US 20100234125A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2010/0234125 A1**

(43) **Pub. Date: Sep. 16, 2010**

Aoyama et al.

(54) **HIGH LAUNCH AND LOW SPIN GOLF BALL AND GOLF CLUB COMBINATION**

(76) Inventors: **Steven Aoyama**, Marion, MA (US); **Andrew Curtis**, Carlsbad, CA (US); **Daniel Stone**, Carlsbad, CA (US)

Correspondence Address:
ACUSHNET COMPANY
333 BRIDGE STREET, P. O. BOX 965
FAIRHAVEN, MA 02719 (US)

(21) Appl. No.: **12/404,701**

(22) Filed: **Mar. 16, 2009**

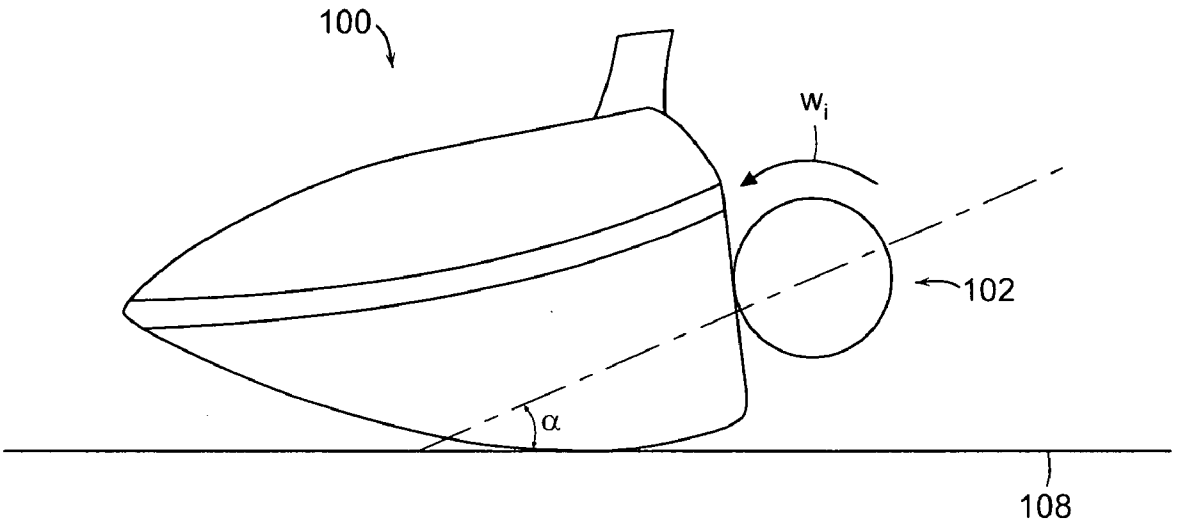
Publication Classification

(51) **Int. Cl.**
A63B 53/04 (2006.01)

(52) **U.S. Cl.** **473/324**; 473/409

(57) **ABSTRACT**

The present invention is directed to a golf club and golf ball combination that maximizes the distance of travel when the golf club strikes the golf ball. More specifically, a golf club and golf ball combination capable of generating a higher launch angle combined with the lower spin rate to maximize the distance. The golf club in accordance with the present invention may generally have a lower center of gravity, a higher loft angle, or may even have a coating on the club face that optimizes the coefficient of friction between the golf club and the golf ball. The golf ball in accordance with the present invention may generally have a ratio of the coefficient of lift (C_L) near the beginning of flight to the coefficient of lift near the end of the flight within a range that maximizes flight distance, with similar ratios in appropriate ranges for the coefficient of drag (C_D) and the lift-to-drag ratio (C_L/C_D).



