US 20090017938A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2009/0017938 A1

(43) Pub. Date: Jan. 15, 2009

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(54) WOOD-TYPE GOLF CLUB HEAD

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(21) Appl. No.: **12/216,455**

(22) Filed: **Jul. 3, 2008**

(30) **Foreign Application Priority Data**

Jul. 12, 2007 (JP) 2007-183446

Publication Classification

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

(52) **U.S. Cl.** **473/349**

(57) **ABSTRACT**

A wood-type golf club head has a club face provided with a face roll, and the radius of curvature Y in inch of the face roll satisfies: Ma/Y=<250 and Ma>=3000, wherein Ma is a vertical moment of inertia in g sq·cm of the head around a horizontal axis extending through the center of gravity of the head in parallel with a toe-heel direction of the head.

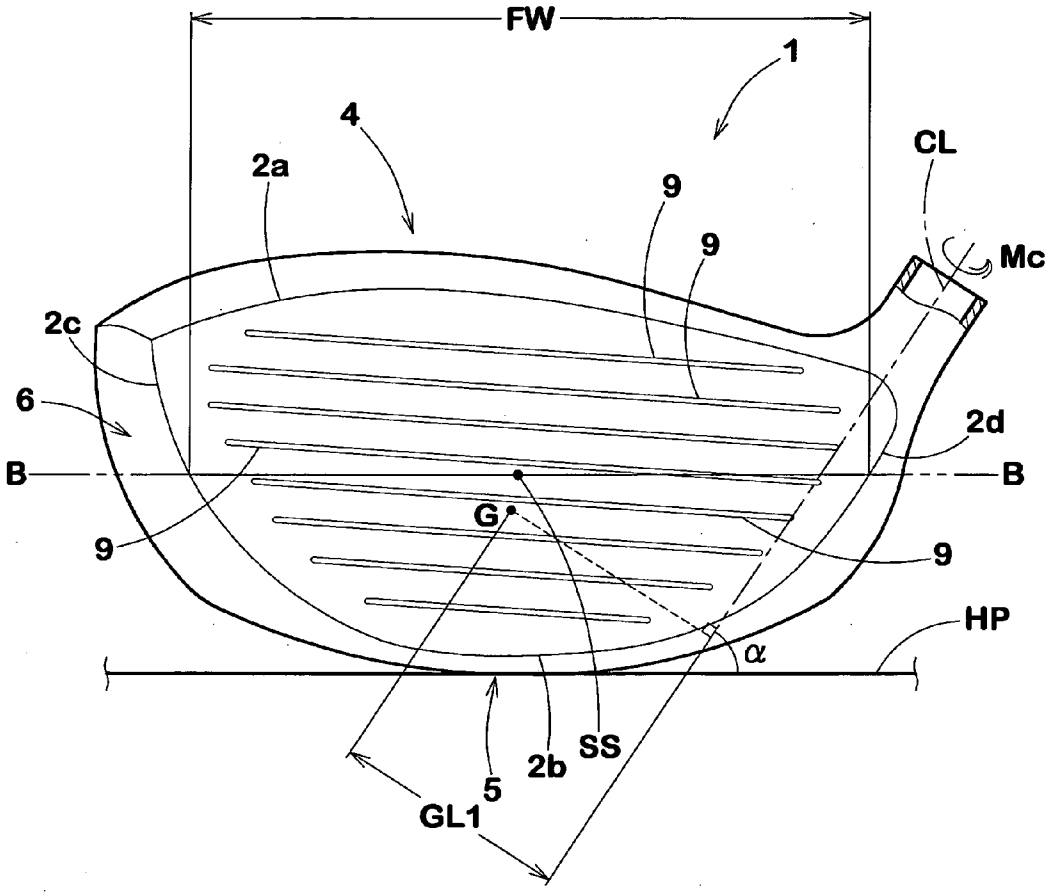


FIG.1

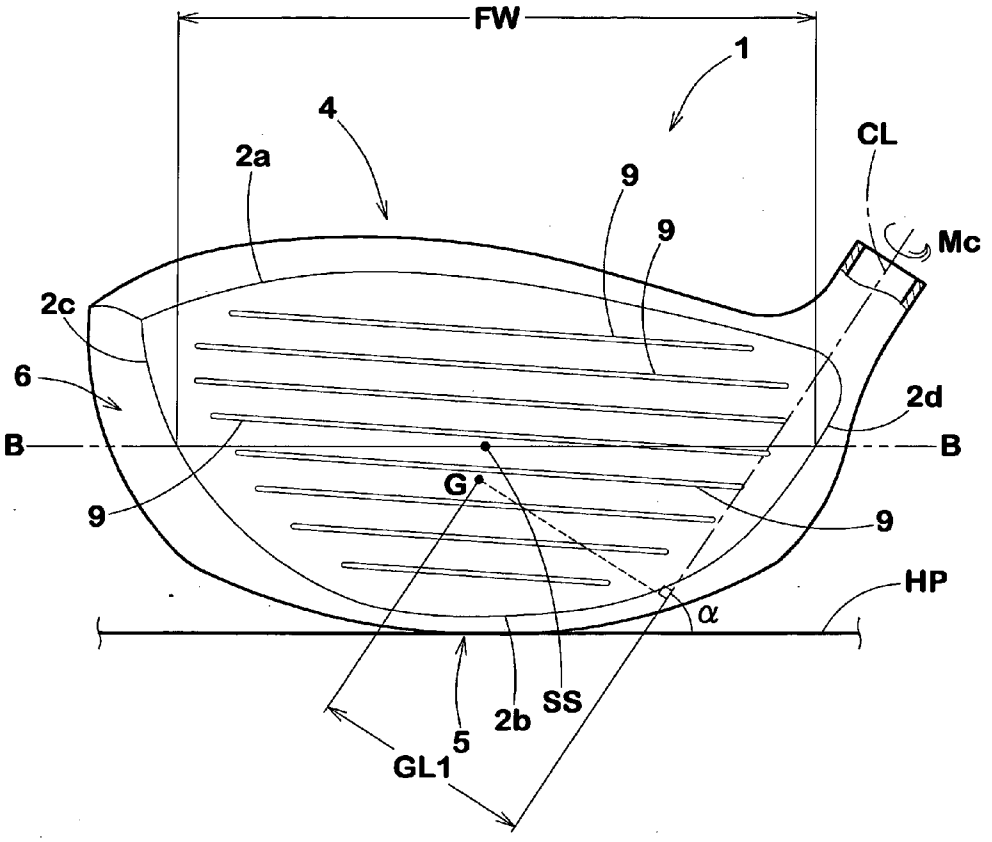
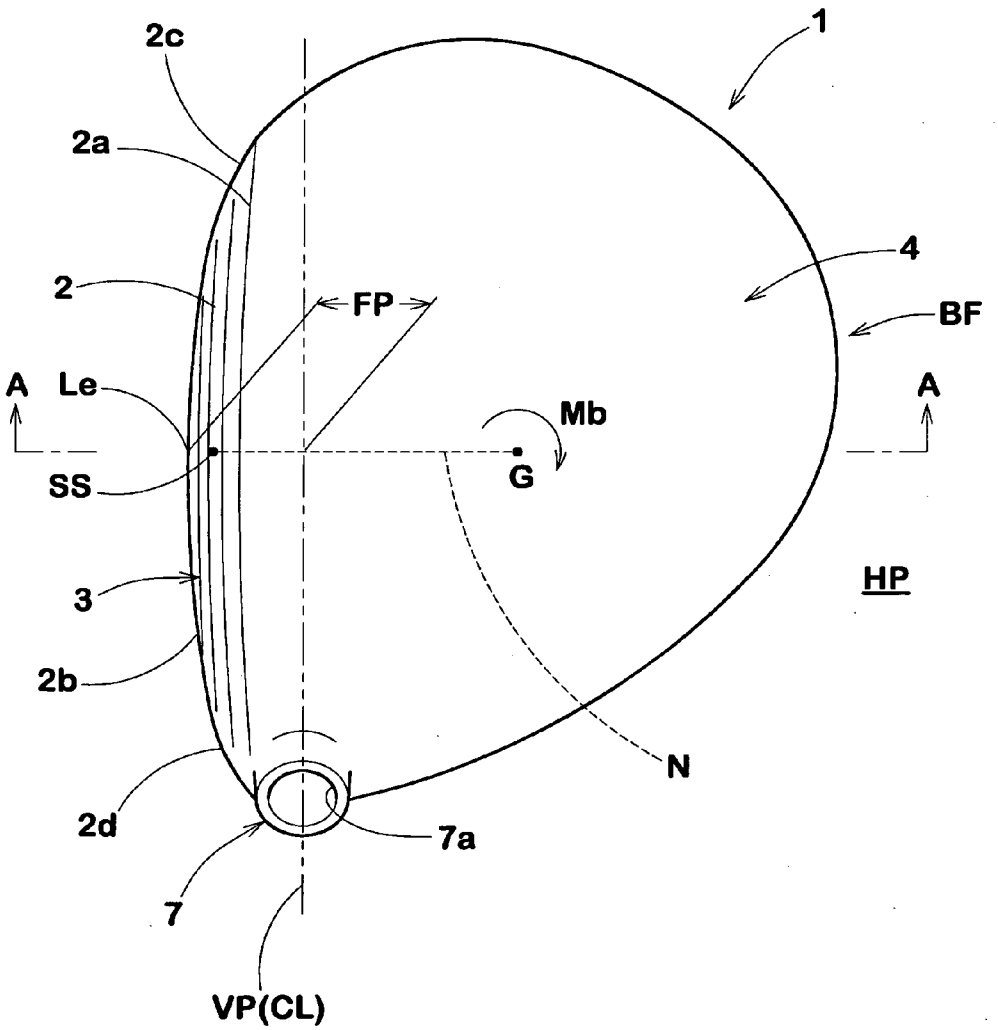


