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(54) IRON-TYPE GOLF CLUB AND FRP SHAFT THEREFOR

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(57) **ABSTRACT**

A club shaft for an iron-type golf club is made of a fiber reinforced resin. The weight W of the club shaft per 39 inches is not less than 55 grams and not more than 95 grams. The average bending rigidity EIa of the club shaft is not more than 1.5 kgf sq.m. An expression (1) EIa=<0.05W−1.25 is satisfied. Preferably, an expression (2) EIa=<0.05W−1.75 is satisfied. More preferably, an expression (3) EIa>=0.1W−6.5 is satisfied. Even if golfers are weak in flexing the club shafts though the golf swings are powerful, the carry distance can be increased.

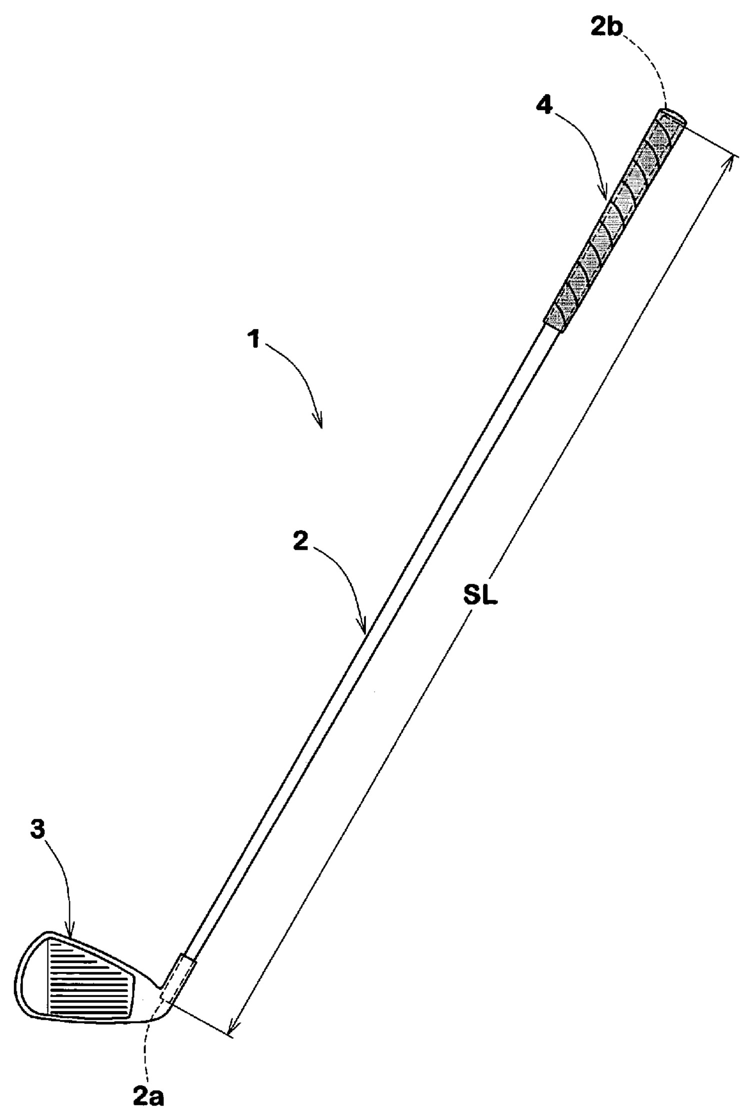


FIG.1

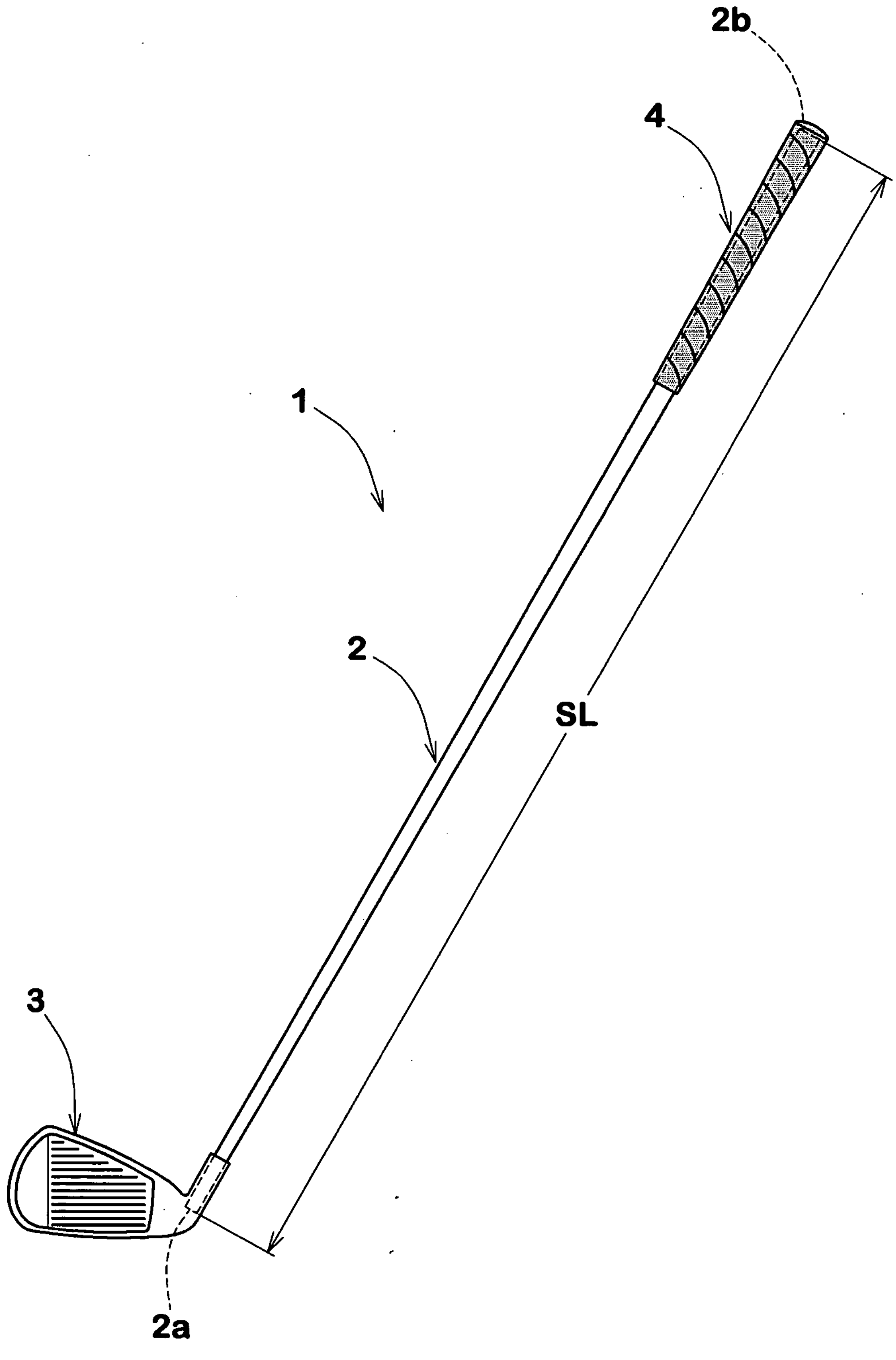


FIG.2

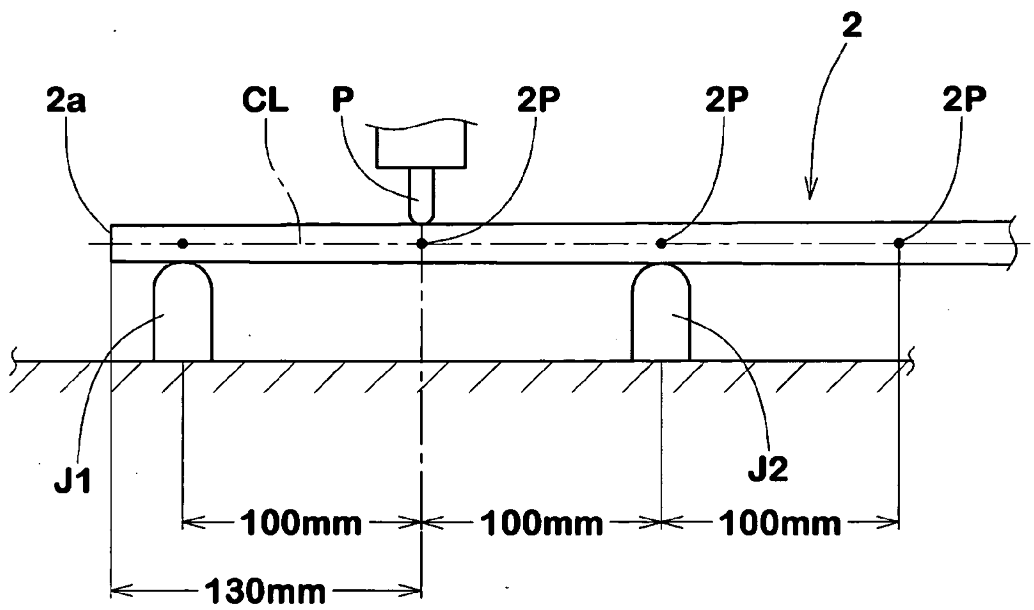


FIG.3

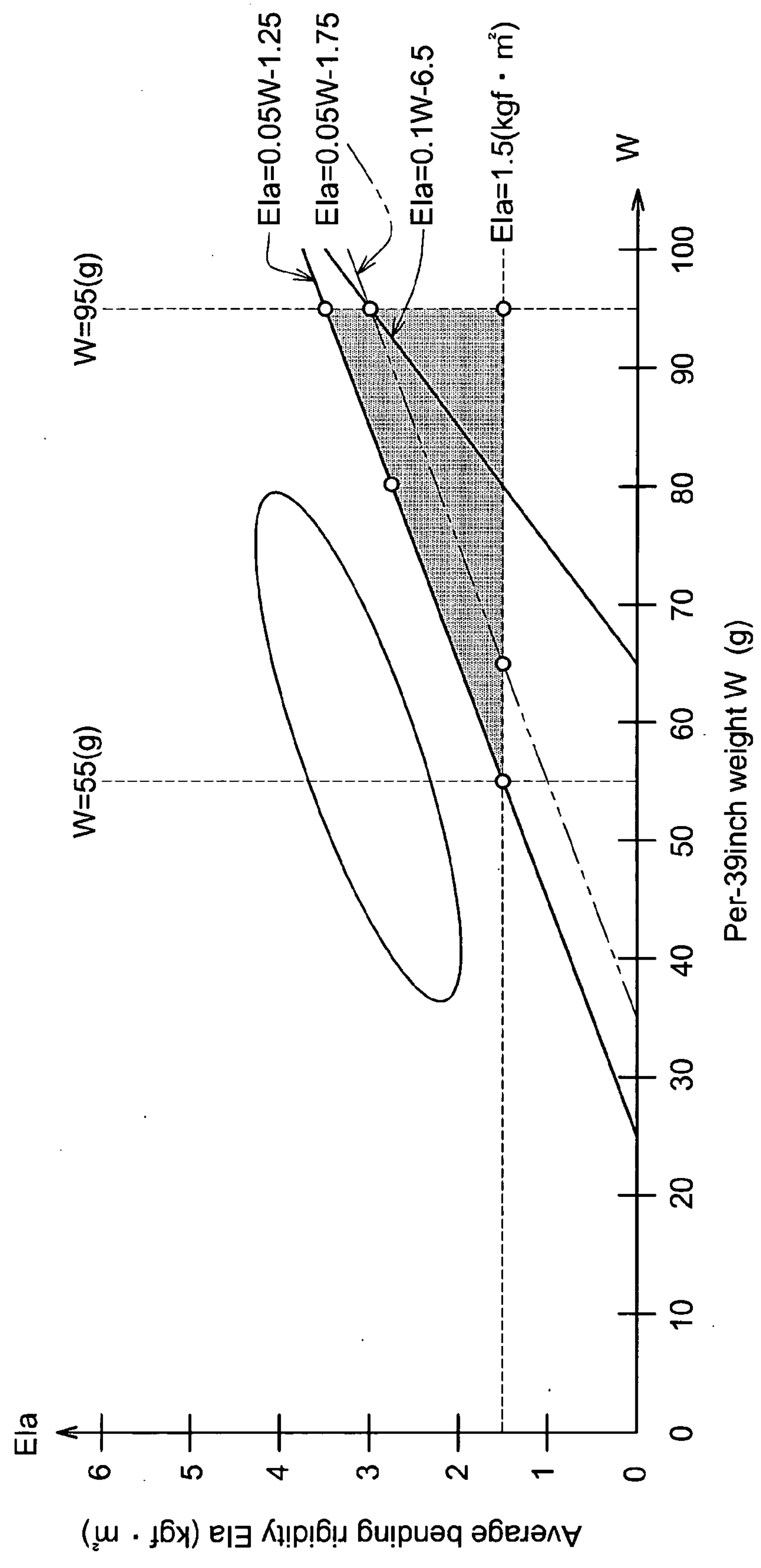

Ela=0.05W-1.25
Ela=0.05W-1.75
Ela=0.1W-6.5
Ela=1.5(kgf · m²)
W=55(g)
W=95(g)
W
Ela
0
10
20
30
40
50
60
70
80
90
100
0
1
2
3
4
5
6
Per-39inch weight W (g)
Average bending rigidity Ela (kgf · m²)