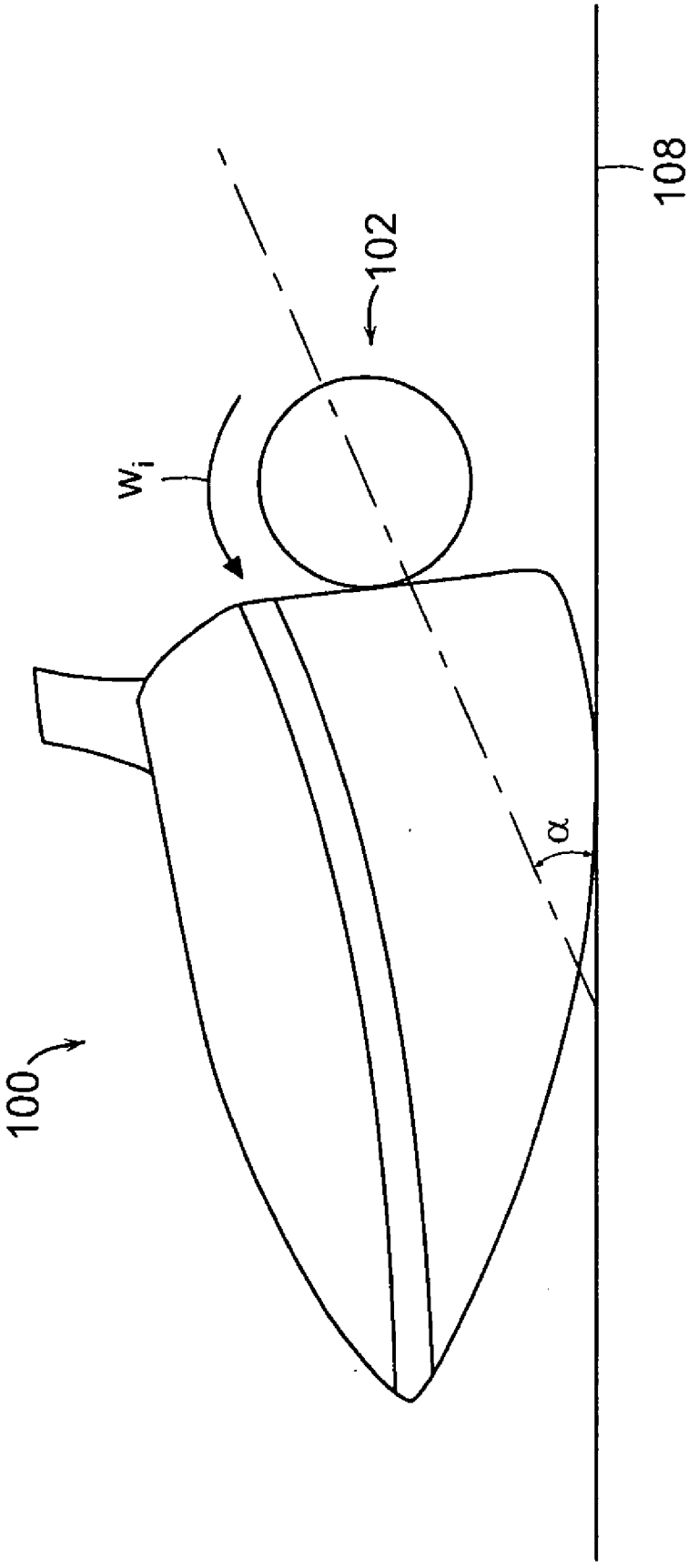


FIG. 1

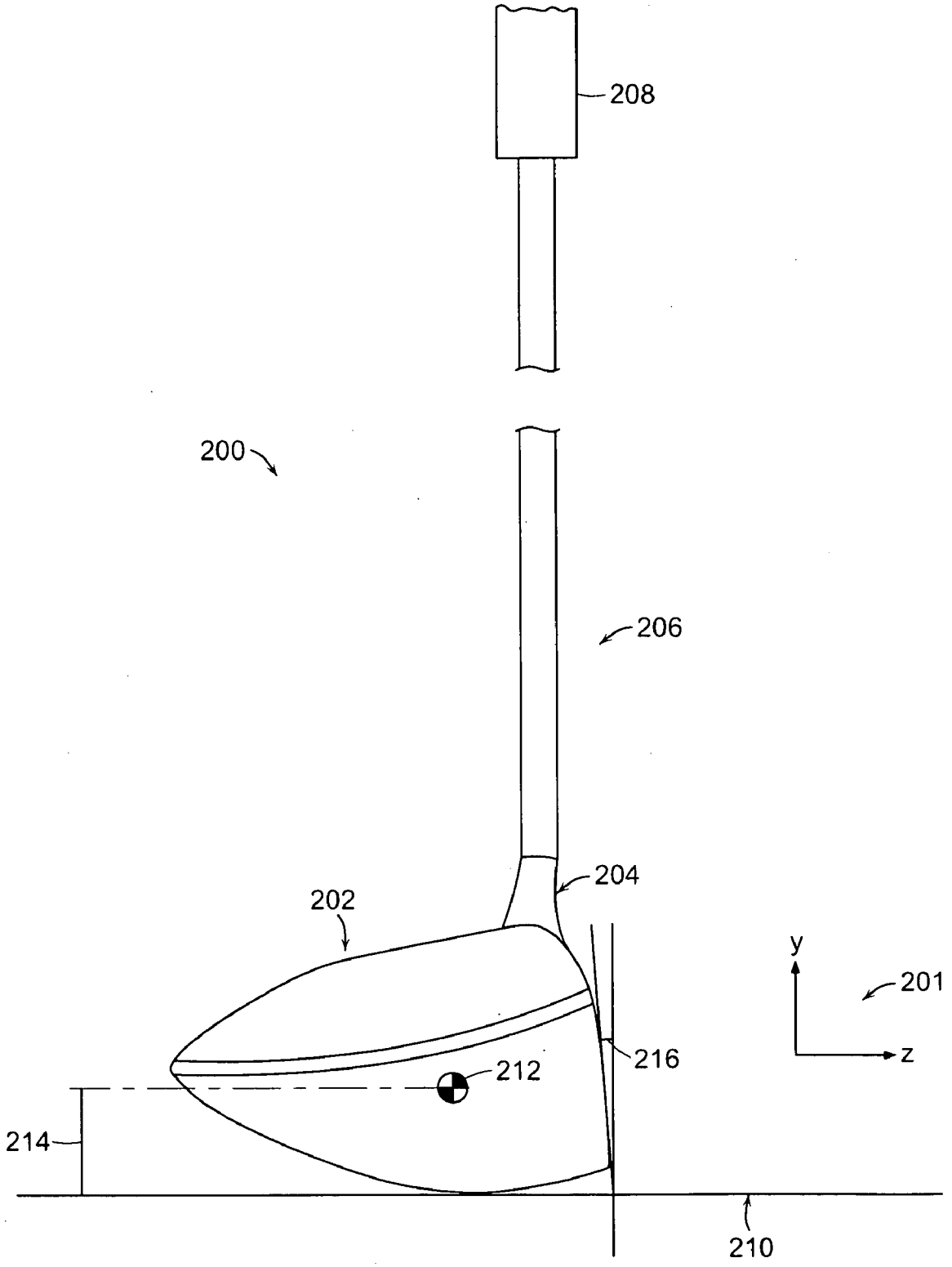


FIG. 2

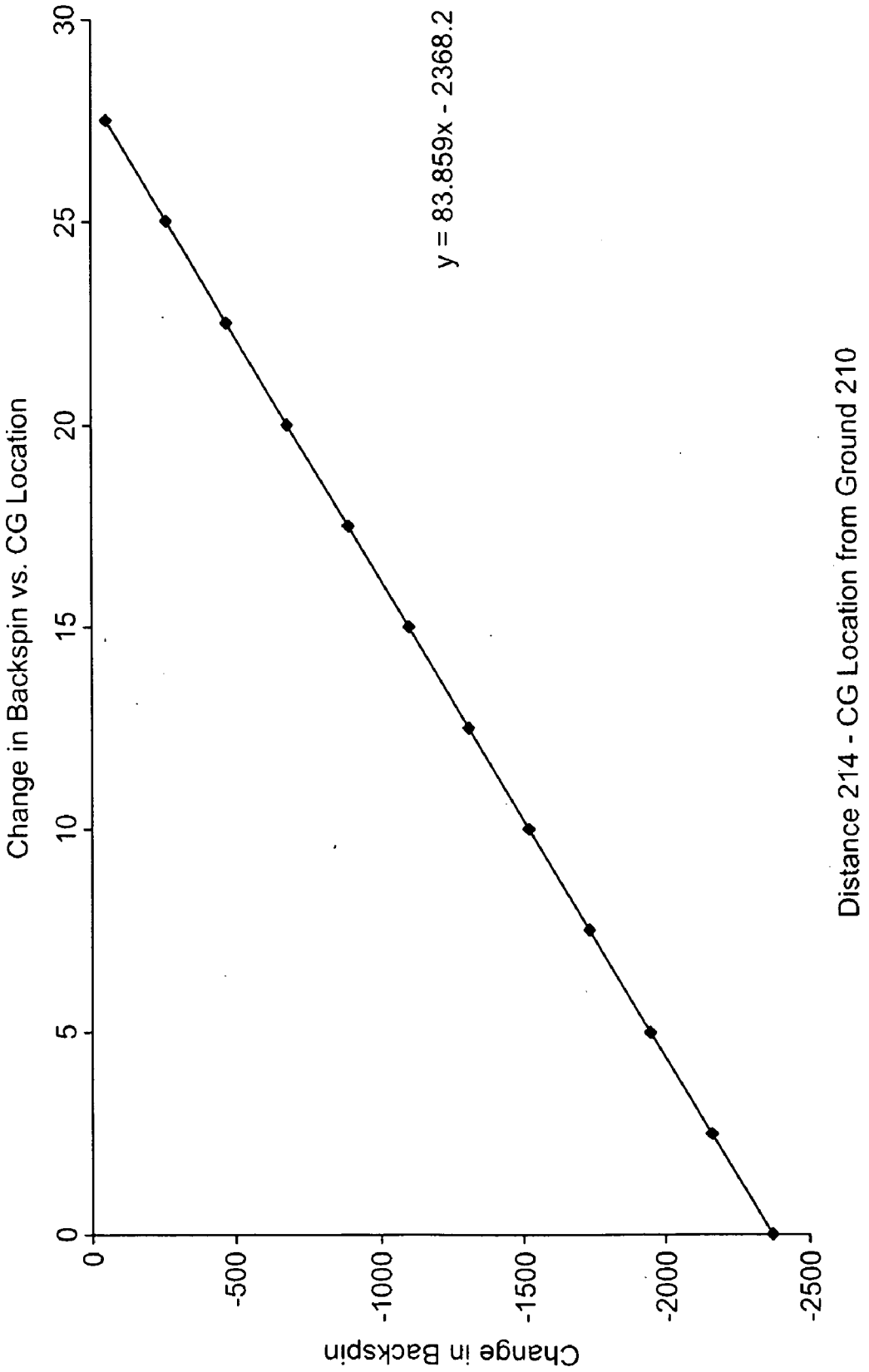

Change in Backspin vs. CG Location
y = 83.859x - 2368.2
Change in Backspin
Distance 214 - CG Location from Ground 210
0
-500
-1000
-1500
-2000
-2500
0
5
10
15
20
25
30

