, the head **102**, **202** of the ball striking device **100**, **200** has a face **112**, **212** with a plurality of cavities **114**, each configured to receive an insert **140** therein. The embodiment of the head **102** illustrated in FIGS. **2-3** and the embodiment of the head **202** illustrated in FIGS. **5-6** both contain cavities **114** and inserts **140** received therein. The face **112**, **212** may have any number of cavities **114** and inserts **140**. For example, in the illustrative embodiment shown in FIG. **2**, the face **112** has eight cavities **114** and inserts **140**, and in the illustrative embodiment shown in FIG. **5**, the face **212** has seven cavities **114** and inserts **140**. In other embodiments, the face **112**, **212** may have a greater or smaller number of cavities **114** and inserts **140**.

[0061] Additionally, the cavities **114** and inserts **140** may have any desired shape, although generally the cavities **114** may be shaped and otherwise configured to receive the appropriate insert **140** in a complementary manner. For example, in the embodiments shown in FIGS. **2-3** and **5-6**, the inserts **140** are circular and cylindrical, and the complementarily-shaped cavities **114** are circular, tubular structures. FIGS. **7-10** show various different shapes for inserts **140**A-D that may be used in connection with the head **102**, **202**, and it is understood that the face **112**, **212** may contain one or more cavities **114** that are shaped to receive each insert **140**A-D. FIG. **7** illustrates an insert **140**A having a substantially triangular shape. FIG. **8** illustrates an insert **140**B having a substantially oval or elliptical shape. FIG. **9** illustrates an insert **140**C having a teardrop shape, which may also be considered a substantially triangular shape. FIG. **10** illustrates an insert **140**D having an elongated shape. Faces **112** may be constructed with inserts having these and other shapes, in order to enable different weighting configurations, as described below. Further, in some embodiments, the face **112** may contain more than one different size and/or shape of insert **140**, and may contain cavities **114** having a variety of different configurations to receive the different inserts **140**.

[0062] The cavities **114** can be arranged in a variety of different configurations, which may depend on the number of cavities **114** present in the face **112**, **212**. In one embodiment, the head **102**, **202** includes at least one cavity **114** located on the top side of the face **112**, **212** and at least one cavity **114** located on the bottom side of the face **112**, **212** (i.e., above and below the horizontal centerline of the face **112**, **212**). Addi-

tionally, in one embodiment, the head **102** includes at least one cavity **114** located on the heel side of the face **112**, **212** and at least one cavity located on the toe side of the face (i.e., left and right of the vertical centerline of the face **112**, **212**).

[0063] In the embodiment of the head **102** shown in FIGS. **2-3**, the face **112** has a cavity **140** located in each of the high-heel quadrant **160**, the high-toe quadrant **162**, the low-heel quadrant **164**, and the low-toe quadrant **166**. Additionally, the face **112** of the head **102** shown in FIG. **2** contains two cavities **114** on the horizontal centerline of the face **112**, one each on the heel and toe sides of the face **112**, and two cavities on the vertical centerline of the face, one each on the top and bottom sides of the face **112**. In the embodiment of the head **202** shown in FIGS. **5-6**, the face **212** has a cavity **140** located in each of the high-heel quadrant **260**, the high-toe quadrant **262**, the low-heel quadrant **264**, and the low-toe quadrant **266**. Additionally, the face **212** contains one cavity at the approximate center of the face **212** and two additional cavities on the vertical centerline of the face, one each on the top and bottom sides of the face **112**. In further embodiments, the head **102**, **202** may have a different configuration, and the arrangement of the cavities **114** may permit different weighting configurations and options, through insertion of different inserts **140** into the cavities **114**, as described below.