FIG.4

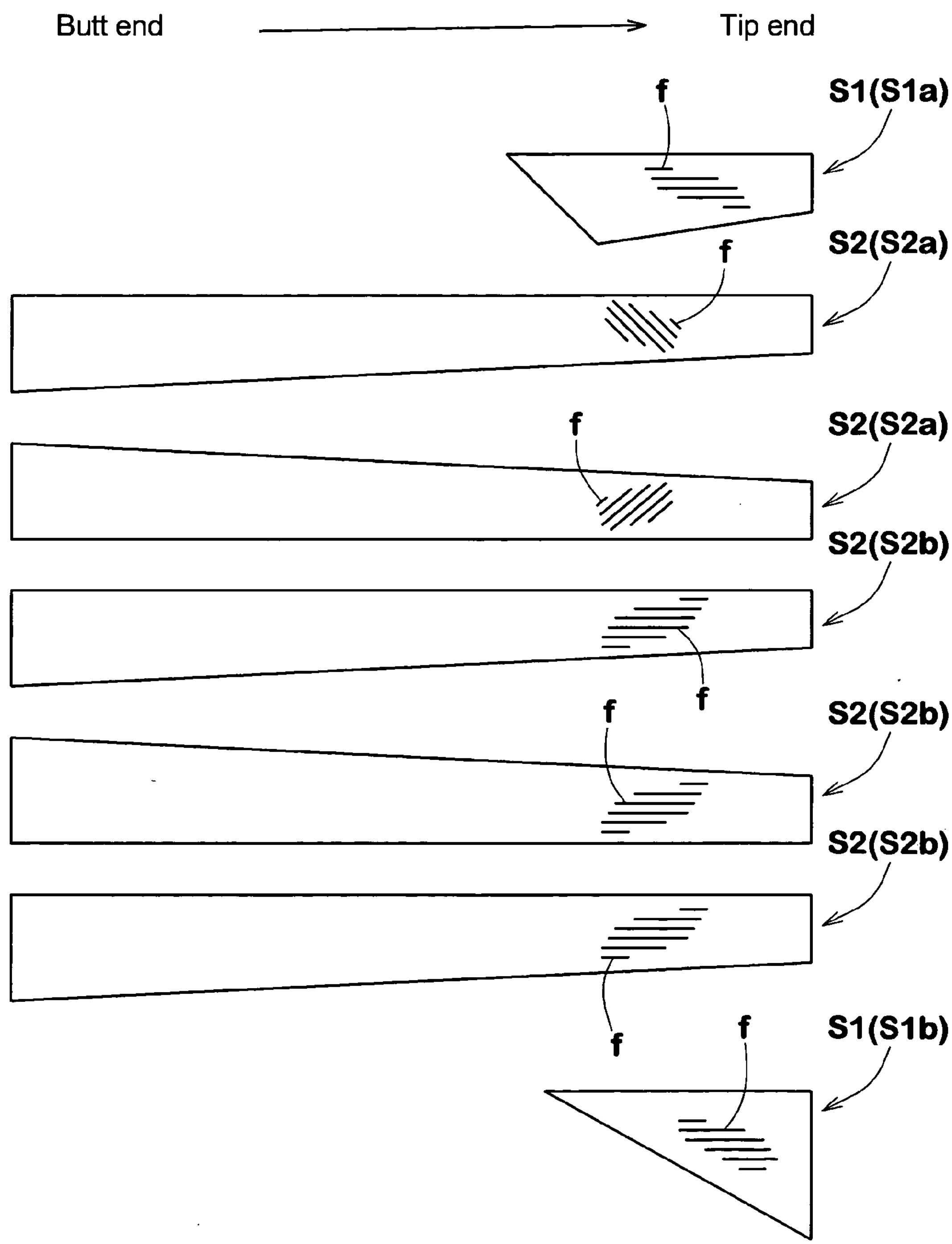
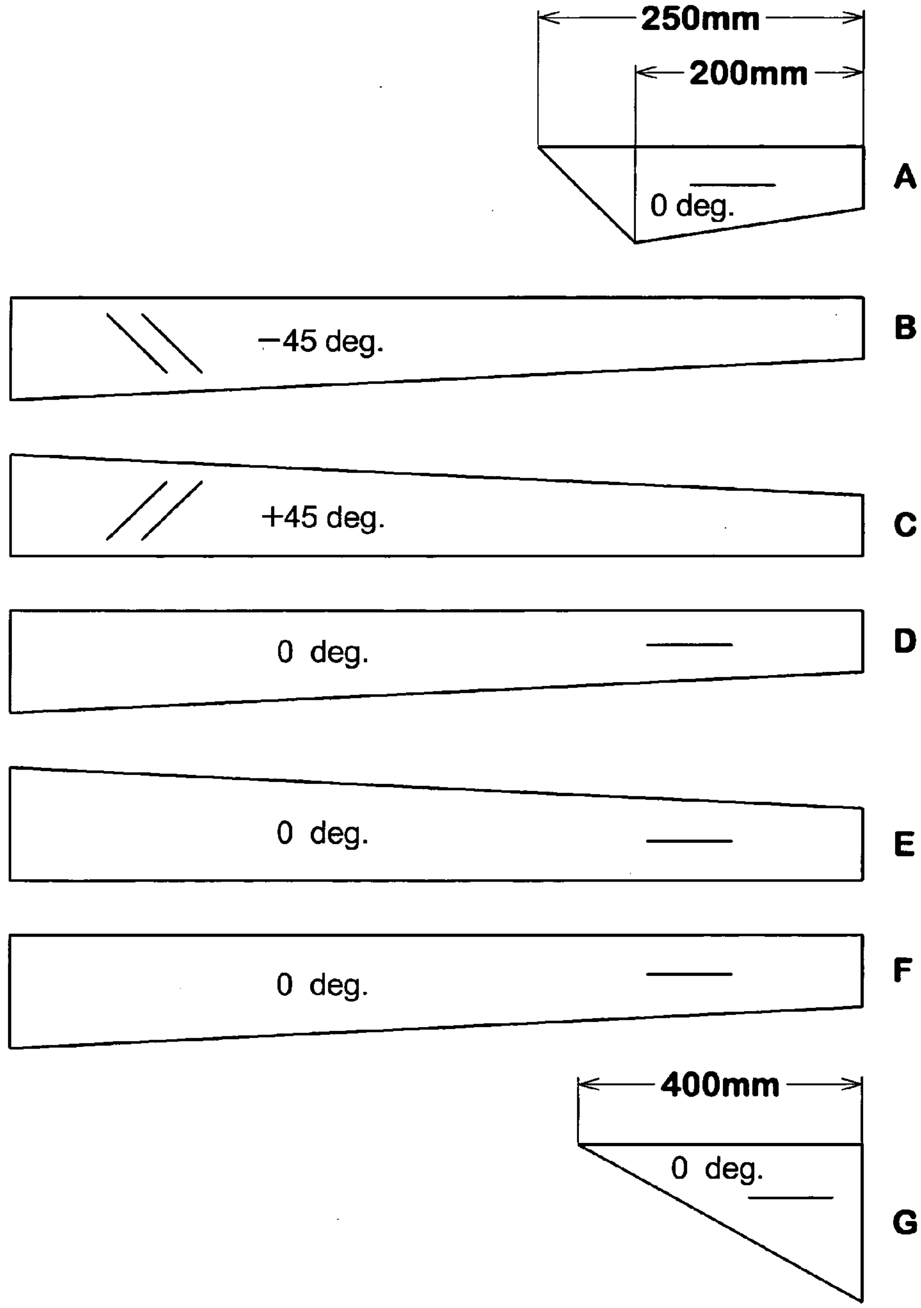

