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(54) **ANGLE ADJUSTMENT DISCONTINUITIES FOR GOLF CLUBS**

(76) Inventors: **John Thomas Stites**, Weatherford, TX (US); **Gary G. Tavares**, Azle, TX (US); **Robert Boyd**, Euless, TX (US); **Michael G. Taylor**, Granbury, TX (US)

Correspondence Address:
BANNER & WITCOFF, LTD.
28 STATE STREET, SUITE 1800
BOSTON, MA 02109-1701 (US)

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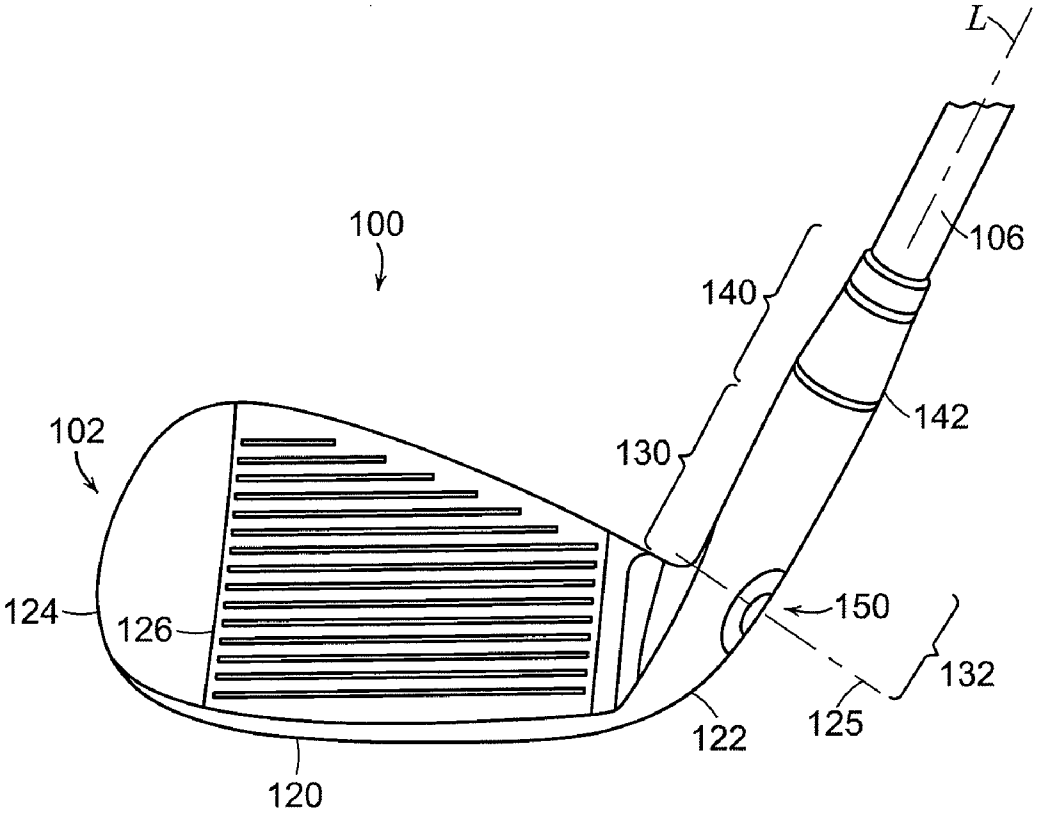
(57) **ABSTRACT**

A golf club having a golf club shaft and a golf club head is provided. The shaft includes a proximal end, a distal end, and a longitudinal axis extending therebetween. The golf club head, which is attached to the distal end of the golf club shaft, extends from a heel region to a toe region. The golf club head includes an angle adjustment discontinuity that is located below the distal end of the golf club shaft. The angle adjustment discontinuity includes a first elongated groove extending over both a transverse distance and a longitudinal distance. The first elongated groove does not encircle the longitudinal axis.