FIG.2



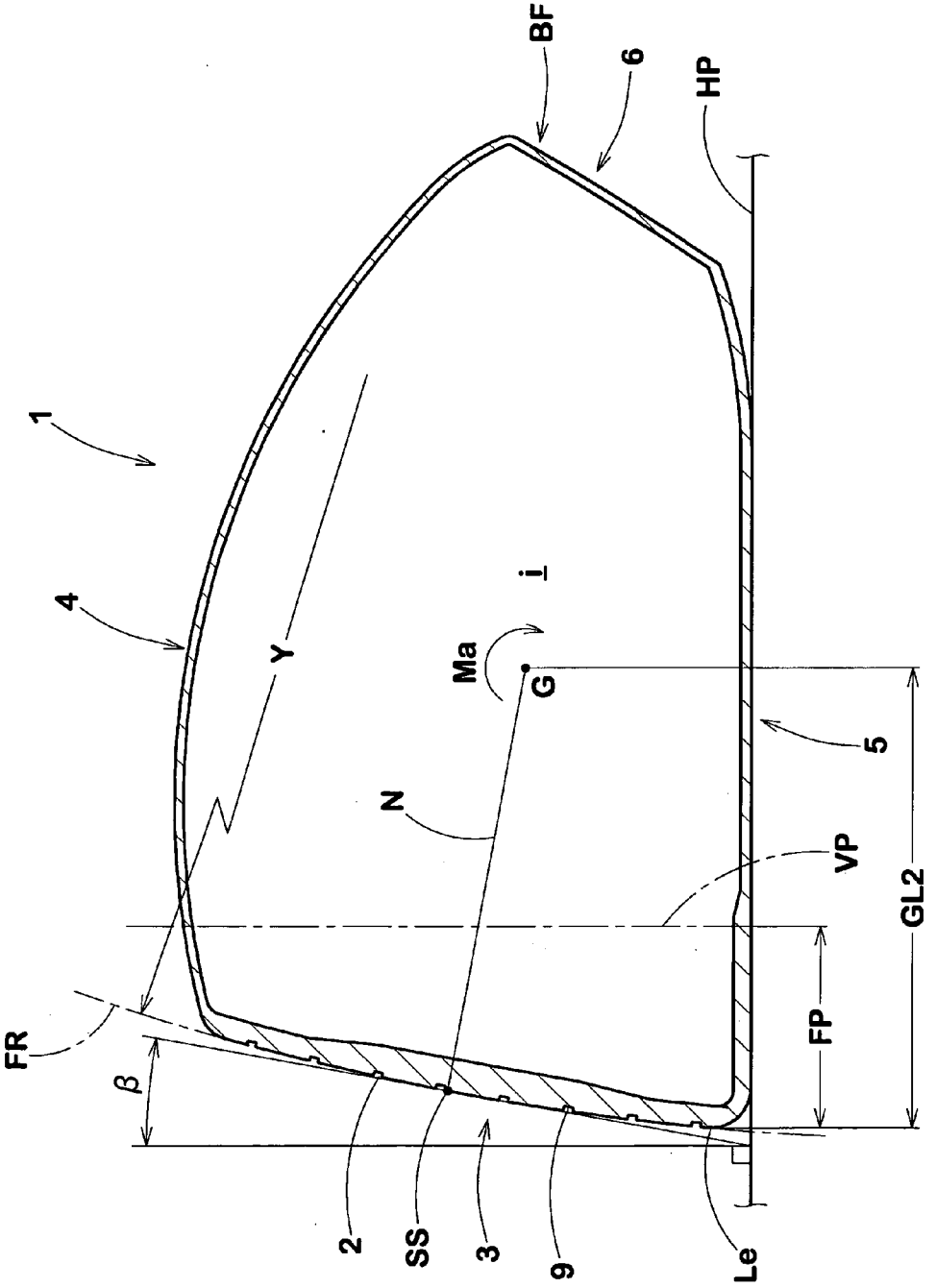


FIG.3

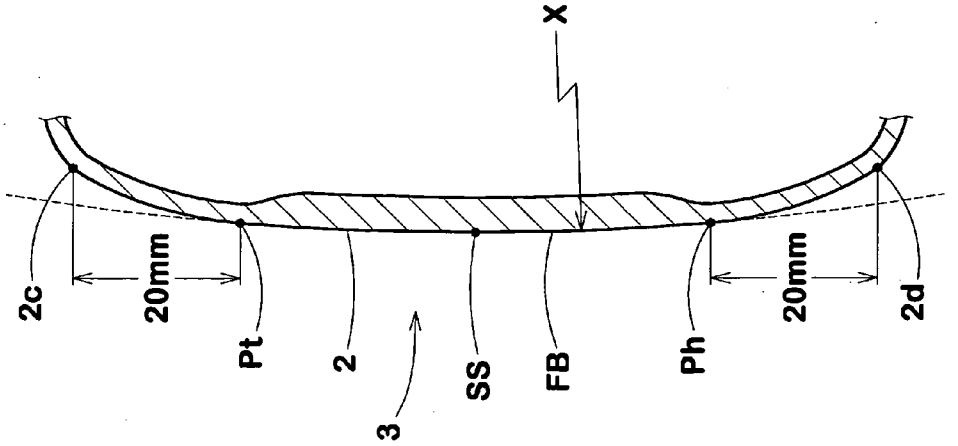

X
2c
20mm
Pt
2
3
SS
FB
Ph
20mm
2d

FIG.5