Butt end
Tip end
S1(S1a)
f
S2(S2a)
f
S2(S2a)
f
S2(S2b)
f
S2(S2b)
f
S2(S2b)
f
S1(S1b)
f

FIG.5


250mm
200mm
0 deg.
A
−45 deg.
B
+45 deg.
C
0 deg.
D
0 deg.
E
0 deg.
F
400mm
0 deg.
G

IRON-TYPE GOLF CLUB AND FRP SHAFT THEREFOR

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an iron-type golf club, more particularly to a FRP shaft having a specific relation between the bending rigidity and weight of the shaft.

[0002] An optimum flexure of the golf club shaft during golf swing can accelerate the head speed just before impact and increase the dynamic loft angle at the impact. Thus, the launch angle of the ball can be optimized.

[0003] In the case of golfers with powerful right swings such as professional golfers and advanced golfers, usually, the head speed is high and the flexure during golf swing is large. Therefore, club shafts with relatively heavy weight and less flexibility (stiff) are conventionally used in iron-type golf clubs targeted at such users. On the other hand, in the case of golfers with less powerful swings such as beginners and senior golfers, usually, the head speed is relatively low and the flexure is small. Therefore, club shafts with light weight and high flexibility are conventionally used in iron-type golf clubs targeted at such users. Thus, the club shafts of the conventional iron-type golf clubs are generally categorized into the above-explained two groups.

[0004] In recent years, on the on other hand, FRP club shafts made of fiber reinforced resins are widely used because the weight, bending rigidity and the like can be controlled easily in comparison with metal club shafts.

[0005] In the case that a golfer is powerful but the golf swing form is not good, therefore, the club shaft can not be bent sufficiently during golf swing, if the golfer uses the former type of a club shaft with relatively heavy weight and less flexibility, then there is a tendency that the head speed is not accelerated effectively because of the less flexure of the club shaft. Further, there is a tendency that the golf club can not come back to its right position at impact, thus the club face can not be squared and as a result the directions of the hit balls become unstable and the carry distance is decreased. If on other hand the golfer uses the later type of a club shaft with light weight and high flexibility, then there is a tendency that the golfer upsets the golf swing timing or golf swing tempo, and the direction of the club face at impact becomes unstable. As a result, the directions of the hit balls become unstable and the carry distance is decreased.

SUMMARY OF THE INVENTION

[0006] It is therefore, an object of the present invention to provide an iron-type golf club and a club shaft therefor, which is suitable for powerful beginners and the like, and in which the directionality of the hit ball become stable, and at the same time, the golf swing power can be transferred to the club head at the maximum, without changing the current golf swing tempo.

[0007] According to the present invention, a club shaft for an iron-type golf club is made of a fiber reinforced resin, and has a per-39 inch weight W of not less than 55 grams and not more than 95 grams, and an average bending rigidity EIa of not more than 1.5 kgf sq.m, wherein an expression (1) $EIa =< 0.05W - 1.25$ is satisfied.

[0008] Preferably, an expression (2) $EIa =< 0.05W - 1.75$ is satisfied.

[0009] More preferably, an expression (3) $EIa >= 0.1W - 6.5$ is satisfied.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a front view of an iron-type golf club according to the present invention.

[0011] FIG. **2** is a diagram for explaining a method for measuring the bending rigidity of the club shaft.

[0012] FIG. **3** is a graph showing the ranges defined by the expressions (1), (2) and (3).

[0013] FIG. **4** shows a set of prepreg pieces which can be used to make the club shaft.

[0014] FIG. **5** shows prepreg pieces of the club shafts used in the undermentioned comparison tests.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] Embodiments of the present invention will now be described in detail in conjunction with accompanying drawings.

[0016] According to the present invention, golf club **1** is an iron-type golf club such as first-ninth irons, sand-wedge, pitching-wedge, approach-wedge and lob-wedge.

[0017] The golf club **1** comprise a club shaft **2**, a club head **3** attached to the tip end **2***a,* and a grip **4** attached to the butt end **2***b*.

[0018] The club head **3** is, in its principal part(s), made of at least one kind of a metal material, e.g. stainless steels, aluminum alloys, titanium alloys, pure titanium and the like. It is of course possible to use a nonmetal material, e.g. fiber reinforced resins and the like in order to form a part of the club head **3**. The club head **1** can be either a hollow structure or a solid structure. Preferably, the club head **1** has a volume in a range of from 25 to 40 cc, and a weight in the range of from 220 to 300 grams.