[0064] The inserts **140** can be connected within the cavities **114** in any manner, including any and all connecting techniques known to those skilled in the art, which may depend on the shape and configuration of the cavities **114** and/or inserts **140**. In one example, shown in FIGS. **3** and **6**, the insert **140** is connected within the cavity **114** using an integral joining technique, such as welding. The inserts **140**G-H in the embodiment of FIG. **13** are connected in a similar manner. In another example, as shown in FIG. **11**, the inserts **140**E include a threaded stem **142** that allows the insert **140** to be connected to the face **112** by threading the stem **142** into a threaded cavity **114**. In the embodiment shown in FIG. **14**, the inserts **140**I-J also contain threaded stems **142** that are connected within threaded cavities **114**, in a similar manner. In a further example, as shown in FIG. **12**, the inserts **140**F include a threaded stem **142** that allows the insert **140** to be connected to the face **112** by use of a threaded nut **144**. The face **112** shown in FIG. **12** includes countersunk portions **146** in the outer surface **110** to accommodate an enlarged head **152** of the insert **140**F, and countersunk portions **146** in the inner surface **111** to accommodate the nuts **144**. The inserts **140**I-J in FIG. **14** similarly include enlarged heads **152** received in countersunk portions **146** in the face **112**. In still a further example, the insert **140** may be connected within the cavity by gluing, cementing, and other such techniques, including various other integral joining techniques. Further connecting techniques that may be used to connect the inserts **140** within the cavities **114** include clamping, friction or interference fit, swedging/swaging, and riveting or using other fasteners. It is also understood that not all the inserts **140** may be connected to the face **112**, **212** in the same manner.

[0065] In some embodiments, the face **112**, **212** may have inserts on the inner surface **111**, **211** and the outer surface **110**, **210**. In one embodiment, shown in FIG. **13**, the face **112** may have front inserts **140**G received in cavities **114** in the outer surface **110** of the face **112** and rear inserts **140**H received in cavities **114** in the inner surface **111** of the face **112**. FIG. **14** illustrates a similar embodiment, where the face **112** has front inserts **140**I and rear inserts **140**J, each of which have a stem **142** to permit the inserts **140**I, **140**J to be threaded into threaded cavities **114** on the outer surface **110** and inner surface **111** of the face, respectively. As described above, the inserts **140**G-J and cavities **114** of the faces **112** shown in FIGS. **13-14** extend only a portion of the way through the face **112**.

[0066] The inserts **140** described herein may be permanently connected to the face **112** in some embodiments. In other embodiments, the inserts **140** may be removably connected to the face **112**, to enable interchanging of inserts **140** to change the weight distribution of the face **112** as desired. The threaded inserts **140**E, **140**F represent examples of interchangeable inserts, and it is understood that different types of interchangeable inserts can be used in other embodiments. For a club head **102** having a face **112** with interchangeable inserts **140**, the weighting of the face **112** can be changed by removing at least one insert **140** and replacing the removed insert **140** with a different insert **140** having a different density. FIGS. **11** and **12** each illustrate interchanging of one of the inserts **140**E, **140**F with a replacement insert **140**E', **140**F'. In the embodiment shown in FIG. **11**, the inserts **140**E can be interchanged from outside the head **112**. However, in other embodiments, access to the inner surface **111** of the face **112** may be required to interchange the inserts **140**. For example, the face **112** shown in FIG. **12** may require access to the inner surface **111** to interchange the inserts **140**F, if the nut **144** is not fixed in place on the inner surface **111**. Likewise, the inner inserts **140**H, **140**J in FIGS. **13** and **14** may require access to the inner face surface **111** for interchanging. When such a face **112** is used in connection with a ball striking device **100** as shown in FIGS. **1-3**, the head **102** may include a removable backbody member **129** to provide this access. Several different configurations for removable and/or interchangeable backbody members are shown and described in U.S. patent application Ser. No. 12/192,402, filed Aug. 15, 2008, which is incorporated by reference herein and made part hereof. Other embodiments of ball striking heads may have portions of the head that are removable by other mechanisms and using other structural configurations, and it is understood that such embodiments are included within the scope of the invention.

[0067] The cavities **114** may extend partially or completely through the face **112**, **212**. In one embodiment, the inserts **140** extend to the outer surface **110**, **210** of the face **112**, **212** and form a portion of the outer surface **110**, **210**. In another embodiment, the inserts **140** extend to the inner surface **111**, **211** of the face **112**, **212**. In the embodiments shown in FIGS. **2-3**, **5-6**, and **11-12**, the inserts **140**, **140**E, **140**F extend completely through the face **112**, **212**. In the embodiments shown in FIGS. **13-14**, described below, the inserts **140**G-J extend only a portion of the way through the face **112**, and extend either to the inner surface **111** or the outer surface **110** of the face **112**. Additionally, as illustrated in FIG. **5**, the inserts **140** may have grooves **150** thereon that are cooperatively positioned to match with the grooves **148** on the outer surface **210** of the face **212**. As stated above, the cavities **114** may have countersunk portions **146** on the inner and outer sides thereof, to accommodate an enlarged head **152** of the insert **140**F and/or a nut **144**, as shown in FIG. **12**. As also described above, the cavities **114** may have internal connecting structures, such as threading, to enable connection of inserts **140**E having complementary threading, as shown in FIG. **11**.

