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(57)

ABSTRACT

A hollow golf club head comprises a face portion, a crown portion and a sole portion. The club face has a face center. In a vertical cross section of the head passing through the face center: a ratio H_f/H of a height H_f of the club face measured in parallel to a tangential line drawn passing the face center, to a maximum height H of the head measured in parallel to the tangential line is not more than 0.65; when measured at a first boundary point between the face portion's inner surface and the crown portion's inner surface, an inner surface of the head has a radius of curvature in a range from 4.0 to 10.0 mm; and when measured at the first boundary point from the inner surface to an outer surface of the head, a wall thickness of the head is not less than 1.5 mm.

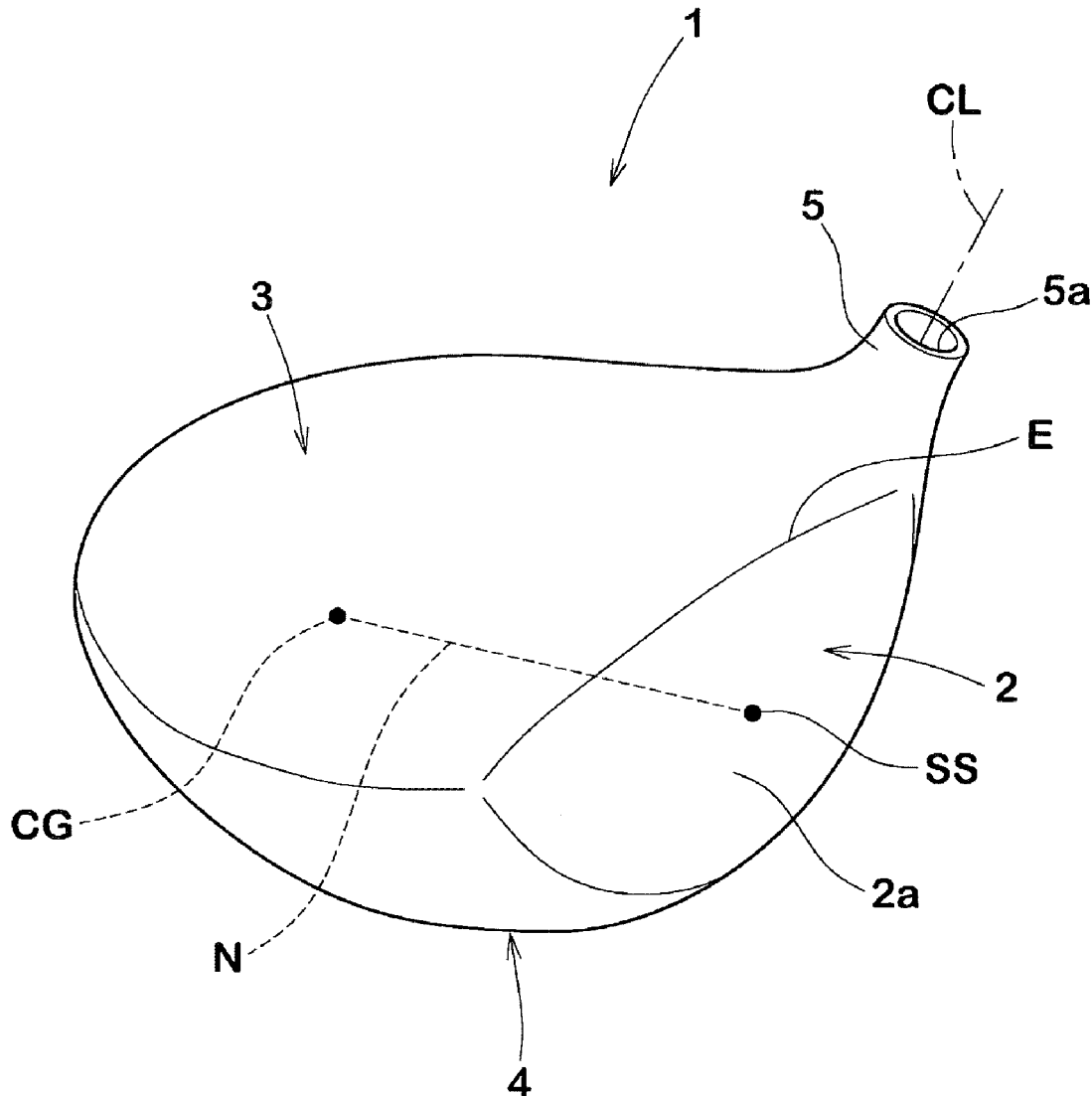


FIG.1

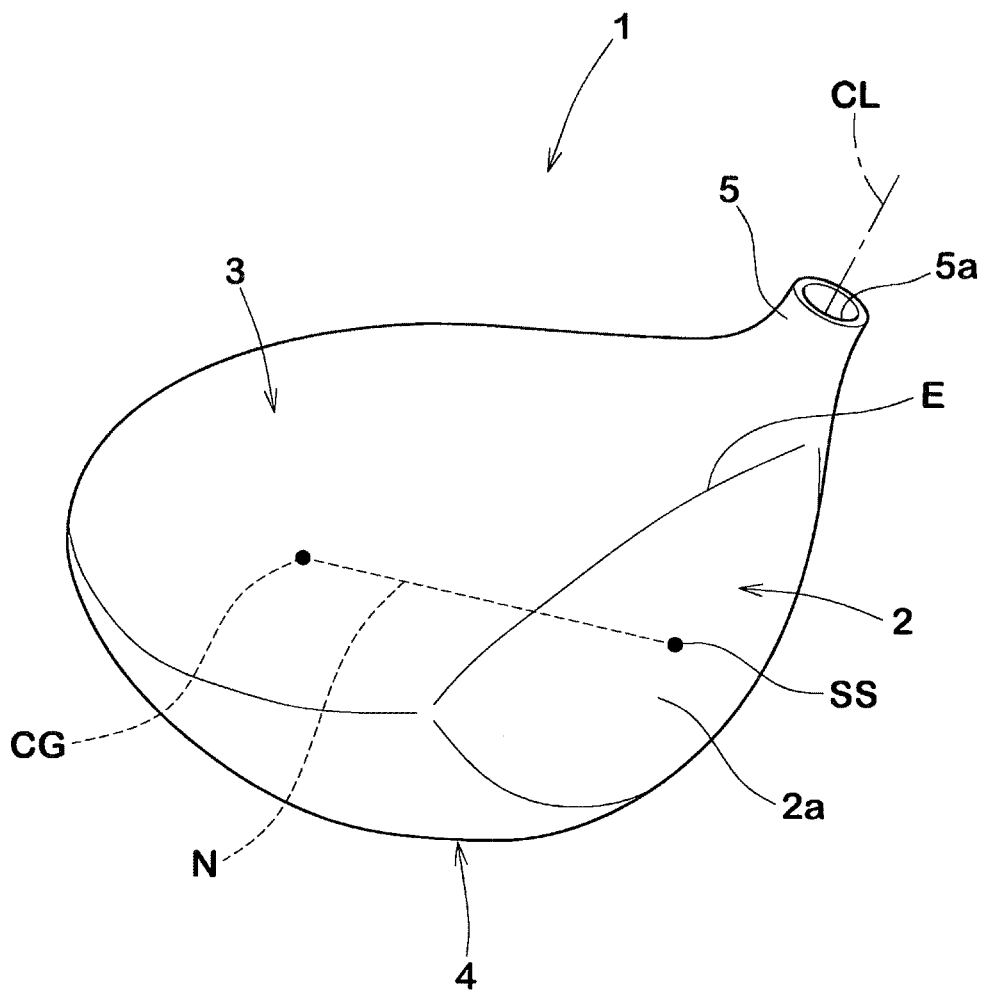


FIG.2

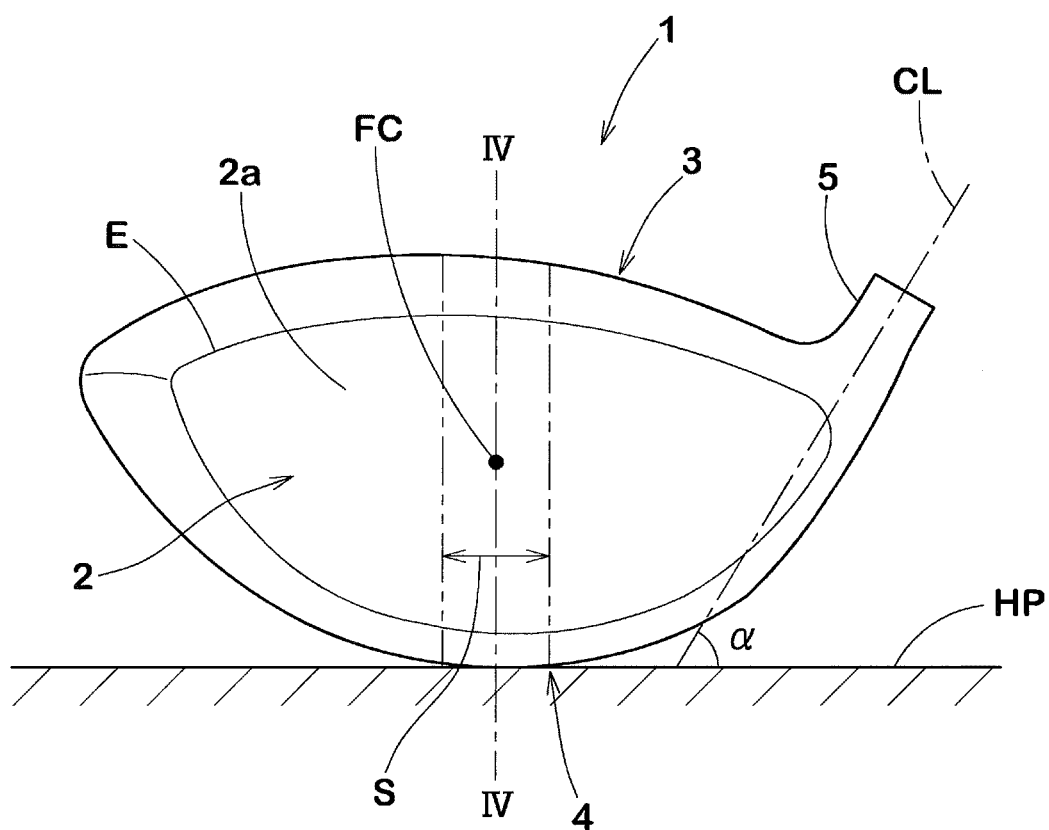


FIG.3

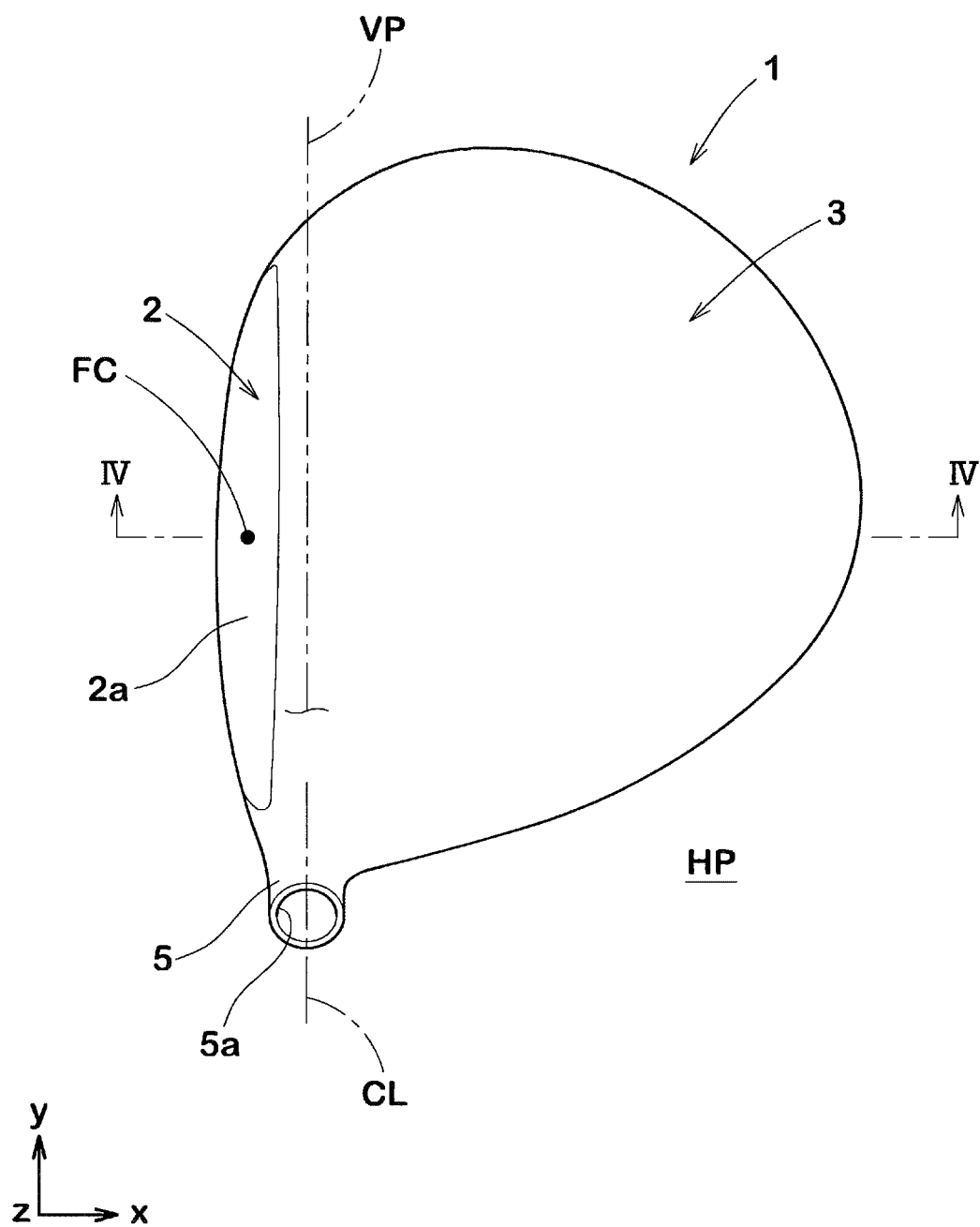


FIG.5A

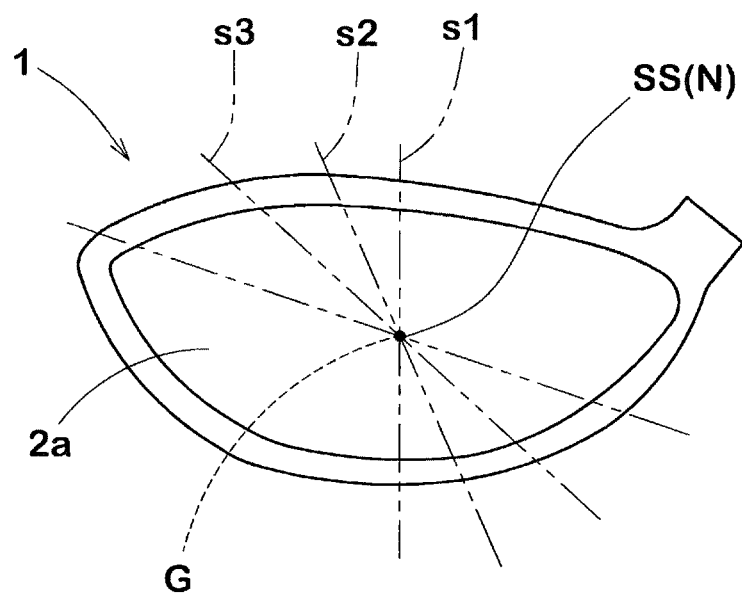


FIG.5B

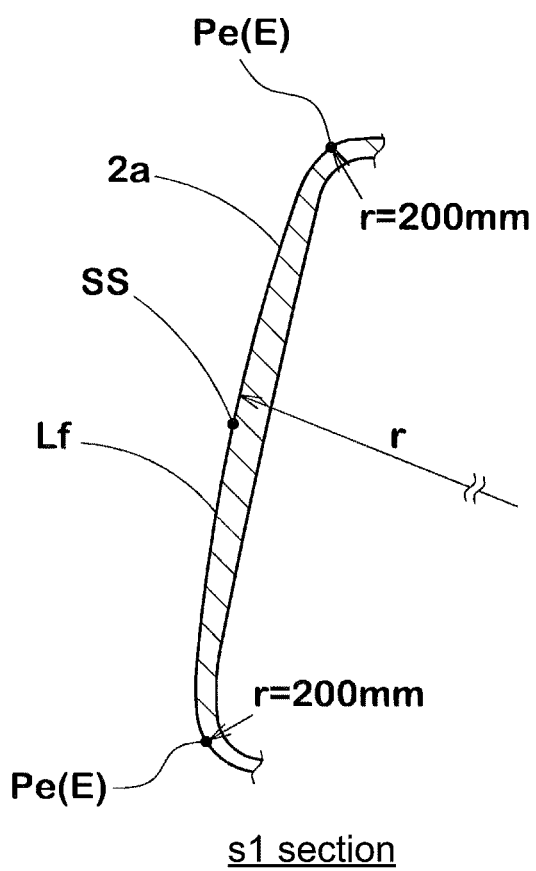


FIG.6

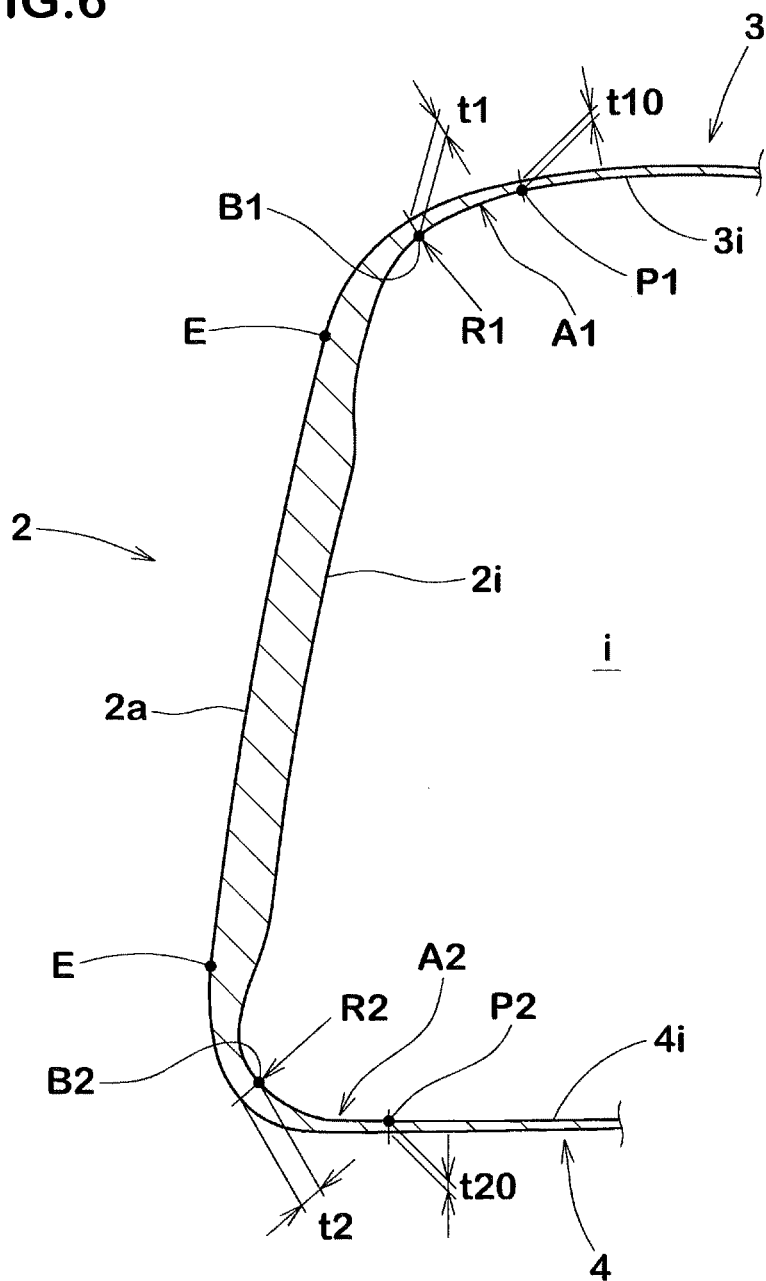
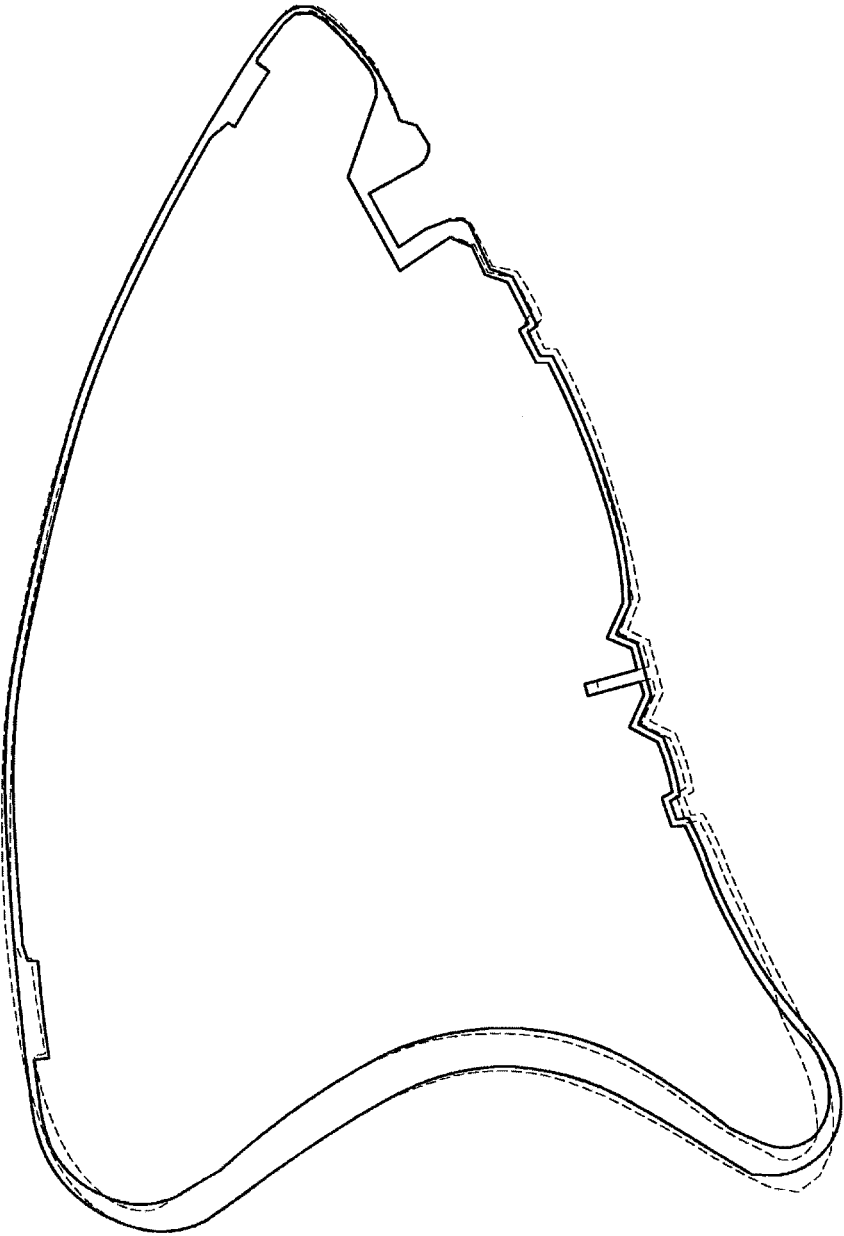