[0019] The grip **4** can be a rubber grip, resin grip, leather grip or the like.

[0020] The club shaft **2** is a circular tube made of a fiber reinforced resin and tapered from a butt end **2***b* towards a tip end **2***a*.

[0021] As to the resin, thermosetting resins and thermoplastic resins can be used.

[0022] As the thermosetting resin, epoxide resin, unsaturated polyester resin, phenol resin, melamine resin, urea resin, diallyl phthalate resin, polyurethane resin, polyimide resin, silicon resin and the like may be used.

[0023] As the thermoplastic resin, polyamide resin, saturated polyester resin, polycarbonate resin, polystyrene resin, polyethylene resin, polyvinyl acetate resin, AS resin, methacrylic resin, polypropylene resin, fluorocarbon resin and the like may be used.

[0024] As to the fiber reinforcement of the fiber reinforced resin, inorganic fibers (carbon fibers, glass fibers, boron fibers, silicon carbide fibers, alumina fibers and the like), organic fibers (polyethylene fibers, polyamide fibers and the like), and metal fibers can be used alone or in combination. Especially, those having a tensile elastic modulus of from 3 to 50 tonF/sq.mm are preferred in view of the strength and weight reduction.

[0025] The club shaft **2** has a length SL inch and a weight Wr grams, and the value $W (= Wr \times 39/SL)$ is preferably set in a range of not less than 55, more preferably not less than 60, but not more than 95, more preferably not more than 80.

[0026] This value W expresses a weight of the club shaft converted into a 39-inch long shaft (hereinafter the "per-39 inch weight" W). Usually, the length of the club shaft is changed according to specifications. e.g. types of club head, loft angle, user's preference and the like. Accordingly, it will be not significant to define the bending rigidity by referring to such unspecified length. In this invention, therefore, based on a new criterion, the weight of the club shaft converted into a constant length of 39 inches, the weight and bending rigidity of the club shaft are defied.

[0027] If the per-39 inch weight W is less than 55 grams, then the target powerful users might feel very light in weight, and feel odd at the time of address. As a result, the golf swing and the directionality of the hit ball might become unstable.

[0028] If the per-39 inch weight W is more than 95 grams, then it becomes difficult even for the target powerful users to swing the club head through the ball, and there is a possibility that the swing speed and carry distance are decreased.

[0029] For the similar reasons, the actual weight Wr is preferably set in a range of not less than 40 grams, more preferably not less than 45 grams, still more preferably not less than 50 grams, but not more than 105 grams, more preferably not more than 100 grams, still more preferably not more than 95 grams.

[0030] If the actual club shaft length SL is too short, the length of the club shaft can not be utilized to increase the head speed. If the actual club shaft length SL is too long, it is difficult to swing the golf club and as a result, there is a possibility that the head speed is decreased.

[0031] Therefore, the actual club shaft length SL is preferably set in a range of not less than 500 mm, more preferably not less than 525 mm, still more preferably not less than 550 mm, but not more than 1100 mm, more preferably not more than 1075 mm, still more preferably not more than 1050 mm.

[0032] The club shaft **2** has an average bending rigidity EIa in a range of not more than 1.5 kgf sq.m, preferably not less than 1.7 kgf sq.m.

[0033] The average bending rigidity EIa is the mean value of the bending rigidity EI measured at a plurality of positions **2**P which are, as shown in FIG. **2**, set up along the club shaft **2** at a distance of 130 mm from the tip end **2***a* and at intervals of 100 mm from this 130 mm position toward the butt end **2***b*. Accordingly, the measuring position **2**P most close to the tip end **2***a* is at 130 mm therefrom. The distance between the butt end **2***b* and the measuring position **2**P most close to the butt end **2***b* depends on the shaft length SL but it should be not less than 130 mm but less than 230 mm.

[0034] The bending rigidity EI at each of the positions **2**P is measured with a universal material testing machine through a three point bending test. More specifically, as shown in FIG. **2**, the club shaft **2** is supported by two fulcrums J**1** and J**2** spaced apart from each other by 200 mm, so that the central axis CL of the shaft is kept horizontally, and one of the above-mentioned measuring positions **2**P is positioned at the midpoint of the two fulcrums J**1** and J**2**. Then, an indenter P is let down onto the measure position **2**P from right above at a descending speed of 5 mm/minutes. When the load applied to the measure position **2**P is increased and reaches to 20 kgf, the indenter P is stopped. And the amount of deflection of the club shaft **2** is measured at the position **2**P.

[0035] From the amount of deflection, the bending rigidity EI at the position **2**P is computed, using the following expression:

Bending rigidity EI=load×(distance between $J1$ and $J2$)^3/(48×amount of deflection)

wherein the tips of the fulcrums J**1** and J**2** are rounded by a radius of 12.5 mm, the tip of the indenter is rounded by a radius 6.0 mm, the units of the distance and the amount of deflection are "meter", and the unit of the load (force) is "kgf".

[0036] If the average bending rigidity EIa is less than 1.5 kgf sq.m, as the club shaft is largely bent during golf swing, it becomes difficult to swing the golf club, and since the direction of the club face becomes unstable, the directionality of the hit ball is liable to become worse. Further, it is difficult to make a powerful shot. If on the other hand, the average bending rigidity EIa is too large, the flexure of the club shaft **2** during golf swing becomes insufficient, and the head speed and dynamic loft angle at impact can not be increased effectively. As a result, it becomes difficult to effectively increase the carry distance.

[0037] In consideration of these facts, the per-39 inch weight W and average bending rigidity EIa are configured to satisfy the following expression (1)

$$EIa=<0.05W-1.25, \quad (1)$$

preferably to satisfy the following expression (2)

$$EIa=<0.05W-1.75, \quad (2)$$

more preferably to satisfy the following expression (3)

$$EIa>=0.1W-6.5. \quad (3)$$

[0038] FIG. **3** is a graph showing the ranges of the average bending rigidity EIa and per-39 inch weight W defined by the expressions (1)-(3). In the graph, an ellipse indicates a range in which conventional club shafts are mapped. Such a design concept that when the per-39 inch weight W is large, the average bending rigidity EI is also large, can be read into this distribution map. As having been explained, if a club shaft with such heavy weight and high rigidity is used by such a golfer that the golf swings are powerful but swing forms are not good, the club shaft can not be bent sufficiently during golf swing, therefore, it is difficult to improve the carry distance and directionality. In the present invention, as the per-39 inch weight W is limited in a specific range. In the present invention, as the per-39 inch weight W is limited in a specific range, the club shaft **2** is provided with an optimum weight by which it becomes easy to address and get appropriate swing timing. Further, as the upper limit for the average bending rigidity EIa is defined within a specific range, a suitable flexure can be secured during golf swing. Furthermore, as the expression (1) is satisfied, the average bending rigidity EIa becomes relatively small for the club shaft weight in comparison with the club shafts of the ordinary concept, therefore, the golfer with powerful swings but no-good swing forms, can obtain a perfect flexure, without the need to changing the previous golf swing timing, and as a result, the directionality and carry distance of the hit ball can be greatly improved.

