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GOLF CLUB WITH BULGE RADIUS AND INCREASED MOMENT OF INERTIA ABOUT AN INCLINED AXIS

5 This invention relates to golf clubs, and, more particularly, to golf clubs which are designed to provide more accurate off-centre hits.

10 It is commonly assumed that when a golf club strikes a golf ball off centre, i.e., at a point spaced from the centre of gravity of the club toward the toe or heel, the club rotates about a vertical axis which extends through the centre of gravity. When the club strikes the ball at a point above or below the centre of gravity, i.e., toward the top or sole of the club, it is assumed that the club tends to rotate about a horizontal axis which extends
15 through the centre of gravity.

The foregoing assumptions have resulted in clubs being designed with increased polar moments of inertia about the vertical and horizontal axes in order to reduce the rotation of the club. The moment
20 of inertia about the vertical axis may be increased by concentrating weight of the club in the toe and the heel. The moment of inertia about the horizontal axis may be increased by concentrating weight of the club in the sole and the top.

25 Wooden clubs, particularly the driver, are conventionally provided with bulge and roll in order to compensate for excessive gear effect. Bulge is convex curvature in the face of the club which can be seen when the face is viewed from above or below.
30 The curvature extends about a vertical axis. Roll is convex curvature in the face which can be seen when the face is viewed from the side. The curvature extends about a horizontal axis. Gear effect in wooden clubs is well known. When a wooden club, e.g.
35 a driver, strikes a golf ball at a point which is

offset from the centre of the face, i.e. toward the toe or heel of the club, a spin is imparted to the ball. A toe hit on a right-handed club will provide a counterclockwise or hook spin, and a heel hit on a right-handed club will provide a clockwise or slice spin.

The gear effect spin is created by a wooden club because the centre of gravity of the club is spaced a substantial distance behind the striking face of the club. When the club strikes a ball on an off-centre hit, the clubhead rotates about its centre of gravity. The rotation of the clubhead in one direction, e.g., clockwise for a toe hit, causes the ball to rotate in the opposite direction, i.e., counterclockwise for a toe hit. An opposite rotation is imparted to the ball because the clubhead and ball rotate together much like two enmeshed gears. On a heel hit, the club rotates counterclockwise, and a clockwise or slice spin is imparted to the ball.

The clockwise rotation of a wooden clubhead on a toe hit opens the face of the club and causes the ball to fly initially to the right of the intended line of flight. However, the counterclockwise or hook spin imparted to the ball by the gear effect will cause the ball to curve back toward the intended line of flight. In most wooden clubs the gear effect spin more than compensates for the effect of the open face, and the ball would hook to the left of the intended line of flight. For this reason the striking face of a wooden club is provided with a bulge, i.e., a curved or convex face. The bulge tends to make a toe hit fly to the right and a heel hit fly to the left. The bulge spin and the gear effect spin are advantageously adjusted so that a ball hit on either the toe or the heel lands

approximately along the intended line of flight.

Similarly, when a wooden club strikes a ball above or below the centre of gravity, the rotation of the clubhead about the centre of gravity imparts gear effect spin on the ball which causes the ball to curve downwardly for a high hit and to curve upwardly for a low hit. The roll curvature is intended to compensate for excessive gear effect spin on high and low hits.

United States Patent No. 3,625,518 describes orienting the bulge curvature of a wooden club about an axis which extends parallel to the axis of the shaft and orienting the roll curvature about an axis which is perpendicular to the first axis. The patent does not precisely describe the manner in which the clubhead rotates at impact. Instead, the orientation of the bulge and roll axes is said to compensate for deviation of the impact from the sweet spot because any tendency to swing out is accompanied by a tendency to raise the club and vice versa. The patent also states that the swing of the club at impact is in a plane passing through the target line and parallel to the shaft.

We have discovered that a golf club head does not rotate about a vertical axis on toe or heel hits and does not rotate about a horizontal axis on high and low hits. Rather, a toe or heel hit will cause the head to rotate about a first axis which extends through the centre of gravity of the clubhead in a plane which intersects the axis of the shaft above the clubhead. A high or low hit will cause the club to rotate about a second axis which extends through the centre of gravity and is perpendicular to the first axis.

