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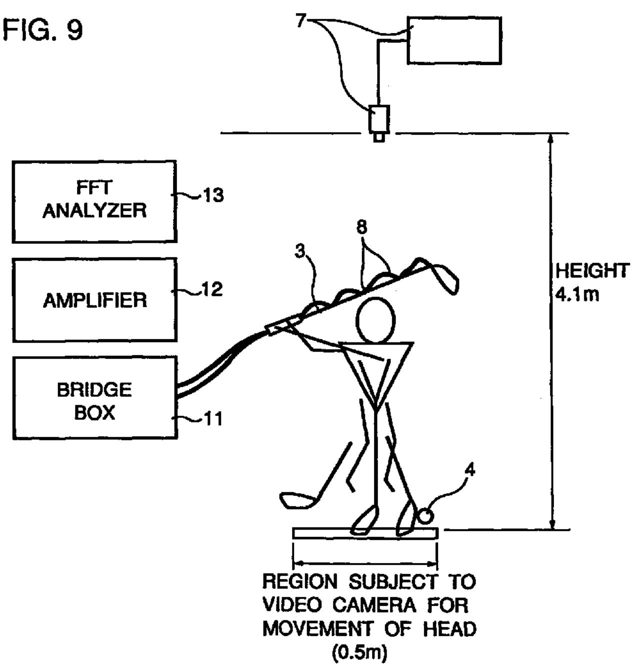
(54) **Golf club and golf club shaft**

(57) A fiber reinforced plastic golf shaft (1) has bending stiffness of 2×10^6kgf • mm^2 or less between a tip end (1A) and the position 200mm apart from the tip end and that of 8×10^6kgf • mm^2 or more for the portion at least 900mm apart from tip end (1A). Golf shaft (1) is mounted on a golf club head (2) having neck length of 50mm or shorter to complete a golf club (3).

FIG. 9



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to golf clubs and golf club shafts, and particularly to a golf club shaft which has been improved to allow enhanced blow angle and direction immediately before impact to achieve longer flight distance by setting the length of the golf club, the neck length of the golf head, and bending and torsional stiffness at the tip end of the golf shaft. The present invention also relates to a golf club with such a golf shaft.

Description of the Background Art

Conventionally, a golf shaft (hereinafter referred to as a shaft) for a golf club of forty-four inches or more generally weighs as light as sixty grams or less. Such shaft must be designed to have sufficient strength to avoid breakage of the tip end of the shaft for connecting a golf head (hereinafter referred to as a head). Thus, the shaft has generally been reinforced with impact resistant carbon fiber with high strength and elasticity.

The golf club as long as forty-four inches or more has high bending stiffness at the tip end of the shaft, so that bending stiffness at the other parts is reduced to achieve greater projecting angle when the ball is hit. In addition, torsional stiffness is reduced for the lightweight shaft. As for the conventional head, longer neck reduces deflection amount at the tip end of the shaft, whereas shorter neck increases torsional amount of the shaft.

For the conventional shaft, bending stiffness is in most cases increased to maintain strength at the tip end. Thus, the tip end of the shaft has little deflection, and among the functions of the shaft, the greater projecting angle when the ball is hit is not effectively achieved. In addition, when bending stiffness at the portion other than the tip end of the shaft is reduced to achieve greater projecting angle, deflection amount of the shaft at the top of the swing increases, making it hard to fix the timing. This makes it difficult for a golfer to perform a desired swing as he or she must reduce deflection amount at the turn of the swing by moving the shaft at lower speed during the swing. In addition, the shaft with reduced bending stiffness has lower torsional stiffness, so that the direction of the head immediately before hitting is not fixed, resulting difficulty in controlling the direction of the flight.

SUMMARY OF THE INVENTION

Therefore, a main object of the present invention is to provide a shaft for a golf club which has been made to solve the aforementioned problems by setting slightly higher bending stiffness at the gripping side and lower bending stiffness at the tip end as well as higher torsional stiffness for the entire shaft as compared with the conventional shaft, and to provide a golf club with such shaft.