FIG. 3

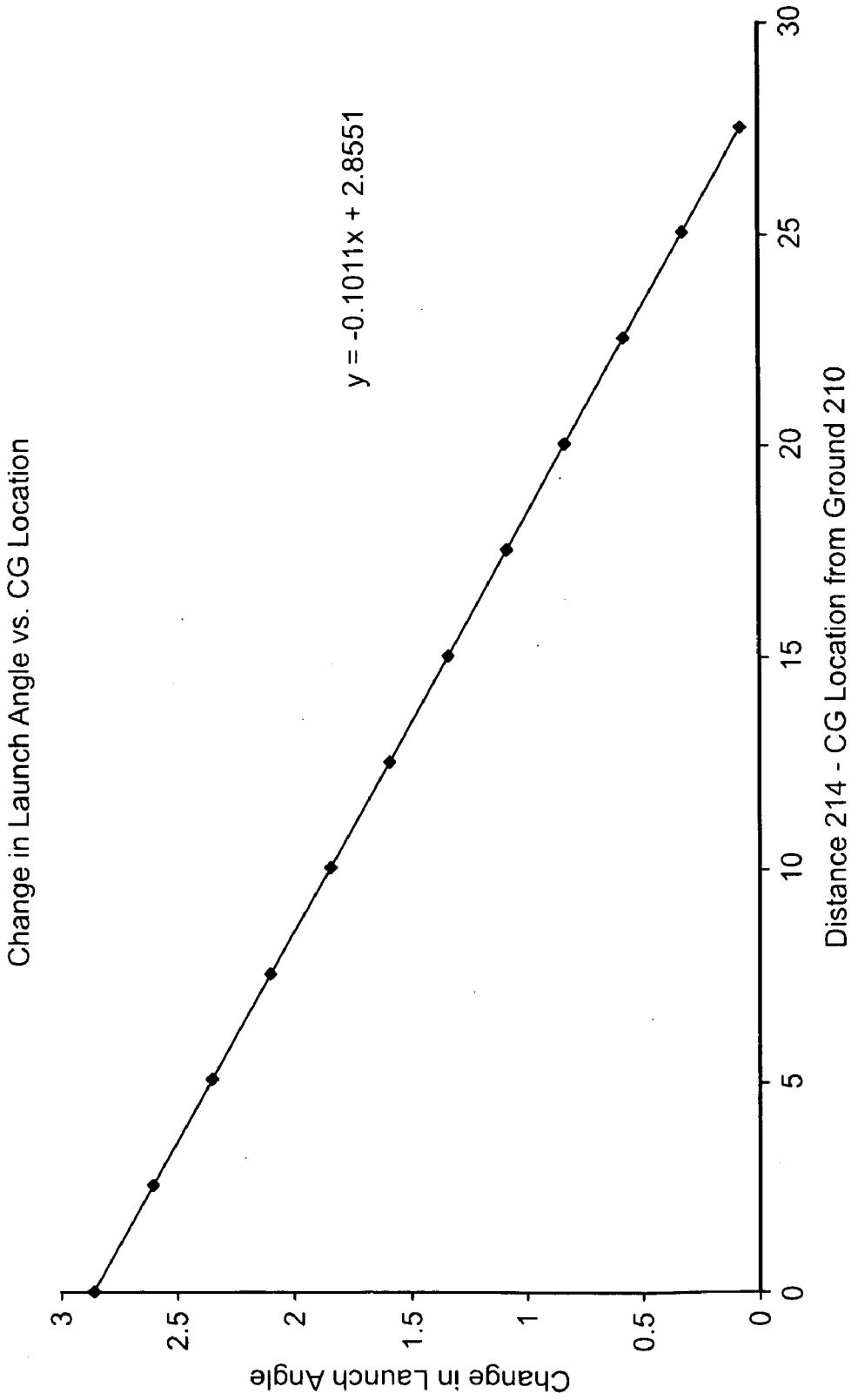

Change in Launch Angle vs. CG Location
y = -0.1011x + 2.8551
Change in Launch Angle
Distance 214 - CG Location from Ground 210
0
0.5
1
1.5
2
2.5
3
0
5
10
15
20
25
30