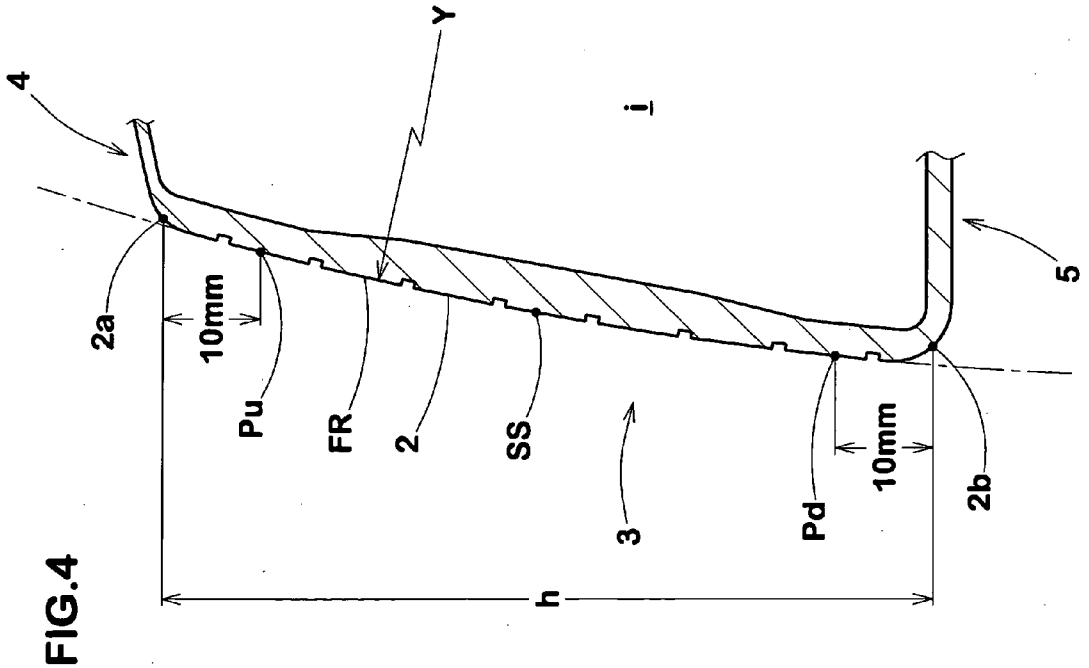

4
Y
i
2a
10mm
Pu
FR
2
SS
3
Pd
10mm
2b
5
h

FIG.4

FIG.6

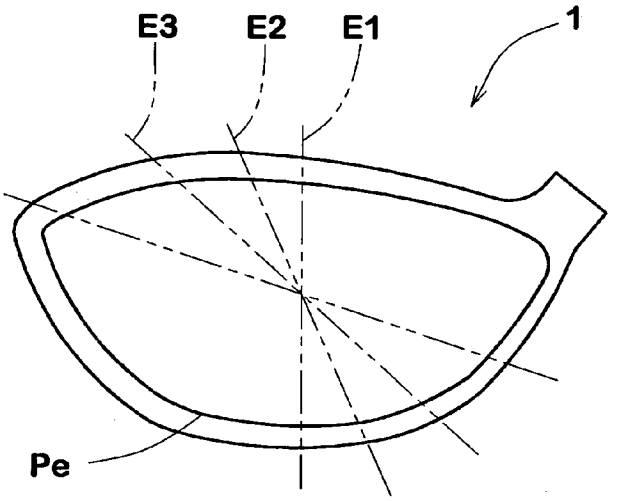
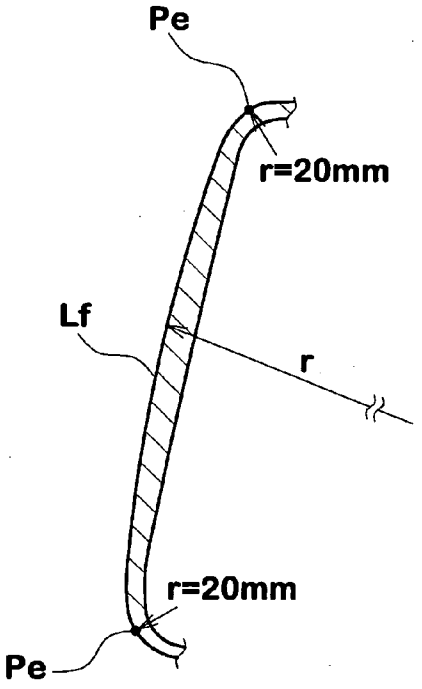