FIG. 7



GOLF CLUB HEAD**BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present disclosure relates to a golf club head.

Background Art

[0002] There is a demand from golfers to increase the flight distance of a hit ball. It is important for increasing the flight distance to improve the repulsive function of a golf club head, for example.

[0003] The following Patent Document 1 discloses a golf club head, in which the distribution of the wall thickness of the face portion is adjusted so that the face portion can be greatly bent at the time of hitting a ball thereby to improve the repulsion performance of the head.

PRIOR ART DOCUMENT

[0004] Patent Document 1: Japanese Patent No. 5583827

SUMMARY OF THE INVENTION**Problems to be Solved by the Invention**

[0005] In order to increase the flight distance of a hit ball, it is also important to reduce the amount of backspin of the hit ball.

[0006] The inventors found that, by suppressing the bending of the face portion when hitting the ball and at the same time promoting the bending of the body portion (that is, crown portion and/or sole portion), it becomes possible to reduce the amount of backspin and increase the flight distance of the hit ball.

[0007] In view of the above circumstances, the present disclosure was invented, and an object of the present disclosure is to provide a golf club head capable of improving the flight distance of a hit ball.

Means for Solving the Problems

[0008] According to the present disclosure, a golf club head has a hollow therein and comprises a face portion, a crown portion and a sole portion which enclose the hollow, wherein

[0009] the face portion has an outer surface forming a club face, and an inner surface facing the hollow,

[0010] the crown portion has an inner surface facing the hollow,

[0011] the club face has a face center, and

[0012] in a vertical cross section of the head passing through the face center,

(a) a ratio H_f/H of a height H_f of the club face measured in parallel to a tangential line drawn passing the face center, to a maximum height H of the head measured in parallel to the tangential line is not more than 0.65.

(b) when measured at a first boundary point between the face portion's inner surface and the crown portion's inner surface, an inner surface of the head has a radius of curvature in a range from 4.0 to 10.0 mm, and

(c) when measured at the first boundary point from the inner surface to an outer surface of the head, a wall thickness of the head is not less than 1.5 mm.

Effects of the Invention

[0013] In the golf club head according to the present disclosure, the above-described configurations are adopted, thereby the flight distance of a hit ball can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1 is a perspective view of a golf club head as an embodiment of the present disclosure.

[0015] FIG. 2 is a front view of the golf club head.

[0016] FIG. 3 is a top view of the golf club head.

[0017] FIG. 4 is a sectional view of the golf club head taken along line IV-IV of FIG. 3.

[0018] FIG. 5A and FIG. 5B are a front view of the golf club head, and a cross-sectional view taken along the line s1, respectively.

[0019] FIG. 6 is a closeup of FIG. 4.

[0020] FIG. 7 is a diagram showing a deformed state of the contour in the vicinity of the face portion of the golf club head.

DETAILED DESCRIPTION OF THE INVENTION

[0021] Embodiments of the present disclosure will now be described in detail in conjunction with accompanying drawings.

[0022] Through all embodiments, the same or common elements are designated by the same reference sign or numeral, and redundant description therefor is omitted.

[0023] In FIGS. 1 to 3 which are a perspective view, a front view and a top view of a golf club head 1 as an embodiment, there is shown the head 1 under its reference state. Further, FIG. 4 is a cross-sectional view taken along line IV-IV of FIG. 3.

[Reference State of Head]

[0024] In this specification, the head 1 is regarded as being under such reference state unless otherwise noted.

[0025] In this application, the "reference state" of a head means a state of the head which is placed on a horizontal plane HP so that its lie angle α (FIG. 2) and loft angle (not shown) specified for the head are kept, and further, a shaft center line CL of the head is held on a reference vertical plane VP perpendicular to the horizontal plane HP as shown in FIG. 3.

Incidentally, The "shaft center line CL" can be defined by the center line of a shaft insertion hole 5a formed in a hosel portion 5 of the head 1.