If the weight of the clubhead is

distributed to increase the moment of inertia and to decrease the tendency of the clubhead to rotate, the weight should be distributed with respect to the actual axes of rotation. Similarly, bulge and roll curvatures on the face of a wood-type club should be oriented with respect to the actual axes of rotation. Bulge should curve about an axis which is parallel to said first axis, and roll should curve about an axis which is parallel to said second axis.

10 We have also discovered that conventional roll radii are too short, and the resulting curvature produces too much loft for high hits and too little loft for low hits. Increasing the radius of curvature of the roll tends to flatten the roll
15 somewhat but makes the loft angle more nearly uniform from the top to the bottom of the club.

 The invention will now be explained, by way of example, with reference to the accompanying diagrammatic drawings, in which:-

20 Figure 1A is a diagrammatic illustration of a toe hit on a wood-type golf club;

 Figure 1B is an illustration similar to Figure 1A showing a heel hit;

25 Figure 2A is a diagrammatic illustration of gear effect spin being imparted to the golf ball by a toe hit;

 Figure 2B is an illustration of gear effect spin being imparted to a ball by a heel hit;

30 Figure 3 is an illustration view of a pair of enmeshed gears rotating in opposite directions;

 Figure 4A is a diagrammatic illustration of heel hits on clubs with and without gear effect;

 Figure 4B is a diagrammatic illustration of toe hits on clubs with and without gear effect;

35 Figure 5A is an illustration of heel hits

on clubs without gear effect and with too much gear effect;

Figure 5B is an illustration of toe hits on clubs without gear effect and with too much gear effect;

Figures 6 and 7 are top plan views of clubs with different bulge radii;

Figures 8 and 9 are diagrammatic illustrations of toe hits on the clubs of Figures 6 and 7, respectively;

Figure 10 is a side elevational view of a conventional clubhead with a 9-1/2" (=241.3 mm) roll radius;

Figure 11 is a diagrammatic illustration of high, centre, and low hits on the club of Figure 10;

Figure 12 is a side elevational view of a clubhead with an increased roll radius;

Figure 13 is a diagrammatic illustration of high, centre and low hits on the club of Figure 12;

Figure 14 is a diagrammatic illustration of high, centre, and low hits on a conventional wood-type club;

Figure 15 is a diagrammatic illustration of the orientation of bulge and roll on a conventional wood-type club;

Figure 16 is a diagrammatic illustration of the orientation of bulge and roll on a wood-type club formed in accordance with the invention;

Figure 17 is a front elevational view of a wood-type club formed in accordance with the invention;

Figure 18 is a side elevational view of the club of Figure 17;

Figure 19 is a bottom view of the club of Figure 17; and

Figure 20 is a front elevational view of an iron club showing the axis of rotation of the club.

Figures 1A and 2A illustrate a toe hit of a golf ball 22 by a clubhead 23 of a wood-type club which provides gear effect spin. The clubhead 23 includes a striking face 24, a toe 25, a heel 26, and a hosel 27. The centre of gravity 28 is located a distance Y behind the face 24. The clubhead 23 is swung toward the ball 22 in the direction of the arrow 29, and the clubhead 23 contacts the ball 22 at a point which is toward the toe 25 of the club.

The impact of the ball 22 on the clubhead 23 causes the clubhead to rotate clockwise about its centre of gravity 28 (Figure 2A). The ball 22 is impacted against the clubhead 23 while the clubhead 23 rotates, and the clockwise rotation of the clubhead 23 in the direction of the arrow 30 causes the ball 22 to rotate counterclockwise in the direction of the arrow 31.

The initial impact between the ball 22 and the clubhead 23 occurs at a point A_1 on the club and point B_1 on the ball. The impact point A_1 is a distance R_c from the centre of gravity 28 of the clubhead 23. As the clubhead 23 rotates clockwise to its Figure 2A position, the ball 22 will rotate counterclockwise so that the point B_2 on the ball 22 contacts the point A_2 on the clubhead.

The counterclockwise spin imparted to the ball by the clockwise rotation of the clubhead is similar to the rotation of mating gears 32 and 33 shown in Figure 3. Rotation of the gear 32 in a clockwise direction causes counterclockwise rotation of the gear 33.