FIG.7



E 1 Section

FIG.8

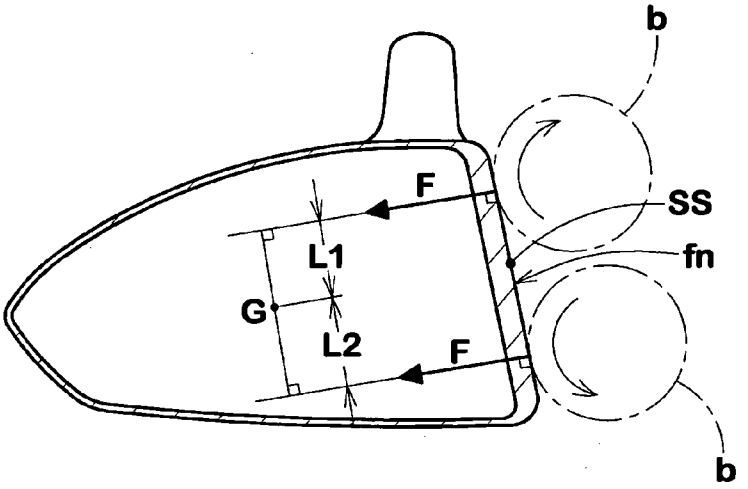


FIG.9

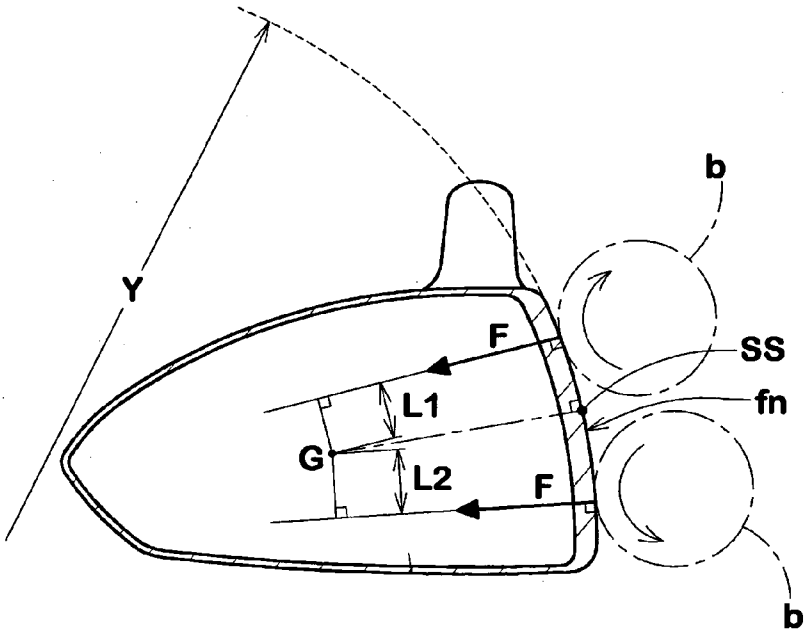


FIG.10

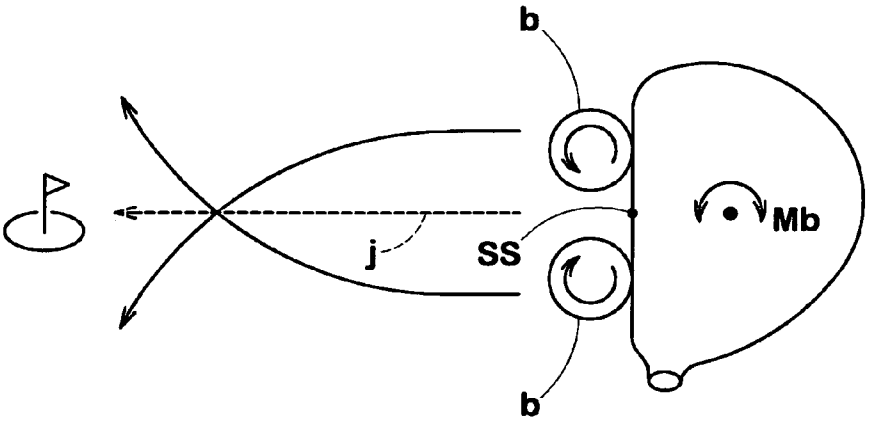
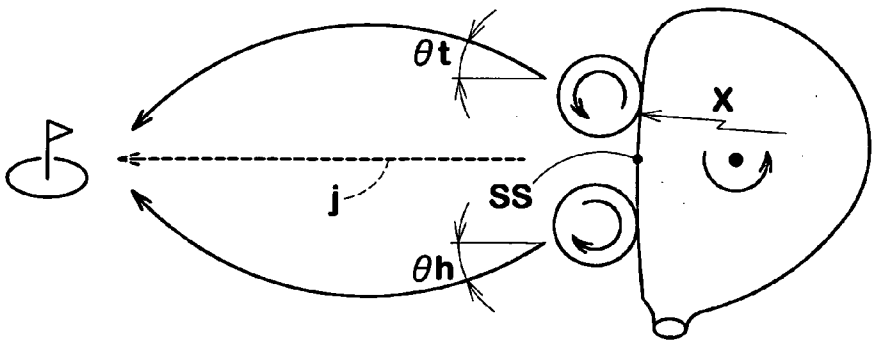


FIG.11



WOOD-TYPE GOLF CLUB HEAD

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a wood-type golf club head, more particularly to a club face having curvature specifically defined in relation to a moment of inertia of the head in order to achieve carry distance and steady directionality.

[0002] In the wood-type golf club heads, in order to increase the carry distance, various studies have been made, and it has been known to be effective to avoid so called "ballooning", or "rising" trajectory by reducing the backspin of the golf ball at impact.

[0003] On the other hand, it is desirable that the carry distance is not so varied even if the ball hitting positions of the club face are off the sweet spot upward or downward, therefore, it is desirable to decrease the variation of backspin due to the change in the ball hitting position in the up-and-down direction.