Briefly speaking, the present invention relates to a fiber reinforced plastic golf shaft having bending stiffness of 2×10^6 kgf • mm^2 or less between the tip end and the position 200mm apart from the tip end, and that of 8×10^6 kgf • mm^2 or more for the portion at least 900mm apart from the tip end. More preferably, such golf shaft is mounted on a head of the golf club having neck length of 50mm or shorter.

According to another aspect of the invention, the fiber reinforced plastic golf shaft has torsional stiffness of 1×10^6 kgf • mm^2 or more and bending stiffness of 2×10^6 kgf • mm^2 or less between the tip end and the position 200mm apart from the tip end. More preferably, such golf shaft is mounted on the head of the golf club having neck length of 50mm or shorter.

According to still another aspect of the present invention, the fiber reinforced plastic golf shaft has torsional stiffness of 1×10^6 kgf • mm^2 or more and bending stiffness of 2×10^6 kgf • mm^2 or less between the tip end and the position 200mm apart from the tip end, and bending stiffness of 8×10^6 kgf • mm^2 or more for the portion at least 900mm apart from the tip end. More preferably, such golf shaft is mounted on the head of the golf club having neck length of 50mm or shorter.

According to still another aspect of the present invention, in the fiber reinforced plastic golf shaft, bending stiffness between the tip end and the position 200mm apart from the tip end is at most one fourth the bending stiffness for the portion at least 900mm apart from the tip end. More preferably, such golf shaft is mounted on the head of the golf club having neck length of 50mm or shorter.

Therefore, according to the present invention, by reducing bending stiffness and increasing the deflection at the tip end of the shaft immediately before impact to achieve greater blow angle, the head can strike the ball with upper blow, thus enabling increased flight distance. In addition, by increasing torsional stiffness at the tip end of the shaft, a desired turn of the head immediately before impact can be achieved.

The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1A, 1B and 1C are diagrams showing blow angles.
Figs. 2A and 2B are diagrams showing dynamic models of diagonal impact between the golf head and the ball.
Figs. 3A and 3B are graphs showing the bending strain for the shaft during the swing over time.
Fig. 4 is a graph showing measurement values of bending stiffness distributions for the shaft in accordance with one embodiment of the present invention.
Fig. 5 is a graph showing measurement values of torsional stiffness distributions for the shaft in accordance with one embodiment of the present invention.
Fig. 6 is a graph showing measurement values of bending stiffness distributions for a conventional shaft.
Fig. 7 is a graph showing measurement values of torsional stiffness distributions for the conventional shaft.
Fig. 8 is a diagram related to a method of measuring the turn of the head when the ball is hit.
Fig. 9 is a diagram related to the method of measuring the turn of the head when the ball is hit.
Fig. 10 is a graph showing ratio of change over time of longitudinal curvature for the shaft immediately before impact in accordance with one embodiment of the present invention.
Fig. 11 is a graph showing ratio of change over time of longitudinal curvature for the conventional shaft immediately before impact.
Figs. 12A and 12B are graphs showing torsional angles over time immediately before impact for the shaft in accordance with one embodiment of the present invention and that for a conventional product.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The inventor of the present application measured movement of the head and the ball before and after impact for a number of golfers including pro golfers using a high speed video camera. As a result, it was found that difference in blow angles produced significant variation in the flight distance with the same head speed. More specifically, measurement results for two pro golfers (golfer A, golfer B) with almost at the same head speed are shown in the following Table 1.

Table 1

Data demonstrating difference in flight distance due to difference in impact (for pro golfers)

	golfer A	golfer B
head speed (m/s)	50.8	50.9
blow angle (degrees)	-0.5	1.9
initial speed of ball (m/s)	70.4	73.1
initial speed of ball/head speed	1.39	1.44
flight distance (carry) (m)	226	247
flight distance (total) (m)	252	268

Referring to the table, it is apparent that initial speed of the ball varies even if it is hit almost at the same head speed, and the difference in initial speed of the ball directly influences flight distance. The initial speed of the ball is determined by a blow angle. A blow angle 5 shown in Fig. 1A is an angle between the horizontal line and the direction of movement of a head 2 immediately before impact between head 2 and a ball 4. When head 2 is moved upward, the blow angle is positive and called upper blow. On the other hand, as shown in Fig. 1B, when head 2 moves downward, the blow angle is negative and called down blow. Fig. 1C shows a diagram related to blow angle 5.