FIG. 4

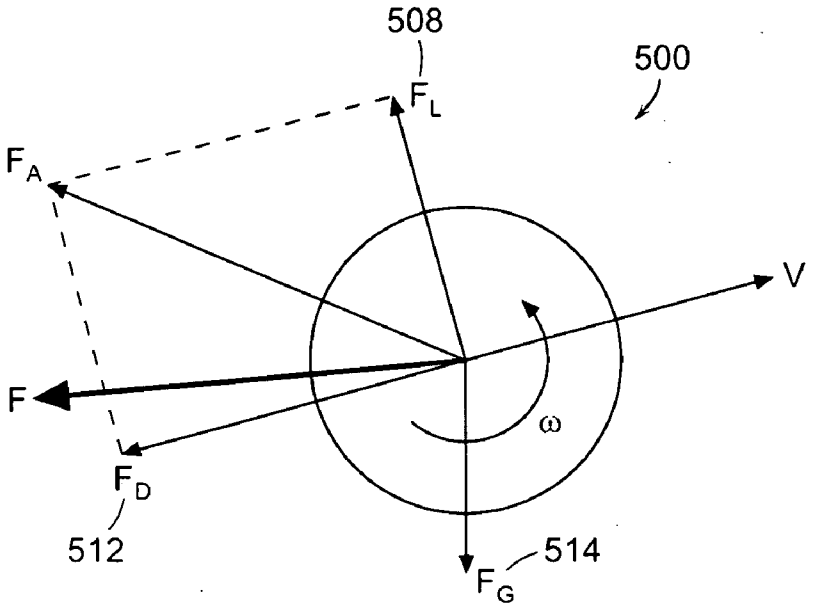


FIG. 5

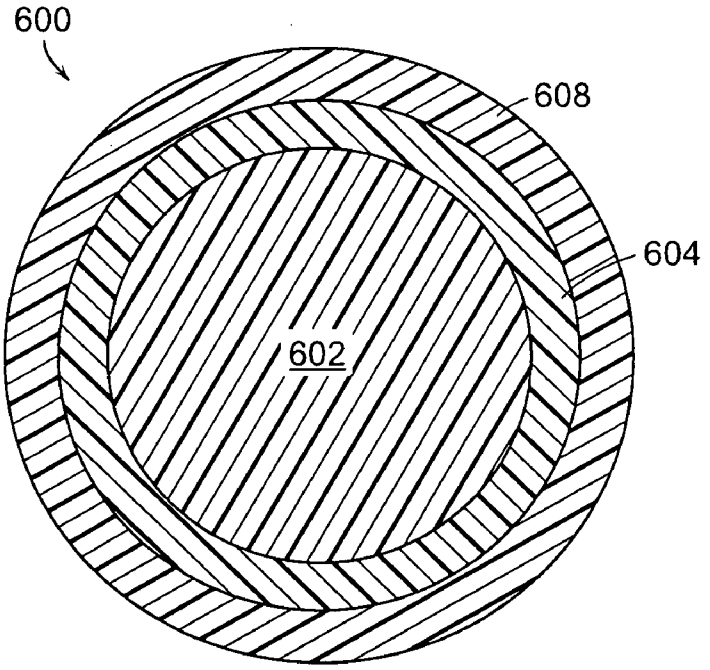


FIG. 6

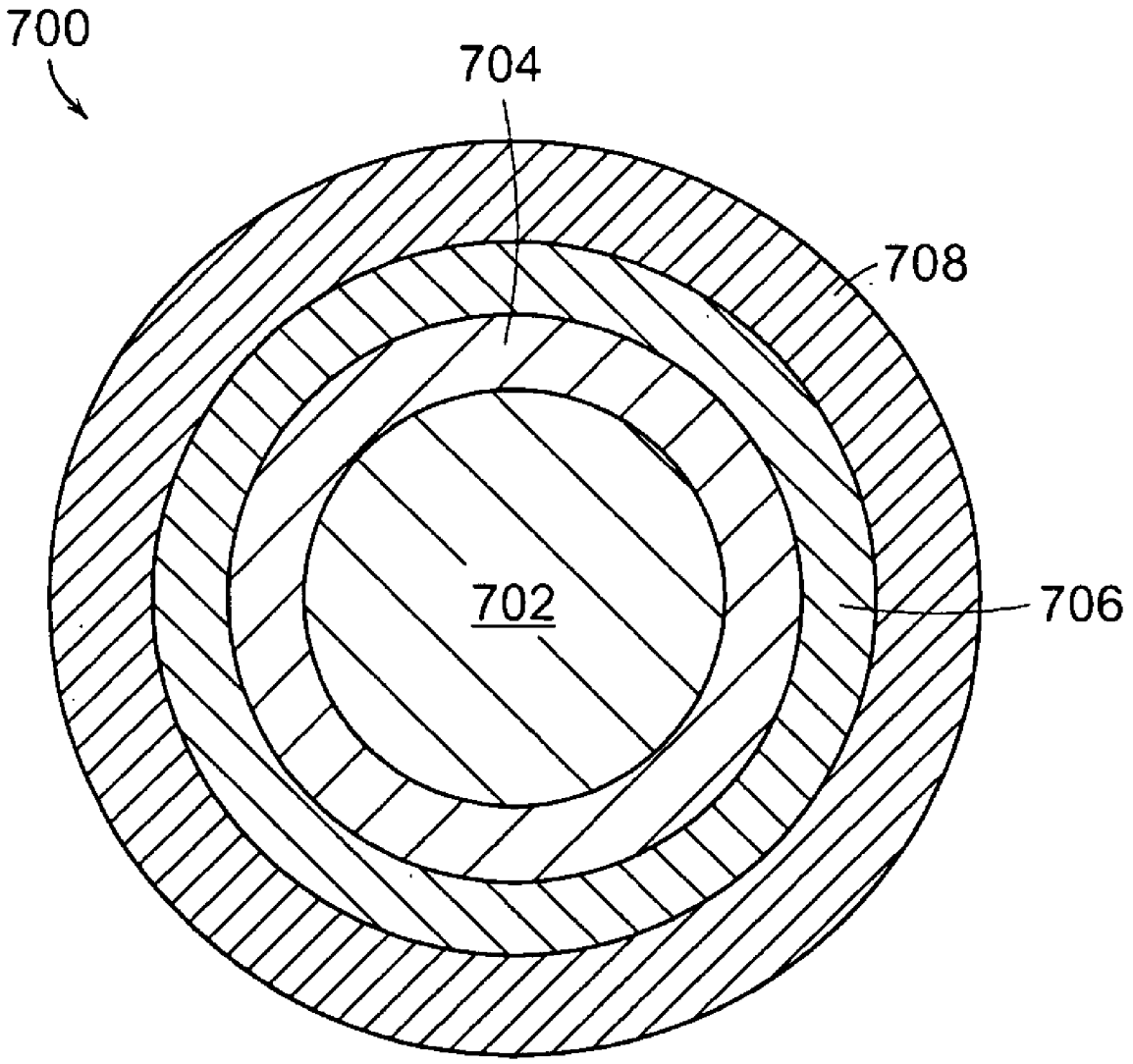


FIG. 7

HIGH LAUNCH AND LOW SPIN GOLF BALL AND GOLF CLUB COMBINATION

FIELD OF THE INVENTION

[0001] The present invention relates to a golf club and golf ball combination that creates high launch and low spin characteristics that maximize the travel distance of a golf ball after impact with a golf club. More specifically, the present invention relates to a golf club capable of generating a high launch angle and a low spin rate via a lower center of gravity. Additionally the present invention also relates to a golf ball having an unusually low spin rate along with certain ratios of the coefficient of lift (C_L), coefficient of drag (C_D), and the lift-to-drag ratio (C_L/C_D) measured near the beginning of the flight to the same parameters measured later in flight.

BACKGROUND OF THE INVENTION

[0002] The complexities of golf club design are known; further, the complexities of golf ball design are also known. The design specifications for a golf club and a golf ball directly impact the launch conditions generated by a golf swing. Designed separately, the design of a golf club and a golf ball can both individually contribute to improved performance characteristics such as high launch and low spin. However, these designs, although effective in maximizing launch angle and minimizing spin rate individually, fail to take into consideration the additional performance gains that are possible by correctly matching a golf club and a golf ball. Thus, varying the performance characteristics of a golf club in parallel with the performance characteristic of a golf ball can produce a synergistic improvement in the performance characteristics of both of the components.

[0003] With respect to the improvements in golf club heads, the current industry has been focused primarily on creating a golf club head that controls and improves the flight characteristics of a golf ball after impact with the golf club head. Amongst the prominent considerations in golf club head design are loft, lie, face angle, horizontal face bulge, vertical face roll, center of gravity, rotational moment of inertia, material selection, and overall head weight. In addition to the above mentioned design variations, the center of gravity is often adjusted to be moved to various locations within the golf club head to increase launch angle and control the spin of the golf ball. One example is described in U.S. Pat. No. 7,407,447 to Beach et al. for a Movable Weight for a Golf Club Head. In that example, embodiments of movable weights, such as weight assemblies and weight screws, for a golf club head are disclosed. More specifically, in one configuration, the club head CG is in a center-back location, resulting in a high launch angle and a relatively low initial spin rate for optimal distance.

[0004] Another example is described in U.S. Pat. App. 2007/0155532 to Adams for a Golf Club Head. In that example, a golf club head includes a club head body having a striking face, a soleplate, a toe, a heel and a hosel, wherein at least a portion of the body shell is composed of a flexible material having a density of less than approximately 2.5 g/cm^3, and a tensile strength of at least approximately 465 $MPa/(g/cm^3)$. More specifically, one may position the weight member(s) on the soleplate, but position it all the way back to increase launch angle while keeping the backspin relatively low (High Launch/Low Spin) or position it all the way forward to control launch angle, lower spin and also lower the amount of gear effect spin caused by off-center hits.

[0005] With respect to golf ball design, the golfing industry has been struggling between the two dichotomies of golf ball designs to either create a hard ball with enhanced flight characteristics or a soft ball with enhanced feel and control. Hard golf balls that have good flight characteristics as well as good rebounding characteristics that minimize spin can tend to sacrifice feel and control. Soft golf balls on the other hand, although capable of providing great feel and control, have less than optimal rebounding characteristics, and generally create too much spin to maximize distance.

[0006] One example of a hard ball design can be seen in U.S. Pat. No. 6,743,124 to Tsunoda et al. for a Golf Ball. In that example, a golf ball with a low spin rate, a high launch angle, and an increased flight distance is characterized by a ratio of primary natural frequency of the golf ball in a direction in which the ball deforms to a primary natural frequency of the ball in vibration mode along a direction of torsion (f_c/f_n) being in the range of 2.22 to 2.45. More specifically, the solid core can effectively be formed from a plurality of layers having a complex modulus smallest at the inner core, larger at the intermediate layer(s) and the largest at the outermost layer to achieve a value (f_c/f_n) in the range of 2.22 to 2.45.

[0007] Alternatively, other examples attempt to strike a balance between a hard golf ball having increased distance and a soft golf ball having increased feel and control. For example, in U.S. Pat. No. 7,232,383 to Kato et al. for a Three-Piece Solid Golf Ball, a three-piece solid golf ball having long flight distance by accomplishing low ball rotation rate and high launch angle at the time of hitting while maintaining good shot feel is disclosed. More specifically, a three-piece solid golf ball comprising a core composed of a center and an intermediate layer formed on the center, and a cover covering the core and having many dimples on the surface thereof is disclosed.