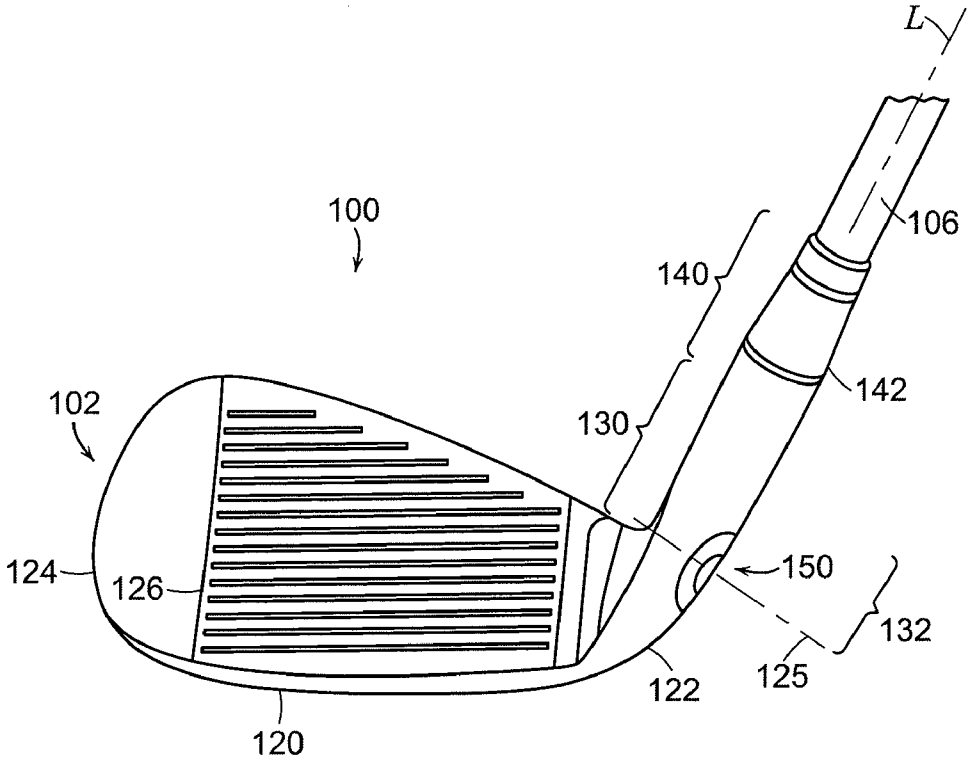


FIG. 1

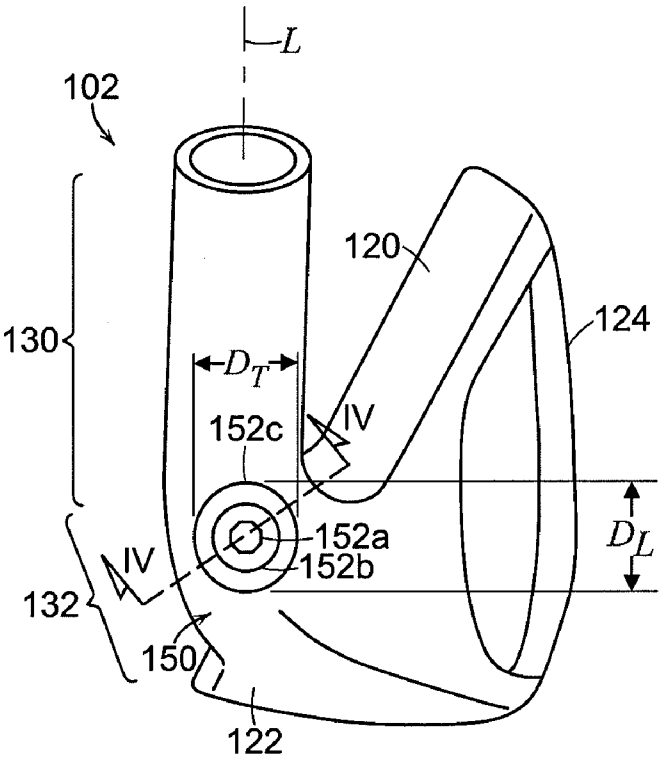

L
102
120
124
130
D_T
152c
IV
152a
152b
D_L
IV
132
150
122

FIG. 2

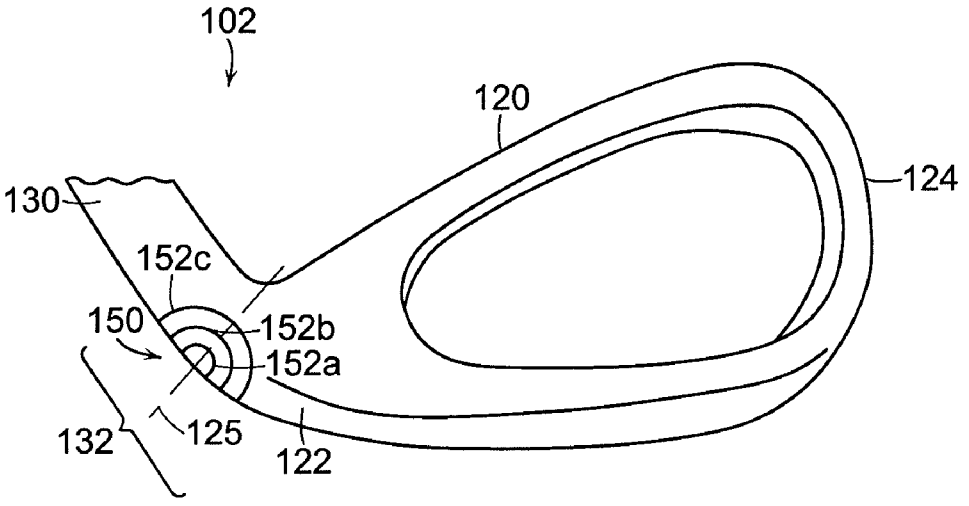

102
120
124
130
152c
150
152b
152a
132
125
122

FIG. 3

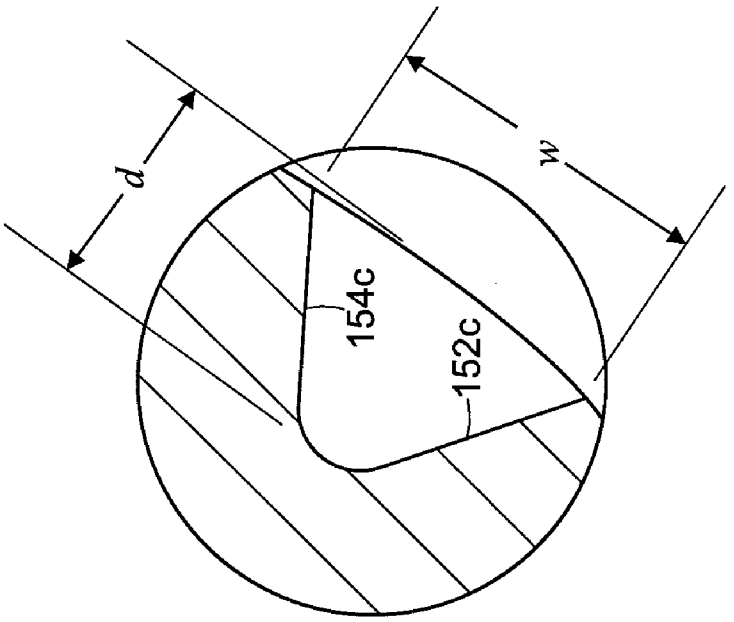

d
w
154c
152c

FIG. 4A

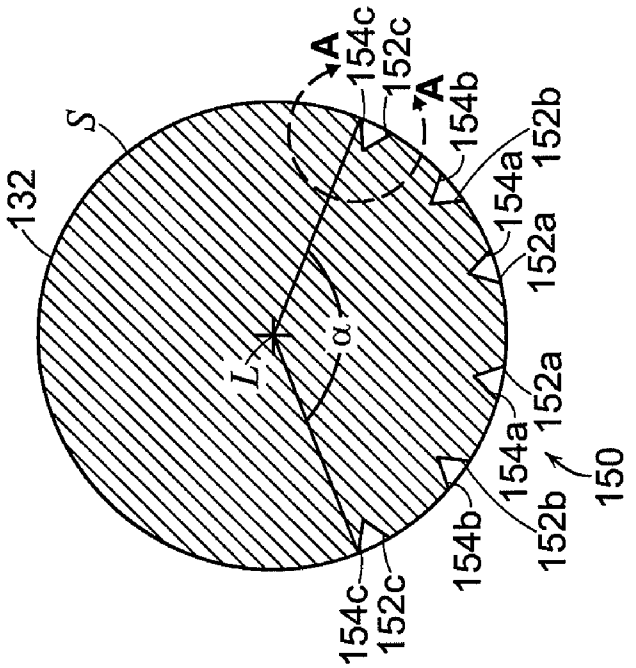

A
154c
152c
A
154b
154a
152b
152a
S
132
L
α
154a
152a
154b
152b
150
154c
152c

FIG. 4

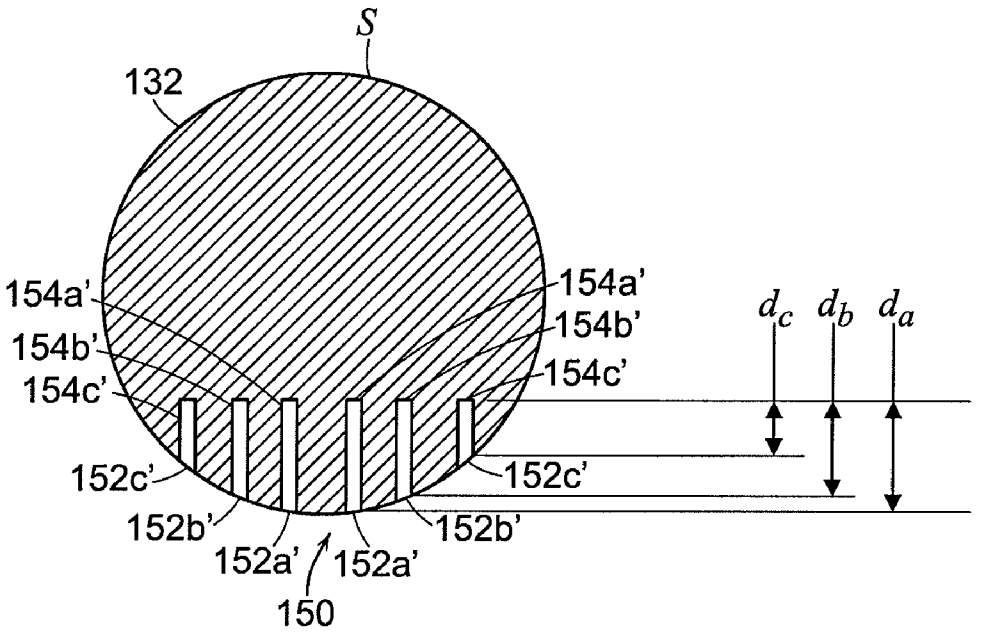

S
132
154a'
154b'
154c'
154a'
154b'
154c'
d_c d_b d_a
152c'
152c'
152b'
152b'
152a'
152a'
150