[0004] Such variation of backspin can be reduced by a face roll because the face roll can lessen the vertical gear effect.

[0005] As well known in the art, the vertical gear effect is as follows. If the ball hitting position is off the sweet spot SS upwards or downwards, then as shown in FIG. **8**, with respect to a horizontal axis extending in the toe-heel direction passing through the center of gravity G of the head, there is caused a moment which is a product of the impact force F received from the golf ball (b) and the distance L**1** or L**2** between the hitting position and the center of gravity G measured perpendicular to the direction of the force F. As a result, the club head is rotated around the horizontal axis by a small angle.

[0006] Due to the frictional engagement between the golf ball and the club face (fn), the contact surface of the golf ball receives a force in the reverse direction to the rotational direction of the club head like a gear. Accordingly, the backspin of the ball is decreased in the case of an upper hitting position or increased in the case of a lower hitting position.

[0007] By providing a face roll as shown in FIG. **9**, the distance L**1** or L**2** becomes relatively small, and the moment is decreased accordingly. Therefore, the vertical gear effect is lessened, and the variation of backspin is also decreased.

Further, in the case of the upper hitting position, the face roll can increase the ball launch angle, therefore, a decrease in the ballistic height due to the above-explained decrease in the backspin can be compensated thereby. On the other hand, in the case of the lower hitting position, the face roll can decrease the ball launch angle, therefore, an increase in the ballistic height due to the above-explained increase in the backspin can be compensated thereby.

[0008] In recent years, on the other hand, large-sized wood-type golf club heads are widely used. Such a large-sized head has a relatively large vertical moment of inertia Ma. As a result, even if the ball hitting positions are off the sweet spot upward or downward, the above-mentioned rotation of the club head at impact becomes decreased, and the vertical gear effect is also lessened.

[0009] Therefore, in the case of the upper hitting position, the backspin is not fully decreased due to the lessened vertical gear effect whereas the launch angle is increased by the face roll. As a result, the trajectory is liable to become "rising" trajectory and thereby the carry distance is decreased.

On the other hand, in the case of the lower hitting position, the backspin is not fully increased due to the lessened vertical gear effect whereas the launch angle is decreased by the face roll. As a result, the ballistic height becomes very low, and again the carry distance is decreased.

SUMMARY OF THE INVENTION

[0010] It is therefore, an object of the present invention to provide a wood-type golf club head in which, although the vertical moment of inertia is large, the decrease in the carry distance due to the ball hitting position which is off the sweet spot upward or downward, can be lessened.

[0011] According to the present invention, a wood-type golf club head has a club face provided with a face roll of which radius of curvature Y (inch) satisfies:

$$Ma/Y=<250 \text{ and}$$

$$Ma>=3000$$

wherein

Ma is a vertical moment of inertia (g sq·cm) of the head around a horizontal axis extending through the center of gravity of the head in parallel with a toe-heel direction of the head.

DEFINITIONS

[0012] In this specification, dimensions, positions, directions and the like relating to the club head refer to those under a standard state of the club head unless otherwise noted.

[0013] Here, the standard state of the club head is such that the club head is set on a horizontal plane HP so that the axis CL of the clubshaft (not shown) is inclined at the lie angle (alpha) while keeping the axis CL on a vertical plane VP, and the club face **2** forms its loft angle (beta) with respect to the horizontal plane HP. Incidentally, in the case of the club head alone, the center line of the shaft inserting hole **7***a* can be used instead of the axis CL of the clubshaft.

[0014] "Sweet spot SS" is the point of intersection between the club face **2** and a straight line N drawn normally to the club face **2** passing through the center of gravity G of the head.

[0015] "Back-and-forth direction" is a direction parallel with the straight line N projected on the horizontal plane HP.

[0016] "Heel-and-toe direction" is a direction parallel with the horizontal plane HP and perpendicular to the back-and-forth direction.

[0017] "up-and-down direction" is a direction perpendicular to the horizontal plane HP.

[0018] "Vertical moment of inertia Ma" is the moment of inertia of the head around a horizontal axis passing through the center of gravity G in parallel to the toe-heel direction of the head.

[0019] "Lateral moment of inertia Mb" is the moment of inertia of the head around a vertical axis passing through the center of gravity G.

[0020] "Face progression FP" is the horizontal distance of the leading edge Le of the club head **1** from the vertical plane VP including the club shaft center line CL, measured in a vertical plane including the sweet spot Ss and the center of gravity G as shown in FIG. **3**.

[0021] "Edge" of the club face **2**: if the edge (**2***a*, **2***b*, **2***c* and **2***d*) is unclear due to smooth change in the curvature of the club face **2**, a virtual edge line (Pe) which is defined based on the curvature change, is used instead as follows. As shown in FIGS. **6** and **7**, in each cutting plane E**1**, E**2** . . . including the straight line N extending between the sweet spot SS and the center of gravity G, a point Pe at which the radius (r) of curvature of the profile line Lf of the face portion first

becomes under 20 mm in the course from the center SS to the periphery of the club face is determined. Then, the virtual edge line is defined as a locus of the points Pe.

[0022] "wood-type golf club" is meant for at least number 1 to 5 woods, and clubs comprising heads having similar shapes may be included.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1** is a front view of a wood-type golf club head according to the present invention.

[0024] FIG. **2** is a top view thereof.

[0025] FIG. **3** is a cross sectional view taken along line A-A in FIG. **2**.

[0026] FIG. **4** is a cross sectional view of the face portion for explaining the face roll.

[0027] FIG. **5** is a cross sectional view of the face portion for explaining the face bulge.

[0028] FIGS. **6** and **7** are a front view and a cross sectional view of a face portion for explaining the edge of the club face.

[0029] FIGS. **8** and **9** are cross sectional views for explaining a vertical gear effect.

[0030] FIGS. **10** and **11** are cross sectional views for explaining a horizontal gear effect.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0031] In the drawings, wood-type golf club head **1** according to the present invention comprises: a face portion **3** whose front face defines a club face **2** for striking a ball; a crown portion **4** intersecting the club face **2** at the upper edge **2***a* thereof; a sole portion **5** intersecting the club face **2** at the lower edge **2***b* thereof; a side portion **6** between the crown portion **4** and sole portion **5** which extends from a toe-side edge **2***c* to a heel-side edge **2***d* of the club face **2** through a back face BF of the club head; and a hosel portion **7** at the heel side end of the crown to be attached to an end of a club shaft (not shown) inserted into the shaft inserting hole **7***a*. Thus, the club head **1** is provided with a hollow (i) and a shell structure with the thin wall.