Thus, repulsion ratio (= initial speed of the ball/head speed) for golfer A who hits the ball with down blow is smaller than that for golfer B who hits the ball with upper blow. As a result, flight distance for golfer B is longer.

Figs. 2A and 2B show dynamic models for diagonal impact between the head and the ball at impact. The component of the force perpendicular to a face 2C, which influences initial speed of the ball, is larger when head 2 hits ball 4 with upper blow as shown in Fig. 2A than when head 2 hits ball 4 with down blow as shown in Fig. 2B. In other words, upper blow allows higher initial speed of the ball and longer flight distance as compared with down blow even if the ball is hit at the same head speed.

To achieve a blow angle which is advantageous for longer flight distance, deflection at the tip end is effectively increased as compared with the conventional shaft, which has little deflection. Thus, bending stiffness at the tip end is desirably made 2×10^6 kgf • mm^2 or less. In addition, to achieve prescribed timing during the swing, bending stiffness at the gripping side must be considered.

Figs. 3A and 3B show data for bending strain over time in the shaft position 835mm apart from a heel end surface of the golf club (the lower portion of the grip) during the swing for the shaft of the present invention and for the conventional shaft, respectively. Referring to Figs. 3A and 3B, it is apparent that bending strain is maximized at the top of the swing, that is, at the turning point from backswing to downswing. In other words, bending stiffness at the gripping side of the shaft is the most important factor for the timing at the top of the swing. In addition, bending stiffness of 8×10^6 kgf • mm^2 or more in the position at least 900mm apart from the tip end restrained deflection of the shaft at the top of the swing to achieve prescribed swings, in accordance with one embodiment of the present invention as shown in Fig. 3A. Further, by setting torsional stiffness at the tip end of the shaft at 1×10^6 kgf • mm^2 or more between the tip end and the position 200mm apart from the tip end, direction of the shaft is dramatically improved.

By setting bending stiffness of the shaft at 2×10^6 kgf • mm^2 or less for the portion between the tip end and the position 200mm apart from the tip end, which portion may have a significant influence on the blow angle, and at 8×10^6 kgf • mm^2 or more for the portion at least 900mm apart from the tip end, which portion may have an influence on flexure, and further by setting the neck length of the head at 50mm or shorter, the ball can be hit with upper blow, thus enabling increased speed of the ball and hence flight distance.

In addition, the following expressions (1) to (4) show that the turn of the head θ (t) is ultimately related to torsional spring constant of the shaft, that is, torsional stiffness of the shaft.

$$\omega_n = \sqrt{\frac{\kappa}{J}} \quad \cdots(1)$$

$$\kappa = \frac{1}{\sum_{i=1}^{n}\left(\frac{\ell_i}{G_i I_i}\right)} \quad \cdots(2)$$

$$J\frac{d^2\theta}{dt^2} + \kappa = T\sin\omega t \quad \cdots(3)$$

$$\text{initial condition } t = 0: \theta = 0, \frac{d\theta}{dt} = 0$$

$$\theta(t) = \frac{T}{J(\omega_n^2 - \omega^2)}\left(-\frac{\omega}{\omega_n}\sin\omega_n t + \sin\omega t\right) \quad \cdots(4)$$

G: modulus of transverse elasticity of shaft
I: polar moment of inertia of area for shaft
ℓ: length of golf club
ω_n: torsional vibration frequency of golf club
J: inertia moment of head about shaft axis
κ: torsional spring constant of shaft
T: torque strength applied to grip portion from hip, shoulder, arm and wrist of golfer during downswing
ω: rotating speed for rotating grip portion about the axis by hip, shoulder, arm and wrist of golfer during downswing
t: time of downswing
$T\sin\omega t$: torque applied to grip portion by golfer at time instant t
θ: torsional angle of club head
GI: torsional stiffness of shaft

More specifically, by setting torsional stiffness at 1×10^6 kgf • mm^2 or more for the portion between the tip end and the position 200mm apart from the tip end, which portion may have the influence on the turn of the head for the above mentioned shaft, a desired turn of the head can be achieved immediately before the ball is hit, thus enabling improved direction of the flight.