[0039] It is preferable that, in addition to the above limitation of the average bending rigidity EIa, the bending rigidity EI at each measuring position **2**P is limited as follows.

[0040] The bending rigidity EI can be expressed as a function EI(x) of a distance "x" in millimeter of the measure position from the tip end **2***a* of the club shaft **2**, namely, El(130), El(230), El(330), El(430), El(530), El(630), El(730), El(830), El(930), El(1030), El(1130) . . . .

[0041] As explained above, the preferable range of the shaft length SL is 500 to 1100 mm.

[0042] If the shaft length SL is 1100 mm, the distance "x" is 130, 230, 330, 430, 530, 630, 730, 830 and 930 mm.

[0043] If the shaft length SL is 500 mm, the distance "x" is 130, 230 and 330 mm.

[0044] Thus, in the case that SL is 500 to 1100 mm, the number (m) of the measuring points **2**P becomes 3 to 9 depending on the shaft length SL.

[0045] The bending rigidity EI(130), EI(230) and EI(330) at the first, second and third measuring points from the tip end **2***a* toward the butt end **2***b* are preferably set in a range of not less than 0.5 kgf sq.m, more preferably not less than 0.6 kgf sq.m, still more preferably not less than 0.7 kgf sq.m, but not more than 3.0 kgf sq.m, more preferably not more than 2.8 kgf sq.m, still more preferably not more than 2.5 kgf sq.m.

[0046] If at least one of EI(130), EI(230) and EI(330) is less than 0.5 kgf sq.m, the flexure of the tip end part of the club shaft becomes excessive, and the durability is decreased. Further, the directionality of the hit ball is liable to become unstable. If at least one of EI(130), EI(230) and EI(330) is more than 3.0 kgf sq.m, the flexure of the tip end part of the club shaft becomes insufficient, and it is difficult to accelerate the head speed just before impact. Moreover, the hit feeling is liable to become worse because the shock of hitting a ball transmitted to the player's hands increases.

[0047] When the number (m) of the measuring points **2**P is 7 or more, the bending rigidity is expressed as follows: EI(130), EI(230), EI(330), EI(n*100+30), EI{(m−2)*100+30)}, EI{(m−1)*100+30)}, and EI(m*100+30), wherein "n" is an integer variable more than 3 and less than m−2. (when m=7, n=4), (when m=9, n=4, 5 and 6)

[0048] If the bending rigidity EI(n*100+30) of the middle part of club shaft **2** is less than 0.8 kgf sq.m, since the flexure of the shaft during golf swing increases in the middle part, there is a tendency that the user upsets the golf swing timing or golf swing tempo. If the bending rigidity EI(n*100+30) is more than 6.5 kgf sq.m, as the flexure is decreased, there is a possibility that the acceleration of the head speed becomes insufficient, and the power of golf swing can not be transferred to the club head effectively.

[0049] Therefore, the bending rigidity EI(n*100+30) is preferably set in a range of not less than 0.8 kgf sq.m, more preferably not less than 0.9 kgf sq.m, still more preferably not less than 1.0 kgf sq.m, most preferably not less than 1.1 kgf sq.m, but not more than 6.5 kgf sq.m, more preferably not more than 6.0 kgf sq.m, still more preferably not more than 5.5 kgf sq.m, most preferably not more than 5.0 kgf sq.m.

[0050] Further, the bending rigidity EI(n*100+30) is more than EI(130), EI(230) and EI(330).

[0051] When the integer variable "n" include a plurality of integers, it is preferred that the bending rigidity EI(n*100+30) gradually increases towards the butt end **2***b*.

[0052] The bending rigidity EI{(m−2)*100+30)}, EI{(m−1)*100+30)} and EI(m*100+30) at the last three measuring points on the butt end side are preferably set in a range of from 1.5 to 8.5 kgf sq.m.

[0053] If at least one of these is less than 1.5 kgf sq.m, since the flexure of the shaft during golf swing increases, there is a tendency that the user upsets the golf swing timing or golf swing tempo. If more than 8.5 kgf sq.m, it becomes difficult for the user to feel the flexure of the club shaft **2** during golf swing, and thus difficult to swing the golf club.

[0054] Further, it is preferred that the bending rigidity gradually increases towards the butt end **2***b*, namely, EI{(m−2)*100+30)}<EI{(m−1)*100+30)}<EI(m*100+30), and EI{(m−2)*100+30)} is 1.5 to 7.0 kgf sq.m, EI{(m−1)*100+30)} is 1.8 to 8.0 kgf sq.m, EI(m*100+30) is 2.0 to 8.5 kgf sq.m.

[0055] The club shaft **2** is, as shown in FIG. **4**, made from pieces S**1** to S**2** of prepreg (hereinafter, generically, the "prepreg pieces S").

[0056] The prepreg pieces S are wound around a mandrel (not shown) into a laminated tube. The mandrel is removed from the tube. An inflatable bladder (not shown) is inserted into the laminated tube. The laminated tube is put in a mold (not shown) together with the bladder. By inflating the bladder and applying heat, the laminated tube is cured and molded into the FRP shaft **2**.

[0057] FIG. **4** shows an example set of prepreg pieces S constituting a shaft **2**, wherein the prepreg pieces S are wound in the order from the prepreg piece shown on the top of the figure to that on the bottom. The prepreg pieces S include: small tip-end-side prepreg pieces S**1** forming a part near the tip end **2***a* of the club shaft **2**; and long prepreg pieces S**2** continuous over the entire shaft length.

[0058] Aside from this example, various combinations of prepreg pieces are possible. For example, a small butt-end-side prepreg piece forming a part near the butt end **2***b* of the club shaft **2** can be used.