[Directions Relating to Head]

[0026] As shown in FIG. 3, under the reference state of the head 1, a head front-rear direction of the head is the direction x orthogonal to the reference vertical plane VP, wherein a front side and a rear side are the club face 2a side and the opposite side, respectively;

a toe-heel direction of the head is the direction y parallel to both the reference vertical plane VP and the horizontal plane HP; and

a vertical direction of the head is the direction z orthogonal to the horizontal plane HP.

[Basic Structure of Head]

[0027] The head 1 in the present embodiment is provided with a hollow “i” therein. This type of heads include wood type, hybrid type and iron type, for example. The head 1 in this embodiment is a wood type head 1 made of a metal material.

[0028] As shown in FIGS. 1 to 4, the head 1 comprises a face portion 2, a crown portion 3, and a sole portion 4.

[0029] The face portion 2 has an outer surface forming a club face 2a for hitting a ball, and an inner surface 2i facing the hollow i, as shown in FIG. 4.

[0030] The club face 2a has a bulge and a roll. Thereby, the club face 2a is formed as a three-dimensional curved surface which is convex outward of the head.

[0031] Although not particularly limited, the maximum wall thickness of the face portion 2 is set to not more than 3.80 mm, preferably not more than 3.70 mm, more preferably not more than 3.60 mm from the viewpoint of maintaining high resilience performance.

[0032] Further, from the viewpoint of maintaining durability, the maximum wall thickness of the face portion 2 is set to not less than 3.10 mm, preferably not less than 3.20 mm, more preferably not less than 3.30 mm.

[0033] The club face 2a has a sweet spot SS and a face center FC.

[0034] The “sweet spot SS” is, as shown in FIG. 1, the intersecting point between the club face 2a and a straight line N drawn perpendicularly to the club face 2a from the center CG of gravity of the head. Such sweet spot SS is a ball hitting point at which high repulsion can be expected.

[0035] The club face 2a is defined as being surrounded by its peripheral edge E. The peripheral edge E is defined as follows:

first, in each cross section s1, s2, s3 . . . of the head including a straight line N extending between the sweet spot SS and the center G of gravity of the head, as shown in FIGS. 5A and 5B, a point Pe at which the radius (r) of curvature of the profile line of the face portion first becomes under 200 mm in the course from the center SS to the periphery of the club face is determined. Then, the peripheral edge E is defined as a locus of the points Pe.

[0036] In this application, the “radius of curvature” is measured on the target curve. Namely, the radius of curvature of a curve at a certain point thereon is determined as the radius of a circle passing through three points: the above-mentioned certain point, a point 1 mm apart from the certain point on one side of the certain point, and a point 1 mm apart from the certain point on the other side of the certain point. The “1 mm” is the measurement along the curve.

[0037] In this application, the “face center” FC is determined as follows.

Step 1: an arbitrary first point P which is considered as a point located near the center of the club face 2a with respect to both the vertical direction and the toe-heel direction, is determined.

Step 2: a first plane parallel to the toe-heel direction which includes a straight line extending from the first point P perpendicularly to the club face 2a, is determined.

Step 3: a first midpoint Px of a line of intersection between the determined first plane and the club face 2a, is determined.

Step 4: a second plane parallel to the vertical direction which includes a straight line extending from the first midpoint Px perpendicularly to the club face 2a, is determined.

Step 5: a second midpoint Py of a line of intersection between the determined second plane and the club face 2a, is determined.

Step 6: a third plane parallel to the toe-heel direction which includes a straight line extending from the second midpoint Py perpendicularly to the club face 2a, is determined.

Step 7: a midpoint of a line of intersection between the third plane and the club face 2a, is determined as the renewed midpoint Px.

Then, using the renewed midpoint Px, Steps 3-7 are repeated while measuring the distance between the renewed midpoint Py and the last midpoint Py. and when the distance first becomes 0.5 mm or less, the renewed midpoint Py is determined as the face center.

[0038] The club face 2a is provided with small parallel grooves extending in the toe-heel direction so called face lines. In the attached drawings, the face lines are omitted as the well-known structure.

[0039] The crown portion 3 is defined as extending rearward of the head from the face portion 2 so as to form the top surface of the head.

The crown portion 3 is provided, on the heel side thereof, with a hosel portion 5. The hosel portion 5 is provided with a shaft insertion hole 5a into which a tip end of a club shaft (not shown) is attached.

The crown portion 3 has an inner surface 3i facing the hollow “i” (hereinafter, the crown portion’s inner surface 3i).

[0040] The sole portion 4 is defined as extending rearward of the head from the face portion 2 so as to form the bottom surface of the head. In this example, the sole portion 4 is such a portion that can be seen in the bottom view of the head.

[0041] The main part of the head 1 is, for example, made of a metal material. The metal material is not particularly limited. For example, pure titanium, titanium alloy, stainless steel, maraging steel, aluminum alloy, magnesium alloy, tungsten-nickel alloy and the like can be used. A part of the head 1 (for example, the crown portion 3) may be made of a non-metal material such as a fiber reinforced resin. The head 1 in the present embodiment is made of a titanium alloy.

[0042] The head 1 as a first embodiment of the present disclosure has the following features (a), (b) and (c).

[0043] The head 1 as a second embodiment of the present disclosure has the following features (a), (d) and (e).

[Feature (a)]

[0044] The feature (a) pertains to a vertical cross section of the head passing through the face center FC as shown in FIG. 4. This vertical cross section is perpendicular to the horizontal plane HP such as the IV-IV plane of FIG. 2.

[0045] The feature (a) is that, when measured in the above-mentioned vertical cross section of the head, a ratio Hf/H is not more than 0.65, wherein Hf is a height of the club face 2a which is the distance between the upper and lower peripheral edges E of the club face 2a measured in parallel with the direction T of a tangent drawn to the face center FC, and H is a maximum height of the head 1 measured in parallel with the direction T of the tangent as shown in FIG. 4.

[Feature (b)]

[0046] As shown in FIG. 6 which is a closeup of FIG. 4 showing a part of the head in front of line VI-VI of FIG. 4,

the feature (b) is that a radius R1 of curvature of the contour line of the inner surface of the head 1 in the above-mentioned vertical cross section of the head, is 4.0 to 10.0 mm when measured at a first boundary point B1 between the inner surface 2i of the face portion and the inner surface 3i of the crown portion, as shown in FIG. 6.

[0047] The first boundary point B1 is a point at which the radius of curvature of the contour line of the inner surface of the head becomes a minimum in the vicinity of the boundary between the face portion's inner surface 2i and the crown portion's inner surface 3i.

If the minimum occurs along a circular arc rather than a point, then the midpoint of the length of such circular arc is regarded as the first boundary point B1.

[Feature (c)]

[0048] The feature (c) is that, as shown in FIG. 6, a wall thickness t1 of the head at the above-mentioned first boundary point B1 is not less than 1.5 mm.

[Feature (d)]

[0049] The feature (d) is that a radius R2 of curvature of the contour line of the inner surface of the head 1 in the above-mentioned vertical cross section of the head, is 3.0 to 10.0 mm when measured at a second boundary point B2 between the inner surface 2i of the face portion and the inner surface 4i of the sole portion, as shown in FIG. 6.