FIG. 5

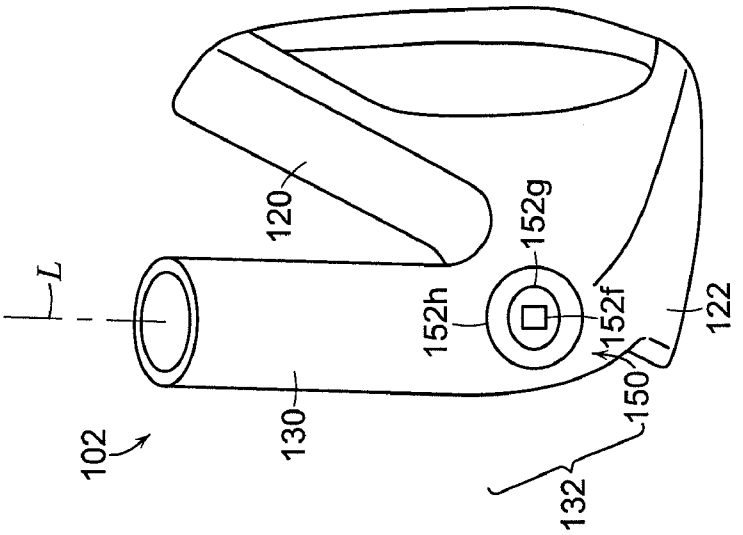

L
120
152g
152h
152f
122
102
130
150
132

FIG. 7

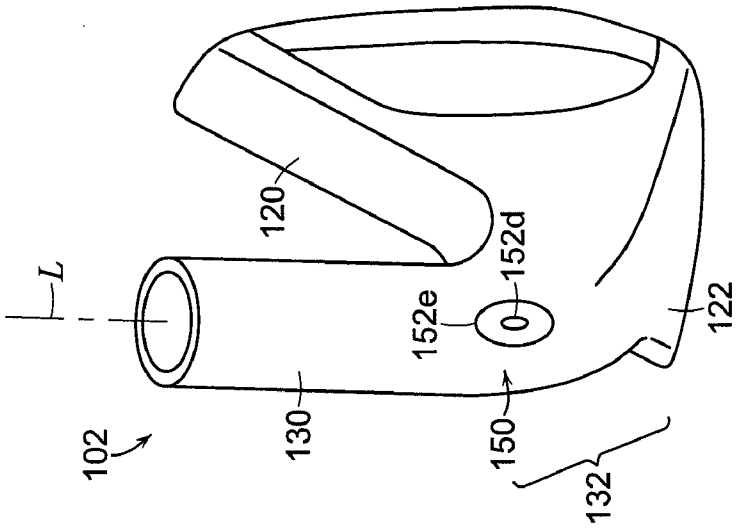

L
120
152d
152e
122
102
130
150
132

FIG. 6

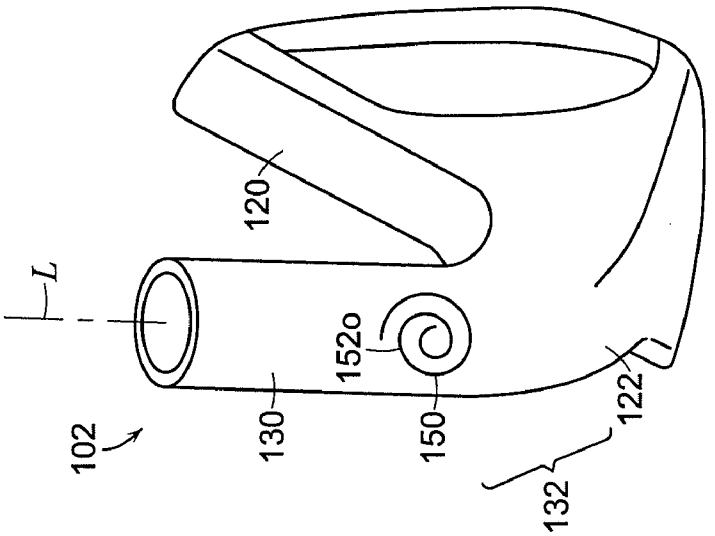

L
120
152o
102
130
150
122
132

FIG. 9

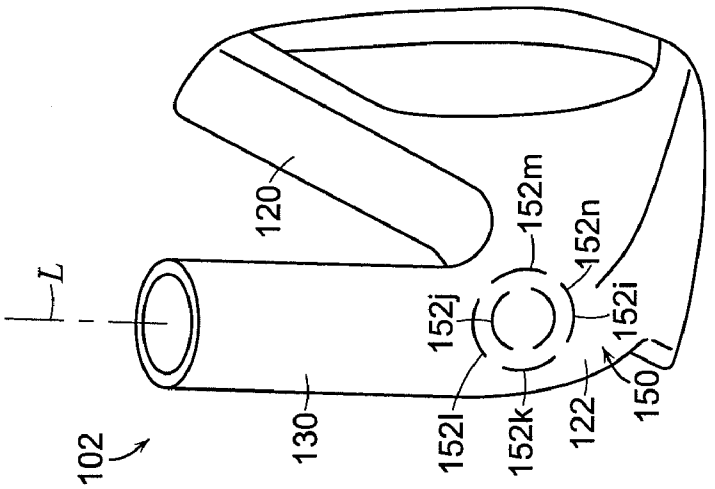

L
120
152m
152n
152j
152i
102
130
152l
152k
122
150

FIG. 8

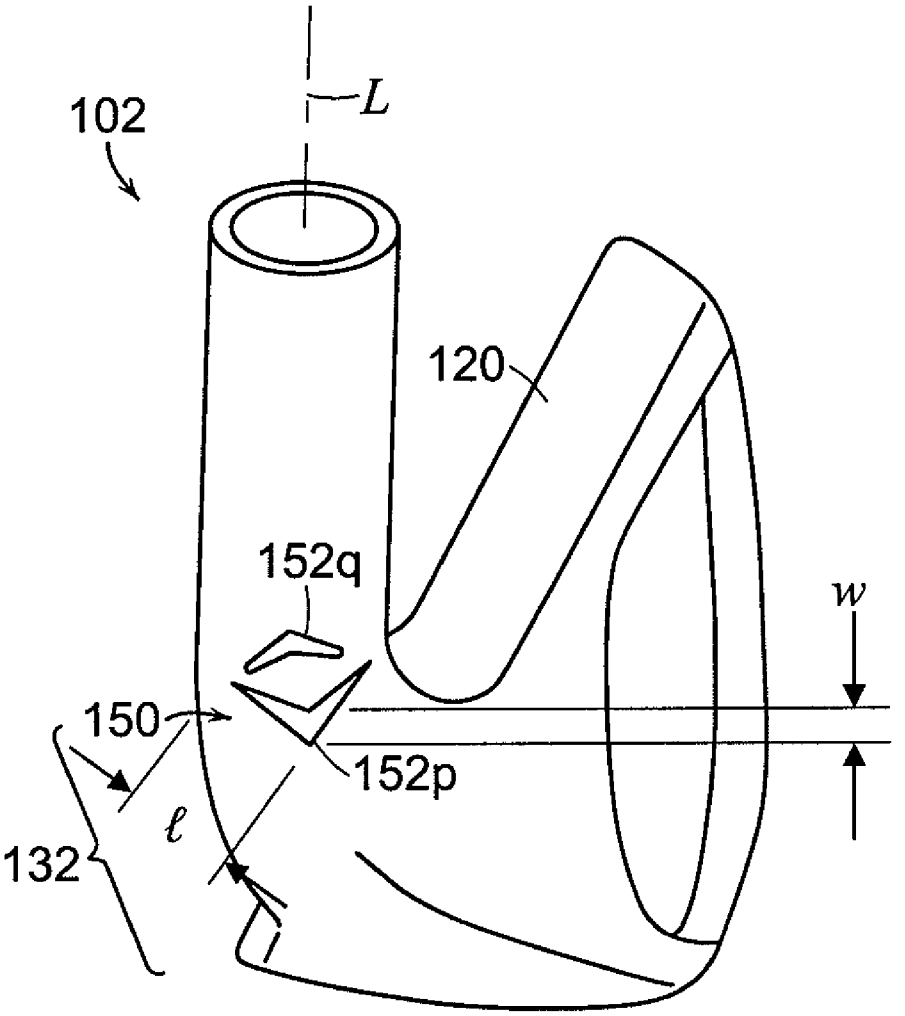


FIG. 10

ANGLE ADJUSTMENT DISCONTINUITIES FOR GOLF CLUBS

FIELD OF THE INVENTION

[0001] This invention relates generally to golf clubs and golf club heads. More particularly, aspects of this invention relate to golf clubs having angle adjustment discontinuities.

BACKGROUND

[0002] Golf is enjoyed by a wide variety of players—players of different genders and dramatically different ages and/or skill levels. Golfers at all skill levels seek to improve their performance, lower their golf scores, and reach that next performance "level." One way to improve performance is to use more technologically advanced equipment. A further way to improve performance is to select equipment that matches an individual golfer's style.

[0003] Golf clubs have been the subject of much technological research and advancement in recent years. Certain technological advancements have been made in an effort to better match the various elements and/or characteristics of the golf club and characteristics of a golf ball to a particular user's swing characteristics (e.g., club fitting technology, ball launch angle measurement technology, ball spin rates, etc.). There now exists a vast array of golf club component parts available to the golfer. For example, individual club head models may include variations in the loft angle, lie angle, offset features, weighting characteristics, etc. These various club heads may be combined with a variety of shafts having, for example, any of various stiffnesses, flex points, kick points or other flexion characteristics. Between the available variations in shafts and club heads, there are literally hundreds of different club head/shaft combinations available to the golfer.