Now, a more specific embodiment of the present invention will be described. A fiber reinforced plastic shaft 1 is provided as the more specific embodiment. Shaft 1 has bending stiffness of 2×10^6 kgf • mm^2 or less between a tip end 1A and the position 200mm apart from tip end 1A and that of 8×10^6 kgf • mm^2 for the portion at least 900mm apart from tip end 1A.

Further, as another specific embodiment of the present invention, a golf club 3 with fiber reinforced plastic shaft 1 is provided. Shaft 1 has bending stiffness of 2×10^6 kgf • mm^2 or less between tip end 1A and the position 200mm apart from tip end 1A and that of 8×10^6 kgf • mm^2 or more for the portion at least 900mm apart from tip end 1A. Shaft 1 is mounted on a head 2 with neck length of 50mm or shorter to complete golf club 3.

Further, as another embodiment, fiber reinforced plastic shaft 1 is provided which has torsional stiffness of 1×10^6 kgf • mm^2 and bending stiffness of 2×10^6 kgf • mm^2 between tip end 1A and the position 200mm apart from tip end 1A.

As another embodiment, golf club 3 with fiber reinforced plastic shaft 1 is provided. The shaft 1 has torsional stiffness of 1×10^6 kgf • mm^2 or more and bending stiffness of 2×10^6 kgf • mm^2 or less between tip end 1A and the position 200mm apart from tip end 1A. Shaft 1 is mounted on head 2 with neck length of 50mm or shorter to complete golf club

3.

Further, as another embodiment, fiber reinforced plastic shaft 1 is provided which has torsional stiffness of 1×10^6 kgf • mm^2 or more and bending stiffness of 2×10^6 kgf • mm^2 or less between tip end 1A and the position 200mm apart from tip end 1A, and bending stiffness of 8×10^6 kgf • mm^2 or more for the portion at least 900mm apart from tip end 1A.

As still another embodiment, golf club 3 with fiber reinforced plastic shaft 1 is provided. The shaft 1 has torsional stiffness of 1×10^6 kgf • mm^2 or more and bending stiffness of 2×10^6 kgf • mm^2 or less between tip end 1A and the position 200mm apart from tip end 1A, and bending stiffness of 8×10^6 kgf • mm^2 or more for the portion at least 900mm apart from tip end 1A. Shaft 1 is mounted on head 2 with neck length of 50mm or shorter to complete golf club 3.

Further, as still another embodiment, fiber reinforced plastic shaft 1 is provided whose bending stiffness between tip end 1A and the position 200mm apart from tip end 1A is at most one fourth the bending stiffness for the portion at least 900mm apart from tip end 1A.

Further, as still another embodiment, golf club 3 with fiber reinforced plastic shaft 1 is provided. Bending stiffness of shaft 1 between tip end 1A and the position 200mm apart from tip end 1A is at most one fourth the bending stiffness for the portion at least 900mm apart from tip end 1A. Shaft 1 is mounted on head 2 with neck length of 50mm or shorter to complete golf club 3.

Figs. 4 and 5 respectively show bending and torsional stiffness distributions for the shaft in accordance with one embodiment of the present invention.

Figs. 6 and 7 respectively show bending and torsional stiffness distributions for the conventional shaft.