[0050] The second boundary point B2 is a point at which the radius of curvature of the contour line of the inner surface of the head becomes a minimum in the vicinity of the boundary between the inner surface 2i of the face portion and the inner surface 4i of the sole portion. If the minimum occurs along a circular arc rather than a point, then the midpoint of the length of such circular arc is regarded as the second boundary point B2.

[Feature (e)]

[0051] The feature (e) is that a wall thickness t2 of the head at the above-mentioned second boundary point B2 is not less than 1.5 mm.

Action of the Present Embodiment

[0052] As a result of detailed examination of the conventional golf club heads regarding the deformation when hitting a ball, it was found that the boundary portion between the face portion and the body portion (that is, crown portion and/or sole portion) becomes a starting point of bending, and only the face portion is bent and the body portion is hardly bent, and that such bending of the head tends to increase the amount of backspin of the hit ball.

[0053] Based on these findings, in order to improve the deflection of the head so that the amount of backspin of the hit ball is reduced, the inventor employed the features (a), (b) and (c) for the first embodiment, and the features (a), (d) and (e) for the second embodiment.

[0054] In the first and second embodiments, due to the feature (a), the club face 2a of the head 1 becomes relatively small with respect to the maximum height H of the head. In such heads 1, therefore, the bending of the club face 2a at the time of hitting a ball can be suppressed to be small.

[0055] In the first embodiment, at the first boundary point B1 between the face portion's inner surface 2i and the crown portion's inner surface 3i, the radius R1 of curvature and the wall thickness t1 are specifically-defined as the features (b) and (c). Thereby, it is possible to prevent the vicinity of the first boundary point B1 from becoming the starting point of bending when a ball is hit. As a result, the impact force

received by the club face 2a is effectively transmitted toward the crown portion 3 so that the deflection of the crown portion 3 is increased.

[0056] In the second embodiment, at the second boundary point B2 between the face portion's inner surface 2i and the sole portions' inner surface 4i, the radius R2 of curvature and the wall thickness t2 are specifically-defined as the features (d) and (e). Thereby, it is possible to prevent the vicinity of the second boundary point B2 from becoming a starting point of bending when a ball is hit. As a result, the impact force received by the club face 2a is effectively transmitted toward the sole portion 4 so that the bending of the sole portion 4 is increased.

[0057] As described above, in the head 1 of each embodiment, when a ball is hit, the bending of the face portion 2 is suppressed, but the bending of the body portion is promoted so that the body portion largely bends.

Such bending characteristic of the head 1 can increase the contact area between the club face 2a and the ball as compared with conventional heads, while maintaining the repulsive performance of the head 1 high.

When the contact area between the club face 2a and the ball becomes large, the amount of backspin of the hit ball decreases due to the recoil effect, and the flight distance of the hit ball increases.

[0058] The head 1 may include all of the features (a), (b), (c), (d) and (e) as a more preferred third embodiment. As a result, when the ball is hit, both the vicinity of the first boundary point B1 and the vicinity of the second boundary point B2 do not bend significantly, and the impact force received by the club face 2a is effectively transmitted to both the crown portion 3 and the sole portion 4, and the deflection thereof is increased. Therefore, in the third embodiment, the flight distance can be further increased.

[0059] In the present disclosure, at least one of the features (a) to (e), preferably two or more of the features (a) to (e), more preferably all of the features (a) to (e) are satisfied in the above-mentioned vertical cross section of the head passing through the face center FC, and more desirably satisfied in every vertical cross sections within a range S in the toe-heel direction which is centered on the face center FC as shown in FIG. 2, and extends not less than 10 mm, preferably not less than 15 mm, more preferably not less than 20 mm in the toe-heel direction. This is desirable in that the above-mentioned functions can be obtained in a wider range in the toe-heel direction of the club face 2a.

[Preferable Ratio Hf/H]

[0060] The ratio Hf/H of the feature (a) may be preferably not more than 0.63, more preferably not more than 0.61. This is desirable in that the bending of the club face 2a at the time of hitting a ball is further suppressed.

[0061] On the other hand, considering the directionality of the hit ball and the like, it is preferable that the club face 2a has a certain height Hf so that the ratio Hf/H is not less than 0.50, more preferably not less than 0.51, still more preferably not less than 0.53.

[Preferable Wall Thicknesses t1 and t2]

[0062] In order to derive the above-mentioned functions more effectively, the wall thickness t1 at the first boundary point B1 and the wall thickness t2 at the second boundary point B2 are preferably not less than 1.8 mm, more preferably not less than 2.0 mm.

[0063] On the other hand, in order to suppress the deterioration of the repulsive performance of the head 1, the wall thickness t_1 at the first boundary point B1 and the wall thickness t_2 at the second boundary point B2 are preferably not more than 4.0 mm, more preferably not more than 3.6 mm, still more preferably not more than 3.3 mm.

[Preferable Crown Portion]

[0064] In a first region A1 which ranges from the first boundary point B1 to a first point P1 which is at a distance of 10 mm from the first boundary point B1 toward the crown side (namely, rear side of the head), the crown portion 3 has the smallest wall thickness at the first point P1 in order that the crown portion 3 is further bent when hitting a ball.

As a result, when the ball is hit, the bending at the first boundary point B1 is further suppressed, while the bending of the crown portion 3 on the rear side of the first boundary point B1 is increased.

Here, the distance of 10 mm is the measurement along the contour line of the inner surface of the head.

[0065] It is preferable that, from the first boundary point B1 to the first point P1, the wall thickness of the crown portion 3 decreases without increasing. In other words, in the first region A1, the wall thickness is continuously decreased toward the first point P1, or the wall thickness does not increase toward the first point P1. In the latter case, the crown portion 3 may include a part or parts where the wall thickness is constant.

As a result, the bending at the first boundary point B1 at the time of hitting the ball can be further suppressed, and the effect of increasing the bending of the crown portion 3 can be further enhanced.

[0066] It is preferable that the wall thickness t_{10} of the crown portion 3 at the first point P1 is not more than 1.0 mm, for example.

By decreasing the wall thickness at the first point P1 in this way, the bending of the crown portion 3 at the time of hitting the ball is shifted from the first boundary point B1 toward the first point P1, and the bending at the first boundary point B1 can be suppressed more reliably.

[0067] From the viewpoint of maintaining the durability of the crown portion 3, the wall thickness t_{10} is, for example, not less than 0.4 mm, preferably not less than 0.6 mm.

[Preferable Sole Portion]

[0068] In a second region A2 which ranges from the second boundary point B2 to a second point P2 which is at a distance of 15 mm from the second boundary point B2 to the crown side (rear side of the head), the sole portion 4 has the smallest wall thickness at the second point P2 in order to bend the sole portion 4 side more when a ball is hit.

As a result, when the ball is hit, the bending at the second boundary point B2 is further suppressed, while the bending of the sole portion 4 on the rear side of the second boundary point B2 can be further increased.

Here, the distance of 15 mm is the measurement along the contour line of the inner surface of the head.

[0069] It is preferable that, from the second boundary point B2 to the second point P2, the wall thickness of the sole portion 4 decreases without increasing. In other words, in the second region A2, the wall thickness is continuously decreased toward the second point P2, or the wall thickness

does not increase toward the second point P2. In the latter case, the sole portion 4 may include a part or parts where the wall thickness is constant.