A heel hit is illustrated in Figures 1B and 2B. The impact between the ball 22 and the

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clubhead 23 occurs at point B_1 on the ball and point A_1 on the club. The heel hit causes the clubhead to rotate counterclockwise (Figure 2B), and the ball rotates clockwise so that the point B_0 on the ball contacts the clubhead at A_2 .

Figure 4A illustrates the result of gear effect spin on a heel hit. If the club face is moving in the direction of the centreline or intended line of flight 35, a heel hit will cause the club face to close and will initially send the ball in the direction of the line 36. However, the clockwise slice spin imparted on the ball by the counterclockwise rotation of the clubhead causes the ball to slice back toward the intended line of flight as indicated by the line 37.

Conversely, a toe hit on a club with gear effect as illustrated in Figure 4B will impart a counterclockwise spin to the ball and will cause the ball to curve to the left from its original direction indicated along the line 38 away from its original direction indicated by the line 39.

It can also be seen that too much gear effect spin can be imparted to the ball if the clubhead rotates too much. This is illustrated in Figures 5A and 5B. Figure 5A illustrates the flight of a ball which has excessive slice spin because of a heel hit, and Figure 5B illustrates the flight of a ball which has excessive hook spin because of a toe hit. If the moment of inertia or radius of gyration with respect to the centre of gravity is too low, the clubhead will rotate excessively on off-centre hits.

Some clubs have been designed with increased moments of inertia to reduce the rotation of the clubhead on off-centre hits. The weight distribution is generally made on the assumption that

the clubhead rotates about a vertical axis through the centre of gravity. If the rotation of the clubhead is reduced, the compensating bulge curvature can also be reduced. Figure 6 illustrates a wood-type clubhead 42 which is provided with conventional bulge, i.e., the striking face 43 curves about an axis which extends parallel to a vertical axis through the centre of gravity 44. The plane in which these two axes lie is generally perpendicular to a plane which is tangent to the centre of the face. In Figure 6 the radius of the bulge curvature is 9-1/2 inches (=241.3 mm).

If the moment of inertia about a vertical axis through the centre of gravity 44 is increased by redistributing the weight of the head, the rotation of the clubhead and therefore the gear effect spin will be reduced on off-centre hits. As a result, a conventional 9-1/2 inch (=241.3 mm) bulge radius on the face 43 will cause a toe hit to remain to the right of the intended line of flight as illustrated in Figure 8. Similarly, a heel hit will remain to the left of the intended line of flight.

When the weight of the clubhead is redistributed to increase the moment of inertia, the bulge radius can be increased as illustrated in Figure 7. A clubhead 45 has a straight face 46 with a 12 inch (304.8 mm) bulge radius. The reduced curvature of the face will cause the ball to land closer to the intended line of flight on off-centre hits as illustrated in Figure 9. Also, less of the impact energy will be converted into spin energy, and the ball will fly farther as can be seen by comparing Figure 8 and 9.

The accuracy of a wood-type club can also be increased by increasing the roll radius.

Figure 10 illustrates a conventional wood-type club 48 having a striking face 49 with a 9-1/2 inch (=241.3 mm) roll radius. A plane tangent to the centre 50 of the face determines the loft angle. A conventional driver might have a loft angle of 11°. However, because of the roll curvature the loft angle at a point 51 at the top of the face is about 15°, and the loft angle at a point 52 at the bottom of the face is about 7°. This 8° variation in loft from top to bottom causes high hits, i.e., balls hit near the top of the face, to fly too high and low hits to fly too low, resulting in decreased distance. The comparison of high, centre, and low hits is illustrated in Figure 11.

Figure 12 illustrates a club 53 having a striking face 54 on which the roll radius has been increased to 16 inches (=406.4 mm). The loft at the centre 55 of the face is still 11°. However, the reduced roll curvature reduces the variations in loft at the top and bottom. The loft at point 56 is 13°, and the loft at point 57 is 9°.

The reduced variation in loft angle results in more uniform ball trajectories for high, centre, and low hits, and increases the distance of high and low hits as illustrated in Figure 13.