[0004] Club fitters and golf professionals can assist in fitting golfers with a golf club head/shaft combination that suits their swing characteristics and needs. Not only should the individual golf head and shaft be selected based on the specific golfer's swing characteristics, but the angle at which the shaft is fitted to the head, i.e. the lie angle, should also be matched to the individual golfer's physical characteristics.

[0005] The lie angle is the angle between the center line of the hosel and the sole of the club head when the sole is touching the ground at the center of the face scoring area. If the center of the face scoring area of the club head is on the ground when a golfer stands at address then the lie of the club is generally considered perfect—this is termed a "standard" lie. If the toe of the club head points in the air and the heel of the club head is on the ground, then the golfer's lie is too "upright" and should be made flatter. In contrast, if the heel of the club head is in the air and the toe is on the ground, then the golfer's lie is too "flat" and should be made more upright. Shorter players generally use a flatter lie angle; taller players generally use a more upright lie angle.

[0006] The lie of the club can have a significant impact on ball flight. If the lie is too flat for a particular golfer, the toe of the club head may impact the ground first and the ball flight may tend to move from the inside outward. If the lie of the club is too upright for the golfer, the ball flight may tend to move from the outside inward.

[0007] Conventionally, shafts are mounted to golf club heads using hosels. In some instances, custom-fitting of golf clubs to an individual golfer has involved bending the hosel to provide the correct lie angle for that golfer/club combination.

[0008] However, the hosel, which is a structural connection between the shaft and the club head, may have material properties that are not amenable to bending. Thus, for example, wrinkles, bulges, stress concentrations, cracks, or other defects may result from the application of the bending forces. Further, bending may result in an attendant loss of strength and/or stiffness.

[0009] The disadvantages associated with conventional structures associated with adjusting a club's lie angle may limit the amount of adjustment and/or reduce the technical performance of the golf club.