As a result, the bending at the second boundary point B2 at the time of hitting the ball can be further suppressed, and the effect of increasing the bending of the sole portion 4 can be further enhanced.

[0070] It is preferable that the wall thickness t_{20} of the sole portion 4 at the second point P2 is not more than 1.0 mm.

By decreasing the wall thickness at the second point P2 in this way, the bending of the sole portion 4 at the time of hitting the ball is shifted from the second boundary point B2 toward the second point P2, and the bending at the second boundary point B2 can be suppressed more reliably.

From the viewpoint of maintaining the durability of the sole portion 4, the wall thickness t_{20} is, for example, not less than 0.4 mm, preferably not less than 0.6 mm.

[0071] While detailed description has been made of preferable embodiments of the present disclosure, the present disclosure can be embodied in various forms without being limited to the illustrated embodiments.

Comparison Tests

[0072] Golf club heads (Working Examples) having structures based on the structure shown in FIGS. 1 to 4 were experimentally manufactured. Further, a golf club head (Comparative Example) was prepared. The club heads were tested for durability and the flight distance and backspin amount of the hit balls. Specifications of the club heads are shown in Table 1.

[0073] Each of the working examples and comparative example was made of a titanium alloy and manufactured by lost wax precision casting, wherein the head volume was 460 cc, the head weight was 200 g, and the loft angle was 9.5 degrees. All the golf club heads were essentially the same except for the specifications shown in Table 1. The test method is as follows.

<Striking Speed, Flight Distance, Backspin Amount>

[0074] Each head was attached to a golf club shaft to form a golf club, and the golf club was attached to a swing robot. Then the golf club hit a ball five times at a head speed of 50 m/s at the face center, and the average over five time measurements of each of the ball launching speed (initial speed), flight distance (total flight distance including run) and backspin amount was obtained.

[0075] The results are indicated in Table 1, wherein the flight distance and backspin amount are indicated by an index based on Comparative Example 1 being 100.

<Durability>

[0076] Each head was attached to a golf club shaft to form a golf club, and the golf club was attached to a swing robot, and repeatedly hit golf balls at a head speed of 50 m/s at the face center up to 6000 times, until the head was broken and the number of hits was recorded.

The results are shown in Table 1. If the head was not broken by hitting 6000 times, it is indicated as "OK". If the head was broken by hitting less than 5000 times, the number of hits at the time of breaking is indicated.

TABLE 1

	compar- ative ex. 1	compar- ative ex. 2	compar- ative ex. 3	working ex. 1	working ex. 2	working ex. 3	working ex. 4	working ex. 5	working ex. 6
H (mm)	66.5	67.2	66.5	68.3	68.3	68.3	68.3	63.4	71.0
Hf (mm)	47.2	47.2	41.2	41.2	41.2	41.2	41.2	41.2	36.2
(a) Hf/H	0.71	0.70	0.62	0.60	0.60	0.60	0.60	0.65	0.51
(b) R1 (mm)	3.0	6.5	3.2	7.3	7.3	7.3	3.0	7.3	7.3
(c) t1 (mm)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
t10 (mm)	2.0	0.8	0.8	0.8	2.0	0.8	0.8	0.8	0.8
(d) R2 (mm)	2.5	7.3	2.6	8.0	8.0	2.6	8.0	8.0	8.0
(e) t2 (mm)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
t20 (mm)	2.0	0.8	0.8	0.8	2.0	0.8	0.8	0.8	0.8
ball hitting speed (m/s)	73.2	75.0	71.5	74.8	74.1	74.3	74.6	74.6	74.5
backspin (rpm)	3200	3000	3300	2700	2900	2800	2850	2780	2700
flight distance (yds.)	271.4	281.0	263.3	283.3	278.4	280.3	280.5	281.8	282.1
durability (times)	3200	4800	3300	OK	OK	OK	OK	OK	OK

[0077] It was confirmed from the test results that, in each working example, the amount of backspin of the hit ball was decreased, and the flight distance of the hit ball was increased as compared with the comparative example.

[0078] Next, with respect the heads as Working Example 1 and Comparative Example 1, the deformed state of the head was obtained by computer simulating, wherein an FEM model of each head was created, and material properties of members were set, then a simulation of colliding a ball was performed. The position where the ball collides was set to the face center, and the collision speed was set to 48.87 m/s.

[0079] FIG. 7 shows the result of this simulation. In FIG. 7, the cross section of the Working Example 1 is indicated by solid line, and the cross section of the Comparative Example 1 is indicated by broken line, and in order to clarify the difference therebetween, these cross sections are overlapped by setting the deformation magnification to 20 times.

[0080] As is clear from FIG. 7, as compared with the Comparative Example 1, in the Working Example 1, the starting point of the deflection shifted towards the body portion, and the deflection is transmitted to both the crown portion and the sole portion and large deflection toward the outside of the head is occurred.

STATEMENT OF THE PRESENT DISCLOSURE

[0081] The present disclosure is as follows:—

Disclosure 1. A golf club head having a hollow therein and comprising a face portion, a crown portion and a sole portion which enclose the hollow,

[0082] the face portion having an outer surface forming a club face and an inner surface facing the hollow,

[0083] the crown portion having an inner surface facing the hollow, and

[0084] the club face having a face center, wherein

[0085] in a vertical cross section of the head passing through the face center.

(a) a ratio Hf/H of a height Hf of the club face measured in parallel to a tangential line drawn passing the face center, to a maximum height H of the head measured in parallel to the tangential line is not more than 0.65,

(b) when measured at a first boundary point between the face portion's inner surface and the crown portion's inner surface, an inner surface of the head has a radius of curvature in a range from 4.0 to 10.0 mm, and

(c) when measured at the first boundary point from the inner surface to an outer surface of the head, a wall thickness of the head is not less than 1.5 mm.

Disclosure 2. The golf club head according to Disclosure 1, wherein in a first region from the first boundary point to a first point which is at a distance of 10 mm from the first boundary point toward the crown portion, the crown portion has the smallest wall thickness at the first point.

Disclosure 3. The golf club head according to Disclosure 2, wherein, from the first boundary point to the first point, the wall thickness of the crown portion decreases without increasing.

Disclosure 4. The golf club head according to Disclosure 2 or 3, wherein the wall thickness of the crown portion at the first point is not more than 1.0 mm.

Disclosure 5. The golf club head according to any one of Disclosures 1 to 4, wherein the sole portion has an inner surface facing the hollow, and

[0086] in said vertical cross section of the head,

(d) a radius of curvature at a second boundary point between the inner surface of the face portion and the inner surface of the sole portion is 3.0 and 10.0 mm, and

(e) a wall thickness at the second boundary point is not less than 1.5 mm.

Disclosure 6. The golf club head according to Disclosure 5, wherein in a second region from the second boundary point to a second point which is at a distance of 15 mm from the second boundary point toward the sole portion, the sole portion has the smallest wall thickness at the second point.

Disclosure 7. The golf club head according to Disclosure 6, wherein, from the second boundary point to the second point, the wall thickness of the sole portion decreases without increasing.