As previously stated, it is commonly assumed that a clubhead rotates about a generally vertical axis on off-centre hits. Referring to Figure 15, a clubhead 59 is assumed to rotate about a vertical axis 60 which extends through the centre of gravity of the clubhead. This assumption leads to the conventional design in which the bulge curvature curves about an axis which is parallel to the axis 60 as illustrated by the arrow 61 and the roll radius curves about an axis which is perpendicular to the

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axis 60 as illustrated by the arrow 62.

5 We have discovered that the true axis of
rotation is substantially inclined from the vertical
and lies in a plane which intersects the axis of the
shaft. This can be demonstrated on a club-swinging
10 machine by striking the ball at various points on the
face of a club which lie along a vertical centreline
formed on the face by a vertical plane which extends
through the centre of gravity and through the centre
15 of the face. A centre hit, i.e., a hit on the line
at the same height as the centre of gravity, will fly
straight as illustrated in Figure 14. However, a
high hit will fly to the left, and a low hit will fly
to the right as illustrated in Figure 14. If the
20 clubhead really rotated about a vertical axis through
the centre of gravity, high and low hits along the
vertical centreline would not cause the club to
rotate and would fly straight.

The true axis of rotation of a clubhead is
25 illustrated in Figure 16. The clubhead 64 rotates
(tilts) about an axis 65 which extends through the
centre of gravity 66 of the clubhead and which lies
in a plane which intersects the shaft 67 at a point
below the grip of the shaft. It is believed that for
most clubs this plane intersects the axis or
25 centreline of the shaft at about the top of the hosel
68 and that the axis of rotation is inclined about
35° to 55° from the vertical. The bulge curvature
should therefore curve about an axis which extends
30 parallel to the axis 65 as illustrated by the arrow
69, and the roll curvature should curve about an axis
which extends perpendicularly to the axis 65 as
illustrated by the arrow 70.

A wood-type clubhead 72 designed in
35 accordance with the invention is illustrated in

Figures 17 and 18. The clubhead has a toe portion 73, a heel portion 74, and a sole portion 75. A hosel 76 extends at an angle F from the horizontal plane 77 when the centre of the sole is tangent to the horizontal plane. The angle F is the lie angle of the club. The hosel has an axis or centreline 78, and the shaft of the club is attached to the hosel so that it extends along the centreline 78.

The striking face 79 of the club is provided with a convex bulge curvature which curves about an axis which is parallel to the axis 80. The axis 80 is the assumed true axis of rotation and extends through the centre of gravity 81 at an angle θ from the vertical in Figure 7. In the preferred embodiment the axis of the bulge of curvature was about 12 inches (=304.8 mm) behind the face to provide a bulge radius of about 12 inches (304.8 mm).

The axis 80 and the axis of the bulge curvature lie in a plane which extends through the centre of gravity and through the centre of the striking face, i.e., the point on the face which is formed by vertical and horizontal planes 82 and 83 which extend through the centre of gravity. The plane in which the axis 80 lies is perpendicular to a plane 84 (Figure 18) which is tangent to the centre of the striking face, and the plane in which the axis 80 lies intersects the axis 78 of the shaft at a point 85 which is just below the top of the hosel 76.

Figure 18 is a side elevational view from a plane which is perpendicular to the plane 84 which is tangent to the centre of the striking face. A plane which passes through the axis of rotation and which is perpendicular to the plane of Figure 18 will intersect the axis 78 of the shaft at a point below

the grip of the shaft.

The face 79 is also provided with a convex roll curvature which curves about an axis which is perpendicular to the axis 80, i.e., parallel to the axis 86. The axis of the roll curvature and the axis 86 lie in a plane which passes through the centre of gravity and which extends perpendicularly to the aforementioned plane in which the bulge axis and the axis 80 lie. In the preferred embodiment the axis of the roll curvature was about 16 inches (=406.4 mm) behind the face to provide a roll radius of about 16 inches (=406.4 mm).

A convex top surface 88 (Figure 18) curves rearwardly from the face 79, and a rear surface 89 extends downwardly and forwardly to the sole.