[0008] In another example described by U.S. Pat. No. 7,354,357 to Sullivan et al., a Multi-Layer Core Golf Ball having an improved multi-layer construction displaying enhanced playing characteristics including high speed, high launch, and low spin is disclosed. More specifically, a golf ball that displays improved performance in areas such as distance and feel for lower swing speed players having a relatively large solid inner core, with at least one solid outer core layer surrounding the inner core, and a thin cover layer surrounding the outermost core layer is disclosed.

[0009] Despite numerous attempts to improve ball flight characteristics in terms of high launch and low spin, the current art has been focused on addressing each of the two important components separately. More specifically, the current art utilizes shifting of weights in a golf club head as well as shifts in the center of gravity location within a golf club head without any consideration for a matching ball design. Alternatively, the current art has also attempted to address the problem by focusing on golf ball design utilizing multiple materials having different hardnesses, different core constructions, or even different complex modulus variations with little consideration for matching the golf club head.

[0010] Hence, it can be seen that there is a need in the field for a golf club and golf ball combination that work in conjunction to optimize and enhance the performance characteristics of the respectively paired equipment. More specifically, there is a need for a golf club that optimizes its design characteristics around that of a golf ball to maximize high launch

and low spin; and for a golf ball that optimizes its design characteristics around that of a golf club to maximize high launch and low spin, while providing matching aerodynamics to optimize the overall flight performance.

BRIEF SUMMARY OF THE INVENTION

[0011] In one aspect of the present invention, a golf club and ball combination may comprises a golf club and a golf ball; wherein said golf ball achieves a launch angle (α) and an initial spin rate (ω_i) relationship defined as $86\alpha+\omega_i \leqq 4310$ (where α is in degrees and ω_i is in rpm) when struck by the golf club.

[0012] In another aspect of the present invention, a golf club and ball combination comprises a golf ball with a beginning to end coefficient of lift ratio of 0.64 to 3.20, a beginning to end coefficient of drag ratio of 0.76 to 0.99, and a beginning to end ratio of lift to drag ratio of 0.65 to 3.40; and a golf club with a center of gravity located 10 mm to 30 mm above a ground level. "Beginning to end" coefficient ratios, as used in the current invention may generally refer to the coefficient measured during the beginning (ascent) portion of the flight divided by the coefficient measured during the end (descent) portion of the flight.

[0013] In a further aspect of the present invention, a method of maximizing travel distance of a golf ball comprises adjusting a center of gravity of a golf club to be located 10 mm to 30 mm above a ground level of the golf club, adjusting a beginning to end coefficient of lift ratio for the golf ball to be 0.64 to 3.20, adjusting a beginning to end coefficient of drag ratio of the golf ball to be 0.76 to 0.99, and adjusting a beginning to end ratio of lift to drag ratio of the golf ball to be 0.65 to 3.40; wherein the golf ball achieves a launch angle (α) and an initial spin rate (ω_i) relationship defined as $86\alpha+\omega_i \leqq 3710$ when struck by the golf club.

[0014] These and other features, aspects and advantages of the present invention will become better understood with references to the following drawings, description and claims.

BRIEF DESCRIPTION OF DRAWINGS

[0015] The foregoing and other features and advantages of the invention will be apparent from the following description of the invention as illustrated in the accompanying drawings. The accompanying drawings, which are incorporated herein and form a part of the specification, further serve to explain the principles of the invention and to enable a person skilled in the pertinent art to make and use the invention.

[0016] FIG. **1** shows a perspective view of a golf club head and a golf ball in accordance with an embodiment of the present invention;

[0017] FIG. **2** shows a perspective view of a golf club in accordance with an embodiment of the present invention;

[0018] FIG. **3** shows a graphical representation of the effect of the center of gravity (CG) location on initial backspin;

[0019] FIG. **4** shows a graphical representation of the effect of the center of gravity (CG) location on launch angle;

[0020] FIG. **5** shows the forces acting on a golf ball in flight;

[0021] FIG. **6** shows a cross-sectional view of a golf ball in accordance with an embodiment of the present invention; and

[0022] FIG. **7** shows a further cross-sectional view of a golf ball in accordance with a further alternative embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The following detailed description is of the best currently contemplated modes of carrying out the invention. The description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention, since the scope of the invention is best defined by the appended claims.

[0024] Various inventive features are described below and can each be used independently of one another or in combination with other features. However, any single inventive feature may not address any or all of the problems discussed above or may only address one of the problems discussed above. Further, one or more of the problems discussed above may not be fully addressed by any of the features described below.

[0025] The present invention generally relates to a golf club and golf ball combination that create a high launch and low spinning golf ball upon impact with a golf club. More specifically, the present invention relates to a golf club and golf ball combination wherein the golf ball achieves a launch angle α and an initial spin rate ω_i that satisfy the following relationship when struck by the golf club:

$$86\alpha+\omega_i \leqq 4310 \quad \text{(Eq. 1)}$$

where

[0026] α is in degrees

[0027] ω_i is in rpm

Even more specifically the present invention relates to a golf club having a lower center of gravity and/or a higher loft combined with a golf ball having a beginning to end coefficient of lift ratio of 0.64 to 3.20, a beginning to end coefficient of drag ratio of 0.76 to 0.99, and a beginning to end ratio of lift to drag ratio of 0.65 to 3.40. The current invention is unlike the prior art approaches on creating a high launch and low spinning golf ball that only focuses on the individual components such as a golf cub or a golf ball separately. Focusing on the individual components without taking in consideration of the additional performance enhancement capabilities that can be achieved by simultaneously adjusting and pairing the performance characteristics of both the golf club and the golf ball may not maximize the performance characteristics that can be achieved when the two components are designed in parallel with one another.

[0028] FIG. **1** shows a golf club **100** and golf ball **102** combination in accordance with an embodiment of the present invention. More specifically, FIG. **1** shows the initial spin rate ω_i of the golf ball **102** and the launch angle α of the golf ball **102** relative to the flat ground surface **108** as it is struck by golf club **100**.

[0029] Here, in the current exemplary embodiment, a golf club **100** and golf ball **102** combination may merge to provide launch angles and initial spin rates that satisfy Equation 1 when the golf ball **102** is struck by golf club **100**. More preferably, the launch angles and spin rates satisfy Equation 2:

$$86\alpha+\omega_i \leqq 4010 \quad \text{(Eq. 2)}$$

Still more preferably, the launch angles and spin rates satisfy Equation 3:

$$86\alpha+\omega_i \leqq 3710 \quad \text{(Eq. 3)}$$

Most preferably, the launch angles and spin rates satisfy Equation 4:

$$86\alpha+\omega_i \leqq 3310 \quad \text{(Eq. 4)}$$

Equations 1 through 4 characterize the initial conditions of the golf ball **102**'s flight performance and ultimately affect the total distance of travel of the golf ball **102**. When the initial spin rate is too high for a given launch angle, the trajectory is not optimal and distance is lost.

[0030] In accordance with the present invention, the greatest distance improvements are achieved with unusually high launch angles in combination with initial spin rates that satisfy Equation 1, 2, 3, or 4. Launch angles are preferably about 15 degrees or greater, more preferably about 18 degrees or greater, and most preferably about 20 degrees or greater.