[0032] The club face **2** is provided with a face roll FR (a curvature from crown to sole) and a face bulge FB (a curvature from heel to toe). Further, the face **2** is provided with parallel score lines **9** extending straight in the toe-heel direction. The score lines **9** are fine grooves for creating a suitable friction between the face and ball at impact even in wet conditions so as to effectively prevent so called drop ball.

[0033] In order to reduce the weight of the head and to adjust the position of the center of gravity G of the head, fiber reinforced resins can be used as light weight materials to form a part of the club head **1**. But, in this example, the club head **1** is made of one or more metal materials only. Various metal materials, for example, stainless alloys, maraging steels, pure titanium, titanium alloys, magnesium alloys, aluminum alloys and the like can be used. But, the use of metal materials having high specific tensile strength is desirable. In the case of titanium alloys for example, Ti-6Al-4V, Ti-15V-3Cr-3Al-3Sn, Ti-15Mo-5Zr-3Al, Ti-13V-11Cr-3Al and the like can be suitably used.

[0034] The club head **1** can be manufactured by assembling two or more (usually up to 5 or 6) parts each prepared through a suitable process for example, casting, forging, pressure molding or the like.

[0035] In this embodiment, the head is for a number 1 wood.

[0036] The volume of the club head **1** is preferably not less than 400 cc, more preferably not less than 420 cc, still more preferably not less than 440 cc in order to increase the moment of inertia and the depth of the center of gravity.

[0037] However, to prevent an excessive increase in the club head weight and deteriorations of swing balance and durability, the club head volume is preferably not more than 600 cc, more preferably not more than 500 cc. According to the golf rules, the club head volume is not more than 470 cc, thus the volume is set to be 460 cc or less as circumstances demand.

[0038] The height h of the face **2** is set in a range of not less than 30 mm, preferably not less than 35 mm, more preferably not less than 40 mm, but not more than 70 mm, preferably not more than 65 mm, more preferably not more than 60 mm when measured between the upper edge **2***a* and the lower edge **2***b* in the vertical plane including the sweet spot as shown in FIG. **4**. If the height h is too small, it becomes difficult to hit the ball, and the impact resilience of the face is decreased to decrease the carry distance. If the height h is too large, there is a possibility that the position of the sweet spot SS becomes unfavorably high, and the carry distance is decreased.

[0039] Also, the width FW of the face **2** is preferably set in a range of not less than 90 mm, more preferably not less than 95 mm, still more preferably not less than 100 mm, but not more than 130 mm, more preferably not more than 127 mm, still more preferably not more than 125 mm when measured in the toe-heel direction between the toe-side edge **2***c* and heel-side edge **2***d* passing through the sweet spot SS as shown in FIG. **1**.

[0040] The vertical moment of inertia Ma is set to be not less than 3000 (g sq·cm), preferably not less than 3200 (g sq·cm), more preferably not less than 3500 (g sq·cm), still more preferably not less than 3900 (g sq·cm).

Therefore, even if the ball hitting position is off the sweet spot upward or downward, the rotation of the club head **1** at impact around the horizontal axis passing through the center of gravity can be reduced, and the vertical gear effect is lessened. Thereby, the variation of backspin due to the variation of the ball hitting positions is reduced.

If the vertical moment of inertia Ma is less than 3000 (g sq·cm), it becomes difficult to obtain these effects. If the vertical moment of inertia Ma is too large contrary, there is possibility that the club head weight unavoidably increases or the shape of the club head becomes peculiar. Therefore, the vertical moment of inertia Ma is preferably not more than 4500 (g sq·cm), more preferably not more than 4000 (g sq·cm).

[0041] Meanwhile, the ball launch angle becomes substantially equal to the angle of a normal line drawn to the club face **2** at the ball hitting position. In the case that the radius of curvature Y of the face roll FR is small, if the ball hitting position is off the sweet spot SS upward, then the launch angle becomes relatively large, when compared with the ball hitting position is the sweet spot SS. If the ball hitting position is off the sweet spot SS downward, then the launch angle becomes relatively small. In either event, the carry distance is decreased.

[0042] In the present invention, therefore, the radius of curvature Y (inch) of the face roll FR is limited in relation to the vertical moment of inertia Ma (g sq·cm) as follows:

$$Ma/Y=<250$$

thereby, the increase in the launch angle at the time of upper hitting is reduced, and "ballooning" or "rising" trajectory can be prevented. Also, the decrease in the launch angle at the time of lower hitting is reduced, and the decrease in the carry distance due to the low ballistic height can be prevented. Preferably, the ratio (Ma/Y) is not more than 245, more preferably not more than 200, still more preferably not more than 195. However, if the ratio (Ma/y) is less than 90, the ballistic course tends to become excessively low at the time of upper hitting, or excessively high at the time of lower hitting, therefore, the ratio (Ma/Y) is not less than 90, preferably not less than 110, more preferably not less than 130.

[0043] If the numerical value of the radius of curvature Y is less than 15 inches, then the above-mentioned advantageous effects are lessened, therefore, the radius of curvature Y is preferably not less than 15 inches, more preferably not less than 16 inches, still more preferably not less than 20 inches.

[0044] Although the radius of curvature Y may be infinitely great, it is preferred that the radius Y is not more than 100 inches, more preferably not more than 50 inches, still more preferably not more than 40 inches in order to slightly fix the ball launch angle at the upper and lower hits because, even in the club head having a large vertical moment of inertia Ma, slight vertical gear effect occurs.

[0045] In this embodiment, further, the lateral moment of inertia Mb is set in a range of not less than 4000 (g sq·cm), preferably not less than 4500 (g sq·cm), more preferably not less than 5000 (g sq·cm), still more preferably not less than 5200 (g sq·cm).

[0046] Therefore, even if the ball hitting position is off the sweet spot toward the toe or heel, the rotation of the head at impact around the vertical axis passing through the center of gravity G can be reduced. As a result, by the user's intentional rotating of the head around the clubshaft center line CL to the proper address position, the deterioration of directionality of the struck ball can be avoided.

[0047] But, if the lateral moment of inertia Mb is too large, then there is possibility that the club head weight unavoidably increases or the shape of the club head becomes peculiar. Therefore, the lateral moment of inertia Mb is preferably not more than 8000 (g sq·cm), more preferably not more than 6000 (g sq·cm).

[0048] When the lateral moment of inertia Mb has a relatively large value as above, similar phenomenon to that explained in relation to the vertical gear effect occurs as follows.