Measurement data for bending and torsional stiffness distributions of the above mentioned shafts shown in Figs. 4 to 7 is obtained through comparison test with the shaft in accordance with one embodiment of the present invention and the conventional shaft. For a reinforcing layer of the shaft in accordance with one embodiment of the present invention, prepreg with carbon fiber XN-05 (having tensile elastic modulus of 5000kgf/mm^2) produced by NIPPON Graphite Fiber is employed. For a reinforcing layer of the conventional shaft, prepreg with carbon fiber T700 (having tensile elastic modulus of 24000 kgf/mm^2) produced by Toray Industries is employed.

Further, prepreg with carbon fiber M50J (having tensile elastic modulus of 50000kgf/mm^2) produced by Toray Industries is employed for a bias layer (having fiber bias angle of $\pm$ 40°) in accordance with one embodiment of the present invention, whereas prepreg with carbon fiber M30S (having tensile elastic modulus of 30000kgf/mm^2) produced by Toray Industries is employed for the conventional shaft.

Further, prepreg with carbon fiber (tensile elastic modulus of 29000kgf/mm^2) is employed for straight layers (having fiber bias angle of $\pm$ 0° to $\pm$ 5°) of the shaft in accordance with one embodiment of the present invention and the conventional shaft.

In addition, in one embodiment of the present invention, adjustment of a mandrel shape, for example by increasing an outer diameter or a thickness of the shaft at the gripping side (the bat side), can increase bending stiffness at the gripping side. Further, employment of highly elastic carbon fiber for the bias layer at the tip end of the shaft can also increase torsional stiffness at the tip end without increasing bending stiffness.

Now, specification of the golf club is shown in the following Table 2.

Table 2 Specification of Golf Club

	Conventional club	Club of present invention
club length (mm)	1145	1145
neck length (mm)	50	50
weight (g)	290	281
14 inch balance	D2.5	D1.5
loft angle (degrees)	11°48'	11°40'
lie angle (degrees)	57°	57°
face angle (degrees)	-1°40' (*)	-1°30' (*)

Note (*): minus indicates hook face, while plus indicates open face.

Here, referring to Fig. 8, length of the club is defined as a distance between a grip end 6 and a heel end surface 2A of head 2, whereas neck length is defined as a distance between a neck end surface 2B and heel end surface 2A of head 2.

Thus, in accordance with one embodiment of the present invention, shaft 1 has bending stiffness of 2×10^6 kgf • mm^2 or less and torsional stiffness of 1×10^6 kgf • mm^2 or more between tip end 1A and the position 200mm apart from tip end 1A, and bending stiffness of 8×10^6 kgf • mm^2 or more for the portion at least 900mm apart from tip end 1A. Using golf club 3 in accordance with one embodiment of the present invention with head 2 having neck length of 50mm or shorter and the conventional golf club, measurement was performed at head speed of 40m/sec, which corresponds to that for an average golfer. It is noted that a high speed video camera was provided at right angle with respect to the direction of the flight of the ball during measurement, and head speed, blow angle, ball speed and projecting angle of the ball were analyzed based on image output from the high speed video camera.

Fig. 9 is a diagram related to the method of measuring the turn of the head when the ball is hit. Referring to Fig. 9, a high speed video camera 7 is provided above a golfer and based on the image output from high speed video camera 7, change of face angle immediately before a golf head 1 hits a ball 4 is analyzed to measure direction of the shot, that is, the turn of head 2. A torsional strain gauge 8 is provided for the shaft of golf club 3. An output from torsional strain gauge 8 is applied to an amplifier 12 through a bridge box 11 for amplification, and input into an FFT analyzer 13 for measurement of torsional angle of the shaft. It is noted that the golf club used in the experiment had total length of 45 inches and neck length of 50mm.

The experiment result for the golf club in accordance with one embodiment of the present invention shows that blow angle and hence the initial speed of the ball were increased though the head speed remained almost the same as shown in the following Table 3.

Table 3 Experimental Result of Golf Club

	Conventional	Present Invention
head speed (m/s)	40.0	40.0
blow angle (degrees)	2.2	4.3
initial speed of ball (m/s)	51.2	56.1
initial speed of ball/head speed	1.28	1.40

As shown in Fig. 9, torsional strain gauge 8 was provided on shaft 1 to measure torsion of the shaft immediately before impact during the swing. In terms of physical amount, distribution of the ratio of change over time of longitudinal curvature of the shaft (dK/dt) immediately before impact (from 5msec to just a moment before impact) is measured.