[0031] Here, in the current exemplary embodiment, in order to achieve the maximum golf ball **102** travel distance, golf club **100** may generally be modeled in accordance to an "exemplary swing" in accordance with the present invention. The "exemplary swing", as described in the current invention may generally have a velocity of approximately 110 miles per hour (mph), with an attack angle of approximately 2 degrees and an effective loft of approximately 13 degrees, while maintaining the static loft angle of approximately 9.5 degrees and impacting the golf ball at the geometric center of the face to achieve ω_i and α values that satisfy Equation 1, 2, 3, or 4 in accordance with the exemplary embodiment of the present invention.

[0032] FIG. **2** shows a golf club **200** designed to satisfy Equation 1, 2, 3, or 4 when striking a golf ball that is in accordance with an exemplary embodiment of the present invention. Two very important variables such as the center of gravity **212** and loft angle **216** may generally affect the performance characteristics of a golf club **200** in conjunction with a golf ball **102**. Golf club **200**, as shown in this current exemplary embodiment may contain a head **202** at a distal end of the golf club **200**, a hosel **204** connected to head **202**, a shaft **206** connected to the hosel **204**, and a grip **208** connected to the shaft **206**. FIG. **2** also shows a ground level **210** on which the head **202** rests, along with the center of gravity **212** of golf club head **202** located at a distance **214** from the ground level **210**.

[0033] Head **202** in this current exemplary embodiment may generally be applicable towards a driver type head and have a preferable volume range of approximately 300 cubic centimeters to approximately 600 cubic centimeters, and more preferably in the volume range of approximately 350 cubic centimeters to approximately 550 cubic centimeters, even more preferably in the volume range of approximately 375 cubic centimeters to approximately 475 cubic centimeters, and most preferably approximately 420 centimeters to approximately 460 centimeters; all without departing from the scope of the present invention. Head **202**, being generally applicable towards drivers, may generally have loft angles **216** ranging from approximately 8.5 degrees to approximately 15.0 degrees.

[0034] Hosel **204** in this current exemplary embodiment may be used to connect the head **202** to shaft **206**, and may generally be made from a low density material such as aluminum located substantially above a plane located at a peak of the crown section of head **202**. The hosel **204** may also provide interchangeability between various head **202** and various shafts **206** without the need for extensive tooling without departing from the scope and content of the present invention.

[0035] Shaft **206** in this current exemplary embodiment may be used to connect the head **202** and the hosel **204** to the grip **208** to complete the golf club **200**; however, various other components in addition to shaft **206** may be used to complete golf club **200** such as a ferrule, a grip tape, a glue, or any other components that may typically be used within a golf club **200** without departing from the scope of the present invention.

[0036] Golf club **200** and more specifically head **202**, as shown in the current exemplary embodiment, may generally rest on a ground level **210** in an address position to create a reference point from where the center of gravity **212** may be measured to yield a distance **214**. Distance **214**, as shown in the current exemplary embodiment refers to a height in the y-direction as indicated by the axis of orientation **201** in FIG. **2**; however, other identifiers may be used to identify this distance away from the ground level **220** such as x-direction, or z-direction without departing from the scope and content of the present invention. In this current exemplary embodiment distance **214** may generally be in the range of approximately 5 millimeters to approximately 35 millimeters, more preferably in the range of approximately 10 millimeters to approximately 30 millimeters, most preferably in the range of approximately 15 millimeters to approximately 25 millimeters all without departing from the scope and content of the present invention.

[0037] FIG. **3** shows a graphical representation of the effect of the location of the center of gravity **212** with respect to changes in the initial spin rate ω_i in accordance with an exemplary embodiment of the present invention. FIG. **3** shows that the initial spin rate ω_i on a golf ball can be dramatically reduced as the center of gravity **212** moves closer and closer to the ground level **210**.

[0038] FIG. **4** shows a graphical representation of the effect of the location of the center of gravity **212** with respect to changes in launch angle α in accordance with an exemplary embodiment of the present invention. FIG. **4** shows that the launch angle α increases as the center of gravity **212** moves closer and closer to the ground level **210**.

[0039] As it can be seen from FIG. **3** and FIG. **4** above, decreasing the distance **214** moves the location of the center of gravity **212** closer to the ground level **210**; which will decrease the initial spin rate ω_i and increase the launch angle α in accordance with an exemplary embodiment of the present invention. The increased launch angle α combined with the decrease in initial spin rate ω_i may allow the golf club head **202** to impart to the golf ball launch conditions that satisfy Equation 1, 2, 3, or 4 in accordance with an exemplary embodiment of the present invention.

[0040] Although adjusting the location, and more specifically, the height distance **214** of the center of gravity **212** may generally be the preferable methodology to satisfy Equation 1, 2, 3, or 4 in accordance with an exemplary embodiment of the present invention, other variables may also be adjusted to affect ω_i and α. For example, adjustments may also be made to the loft angle **216** to significantly increase a without departing from the scope of the present invention. More specifically, loft angle **216** may be adjusted to range from approximately 8.5 degrees to approximately 15.0 degrees for a driver type golf head to satisfy Equation 1, 2, 3, or 4 in accordance with an exemplary embodiment of the present invention.

[0041] In a further alternative embodiment of the present invention, loft angle **216** may be further increased to achieve a higher launch angle α through adjustments in the shaft **206**. In this alternative embodiment, shaft **206** may effective increase a higher launch angle α without changing the loft angle **216** by adjusting the way shaft **206** whips and snaps at the point of impact. More specifically, shaft **206** in accor-

dance with an embodiment of the present invention may generally have a softer tip at the tip section of shaft **206** in order to crease a lower kick point that may effectively increase launch angle α without adjusting the loft angle **216** without departing from the scope and content of the present invention. In essence, shaft **206** may allow golf club **200** to be swinging up on a golf ball, which effectively adds launch angle α without adding loft angle **216**. Alternatively, shaft **206** may also contain a swing hinge, a higher kick point, a difference in stiffness variation, or any other mechanism capable of increasing launch angle α without adding loft angle **216** all without departing from the scope and content of the present invention.

[0042] FIG. **5** shows the forces acting during flight on a golf ball **500** in accordance with an exemplary embodiment of the present invention. The total aerodynamic force F_A acting on a golf ball **500** is typically resolved into orthogonal components of lift (F_L) and drag (F_D). Lift is defined as the aerodynamic force component acting perpendicular to the flight path, and it results from a difference in pressure created by a distortion in the air flow that is caused by the backspin ω of the ball. Drag is defined as the aerodynamic force component acting parallel to the ball flight direction. As the ball travels through the air, the pressure at the front of the ball is greater than the pressure at the rear of the ball, the difference being primarily responsible for the drag force.

[0043] More particularly, FIG. **5** shows the various forces as enumerated in Equation 5 below.

$$F=F_L+F_D+F_G \quad \text{(Eq. 5)}$$

where

[0044] F=total force vector acting on the ball

[0045] F_L=lift force vector **508**

[0046] F_D=drag force vector **512**

[0047] F_G=gravity force vector **514**

[0048] The lift force vector (F_L) **508** acts in a direction dictated by the cross product of the spin vector and the velocity vector. The drag force vector (F_D) **512** acts in a direction that is directly opposite the velocity vector. The magnitudes of the lift and drag forces of Equation 5 are calculated in Equations 6 and 7, respectively:

$$F_L=0.5C_L\rho AV^2 \quad \text{(Eq. 6)}$$

$$F_D=0.5C_D\rho AV^2 \quad \text{(Eq. 7)}$$

where

[0049] ρ=density of air(slugs/ft^3)

[0050] A=projected area of the ball (ft^2) ($(\pi/4)D^2$)

[0051] D=ball diameter (ft)

[0052] V=ball speed (ft/s)