[0049] In the case that the ball hitting position is off the sweet spot SS towards the toe, as shown in FIG. **10** (illustrating a right-handed case), the club head **1** is rotated clockwise around the center of gravity G, and a counterclockwise sidespin is given to the ball (b). On the other hand, in the case that the ball hitting position is off the sweet spot SS towards the heel, the club head **1** is rotated counterclockwise around the center of gravity G, and a clockwise sidespin is given to the ball (b). Such phenomenon is known as horizontal gear effect.

[0050] Due to the sidespin, therefore, the struck ball is liable to travel out of the target trajectory J to the left or right.

[0051] Such deviation, namely, deterioration of the directionality due to the horizontal gear effect can be reduced by a face bulge.

[0052] By providing a face bulge, as shown in FIG. **11**, in the case that the ball hitting position is off the sweet spot SS toward the toe (toe-side hitting), the ball is launched rightward at an angle θt with respect to the target trajectory j, and due to the sidespin (hook spin), the ball returns towards the target trajectory j. In the case that the ball hitting position is off the sweet spot SS toward the heel (heel-side hitting), the ball is launched leftward at an angle θh with respect to the target trajectory j, and due to the sidespin (slice spin), the ball returns towards the target trajectory j. Thus, the deterioration of the directionality is reduced.

[0053] When the lateral moment of inertia Mb becomes more than 4000 (g sq·cm), the horizontal gear effect is decreased, and accordingly the sidespin is decreased whereas the ball is launched at the angle θt or θh due to the face bulge at the time of toe-side or heel-side hitting. Accordingly, there is possibility that the face bulge deteriorates the directionality.

[0054] In this embodiment, therefore, the face bulge FB is provided with a radius of curvature X (inch) satisfying

$$Mb/X=<350$$

wherein

Mb is the above-mentioned lateral moment of inertia in g sq·cm. Preferably, the ratio (Mb/x) is not more than 325, more preferably not more than 260, but not less than 50, more preferably not less than 100, still more preferably not less than 130.

As a result, the horizontal launch angle θt or θh at the time of toe-side or heel-side hitting, is optimized and the deterioration of the directionality can be prevented. If the ratio (Mb/X) is less than 350, hook tendency and slice tendency become noticeable at the time of toe-side hitting and heel-side hitting, respectively.

[0055] The numerical value of the radius of curvature X of the face bulge FB is preferably not less than 15 inches, more preferably not less than 16 inches, still more preferably not less than 20 inches. If the radius X is less than 15 inches, the above-mentioned advantageous effect tends to decrease. Although the radius of curvature X may be infinitely great, it is preferred that the radius X is not more than 100 inches, more preferably not more than 50 inches, still more preferably not more than 40 inches, so that the ball is launched at a small horizontal launch angle at the time of toe-side or heel-side hitting because, even in the club head having a large lateral moment of inertia Mb, slight horizontal gear effect occurs.

[0056] In this embodiment, the vertical moment of inertia Ma is less than the lateral moment of inertia Mb. In this case, there is a tendency that the vertical gear effect comes out stronger than the horizontal gear effect. Therefore, it is desirable to make the radius of curvature Y of the face-roll FR less than the radius of curvature X of the face bulge FB in order to lessen the difference between the vertical and horizontal gear effects. Preferably, the radius ratio (X/Y) is not less than 1.2, more preferably not less than 1.5. But, if the ratio (X/Y) is more than 3.5, the radius of curvature Y of the face roll is decreased and the above-mentioned negative aspects arise, therefore, the radius ratio (X/Y) is not more than 3.5, more preferably not more than 3.0.

[0057] In this embodiment, the face roll FR and face bulge FB extend over the almost entirety of the club face **2**.
The center of the radius of curvature Y is positioned backwardly far from the center of gravity G.
The center of the radius of curvature X is positioned backwardly far from the center of gravity G of the head.
In the vertical plane including the sweet spot SS and the center of gravity G, as shown in FIG. **4**, at least between an upper point Pu 10 mm downward from the upper edge **2***a* of the face **2** and a lower point Pd 10 mm upward from the lower edge **2***b* of the face **2**, the radius of curvature Y is a single radius.
In the horizontal plane including the sweet spot SS, as shown in FIG. **5**, at least between a toe-side point Pt 20 mm toward the sweet spot from the toe-side edge **2***c* and a heel-side point Ph 20 mm toward the sweet spot from the heel-side edge **2***d*, the radius of curvature X is a single radius.
However, in the above-mentioned range between (Pu and Pd) or (Pt and Ph), the radius Y or X may be varied as far as the above-mentioned limitations are satisfied.
[0058] In this embodiment, further, the face progression FP is increased to at least 20 mm, preferably not less than 21 mm as shown in FIG. **3**. By increasing the face progression FP in this way, the center line CL of the shaft axis is relatively shifted toward the backward of the club face. Namely, without decreasing the lateral moment of inertia Mb and the depth GL**2** of the center of gravity G, the center line CL of the shaft axis approaches the center of gravity G, and the moment of inertia Mc of the head around the center line CL is decreased. Therefore, it becomes easy even for the beginner and intermediate golfers to rotate the head around the clubshaft center line CL during swing. As the club head **1** is easy to control, in cooperation with the large lateral moment of inertia Mb, good directionality can be obtained.
But, if the face progression FP is excessively large, then the moment of inertia Mc decreases and the club head is liable to rotate in excess. As a result, hook tends to occur. Further, it becomes difficult to address the ball. In this light, the face progression FP is preferably not more than 25 mm, more preferably not more than 24 mm, still more preferably not more than 23 mm.

Comparison Tests

[0059] Wood-type hollow metal heads were prepared and tested for carry distance and directionality.
[0060] Each of the club heads was composed of:
a hollow main body formed by casting a titanium alloy Ti-6Al-4V and provided with an opening in the crown portion;
a tungsten-alloy weight fixed to the inside of the main body by the use of an epoxide resin adhesive; and
a crown plate formed by forging a titanium alloy Ti-15V-3Cr-3Sn and fixed to main body by laser-welding so as to cover the opening.
The specifications common to all of the heads are as follows:
[0061] Head volume: 460 cc
[0062] Head mass: 198 g
[0063] Lie angle: 58 degrees
[0064] Loft angle: 10.5 degrees
[0065] Face height h: 52 mm
[0066] Face width FW: 105 mm
[0067] Thickness of the crown portion: 0.4 mm
[0068] Thickness of the face portion:
[0069] 3.8 mm in a central portion including the sweet spot
[0070] 2.5 mm in the peripheral portion
The moments of inertia Ma and Mb were changed by changing the thicknesses of the sole portion, side portion and/or crown portion, the mass of the weight member, the position of the hosel portion as shown in Tables 1, 2 and 3.