[0068] Each insert **140** may be made of one or more different materials, and the properties of each insert **140** can influence the properties of the face **112**, **212**. In one embodiment, at least one of the inserts **140** is made from a material that is

different from the material from which the face **112**, **212** is made. Additionally, in one embodiment, at least one of the inserts **140** is made from a material that is different from the material from which at least one of the other inserts **140** is made. The use of inserts **140** made from different materials and having different properties can allow for customization of the face **112**, **212** to achieve specified performance characteristics.

[0069] One such property is the density of the material of the insert **140**. It is understood that the density of the material can be influenced by the natural density properties of the bulk material, as well as other factors, such as the porosity of the material. Additionally, the local density of the insert **140** may vary at different points on the insert, for example, if the insert **140** is made from multiple materials, has varying porosity, etc. In this case, the density of the insert **140** can be expressed as an average density, overall density, or bulk density. In one embodiment, at least one of the inserts **140** has a density that is different from the density of the material of the face **112**, **212**. Additionally, in one embodiment, at least one of the inserts **140** has a different density than at least one of the other inserts **140**. By using inserts **140** having different densities, the weight distribution, center of gravity, and moment of inertia of the head **102** and face **112**, **212** can be adjusted. For example, by connecting inserts **140** having lower densities near or at the center of the face **112**, **212** and inserts **140** having higher densities near the heel **120** and toe **122** of the face **112**, **212**, the weight of the face **112**, **212** can be distributed toward the edges of the face **112**, **212**, increasing the moment of inertia of the face **112**, **212**. Additionally, inserts **140** having different densities can be used to shift the center of gravity of the face **112**, **212** toward a desired area of the face **112**, **212**, such as an area where missed hits frequently occur. For example, to shift the center of gravity of the face **112**, **212** to the low-toe quadrant **166**, **266** of the face **112**, **212**, heavier inserts **140** can be connected within the cavities **114** in the low-toe quadrant **166**, **266**, and lighter inserts can be connected within the high-heel quadrant **160**, **260**. As a result, hits in the low-toe area **166**, **266** of the face **112**, **212** will result in less twisting of the club head, since those hits will be closer to the center of gravity of the face **112**, **212**.

[0070] As stated above, in some embodiments, the face **112**, **212** may have inserts on both the inner surface **111**, **211** and the outer surface **110**, **210**, such as shown in FIGS. **13** and **14**. Inserts **140**G-J of different densities can be used in these embodiments to create front-weighting or rear-weighting of the face **112**, as desired, as well as shifting the center of gravity and/or changing the moment of inertia of the face **112**. Each of the inserts **1401**, **140**J in FIG. **14** includes an enlarged head portion **152** that can assist with front- and rear-weighting of the face **112**.

[0071] The shapes of the inserts **140** also influence the weighting distribution of the face **112**, **212**, once the insert is connected. For example, with a substantially triangular-shaped insert **140**A as shown in FIG. **7**, the weight of the insert **140**A is disproportionately distributed toward the top of the insert **140**A. Thus, the effect of connecting a heavier or lighter insert **140**A of this shape to the face **112**, **212** will have a disproportionate effect on the weighting of the face **112**, **212**. The oval-shaped inserts **140**B, teardrop-shaped inserts **140**C, and elongated inserts **140**D in FIGS. **8-10**, as well as many other different shapes of inserts, have disproportionate and/or asymmetrical weight distributions as well, and can likewise be used to disproportionately affect the weighting of the face **112**, **212**.

[0072] Although the face **112**, **212** is described above as having inserts **140** connected thereto, the face **112**, **212** can alternately be described as being made from at least two different materials, having different properties, where at least one of the materials is distributed in isolated areas across the face **112**, **212**, and may or may not utilize inserts to achieve this configuration. As described above, in one embodiment, the various materials have at least two different densities, and the densities of the materials may influence the weighting and weight distribution of the face **112**, **212**. The different materials may have additional differing properties as well. It is understood that the face **112**, **212** may contain more than two different materials, such as by the use of multiple inserts **140** made from different materials, and the use of multiple-material inserts **140**. It is understood that in an insert made from multiple materials, different portions of the insert may have different densities or other properties. As also described above, in one embodiment, the various different materials each form a portion of the outer surface or ball striking surface **110**, **210** of the face **112**, **212**.