Fig. 10 is a graph showing ratio of change over time of longitudinal curvature of the shaft (dK/dt) immediately before impact in accordance with one embodiment of the present invention, whereas Fig. 11 shows that for the conventional shaft. As is apparent from comparison between Figs. 10 and 11, change of curvature at the head side for the shaft in accordance with one embodiment of the present invention is larger than that for the conventional shaft shown in Fig. 11. As a result, the shaft in accordance with one embodiment of the present invention can increase blow angle for upper blow, so that initial speed of the ball is increased. Thus, it is apparent that dK/dt between the tip end and the position 200mm apart from the tip end has a significant influence on blow angle and is also related to neck length. Unless neck length is 50mm or shorter, bending stiffness of the neck influences dK/dt, whereby sufficient deflection at the tip end cannot be ensured even if bending stiffness at the tip end of the shaft is reduced.

Figs. 12A and 12B are graphs showing torsion angles over time immediately before impact for the shaft in accordance with one embodiment of the present invention and for the conventional shaft, respectively. As is apparent from comparison between Figs. 12A and 12B, the turn of the head in accordance with one embodiment of the present invention is more greatly improved.

As in the foregoing, according to the embodiment of the present invention, in the shaft allowing prescribed swings, by setting higher and lower bending stiffness at the gripping side and at the tip end of the shaft, respectively, deflection amount at the tip end of the shaft immediately before impact is increased for larger blow angle. Thus, the head can hit the ball with upper blow to increase the flight distance. In addition, higher torsional stiffness at the tip end of the shaft allows a desired turn of the head immediately before impact.

Although the present invention has been descried and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

Claims

1. A fiber reinforced plastic golf shaft (1) having bending stiffness of 2×10^6kgf • mm^2 or less between a tip end (1A) and a position 200mm apart from the tip end (1A), and bending stiffness of 8×10^6kgf • mm^2 or more for a portion at least 900mm apart from the tip end (1A).

2. A golf club (3) with the golf shaft (1) according to claim 1, wherein

   said golf shaft (1) is mounted on a golf head (2) having neck length of 50mm or shorter.

3. A fiber reinforced plastic golf shaft (1), having torsional stiffness of 1×10^6kgf • mm^2 or more and bending stiffness of 2×10^6kgf • mm^2 or less between a tip end (1A) and a position 200mm apart from the tip end.

4. A golf club (3) with the golf shaft according to claim 3, wherein

said golf shaft (1) is mounted on a golf club head (2) having neck length of 50mm or shorter.

5. A fiber reinforced plastic golf shaft (1) having torsional stiffness of 1×10^6kgf • mm^2 or more and bending stifness 2×10^6kgf • mm^2 or less between a tip end (1A) and a position 200mm apart from the tip end, respectively, and bending stiffness of 8×10^6kgf • mm^2 or more for the portion at least 900mm apart from the tip end (1A).

6. A golf club (3) with the golf shaft (1) according to claim 5, wherein

said golf shaft (1) is mounted on a golf club head (2) having neck length of 50mm or shorter.

7. A fiber reinforced plastic golf shaft (1), wherein bending stiffness for a portion between a tip end (1A) and a position 200mm apart from the tip end of said golf shaft is at most one fourth that for a portion at least 900mm apart from the tip end.

8. A golf club (3) with the golf shaft according to claim 3, wherein

said golf shaft (1) is mounted on a golf club head (2) having neck length of 50mm or shorter.