SUMMARY

[0010] The following presents a general summary of aspects of the disclosure in order to provide a basic understanding of the invention and various features of it. This summary is not intended to limit the scope of the invention in any way, but it simply provides a general overview and context for the more detailed description that follows.

[0011] In accordance with illustrative aspects of the disclosure, a golf club head may include an angle adjustment discontinuity that is located below a distal end of an attached golf club shaft. The angle adjustment discontinuity may include a first elongated groove extending over both a transverse distance and a longitudinal distance. According to certain aspects, the first elongated groove does not encircle the longitudinal axis.

[0012] In accordance with other illustrative aspects of the disclosure, the angle adjustment discontinuity may include a first elongated groove extending over both a transverse distance and a longitudinal distance and a second elongated groove extending over both a transverse distance and a longitudinal distance.

[0013] In accordance with additional illustrative aspects of the disclosure, a golf club may include a golf club shaft attached to a golf club head as provided above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] A more complete understanding of the present invention and certain advantages thereof may be acquired by referring to the following detailed description in consideration with the accompanying drawings, in which:

[0015] FIG. **1** generally illustrates a front view of a portion of an example golf club according to an aspect of this disclosure;

[0016] FIG. **2** generally illustrates a heel-side view of a portion of an example golf club head in accordance with this disclosure and the aspect of FIG. **1**;

[0017] FIG. **3** generally illustrates a back view of a portion of an example golf club head in accordance with this disclosure and the aspect of FIG. **1**;

[0018] FIG. **4** generally illustrates a cross-section view taken through section IV-IV of FIG. **2** in accordance with this disclosure and the aspect of FIG. **1**;

[0019] FIG. **4**A generally illustrates an enlarged portion of FIG. **4**, taken at section A-A club in accordance with this disclosure and the aspect of FIG. **1**;

[0020] FIG. **5** generally illustrates a cross-section view taken through section IV-IV of FIG. **2** in accordance with this disclosure and an alternative embodiment of the aspect of FIG. **1**;

[0021] FIG. **6** generally illustrates a heel-side view of a portion of an example golf club head according to another aspect of this disclosure;

[0022] FIG. **7** generally illustrates a heel-side view of a portion of an example golf club head according to a further aspect of this disclosure;

[0023] FIG. **8** generally illustrates a heel-side view of a portion of an example golf club head according to still another aspect of this disclosure;

[0024] FIG. **9** generally illustrates a heel-side view of a portion of an example golf club head according to an aspect of this disclosure; and

[0025] FIG. **10** generally illustrates a heel-side view of a portion of an example golf club head according to yet another aspect of this disclosure.

[0026] The reader is advised that the attached drawings are not necessarily drawn to scale and that certain features may have been exaggerated in or removed from the drawings for purposes of discussion.

DETAILED DESCRIPTION

[0027] In the following description of various example structures in accordance with the disclosure, reference is made to the accompanying drawings, which form a part hereof, and in which are shown by way of illustration various example connection assemblies, golf club heads, and golf club structures in accordance with the disclosure. Additionally, it is to be understood that other specific arrangements of parts and structures 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," "rear," "side," "underside," "overhead," and the like may be used in this specification to describe various example features and elements of the disclosure, these terms are used herein as a matter of convenience, e.g., based on the example orientations shown in the figures and/or the orientations in typical use. Nothing in this specification should be construed as requiring a specific three dimensional or spatial orientation of structures in order to fall within the scope of this invention.

A. General Description of Golf Club Angle Adjustment Discontinuities and Golf Clubs Including Such Features According to Examples of the Disclosure

[0028] In general, as described above, aspects of this disclosure relate to features for adjusting the lie and/or loft angles of golf clubs so that the club heads and shafts can be oriented at various angles with respect to one another. More detailed descriptions of aspects of this disclosure follow.

[0029] Illustrative aspects of this disclosure relate to features provided on golf club heads so that any of various lie and/or loft angles of a golf club shaft with respect to the club head body (and its ball striking face) can be readily achieved. The angle of a golf club shaft may be adjusted with respect to a golf club head body by deforming a portion of the club head. Generally, the deformation occurs as a result of bending stresses experienced in a bend region or at a bendline located between the distal end of the golf club shaft and body of the golf club head. Aspects of this disclosure relate to reducing stresses, strains and/or deformations in the bend region, that arise due to the angle of a club shaft to a club head being changed, by providing a means for relieving strains and/or stresses. A means for relieving these strains may include providing an angle adjustment discontinuity on the surface of the club head. An angle adjustment discontinuity may include one or more groove-like, crack-like, notch-like or other gap-forming elements that locally disrupt the continuity of the surface of the golf club head. The angle adjustment discontinuity may relieve or ameliorate strains in the bend region in both the longitudinal and the transverse directions. Further, the angle adjustment discontinuity may relieve stress concentrations and reduce the likelihood that wrinkles and or cracks may develop in the bend region.

[0030] 1. Example Angle Adjustment Discontinuities and Golf Club Structures

[0031] A golf club having a golf club shaft and a golf club head is provided. The shaft includes a proximal end, a distal end, and a longitudinal axis extending therebetween. The golf club head, which is attached to the distal end of the golf club shaft, extends from a heel region to a toe region. The golf club head may include an angle adjustment discontinuity that is located below the distal end of the golf club shaft. The angle adjustment discontinuity may include a first elongated groove extending over both a transverse distance and a longitudinal distance. The first elongated groove does not encircle the longitudinal axis. In some aspects, the first groove does not extend more than 180 degrees around the longitudinal axis.

[0032] The angle adjustment discontinuity provides grooves extending over both transverse and longitudinal directions, with respect to the longitudinal axis defined by the golf club shaft. When the angle between the shaft and the club head body is adjusted, bending occurs in a bend region below the distal end of the shaft in the neck and/or heel region of the club head. On one side of the bend region, the material of the club head is stretched (or placed in tension) and on the other side of the bend region, the material of the club head is squashed (or place in compression). When a material is compressed in a first direction, it tends to want to expand in a direction perpendicular to the first direction. Similarly, when a material is stretched in a first direction, it tends to want to shrink in a direction perpendicular to the first direction. Thus, biaxial stresses and strains are developed in the bend region when the lie and/or loft angles are adjusted. By providing an angle adjustment discontinuity having one or more grooves extending in both the longitudinal and transverse directions, these biaxial stresses and strains may be better accommodated than grooves extending only in the transverse direction, for example.

[0033] According to aspects of this disclosure, a second elongated groove may also be provided. The second elongated groove may extend over both a transverse distance and a longitudinal distance. Further, the second elongated groove does not encircle the longitudinal axis. The first and second grooves may be formed as a series of concentric circles. More generally, the first groove and/or the second groove may form closed loops that extend substantially parallel to one another. The angle adjustment discontinuity may include more than two grooves.