Disclosure 8. The golf club head according to Disclosure 6 or 7, wherein the wall thickness of the sole portion at the second point is not more than 1.0 mm.

Disclosure 9. A golf club head having a hollow therein and comprising a face portion, a crown portion and a sole portion which enclose the hollow,

[0087] the face portion having an outer surface forming a club face and an inner surface facing the hollow,

[0088] the sole portion having an inner surface facing the hollow, and

[0089] the club face having a face center, wherein

[0090] in a vertical cross section of the head passing through the face center.

(a) a ratio H_f/H of a height H_f of the club face measured in parallel to a tangential line drawn passing the face center, to a maximum height H of the head measured in parallel to the tangential line is not more than 0.65.

(d) a radius of curvature at a second boundary point between the inner surface of the face portion and the inner surface of the sole portion is 3.0 and 10.0 mm, and

(e) a wall thickness at the second boundary point is not less than 1.5 mm.

Disclosure 10. The golf club head according to any one of Disclosures 1 to 9, wherein the ratio H_f/H is not less than 0.50.

DESCRIPTION OF THE REFERENCE SIGNS

[0091]	1 golf club head
[0092]	2 face portion
[0093]	2a club face
[0094]	2i inner surface of face portion
[0095]	3 crown portion
[0096]	3i inner surface of crown portion
[0097]	4 sole portion
[0098]	4i inner surface of sole portion
[0099]	i hollow
[0100]	FC face center
[0101]	H_f face height
[0102]	H maximum height of golf club head
[0103]	B1 first boundary point
[0104]	P1 first point
[0105]	A1 first region
[0106]	B2 second boundary point
[0107]	P2 second point
[0108]	A2 second region
[0109]	T tangent direction

1. A golf club head having a hollow therein and comprising a face portion, a crown portion and a sole portion which enclose the hollow,

the face portion having an outer surface forming a club face and an inner surface facing the hollow,

the crown portion having an inner surface facing the hollow, and

the club face having a face center, wherein

in a vertical cross section of the head passing through the face center,

(a) a ratio H_f/H of a height H_f of the club face measured in parallel to a tangential line drawn passing the face center, to a maximum height H of the head measured in parallel to the tangential line is not more than 0.65,

(b) when measured at a first boundary point between the face portion's inner surface and the crown portion's inner surface, an inner surface of the head has a radius of curvature in a range from 4.0 to 10.0 mm, and

(c) when measured at the first boundary point from the inner surface to an outer surface of the head, a wall thickness of the head is not less than 1.5 mm.

2. The golf club head according to claim 1, wherein in a first region from the first boundary point to a first point which is at a distance of 10 mm from the first boundary point toward the crown portion, the crown portion has the smallest wall thickness at the first point.

3. The golf club head according to claim 2, wherein from the first boundary point to the first point, the wall thickness of the crown portion decreases without increasing.

4. The golf club head according to claim 2, wherein the wall thickness of the crown portion at the first point is not more than 1.0 mm.

5. The golf club head according to claim 1, wherein the sole portion has an inner surface facing the hollow, and

in said vertical cross section of the head,

(d) a radius of curvature at a second boundary point between the inner surface of the face portion and the inner surface of the sole portion is 3.0 and 10.0 mm, and

(e) a wall thickness at the second boundary point is not less than 1.5 mm.

6. The golf club head according to claim 2, wherein the sole portion has an inner surface facing the hollow, and

in said vertical cross section of the head,

(d) a radius of curvature at a second boundary point between the inner surface of the face portion and the inner surface of the sole portion is 3.0 and 10.0 mm, and

(e) a wall thickness at the second boundary point is not less than 1.5 mm.

7. The golf club head according to claim 4, wherein the sole portion has an inner surface facing the hollow, and

in said vertical cross section of the head,

(d) a radius of curvature at a second boundary point between the inner surface of the face portion and the inner surface of the sole portion is 3.0 and 10.0 mm, and

(e) a wall thickness at the second boundary point is not less than 1.5 mm.

8. The golf club head according to claim 5, wherein in a second region from the second boundary point to a second point which is at a distance of 15 mm from the second boundary point toward the sole portion, the sole portion has the smallest wall thickness at the second point.

9. The golf club head according to claim 6, wherein in a second region from the second boundary point to a second point which is at a distance of 15 mm from the second boundary point toward the sole portion, the sole portion has the smallest wall thickness at the second point.

10. The golf club head according to claim 7, wherein in a second region from the second boundary point to a second point which is at a distance of 15 mm from the second boundary point toward the sole portion, the sole portion has the smallest wall thickness at the second point.

11. The golf club head according to claim 8, wherein from the second boundary point to the second point, the wall thickness of the sole portion decreases without increasing.

12. The golf club head according to claim 8, wherein the wall thickness of the sole portion at the second point is not more than 1.0 mm.

13. The golf club head according to claim 9, wherein the wall thickness of the sole portion at the second point is not more than 1.0 mm.

14. The golf club head according to claim 10, wherein the wall thickness of the sole portion at the second point is not more than 1.0 mm.

15. A golf club head having a hollow therein and comprising a face portion, a crown portion and a sole portion which enclose the hollow,

the face portion having an outer surface forming a club face and an inner surface facing the hollow,
the sole portion having an inner surface facing the hollow,
and

the club face having a face center, wherein
in a vertical cross section of the head passing through the face center,

(a) a ratio H_f/H of a height H_f of the club face measured in parallel to a tangential line drawn passing the face center, to a maximum height H of the head measured in parallel to the tangential line is not more than 0.65,

(d) a radius of curvature at a second boundary point between the inner surface of the face portion and the inner surface of the sole portion is 3.0 and 10.0 mm, and

(e) a wall thickness at the second boundary point is not less than 1.5 mm.

16. The golf club head according to claim **15**, wherein
in a first region from the first boundary point to a first point which is at a distance of 10 mm from the first boundary point toward the crown portion, the crown portion has the smallest wall thickness at the first point.

17. A golf club head having a hollow therein and comprising a face portion, a crown portion and a sole portion which enclose the hollow,

the face portion having an outer surface forming a club face and an inner surface facing the hollow,

the crown portion having an inner surface facing the hollow, and

the club face having a face center,

wherein

in a vertical cross section of the head passing through the face center,

(a) a ratio H_f/H of a height H_f of the club face measured in parallel to a tangential line drawn passing the face center, to a maximum height H of the head measured in parallel to the tangential line is not more than 0.65,

(b) when measured at a first boundary point between the face portion's inner surface and the crown portion's inner surface, an inner surface of the head has a radius of curvature in a range from 4.0 to 10.0 mm, and

(d) a radius of curvature at a second boundary point between the inner surface of the face portion and the inner surface of the sole portion is 3.0 and 10.0 mm.

18. The golf club head according to claim **1**, wherein
the ratio H_f/H is not less than 0.50.

19. The golf club head according to claim **15**, wherein
the ratio H_f/H is not less than 0.50.

20. The golf club head according to claim **17**, wherein
the ratio H_f/H is not less than 0.50.

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