[0059] In order to control the rigidity and to increase the strength of the tip end part of the club shaft **2**, the number of layers formed by the winded prepreg pieces S**1** is preferably at least 2, but at most 20, preferably not more than 19, more preferably not more than 18.

[0060] The orientation angle of the fiber reinforcements (f) in the tip-end-side prepreg piece S**1** can be set in a wide range of from 0 to 90 degrees with respect to the direction of the shaft axis. For example, if it is desired to increase the bending rigidity EI near the tip end **2***a*, it is preferred to set the orientation angle in a range of not more than 10 degrees, most preferably at 0 degree. If it is desired to increase the torsional rigidity, it is preferred to set the orientation angle in a range of from 40 to 50 degrees, most preferably at 45 degrees.

[0061] The shape of the tip-end-side prepreg piece S**1** (the shape developed on a plane) can be either a quadrangular shape S**1***a* or a triangular shape S**1***b*.

[0062] In either case, it is preferable that a side on the butt end side (and at least one of two lateral sides in the case of the quadrangular shape S**1***a*) is inclined at an angle of 30 to 60 degrees with respect to the longitudinal direction of the shaft in order to avoid a formation of a large step difference in rigidity.

[0063] The long prepreg pieces S**2** determine the fundamental bending rigidity and strength of the club shaft **2**.

[0064] If the number of layers formed by the winded long prepreg pieces S**2** is less than 5, there is a possibility that the club shaft **2** lacks necessary rigidity and strength. If more than 20, not only the production efficiency is lowered, but also the likelihood of getting voids between the layers is increased. Therefore, the number of layers formed by the winded long prepreg pieces S**2** is set in a range of not less than 5, preferably not less than 6, more preferably not less than 7, but not more than 20, preferably not more than 19, more preferably not more than 18.

[0065] The long prepreg pieces S2 include:

[0066] a bias piece S2*a* whose fiber reinforcements (f) are oriented at an angle of not less than 10 degrees, preferably not less than. 20 degrees, but not more than 80 degrees, preferably not more than 70 degrees;

[0067] a parallel piece S2*b* whose fiber reinforcements (f) are oriented at an angle of substantially 0 degree; and optionally an orthogonal piece S2*c* whose fiber reinforcements (f) are oriented at an angle of substantially 90 degrees,

[0068] wherein the angles are referred to with respect to the direction of the shaft axis.

[0069] The bias piece S2*a* is most useful for increasing the torsional rigidity. For that purpose, the number of layer formed by the winded bias piece(s) S2*a* is set in a range of not less than 1, preferably not less than 2, more preferably not less than 3, but not more than 12, preferably not more than 11, more preferably not more than 10. Here, the term "not less than 1" means that the bias piece S2*a* is winded completely at least once around the shaft. It is preferable that the layers of the bias piece(s) S2*a* include a pair of layers whose orientation angles are directionally opposite with respect to the longitudinal direction of the shaft, more preferably orientation angles are same in the absolute values (for example 45 degrees with respect to the longitudinal direction).

[0070] The parallel piece S2*b* is most useful for increasing the bending rigidity. For that purpose, the number of layers formed by the winded parallel piece(s) S2*b* is set in a range of not less than 2, preferably not less than 3, but not more than 10, preferably not more than 9, more preferably not more than 8.

[0071] The use of the orthogonal piece S2*c* in combination with the bias piece S2*a* and parallel piece S2*b* is very useful for increasing the crush strength of the shaft.

[0072] If the club shaft is already provided with a sufficient crush strength by the arrangement of the bias piece S2*a* and parallel piece S2*b*, it is not always necessary to use the orthogonal piece S2*c*. It can be omitted. Even when used, the number of layers formed by the winded orthogonal piece(s) S2*c* is preferably set in a range of not more than 4, more preferably not more than 3, still more preferably not more than 2, in order to avoid an unwanted increase of the club shaft weight.

[0073] Aside from the above method, various methods, e.g. so called filament winding method, sheet winding method and the like can be employed.

Comparison Tests

[0074] FRP shafts were made using prepreg pieces and comparison tests were carried out.

[0075] The prepreg pieces used are shown in FIG. **5**.

[0076] The prepreg pieces A-G were winded around a mandrel from A to G. Firstly, an intermediate of the club shaft having a length of about 1200 mm was made and then cut into the target length of 1000 mm by removing both of the ends.

[0077] In order to change the average bending rigidity EIa, the tensile elastic modulus of the fiber reinforcement and the number of layers (winding number) of each prepreg piece were changed as shown in Table 1.

[0078] The specifications of the prepreg pieces are as follows:

[0079] Prepreg Tensile elastic modulus of fibers

[0080] Toray "8255S-12" 30 ton/sq.mm

[0081] Toray "3255G-12" 24 ton/sq.mm

[0082] NGF "E1026A-09N" 10 ton/sq.mm

[0083] NGF "E052AA-10N" 5 ton/sq.mm

[0084] Toray: Toray Industries, Inc.

[0085] NGF: Nippon Graphite Fiber corporation

[0086] Golf clubs were made by attaching an iron-type golf club head and a rubber grip to the tip end and butt end, respectively, of each of the shafts.

[0087] The club head was made of a soft iron and having a loft angle of 32 degrees.

[0088] Comparison tests were carried out by ten right-handed golfers (handicap 0 to 20, age 20 to 40). Each of the golfers hit golf balls (SRI sport limited, "XXIO") ten times par each golf club. Thus, 100 shots (10 shots×10 golfers) were made per each club.

[0089] The head speed just before impact and the ball lunching angle of each shot were measured to obtain the mean values of the 100 shots. The results are shown in Table by an index based on Ex.1 being 100.

[0090] As to the head speed, the larger index number means that the head speed was more accelerated by the flexure of the club shaft. As to the launching angle, the larger index number means that the launching angle was more increased by the optimal flexure of the club shaft.

[0091] Further, with respect to the ten shots made by each of the golfers with each club, the difference between the direction of the trajectory of the ball and the direction of the target trajectory was measured and the standard deviation was computed. With respect to each of the clubs, the mean value of the standard deviation obtained by the ten golfers was computed. The results are indicated by an index based on Ex.1 being 100, wherein the smaller the index number, the better the directionality.

[0092] Furthermore, with respect to each of the shafts, easiness of swing was evaluated into five ranks as follows, based on the ten golfers' feeling.

[0093] 5: very good, 4: good, 3: ordinary, 2: baddish, 1: bad The mean values of the rank numbers are shown in Table 1.