[0034] The angle adjustment discontinuity may be provided at least partially in a neck region of the club head. Optionally, the angle adjustment discontinuity may be provided at least partially in a heel region of the club head. In some aspects, the angle adjustment discontinuity may be symmetric with respect to an axis parallel to the longitudinal axis. In other aspects, the angle adjustment discontinuity may be symmetric with respect to an axis perpendicular to the longitudinal axis.

[0035] While the angle adjustment discontinuity provides relief for the biaxial bending stresses and strains developed during bending, it does so with the removal a very little material from the cross-section of the neck and/or heel region. Thus, the properties of the club head that affect the bending and rotational stiffness of the club (i.e., the moment of inertia and the center of gravity) are only minimally affected.

[0036] According to certain aspects of this disclosure a golf club includes a golf club shaft having a proximal end, a distal end, and a longitudinal axis defining a longitudinal direction extending therebetween. The golf club head is attached to the distal end of the golf club shaft. The head includes a means for relieving strain located below the distal end of the golf club shaft. The means for relieving strain including a first elongated gap-forming element extending over both a transverse distance and a longitudinal distance. The first elongated gap-forming element does not encircling the longitudinal axis.

[0037] According to other aspects of this disclosure a golf club includes a golf club shaft having a proximal end, a distal end, and a longitudinal axis defining a longitudinal direction extending therebetween. The golf club further includes a golf club head attached to the distal end of the golf club shaft. The golf club head includes an angle adjustment discontinuity located below the distal end of the golf club shaft. The angle adjustment discontinuity may include a first elongated groove extending over both a transverse distance and a longitudinal distance and a second elongated groove also extending over both a transverse distance and a longitudinal distance.

[0038] The first and second grooves may have a synergistic effect. For example, each groove may relieve a portion of the biaxial bending stresses and strains. Further, multiple grooves may provide a more distributed relief feature. Even further, the multiple grooves may better accommodate potential variations in the orientation of the angle being adjusted. Unsightly wrinkles or other undesirable deformations at the bend region may be avoided.

[0039] The angle adjustment discontinuities described herein can help keep the overall connection assembly relatively compact and lightweight, while facilitating lie and loft angle adjustment and maintaining rotational and bending stiffness.

[0040] Aspects of this disclosure relating to the angle adjustment discontinuities and to golf club structures that incorporate the angle adjustment discontinuities will be described in more detail below.

[0041] Specific examples of the disclosure are described in more detail below. The reader should understand that these specific examples are set forth merely to illustrate examples of the disclosure, and they should not be construed as limiting the disclosure.

B. Specific Examples of the Disclosure

[0042] FIGS. **1-3** generally illustrate example golf clubs **100** in accordance with at least certain aspects of this disclosure. FIGS. **4-9** generally illustrate various embodiments of angle adjustment discontinuities according to aspects of this disclosure.

[0043] Referring to FIG. **1**, the club **100** includes a club head **102** and a club shaft **106**. The club shaft **106** has a proximal end where a golfer grips the shaft (not shown), a distal end where the club head **102** is attached to shaft **106**, and a longitudinal axis (L) extending along the length of the shaft from the proximal to the distal end.

[0044] As shown in FIG. **1**, the club head **102** includes a main body **120**, a neck **130** and a club head-to-shaft connection region **140**. The club head **102** may be attached to the distal end of the club shaft **106** at the club head-to-shaft connection region **140**. The club head-to-shaft connection region **140** may be provided by a hosel **142**. The club head-to-shaft connection region **140** may be defined as the region where the shaft **106** and the club head **102** overlap. In certain embodiments, the club head-to-shaft connection region **140** is that region where the distal end of the club shaft **106** and the hosel **142** overlap.

[0045] The club head **102** includes a main body **120** that extends from a heel region **122** to a toe region **124**. A ball-striking face member **126** may be provided on the front face of the main body **120**. Neck region **130** extends between the main body **120** and the club head-to-shaft connection region **140**. The neck region **130** generally includes an elongated structure that extends generally in the same direction as the longitudinal axis L of the club shaft **106**. The main body **120** extends from the neck region **130** in a direction that is generally transverse to the direction of extension of the neck region **130**. However, it is recognized that the demarcation between the heel region **122** of the main body **120** and the neck region **130** may not be clearly defined. Thus, a transition region **132** is defined where the neck region **130** and the heel region **122** merge. Transition region **132** may include portions of both the neck region **130** and the heel region **122**.

[0046] An angle adjustment discontinuity **150** is provided on the club head **102**. The angle adjustment discontinuity **150** is located below the club head-to-shaft connection region **140**. In other words, the angle adjustment discontinuity **150** is located distally beyond the distal end of the golf club shaft. In certain aspects, the angle adjustment discontinuity **150** may be located in the neck region **130**. In other aspects, the angle adjustment discontinuity **150** may be located in the transition region **132**. In even other aspects, the angle adjustment discontinuity **150** may be located in the heel region **122**.

[0047] The angle adjustment discontinuity **150** facilitates the adjustment of the angle (lie and/or loft) of the club shaft **106** relative to the club head **102**. This angle of the club shaft **106** relative to the club head **102** may be adjusted by deforming (e.g., bending) the club head **102** at a bend line **125**. The bend line **125** is located below the head-to-shaft connection region **140** and may be located in the neck region **130**, the heel region **122**, or the transition region **132**. According to certain aspects, the angle adjustment discontinuity **150** may reduce bending stresses and reduce or eliminate undesirable deformations when the angle of the club shaft **106** is changed. According to other aspects, the angle adjustment discontinuity **150** may assist in defining the location of the bend line **125**.

[0048] A range of desired angle adjustments may be accommodated without departing from this disclosure. By way of non-limiting example, adjustments of at least 0.25 degrees, at least 0.5 degrees, at least 1 degree, at least 2 degrees, at least 4 degrees, or even at least 8 degrees may be accommodated by the angle adjustment discontinuity. In some example structures, the desired adjustment will be between 0.25 and 25 degrees, between 0.5 and 15 degrees, between 1 and 10 degrees, or even between 1 and 5 degrees.

[0049] The angle adjustment discontinuity **150** in accordance with some aspects of this disclosure will now be described in more detail with reference to FIGS. **2** and **4** through **10**.

[0050] As shown in FIG. **2**, the angle adjustment discontinuity **150** includes a plurality of grooves **152** located in the transition region **132**. A groove is a relatively long, narrow channel, i.e. a groove has a length that is elongated compared to its width. According to certain aspects, a groove may be defined as having a length-to-width ratio of 5 or more. More typically, a groove may have a length-to-width ratio of 10 or more, or 15 or more, or even 20 or more.