In one specific embodiment for a driver, the lie angle F was 55° , and the angle θ of inclination of the axis of rotation 80 from the vertical was 45° . The plane in which the axis 80 and the bulge axis lie intersected the centreline of the shaft at an angle of about 10° .

Referring to Figure 19, the moment of inertia of a club designed in accordance with the invention can be increased by redistributing the weight of the club about the true axis of rotation. The clubhead 72 is provided with a generally cylindrical recess 92 which extends upwardly from the sole of the clubhead to reduce the weight of the clubhead at the centre. Three weights 93 are inserted into inclined bores which are drilled into the toe of the clubhead, and a weight 94 is inserted into an inclined bore which is drilled into the heel of the clubhead.

The weights 93 and 94 are located to increase the moment of inertia along the true axis of rotation as illustrated in Figures 16 and 17 rather

than along a vertical assumed axis of rotation. The weights therefore will reduce the tendency of the clubhead to rotate about its true axis of rotation and will decrease the amount of impact energy which is converted in spin energy of the ball.

The terms "wood" and "wood-type" as used herein are not limited to real wood and are meant to include clubheads which are shaped like traditional wooden clubheads but which are made of metal, plastics, and other materials.

Figure 20 illustrates the axis of rotation 96 of an iron club 97. The iron club includes a clubhead 98 and a shaft 99 which has a centreline or axis 100. The axis 96 passes through the centre of gravity 101 and lies in a plane which intersects the shaft axis 100 between the grip and the clubhead. The axis 96 is inclined at an angle θ from the vertical line 102.

While in the foregoing specification a detailed description of specific embodiments of the invention were set forth for the purpose of illustration, it will be understood that many of the details herein given may be varied considerably by those skilled in the art without departing from the scope of the claims.



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CLAIMS

1. A wood-type golf club comprising a clubhead and a shaft attached to the clubhead, the clubhead comprising a body having a toe portion and a heel portion, a top surface, a sole surface, and a striking face extending between the top and sole surfaces, the striking face having a convex curvature about a first axis which extends parallel to a second axis which extends through the centre of gravity of the clubhead, said first and second axes lying in a first plane which extends through the centre of the striking face and which intersects the centreline of the shaft.
2. A golf club according to Claim 1 in which said first plane extends at an angle of about 35° to about 55° with respect to a second plane which passes through the centre of the striking face and the centre of gravity of the clubhead, said second plane being perpendicular to a third plane which is tangent to the centre of the sole surface.
3. A golf club according to Claim 1 or 2 in which said first plane intersects the centre line of the shaft at an angle of about 10° .
4. A golf club according to Claim 1, 2 or 3 in which said clubhead includes a hosel which is connected to the shaft, said first plane intersects the centreline of the shaft adjacent the top of the hosel.
5. A golf club according to any one of Claims 1 to 4 in which said first axis is about 12 inches (=304.8 mm) behind the striking face whereby the radius of curvature of said convex curvature is about 12 inches (=304.8 mm).
6. A golf club according to any one of Claims 1 to 5 including first and second weights in

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the clubhead on opposite sides of said first plane.

7. A golf club according to any one of Claims 1 to 6 in which the striking face has a second convex curvature of about a third axis which extends parallel to a fourth axis which extends through the centre of gravity of the clubhead, said third and fourth axes lying in a plane which extends through the centre of the striking face and perpendicular to said second axis.

8. A golf club according to Claim 7 in which said third axis is about 16 inches (=406.4 mm) behind the striking face whereby the radius of said second convex curvature is about 16 inches (=406.4 mm).

9. A golf club according to Claim 8 in which the loft angle of the striking face at the centre thereof is about 11°, the loft angle of the striking face at the top thereof is about 13°, and the loft angle of the striking face at the bottom thereof is about 9°.

10. A golf club according to Claim 1 in which said first plane extends at an angle of about 45° with respect to a second plane which passes through the centre of the striking face and the centre of gravity of the clubhead, said second plane being perpendicular to a third plane which is tangent to the centre of the sole surface.

11. A wood-type golf club constructed arranged and adapted to operate substantially as herein described with reference to, and as shown in, any one of Figures 16 to 19 of the accompanying drawings.