Carry Distance Test:

[0071] Each of the club heads was attached to a FRP shaft ("MP400" manufactured by SRI Sports Limited, flex R, mass 48 grams) to make a number 1 wood, and the wood club was mounted on a swing robot. Then, the each head hit three-piece balls (SRIXON Z-UR, manufactured by SRI Sports Limited) six times par each of the following five hitting positions to obtain the average carry distance of the six shots. The head speed was 45 meter/second.

Hitting Positions:

[0072] Center: sweet spot SS
[0073] Upside: 10 mm upside of SS
[0074] Downside: 10 mm downside of SS
[0075] Toe-side: 10 mm toe-side of SS
[0076] Heel-side: 10 mm heel-side of SS
Directionality Test (Deviation from Target Trajectory)
[0077] Five golfers having handicap ranging from 10 to 20 hit the above-mentioned three-piece balls ten times each with each of the above-mentioned golf clubs.
The deviation or difference of the stop position of the struck ball from the target trajectory was measured in each shot, and "+" plus sign and "−" minus sign which mean slice and hook, respectively, were added to the measurements. Using such measurements, the following criteria were calculated:
Average deviation (average of 50 shots=10 shots×5 golfers);
Slice tendency (average of most sliced five shots of 5 golfers);
Hook tendency (average of most hooked five shots of 5 golfers);
Maximum variation (slice tendency−hook tendency).
The test results are shown in Tables 1 to 3.

TABLE 1

	Ref. 1	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ref. 2	Ex. 6	Ref. 3	Ex. 7
Head										
Vertical moment Ma (g sq.cm)	3900	3900	3900	3900	3900	3900	3200	3200	4500	4500
Lateral moment Mb (g sq.cm)	5200	5200	5200	5200	5200	5200	4500	4500	6000	6000
Face progression FP (mm)	22	22	22	22	22	22	22	22	22	22
Face bulge radius X (inch)	30	30	30	30	30	30	30	30	30	30
Face roll radius Y (inch)	12	16	20	25	30	40	12	20	12	30
Ma/Y	325	244	195	156	130	98	267	160	375	150

TABLE 1-continued

	Ref. 1	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ref. 2	Ex. 6	Ref. 3	Ex. 7
Mb/X	173	173	173	173	173	173	150	150	200	200
X/Y	2.5	1.9	1.5	1.2	1.0	0.8	2.5	1.5	2.5	1.0
Carry distance (m)										
Center	254	253	253	254	255	254	252	253	256	255
Upside	241	244	246	249	246	243	240	246	240	248
Downside	232	235	238	243	240	234	230	238	230	240
Toe-side	245	246	245	246	245	245	241	241	246	247
Heel-side	234	235	235	234	234	235	232	233	236	237

TABLE 2

	Ex. 2	Ex. 8	Ex. 9	Ex. 10
Head				
Vertical moment Ma (g sq.cm)	3900	3900	3900	3900
Lateral moment Mb (g sq.cm)	5200	5200	5200	5200
Face progression FP (mm)	22	18	20	24
Face bulge radius X (inch)	30	30	30	30
Face roll radius Y (inch)	20	20	20	20
Ma/Y	195	195	195	195
Mb/X	173	173	173	173
X/Y	1.5	1.5	1.5	1.5

TABLE 2-continued

	Ex. 2	Ex. 8	Ex. 9	Ex. 10
Carry distance (m)				
Center	253	252	253	252
Upside	246	246	246	247
Downside	238	237	238	237
Toe-side	245	242	243	244
Heel-side	235	236	235	235
Directionality				
Average deviation (m)	−1	10	4	−9
Slice tendency (m)	9	22	14	0
Hook tendency (m)	−8	0	−5	−18
Maximum variation (m)	17	22	19	18

TABLE 3

	Ex. 2	Ex. 11	Ex. 12	Ex. 13	Ex. 14	Ex. 15
Head						
Vertical moment Ma (g sq.cm)	3900	3900	3900	3900	3900	3900
Lateral moment Mb (g sq.cm)	5200	5200	5200	5200	5200	5200
Face progression FP(mm)	22	22	22	22	22	22
Face bulge radius X (inch)	30	12	16	20	40	50
Face roll radius Y (inch)	20	20	20	20	20	20
Ma/Y	195	195	195	195	195	195
Mb/X	173	433	325	260	130	104
X/Y	1.5	0.6	0.8	1.0	2.0	2.5
Carry distance (m)						
Center	253	250	251	251	252	251
Upside	246	245	246	246	247	245
Downside	238	239	239	238	238	239
Toe-side	245	239	241	243	244	242
Heel-side	235	230	231	232	233	231
Directionality						
Average deviation (m)	−1	4	2	1	2	2
Slice tendency (m)	9	18	15	13	12	16
Hook tendency (m)	−8	−14	−12	−9	−8	−12
Maximum variation (m)	17	32	27	22	20	28

1. A wood-type golf club head having a club face provided with a face roll whose radius of curvature Y in inch satisfies:

$Ma/Y=<250$ and

$Ma>=3000$,

wherein Ma is a vertical moment of inertia in g sq·cm of the head around a horizontal axis extending through the center of gravity of the head in parallel with a toe-heel direction of the head.

2. The golf club head according to claim **1**, wherein

a lateral moment of inertia Mb of the head around a vertical axis extending through the center of gravity of the head is not less than 4000 g sq·cm.

3. The golf club head according to claim **2**, wherein

the club face has a face progression of not less than 20 mm.

4. The golf club head according to claim **3**, wherein

the club face is provided with a face-bulge whose radius of curvature X in inch satisfies:

$Mb/x=<350$

wherein Mb is said lateral moment of inertia in g sq·cm.

5. The golf club head according to claim **2**, wherein

the club face is provided with a face bulge whose radius of curvature X in inch satisfies:

$Mb/x=<350$

wherein Mb is the lateral moment of inertia in g sq·cm.

6. The golf club head according to claim **5**, wherein

the vertical moment of inertia Ma is less than the lateral moment of inertia Mb.

7. The golf club head according to claim **6**, wherein

the radius ratio (X/Y) is not less than 1.2.

8. The golf club head according to claim **5**, wherein

the radius ratio (X/Y) is not less than 1.2.

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