[0051] In FIG. **2** a series of three concentric, circular grooves **152***a*-**152***c* are illustrated. Each of these grooves **152** extends in at least two dimensions: over a transverse distance and over a longitudinal distance. A transverse distance is measured perpendicular to the longitudinal axis L of the club shaft **106**. A longitudinal distance is measured in a direction that is aligned with the longitudinal axis L of the club shaft **106**. In other words, the grooves **152** do not lie in a plane that is perpendicular to the longitudinal axis L of the club shaft **106**. For example, referring to FIG. **2**, the outermost groove **152***c* extends over a transverse distance DT and a longitudinal distance DL.

[0052] In the embodiment shown in FIGS. **1**-**3**, the grooves **152** form closed loops.

[0053] However, these grooves are not circumferential grooves, i.e., the closed loops of the grooves **152** do not encircle the longitudinal axis L. Rather, the closed loops of the grooves **152** encircle an axis that is extends at an angle to the longitudinal axis. The groove **152***b* extends around groove **152***a*; groove **152***c* extends around both groove **152***b* and groove **152***a*. Further, the grooves **152***a*-**152***c* extend substantially parallel to each other, when viewed perpendicular to the surface of the transition region **132**. For purposes of this disclosure, a person of ordinary skill in the art would recognize when grooves are substantially parallel. By way of non-limiting example, grooves that deviate from the parallel by 5 or even 10 degrees would be considered substantially parallel.

[0054] In general, when the angle of the longitudinal axis L of the club shaft **106** is adjusted relative to the main body **120**, the material at the bendline **125** undergoes permanent deformation. The grooves **152** may provide a strain relief feature, in that the sides of the groove channels **154** may be deformed toward or away from one another when the club shaft angle is adjusted. With a groove **152** extending in both a transverse and a longitudinal direction on the surface of the club head **102**, strain relief in both the transverse and the longitudinal directions may be provided. The grooves **152** may be formed by any conventional method, including for example by casting, forging, molding, machining, etching, incising, scoring etc.

[0055] The cross-sectional shape of the groove channels **154** may be substantially rectangular, rounded, triangular, or any other suitable shape. For example, in FIGS. **4** and **4**A, grooves **152***a*-**152***c* have groove channels **154***a*-**154***c* with substantially triangular cross sections. The depth of the groove channel (d) may range from 0.1 mm to 5 mm. A depth greater than 0.5 mm, or greater than 1 mm, or even greater than 1.5 mm may be most desirable. Further, the width of the groove channels as measured at the surface (w) may range from 0.1 mm to 5 mm. A width of greater than 0.5 mm, or greater than 1 mm, or even greater than 1.5 mm may be most desirable.

[0056] In general, the groove channels may range from very shallow to very deep. Thus, for example, groove channels may have a width-to-depth ratio of 0.5, or 0.2 or even 0.1 or less for grooves that are considered to be deep. For shallow grooves, the width-to-depth ratio of 1.5 or more may be suitable, including for example ratios of 2, or 5, or even of 10 or greater. This width-to-depth ratio need not be constant for any given groove.

[0057] As shown in FIG. **4**A, the depth dimensions (d) of the groove channels **154***a*-**154***c* are oriented substantially perpendicular to the surface (S). Slight deviations from the perpendicular, for example, by 5, 10, or even 15 degrees, would still be considered substantially perpendicular. Further, the depths of the groove channels **154***a*-**154***c* for each of the grooves **152***a*-**152***c* are substantially equal. FIG. **5** illustrates an alternative embodiment for grooves **152***a*-**152***c* of FIGS. **1**-**3**. In this alternative embodiment, grooves **152***a*'-**154***c*' have groove channels **154***a*'-**154***c*' with substantially rectangular cross sections. The depth dimensions of the groove channels **154***a*'-**154***c*' are oriented parallel to one another. Further, the depths d_a, d_b, d_c of the groove channels **154***a*'-**154***c*' vary for the different grooves.

[0058] Thus it can be seen that the plurality of grooves **152** need not have the same cross-sectional shape or dimensions. By way of non-limiting example, a first groove may have a depth (and/or a width) that is different than the depth (and/or width) of a second groove. Further, each individual groove need not have the same cross-sectional shape or dimension along its length. Thus, by way of other non-limiting examples, the depth of any one groove may vary along the length of the groove and/or the width of any one groove may vary along the length of the groove. Further, the plurality of grooves **152** need not be equally spaced from each other.

[0059] Referring back to FIG. **4**, an angle α defines the extent to which the angle adjustment discontinuity **150** extends around the longitudinal axis L. In this particular embodiment, the angle α also defines the extent to which the groove **152***c* extends around the longitudinal axis L.

[0060] FIG. **6** illustrates aspects of the disclosure wherein the adjustment feature includes two grooves **152***d* and **152***e*, each extending in both a transverse and a longitudinal direction on the surface of the club head **102** in the transition region **132**. These grooves are generally elliptical in shape. Further, these grooves are shown being substantially parallel to each other, when view from a perpendicular to the surface in the transition region **132**. Even further, grooves **152***d* and **152***e* are substantially positioned with respect to a common center.

[0061] FIG. **7** illustrates other aspects of the disclosure wherein the adjustment feature **150** includes three grooves **152***f*, **152***g* and **152***h*, each extending in both a transverse and a longitudinal direction on the surface of the club head **102** in the transition region **132**. Groove **152***f* is rectangular; groove **152***g* is elliptical; and groove **152***h* is circular. Grooves **152***f*-**152***h* have a common center.

[0062] FIG. **8** illustrates even other aspects of the disclosure wherein the adjustment feature **150** includes six grooves **152***i*-**152***n*, each extending in both a transverse and a longitudinal direction on the surface of the club head **102** in the transition region **132**. Grooves **152***i* and **152***j* are segments of a circle of a first radius, with the segments placed in mirror-image opposition to one another. Grooves **152***k* and **152***n* are segments of a circle of a second radius, equally spaced on a circle of the second radius. Thus, it can be seen that groove **152***k* extends substantially in the longitudinal direction, but also extends in the transverse direction and that groove **152***l* extends substantially in the transverse direction, but also extends in the longitudinal direction. FIG. **9** illustrates certain other aspects of the disclosure wherein the adjustment feature

150 includes a single, circular, spiral groove **152***o* extending in both a transverse and a longitudinal direction on the surface of the club head **102**. The axis of the spiral is not aligned with the longitudinal axis L. Indeed, the axis of the spiral is substantially perpendicular to the longitudinal axis L. The number of windings of the spiral is not critical. Further, the windings need not be even spaced from the center of the spiral. Even further, the spiral need not be based on a circle, but could be based on an elliptical, square, rectangular, triangular, or other regular or irregular shapes.