[0073] As stated above, the inserts **140** described herein can be made from a variety of different materials to achieve the desired properties, such as a particular density and weight. For example, in one embodiment, materials such as +8 density alloys and powder tungsten can be used for high-density inserts and materials such as aluminum or composites can be used for low-density inserts. Other materials can be used in other embodiments, including any metals (including metal alloys), ceramics, polymers, composites (including fiber-reinforced composites), and wood. Additionally, as described above, one or more of the inserts **140** may be made from multiple materials. In multiple material inserts **140**, at least a portion of each insert **140** may have a density that is different from the density of the face **112**, **212**, and each insert **140** may also have two or more portions with densities that are not only different from each other, but also different from the property of the face **112**, **212**. Likewise, a portion of each insert **140** may have a different density from the face **112**, **212**, and another portion may have the same density as the face **112**, **212**. In other embodiments of single-material or multiple-material inserts **140**, the entire insert may have a density that is different from a density of the face **112**, **212**.

[0074] Heads **102**, **202** incorporating the inserts **140**, et seq. disclosed herein may be used as a ball striking device or a part thereof. For example, a golf club **100**, **200** as shown in FIGS. **1-6** may be manufactured by attaching a shaft or handle **104**, **204** to a head that is provided, such as the head **102**, **202** as described above. "Providing" the head, as used herein, refers broadly to making an article available or accessible for future actions to be performed on the article, and does not connote that the party providing the article has manufactured, produced, or supplied the article or that the party providing the article has ownership or control of the article. In other embodiments, different types of ball striking devices can be manufactured according to the principles described herein. Manufacturing the head **102** shown in FIGS. **2-3** may include attachment of a backbody member **129** to a face frame member **128**, as described above. Additionally, the head **102**, **202**, golf club **100**, **200**, or other ball striking device may be fitted or customized for a person by connecting inserts **140** having different densities to customize the weighting of the face **112**,

212. Such customization may include selecting inserts 140 having specific densities and connecting the inserts 140 to the face 112, 212 in an arrangement to achieve the desired weight distribution of the face 112, 212. Such customization may further include removing one insert 140 and interchanging the removed insert 140 with another insert 140 having at least one different property.

[0075] Heads 102, 202 incorporating the inserts 140 disclosed herein may be used as part of a kit or assembly that includes a head 102, 202 as described above, along with one or more inserts 140 configured for connection to the head 102, 202. If the kit includes multiple inserts 140, each of the inserts 140 may have different properties. In one embodiment, the head 102, 202 may have one or more cavities 114 with specific shapes, and the kit may include one or more inserts 140 having the same shape. In another embodiment, the head 102, 202 may have multiple cavities 114 with differing shapes, and the kit may include one or more inserts 140 having the same shape as each of the cavities 114. In a further embodiment, the kit may include inserts 140 having different shapes, and the head 102, 202 may require further processing to connect the inserts 140 to the face 112, 212, such as by forming one or more cavities 114 in the face 112, 212. The kit may also include one or more shafts 104, 204 for connection to the head. In some embodiments, the kit may include a plurality of inserts 140 that are removable and interchangeable with each other.

[0076] The ball striking devices and heads therefor as described herein provide many benefits and advantages over existing products. For example, inserts having different densities and weights can be strategically located and weighted to provide a specific weight distribution. This enables the overall moment of inertia of the head to be changed, such as by adjusting the weight distribution between the center of the face and the edges of the face. This also enables the center of gravity of the face to be moved and/or the relative moment of inertia for various points on the face to be changed, such as by increasing or decreasing the weight of the face in a specific area. Weighting the face in a customized manner can provide superior ball striking function for the head, such as by reducing twisting upon impact. Additionally, the weighting can be customized so that the areas of the face that most frequently impact the ball during play will result in greater energy and velocity transfer and truer and straighter ball flight.

[0077] While the invention has been described with respect to specific examples including presently preferred modes of carrying out the invention, those skilled in the art will appreciate that there are numerous variations and permutations of the above described systems and methods. Thus, the spirit and scope of the invention should be construed broadly as set forth in the appended claims.

What is claimed is:

1. A golf club head comprising:
- a face having an outer surface configured for striking a ball;
- a body connected to the face; and
- a plurality of cavities in the face, each cavity configured to receive an insert.

2. The golf club head of claim 1, wherein at least one of the cavities is located on a heel side of the face and at least one of the cavities is located on a toe side of the face.