[0053] C_L=dimensionless lift coefficient

[0054] C_D=dimensionless drag coefficient

[0055] Lift and drag coefficients are typically used to quantify the aerodynamic forces imparted to a ball in flight and are dependent on air density, air viscosity, ball speed, and spin rate. The influence of all these parameters may be captured by two dimensionless parameters: Spin Ratio (SR) and Reynolds Number (N_{Re}). Spin Ratio is the rotational surface speed of the ball divided by ball speed. Reynolds Number quantifies the ratio of inertial to viscous forces acting on the golf ball moving through air. SR and N_{Re} are calculated in Equations 8 and 9 below:

$$SR=\omega(D/2)/V \quad \text{(Eq. 8)}$$

$$N_{Re}=DV\rho/\mu \quad \text{(Eq. 9)}$$

where

[0056] ω=ball rotation rate (radians/s) (2π(rpm/60))

[0057] rpm=ball spin rate ω (revolution/min)

[0058] V=ball speed (ft/s)

[0059] D=ball diameter (ft)

[0060] ρ=air density (slugs/ft^3)

[0061] μ=absolute viscosity of air (lb sec/ft^2)

[0062] There is a number of suitable methods for determining the lift and drag coefficients for a given range of SR and N_{Re}, which include the use of indoor test ranges with ballistic screen technology. U.S. Pat. No. 5,682,230, the entire disclosure of which is incorporated by reference herein, teaches the use of a series of ballistic screens to acquire lift and drag coefficients. U.S. Pat. Nos. 6,186,002 and 6,285,445, also incorporated in their entirety by reference herein, disclose methods for determining lift and drag coefficients for a given range of velocities and spin rates using an indoor test range, wherein the values for C_L and C_D are related to SR and N_{Re} for each shot. One skilled in the art of golf ball aerodynamics testing may readily determine the lift and drag coefficients through the use of an indoor test range, or alternatively in a wind tunnel.

[0063] In order to better classify the above variables, it is often more effective to characterize the aerodynamics of a golf ball **500** based on a ratio of the coefficient near the beginning of a flight over the coefficient near the end of the flight, labeled here as a "beginning to end coefficient ratio". This beginning to end coefficient ratio can be applicable to the coefficient of lift (C_L), coefficient of drag (C_D), and the lift-to-drag ratio (C_L/C_D), yielding a beginning to end coefficient of lift ratio ($C_{L\text{-}Beg}/C_{L\text{-}End}$), a beginning to end coefficient of drag ratio ($C_{D\text{-}Beg}/C_{D\text{-}End}$), and beginning to end ratio of lift to drag

$$\text{ratio}\left(\frac{C_{L-Beg}}{C_{D-Beg}} \Big/ \frac{C_{L-End}}{C_{D-End}}\right).$$

[0064] For the purposes of this invention, a Reynolds Number (N_{Re}) of approximately 220,000 with a Spin Ratio (SR) of approximately 0.054 is used to represent the exemplary aerodynamic conditions during the beginning (ascent) portion of the golf ball flight. These conditions generally translate into a golf ball **500** velocity of approximately 168 mph at a spin rate of approximately 1800 rpm.

[0065] Furthermore, a Reynolds Number (N_{Re}) of approximately 80,000 with a Spin Ratio (SR) of approximately 0.120 is used to represent the exemplary aerodynamic conditions during the end (descent) portion of golf ball flight. These conditions generally translate into a golf ball **500** velocity of approximately 61 mph at a spin rate of approximately 1460 rpm.

[0066] In this current exemplary embodiment the beginning to end coefficient of lift ratio ($C_{L\text{-}Beg}/C_{L\text{-}End}$) may be approximately within the range of 0.64 to 3.20, more preferably within the range of 0.72 to 2.03, most preferably within the range of 0.80 to 0.86. Additionally, the beginning to end coefficient of drag ratio ($C_{D\text{-}Beg}/C_{D\text{-}End}$) may be approximately within the range of 0.76 to 0.99, more preferably within the range of 0.82 to 0.96, most preferably within the range of 0.87 to 0.93. Lastly, the beginning to end lift to drag ratio

$$\left(\frac{C_{L-Beg}}{C_{D-Beg}} \Big/ \frac{C_{L-End}}{C_{D-End}}\right)$$

may be approximately within the range of 0.65 to 3.40, more preferably within the range of 0.76 to 2.25, most preferably within the range of 0.86 to 1.10 all without departing from the scope and content of the present invention.

[0067] The above discussion only provides a brief introduction to the aerodynamic properties of a golf ball **500** that can be combined with a golf club **200** to achieve the high launch and low spin characteristics in accordance with an exemplary embodiment of the present invention; more details regarding the above discussion relating to the aerodynamic properties and forces acting on a golf ball **500** may be found in U.S. Pat. No. 7,226,369, the disclosure of which is incorporated by reference in its entirety herein.

[0068] FIG. **6** shows a multi-layered golf ball **600** capable of achieving launch conditions that satisfy Equation 1, 2, 3, or 4 in accordance with the exemplary embodiment of the present invention. Golf ball **600** may generally have an inner core **602**, a cover layer **608**, and at least one intermediate layer **604** between the inner core **602** and the cover layer **608**. The inner core **602**, the intermediate layers **604**, and the cover layer **608** may all be constructed to have different properties. In an exemplary embodiment, the inner core **602** preferably has a low specific gravity, a low flexural modulus, and low hardness; wherein the cover layer **608** has a higher specific gravity, a higher flexural modulus, and a higher hardness than the intermediate layer **604** and the core **602**. The hardness of the cover layer **608** may generally be in the range of 80 Shore C to 100 Shore C, most preferably 90 Shore C, when measured in place on the ball to achieve launch conditions that satisfy Equation 1, 2, 3, or 4 in accordance with the exemplary embodiment of the present invention; however, various other hardness ranges for cover layer **608** may also be used so long as it adheres to the composition above without departing from the scope and content of the present invention.

[0069] In another embodiment of the present invention, a multi-layer golf ball that is substantially similar to the first embodiment may be disclosed that provides a coefficient of restitution (COR) gradient from slow to fast, e.g., the inner core **602** has a lower COR value, the intermediate layer **604** has a higher COR value, and the cover layer **608** has an even higher COR value. In a further alternative embodiment, the golf ball **600** may also contain a higher moment of inertia wherein the inner core **602** may have various fillers removed while other fillers may be adding various fillers to the cover **608**. The elimination of fillers from inner core **602**, combined with the addition of fillers to cover **608** may create additional mass towards the outer perimeter of the golf ball **600**; hence generating a higher moment of inertia within golf ball **600** to create a lower initial spin rate ω_i without departing from the scope and content of the present invention.

[0070] FIG. **6** also shows a further alternative embodiment of the present invention wherein the golf ball **600** may have a relatively low Atti compression in the range of 70 to 80 to achieve launch conditions that satisfy Equation 1, 2, 3, or 4 in accordance with the exemplary embodiment of the present invention. However, it should be noted that a golf ball **600** with a really low compression may create an undesirably soft feel for some golfers; thus creating a preferable compression in the range of 80 to 90.

[0071] In a further alternative embodiment of the present invention, golf ball **600** may have the cover **608** coated with a material that optimizes a coefficient of friction to achieve launch conditions that satisfy Equation 1, 2, 3, or 4 in accordance with the exemplary embodiment of the present invention. The detail of this film coating that optimizes the coefficient of friction may be disclosed by U.S. Pat. No. 5,827,133; the disclosure of which is incorporated here by reference in its entirety. It should be noted that although this film that optimizes a coefficient of friction may generally be applied to the golf ball, it could alternatively be applied to the face of the golf club or to both the golf ball and the face of the golf club to create the same effect or even enhancing the reduction in coefficient of friction all without departing from the scope and content of the present invention.