TABLE 1

	Ex. 1			Ex. 2		
Shaft	prepreg	fibers angle	number of layers	prepreg	fibers angle	number of layers
A	3255G-12	0 deg.	6	3255G-12	0 deg.	6
B	8255S-12	45 deg.	2	8255S-12	45 deg.	2
C	8255S-12	−45 deg.	2	8255S-12	−45 deg.	2
D	3255G-12	0 deg.	1	E1026A-09N	0 deg.	2
E	E1026A-09N	0 deg.	1	E052AA-10N	0 deg.	3
F	E052AA-10N	0 deg.	1	3255G-12	0 deg.	3
G	3255G-12	0 deg.	3	—	—	—
Per-39 inch weight W (g)		55			65	
Average bending rigidity Ela (kgf sq.m)		1.5			1.5	

TABLE 1-continued

Upper limit of Ela by Exp. (1) (kgf sq.m)		1.5			2.0	
Upper limit of Ela by Exp. (2) (kgf sq.m)		1.0			1.5	
Lower limit of Ela by Exp. (3) (kgf sq.m)		−1.0			0	
Head speed		100			107	
Launching angle		100			105	
Directionality		100			88	
Easiness of swing		4.7			4.9	

	Ex. 3			Ex. 4		
Shaft	prepreg	fibers angle	number of layers	prepreg	fibers angle	number of layers
A	3255G-12	0 deg.	6	3255G-12	0 deg.	6
B	8255S-12	45 deg.	2	8255S-12	45 deg.	2
C	8255S-12	−45 deg.	2	8255S-12	−45 deg.	2
D	3255G-12	0 deg.	1	E052AA-10N	0 deg.	10
E	E1026A-09N	0 deg.	3	3255G-12	0 deg.	3
F	E052AA-10N	0 deg.	3			
G	3255G-12	0 deg.	3			
Per-39 inch weight W (g)		80			95	
Average bending rigidity Ela (kgf sq.m)		2.75			1.5	
Upper limit of Ela by Exp. (1) (kgf sq.m)		2.75			3.5	
Upper limit of Ela by Exp. (2) (kgf sq.m)		2.25			3.0	
Lower limit of Ela by Exp. (3) (kgf sq.m)		1.5			3.0	
Head speed		98			99	
Launching angle		99			98	
Directionality		105			101	
Easiness of swing		4.7			4.7	

	Ex. 5			Ex. 6		
Shaft	prepreg	fibers angle	number of layers	prepreg	fibers angle	number of layers
A	3255G-12	0 deg.	6	3255G-12	0 deg.	6
B	8255S-12	45 deg.	2	8255S-12	45 deg.	2
C	8255S-12	−45 deg.	2	8255S-12	−45 deg.	2
D	3255G-12	0 deg.	1	3255G-12	0 deg.	1
E	E1026A-09N	0 deg.	2	E1026A-09N	0 deg.	3
F	E052AA-10N	0 deg.	7	E052AA-10N	0 deg.	6
G	3255G-12	0 deg.	3	3255G-12	0 deg.	3
Per-39 inch weight W (g)		95			95	
Average bending rigidity Ela (kgf sq.m)		3.0			3.5	
Upper limit of Ela by Exp. (1) (kgf sq.m)		3.5			3.5	
Upper limit of Ela by Exp. (2) (kgf sq.m)		3.0			3.0	
Lower limit of Ela by Exp. (3) (kgf sq.m)		3.0			3.0	
Head speed		106			98	
Launching angle		106			100	
Directionality of the hit ball		86			100	
Easiness of swing		4.9			4.7	

	Ref. 1			Ref. 2		
Shaft	prepreg	fibers angle	number of layers	prepreg	fibers angle	number of layers
A	3255G-12	0 deg.	6	3255G-12	0 deg.	6
B	8255S-12	45 deg.	2	8255S-12	45 deg.	2
C	8255S-12	−45 deg.	2	8255S-12	−45 deg.	2
D	3255G-12	0 deg.	2	3255G-12	0 deg.	4
E	E1026A-09N	0 deg.	1	E1026A-09N	0 deg.	3
F	3255G-12	0 deg.	3	3255G-12	0 deg.	3
G						
Per-39 inch weight W (g)		55			80	
Average bending rigidity Ela (kgf sq.m)		3.0			4.0	
Upper limit of Ela by Exp. (1) (kgf sq.m)		1.5			2.75	
Upper limit of Ela by Exp. (2) (kgf sq.m)		1.0			2.25	
Lower limit of Ela by Exp. (3) (kgf sq.m)		−1.0			1.5	
Head speed		96			94	
Launching angle		88			84	
Directionality of the hit ball		173			226	
Easiness of swing		3.5			3.1	

[0094] From the test results, it was confirmed that the head speed and carry distance can be increased and the directionality can be improved.

[0095] As described above, in the FRP golf club shaft according to the present invention, since the club shaft weight converted into 39-inch club shaft length is set in a relatively heavy weight range, it is possible for the golfers with powerful swings to swing the club without upsetting the golf swing timing or golf swing tempo. Further, since the average bending rigidity EIa of the club shaft is set in a specific range, the club shaft is provided with a considerably small bending rigidity for the per-39 inch weight, therefor, even for the golfers being powerful but not good at flexing the shaft, it becomes possible to flex the club shaft during golf swing, and as a result, the head speed and carry distance can be increased. Further, it becomes easy to return the club face to the proper address position and the directionality of the hit ball can be improved.

1. A club shaft for an iron-type golf club made of a fiber reinforced resin, and having a per-39 inch weight W of not less than 55 grams and not more than 95 grams, and an average bending rigidity EIa of not more than 1.5 kgf sq.m, wherein

an expression (1) $EIa =< 0.05W-1.25$ is satisfied.

2. The club shaft according to claim **1**, wherein

an expression (2) $EIa =< 0.05W-1.75$ is further satisfied.

3. The club shaft according to claim **1**, wherein

an expression (3) $EIa >= 0.1W-6.5$ is further satisfied.

4. An iron-type golf club comprising

the club shaft according to claim **1**, and

an iron-type golf club head attached to the tip end of the club shaft.

5. An iron-type golf club comprising

the club shaft according to claim **2**, and

an iron-type golf club head attached to the tip end of the club shaft.

6. An iron-type golf club comprising

the club shaft according to claim **3**, and

an iron-type golf club head attached to the tip end of the club shaft.

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