3. The golf club head of claim 2, wherein at least one of the cavities is located on a vertical centerline of the face.

4. The golf club head of claim 1, wherein at least one of the cavities is located on a top side of the face and at least one of the cavities is located on a bottom side of the face.

5. The golf club head of claim 4, wherein at least one of the cavities is located on a horizontal centerline of the face.

6. The golf club head of claim 1, wherein the face comprises four quadrants extending from a geometric center of the face, and wherein at least one cavity is located entirely in a high-heel quadrant, at least one cavity is located entirely in a high-toe quadrant, at least one cavity is located entirely in a low-heel quadrant, and at least one cavity is located entirely in a low-toe quadrant.

7. The golf club head of claim 6, wherein at least one of the cavities is located on a horizontal centerline of the face.

8. The golf club head of claim 1, wherein the plurality of cavities extend to the outer surface of the face.

9. The golf club head of claim 1, wherein the plurality of cavities extend to an inner surface of the face opposite the outer surface.

10. The golf club head of claim 1, wherein the plurality of cavities extend completely through the face.

11. A golf club comprising the golf club head of claim 1 and a shaft connected to the golf club head.

12. A face member for use in a ball striking device, comprising:
- a face having an outer surface configured for striking a ball;
- a wall extending rearward from an outer periphery of the face; and
- a plurality of cavities in the face, each cavity configured to receive an insert.

13. A method comprising:
- providing a golf club head including a face having an outer surface configured for striking a ball and an inner surface, and a plurality of cavities in the face; and
- inserting a plurality of inserts into the plurality of cavities.

14. The method of claim 13, further comprising removing at least one of the plurality of inserts and replacing the removed insert with a second insert having a density different from the removed insert.

15. The method of claim 13, wherein at least one of the inserts has a first density and at least one of the inserts has a second density that is different from the first density.

16. The method of claim 13, wherein at least one of the inserts has a density that is different from a density of at least a portion of the face.

17. A golf club head comprising:
- a face having an outer surface configured for striking a ball and a plurality of cavities in the face;
- a body connected to the face; and
- a plurality of inserts, each insert received within one of the cavities.

18. The golf club head of claim 17, wherein the plurality of inserts extend completely through the face.

19. The golf club head of claim 17, wherein the plurality of inserts extend to the outer surface of the face and each insert has an outer surface that is flush with the outer surface of the face.

20. The golf club head of claim 17, wherein at least one of the inserts has a density that is different from a density of at least a portion of the face.

21. The golf club head of claim 17, wherein at least one of the inserts is made from a first material and at least a portion of the face is made from a second material that is different from the first material.

22. The golf club head of claim **17**, wherein at least one of the inserts has a first density and at least one of the inserts has a second density that is greater than the first density.

23. The golf club head of claim **17**, wherein at least one of the inserts is made from a first material and at least one of the inserts is made from a second material that is different from the first material.

24. The golf club head of claim **17**, wherein the inserts are removable.

25. The golf club head of claim **17**, wherein the outer surface of the face has grooves and at least one of the inserts has an outer surface with grooves that are contiguous with the grooves of the face.

26. A golf club comprising the golf club head of claim **17** and a shaft connected to the golf club head.

27. A face member for use in a ball striking device, comprising:

a face having an outer surface configured for striking a ball and a plurality of cavities in the face;

a wall extending rearward from an outer periphery of the face; and

a plurality of inserts, each insert received within one of the cavities.

28. A golf club kit comprising:

a golf club head comprising a face having a ball striking surface configured for striking a ball, a plurality of cavities in the face, and a body connected to the face; and

a plurality of inserts, each configured for connection to the face.

29. The golf club kit of claim **28**, wherein at least one of the cavities has a first shape and at least another of the cavities has a second shape, and the plurality of inserts comprise at least one insert having the first shape and at least one insert having the second shape, such that each cavity is configured to receive at least one of the plurality of inserts.

30. The golf club kit of claim **28**, wherein at least a portion of the face is made from a first material, and wherein at least one of the inserts is made from a second material that is different from the first material.

31. The golf club kit of claim **30**, wherein at least one of the inserts is made from a third material that is different from the first material and the second material.

32. The golf club kit of claim **28**, wherein at least one of the inserts has a first density and at least one of the inserts has a second density that is greater than the first density.

33. The golf club kit of claim **28**, further comprising:

a shaft configured for connection to the golf club head to form a golf club.

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