[0072] In an even further alternative embodiment of the present invention, golf ball **600** may also be oversized to achieve launch conditions that satisfy Equation 1, 2, 3, or 4 in accordance with the exemplary embodiment of the present invention. The details of this oversized golf ball with a diameter greater than the standard 1.68 inches may be found in U.S. Pat. No. 5,273,287; the disclosure of which is incorporated by reference in its entirety.

[0073] FIG. **7** shows yet another embodiment of the present invention directed at a multi-layer golf ball **700** comprising an inner core **702**, at least one intermediate core layer **704**, and outer core layer **706**, and a cover layer **708**. In this embodiment, a volume-decreasing gradient is present, e.g., the volume of the inner core **702** is larger than volume of the intermediate core layer **704**, which is larger than the volume of the outer core **706**, which is larger than the volume of the cover layer **708**. A hardness-increasing gradient may also be present in this alternative embodiment as shown in FIG. **7** resulting in a soft inner core **702**, a slightly harder intermediate core **704**, a still harder outer core **706**, and an even harder cover layer **708**. Finally, a specific gravity gradient may also be present, progressing form an inner core **702** with a lower specific gravity to an outer core **704** with a higher specific gravity. However, it should be noted that in this alternative embodiment the specific gravity gradient may not progress all the way through the cover layer **708**, as it may be preferred that the specific gravity of the outer core layer **706** be higher than the specific gravity of the cover layer **708**.

[0074] The above discussion only provides a brief introduction to the material properties of a golf ball **700** that can be combined with a golf club **200** to achieve high launch angle α and low initial spin ω_i characteristics in accordance with an exemplary embodiment of the present invention; however, more details regarding the above discussion relating to the material properties of a golf ball **700** in accordance with the present invention may be found in U.S. Pat. No. 7,354,357, the disclosure of which is incorporated by reference in its entirety herein.

[0075] It should be understood, of course, that the foregoing relates to exemplary embodiments of the invention and that modifications may be made without departing from the scope and content of the invention as set forth in the following claims.

What is claimed is:

1. A golf club and golf ball combination comprising:

a golf club and a golf ball;

wherein said golf ball achieves a launch angle (α) and an initial spin rate (ω_i) satisfying a relationship defined as $86\alpha+\omega_i \leqq 4310$ when struck by said golf club.

2. The golf club and golf ball combination of claim **1**, wherein said golf club is swung at an exemplary swing; and wherein said exemplary swing is further comprising:
a velocity of about 110 miles per hour;
an attack angle of about 2 degrees;
an effective loft of about 13 degrees; and
a static loft of about 9.5 degrees;
wherein said golf ball contacts said golf club at the geometric center of the face of said golf club.

3. The golf club and ball combination of claim **2**, wherein said launch angle (α) is at least about 15 degrees.

4. The golf club and ball combination of claim **2**, wherein said launch angle (α) is at least about 18 degrees.

5. The golf club and ball combination of claim **2**, wherein said launch angle (α) is at least about 20 degrees.

6. The golf club and ball combination of claim **3**, wherein said launch angle (α) and said initial spin rate (ω_i) relationship is defined as $86\alpha+\omega_i \leqq 4310$ when struck by said golf club.

7. The golf club and ball combination of claim **3**, wherein said launch angle (α) and said initial spin rate (ω_i) relationship is defined as $86\alpha+\omega_i \leqq 3710$ when struck by said golf club.

8. The golf club and ball combination of claim **3**, wherein said launch angle (α) and said initial spin rate (ω_i) relationship is defined as $86\alpha+\omega_i \leqq 3310$ when struck by said golf club.

9. The golf club and ball combination of claim **3**, wherein said golf club head has a center of gravity located about 10 mm to about 30 mm above a ground level of said golf club.

10. The golf club and ball combination of claim **3**, wherein said golf club head has a center of gravity located about 15 mm to about 25 mm above a ground level of said golf club.

11. The golf club and ball combination of claim **9**, wherein said golf ball has a beginning to end coefficient of lift ratio of about 0.64 to about 3.20;
a beginning to end coefficient of drag ratio of about 0.76 to about 0.99; and
a beginning to end ratio of lift to drag ratio of about 0.65 to about 3.40.

12. The golf club and ball combination of claim **9**, wherein said golf ball has
a beginning to end coefficient of lift ratio of about 0.72 to about 2.03;
a beginning to end coefficient of drag ratio of about 0.82 to about 0.96; and
a beginning to end ratio of lift to drag ratio of about 0.76 to about 2.25.

13. The golf club and ball combination of claim **9**, wherein said golf ball has
a beginning to end coefficient of lift ratio of about 0.80 to about 0.86;
a beginning to end coefficient of drag ratio of about 0.87 to about 0.93; and
a beginning to end ratio of lift to drag ratio of about 0.86 to about 1.10.

14. A golf club and ball combination comprising:
a golf club with a center of gravity located about 10 mm to about 30 mm above a ground level; and
a golf ball that has a beginning to end coefficient of lift ratio of about 0.64 to about 3.20; a beginning to end coefficient of drag ratio of about 0.76 to about 0.99; and a beginning to end ratio of lift to drag ratio of about 0.65 to about 3.40 when struck by said golf club.

15. The golf club and ball combination of claim **14**, wherein said golf ball achieves a launch angle (α) and an initial spin rate (ω_i) satisfying a relationship defined as $86\alpha+\omega_i \leqq 3710$ when struck by said golf club.

16. The golf club and ball combination of claim **15**, wherein said golf club is swung at an exemplary swing; and wherein said exemplary swing is further comprising:
a velocity of about 110 miles per hour;
an attack angle of about 2 degrees;
an effective loft of about 13 degrees; and
a static loft of about 9.5 degrees;
wherein said golf ball contacts said golf club at the geometric center of the face of said golf club.

17. The golf club and ball combination of claim **14**, wherein said golf ball achieves a launch angle (α) and an initial spin rate (ω_i) satisfying a relationship defined as $86\alpha+\omega_i \leqq 3310$ when struck by said golf club.

18. The golf club and ball combination of claim **17**, wherein said golf club is swung at an exemplary swing; and wherein said exemplary swing is further comprising:
a velocity of about 110 miles per hour;
an attack angle of about 2 degrees;
an effective loft of about 13 degrees; and
a static loft of about 9.5 degrees;
wherein said golf ball contacts said golf club at the geometric center of the face of said golf club.

19. The golf club and ball combination of claim **16**, wherein said launch angle (α) is at least about 18 degrees.

20. The golf club and ball combination of claim **16**, wherein said launch angle (α) is at least about 20 degrees.

21. A method of maximizing a travel distance of a golf ball comprising:
adjusting a center of gravity of a golf club to be located about 10 mm to about 30 mm above a ground level of said golf club;
adjusting a beginning to end coefficient of lift ratio for said golf ball to be about 0.64 to about 3.20;
adjusting a beginning to end coefficient of drag ratio of said golf ball to be about 0.76 to about 0.99; and
adjusting a beginning to end ratio of lift to drag ratio of said golf ball to be about 0.65 to about 3.40;
wherein said golf ball achieves a launch angle (α) and an initial spin rate (ω_i) satisfying a relationship defined as $86\alpha+\omega_i \leqq 4310$ when struck by said golf club.

22. The method of maximizing said travel distance of said golf ball according to claim **21**, further comprising of swinging said golf club at an exemplary swing;
wherein said exemplary swing is further comprising:
a velocity of about 110 miles per hour;
an attack angle of about 2 degrees;
an effective loft of aboutl3 degrees; and
a static loft of about 9.5 degrees;
wherein said golf ball contacts said golf club at a center of a face of said golf club.

23. The method of maximizing said travel distance of said golf ball according to claim **21**, wherein said launch angle (α) is at least about 18 degrees.

* * * * *