FIG. 1A

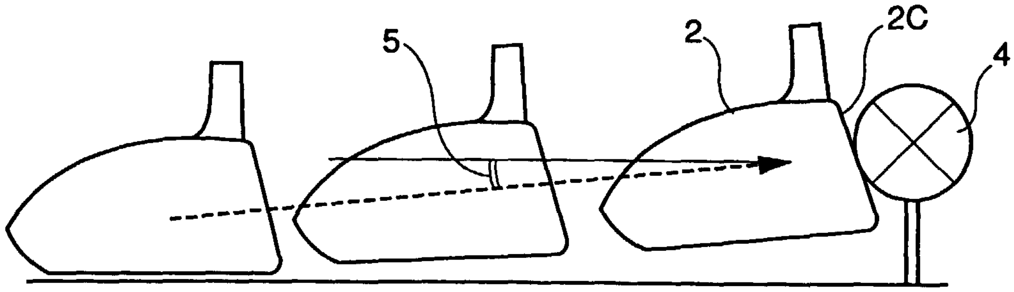


FIG. 1B

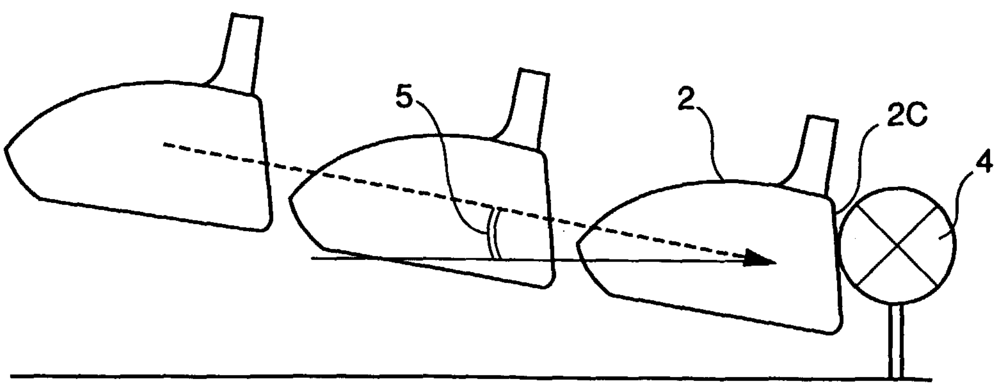


FIG. 1C

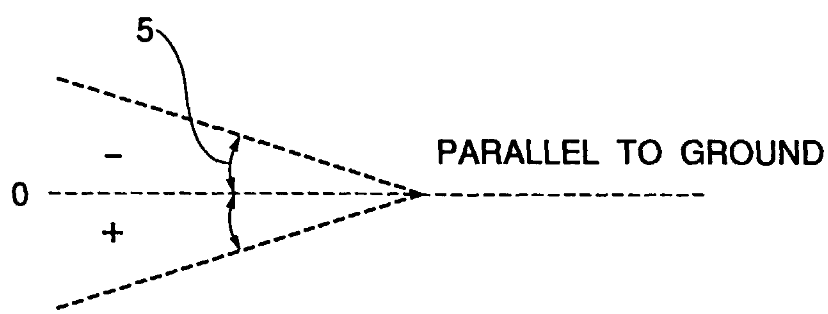


FIG. 2A

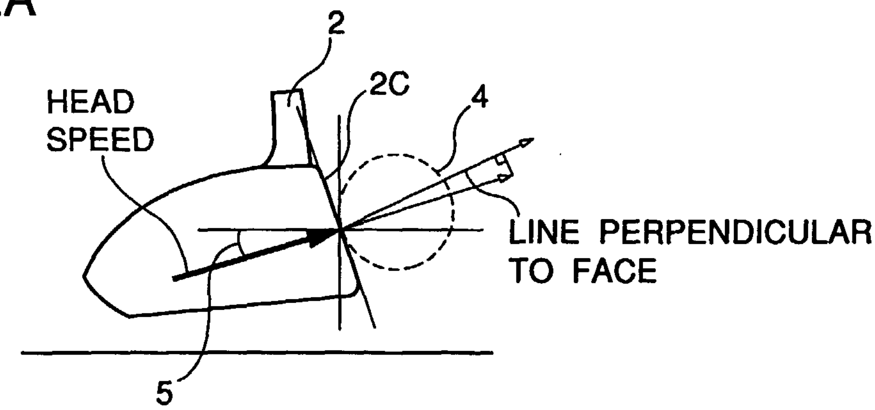

2
2C
4
HEAD
SPEED
LINE PERPENDICULAR
TO FACE
5

FIG. 2B