[0063] FIG. **10** illustrates even other aspects of the disclosure wherein the adjustment feature **150** includes at least one chevron-like groove **152***p* extending in both a transverse direction and a longitudinal direction on the surface of the club head **102**. This particular groove embodiment further includes a second chevron-like groove **152***q*. The points of the chevron-like grooves **152***p*, **152***q* are shown facing away from each other in the embodiment of FIG. **10**. Alternatively, the points of the chevrons may face toward each other, may face in the same direction, or may face in any direction. The chevron-like grooves may have relatively low groove length-to-width ratios. The length (l) of the chevron-like groove may be taken as the sum of the length of each leg of the chevron; the width (w) of the chevron-like groove is, at its maximum, the dimension across the groove where the legs of the chevron meet. By way of non-limiting example, the groove length-to width ratio may range from approximately 3 to approximately 30.

[0064] Club head **102** may be formed as a unitary piece (i.e., a single piece) or assembled from multiple pieces. The various parts of the club heads **102** may be made from conventional materials, in conventional constructions, in conventional manners, as are known and used in the art, optionally modified (if necessary, e.g., in size, shape, etc.) to accommodate the lie angle adjustment discontinuities described herein. For example, one or more of the various parts comprising the club head **102** may be made from a metal material, including lightweight metals conventionally used in golf club head constructions, such as aluminum, titanium, magnesium, nickel, alloys of these materials, steel, stainless steel, and the like, optionally anodized finished materials. Alternatively, if desired, one or more of the various parts of the club head **102** may be made from rigid polymeric materials, such as polymeric materials conventionally known and used in the golf club industry. The various parts of the club head **102** may be made from the same or different materials without departing from this disclosure. The parts may be made in conventional manners as are known and used in the metal working and/or polymer production arts. Further, any desired materials also may be used for the shaft **106**, including conventional materials that are known and used in the art, such as steel, graphite, polymers, composite materials, combinations of these materials, etc. Even further, the club head **102** may be attached to the club shaft **106** in any known manner using conventional fittings and materials. For example, the club head **102** may be permanently attached to the club shaft **106**, via bonding, brazing, welding, cements, adhesives, etc., or the club head **102** may be releasably attached to the club shaft, via threads, mechanical fasteners, etc. Optionally, a grip member (not shown) may be provided at the proximal end of the shaft **106**.

[0065] Many variations in the overall structure of the shaft, club head, and club head/shaft connection assembly are possible without departing from this disclosure. For example, more than one angle adjustment discontinuity may be provided on the club head. The first and second angle adjustment discontinuities may be located on opposite sides of the longitudinal axis. While an iron-type golf club head is illustrated in these figures, aspects of this disclosure may be applied to any type of club head, including, for example: fairway wood club heads; driver/wood-type golf club heads; hybrid golf club heads; putter heads; and the like.

Conclusion

[0066] While the disclosure has been described in detail in terms of specific examples including presently preferred modes of carrying out the disclosure, those skilled in the art will appreciate that there are numerous variations and permutations of the above described features and systems. Thus, the spirit and scope of the disclosure should be construed broadly as set forth in the appended claims.

We claim:

1. A golf club comprising:
- a golf club shaft having a proximal end, a distal end, and a longitudinal axis defining a longitudinal direction extending therebetween; and
- a golf club head attached to the distal end of the golf club shaft, the head including:
  - an angle adjustment discontinuity located below the distal end of the golf club shaft, the angle adjustment discontinuity including a first elongated groove extending over both a transverse distance and a longitudinal distance, the first elongated groove not encircling the longitudinal axis.

2. The golf club according to claim **1**, wherein the first groove forms a closed loop.

3. The golf club according to claim **1**, further including a second elongated groove extending over both a transverse distance and a longitudinal distance, the second elongated groove not encircling the longitudinal axis.

4. The golf club according to claim **3**, wherein the second elongated groove extends substantially parallel to the first elongated groove.

5. The golf club according to claim **1**, wherein the angle adjustment discontinuity is symmetric with respect to an axis parallel to the longitudinal axis.

6. The golf club according to claim **1**, wherein the angle adjustment discontinuity is symmetric with respect to an axis perpendicular to the longitudinal axis.

7. The golf club according to claim **1**, wherein the first elongated groove does not extend more than 180 degrees around the longitudinal axis.

8. The golf club according to claim **1**, wherein the head includes a neck region and wherein the first elongated groove is located at least partially in the neck region.

9. The golf club according to claim **1**, wherein the head includes a heel region and wherein the first elongated groove is located at least partially in the heel region.

10. The golf club according to claim **1**, further including at least a third elongated groove.

11. A golf club comprising:
- a golf club shaft having a proximal end, a distal end, and a longitudinal axis defining a longitudinal direction extending therebetween; and
- a golf club head attached to the distal end of the golf club shaft, the head including:
  - a means for relieving strain located below the distal end of the golf club shaft, the means for relieving strain including a first elongated gap-forming element

extending over both a transverse distance and a longitudinal distance, the first elongated gap-forming element not encircling the longitudinal axis.

12. The golf club according to claim **11**, wherein the second elongated gap-forming element extends substantially parallel to the first elongated gap-forming element.

13. The golf club according to claim **11**, wherein the first elongated gap-forming element forms a closed loop that does not encircle the longitudinal axis.

14. The golf club according to claim **11**, wherein the means for relieving strain is symmetric with respect to an axis parallel to the longitudinal axis.

15. The golf club according to claim **11**, wherein the means for relieving strain is symmetric with respect to an axis perpendicular to the longitudinal axis.

16. The golf club according to claim **11**, wherein the first elongated gap-forming element does not extend more than **180** degrees around the longitudinal axis.

17. The golf club according to claim **11**, wherein the head includes a neck region and wherein the first elongated gap-forming element is located at least partially in the neck region.

18. The golf club according to claim **11**, wherein the head includes a heel region and wherein the first elongated gap-forming element is located at least partially in the heel region.

19. The golf club according to claim **11**, further including at least a third elongated gap-forming element.

20. A golf club head comprising:

a main body extending from a heel region to a toe region;

a neck region extending from the heel region to a connection region and defining a longitudinal axis, the connection region configured for attachment to a distal end of a golf club shaft; and

an angle adjustment discontinuity located below the connection region, the angle adjustment discontinuity including a first elongated groove extending over both a transverse distance and a longitudinal distance, the first elongated groove not encircling the longitudinal axis.

21. A golf club comprising:

a golf club shaft having a proximal end, a distal end, and a longitudinal axis defining a longitudinal direction extending therebetween; and

a golf club head attached to the distal end of the golf club shaft, the head including:

an angle adjustment discontinuity located below the distal end of the golf club shaft, the angle adjustment discontinuity including a first elongated groove extending over both a transverse distance and a longitudinal distance and a second elongated groove extending over both a transverse distance and a longitudinal distance.

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