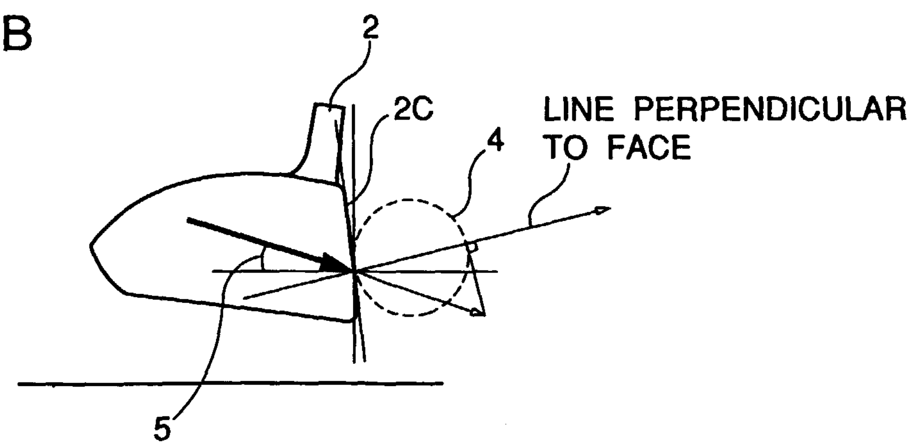
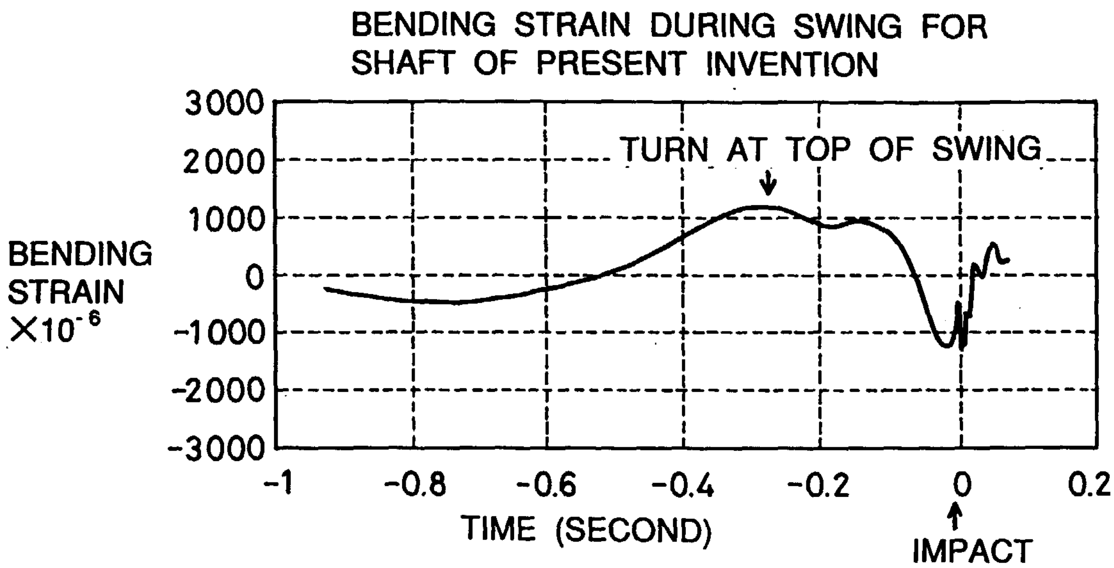

2
2C
LINE PERPENDICULAR
TO FACE
4
5

FIG. 3A


BENDING STRAIN DURING SWING FOR
SHAFT OF PRESENT INVENTION
TURN AT TOP OF SWING
BENDING
STRAIN
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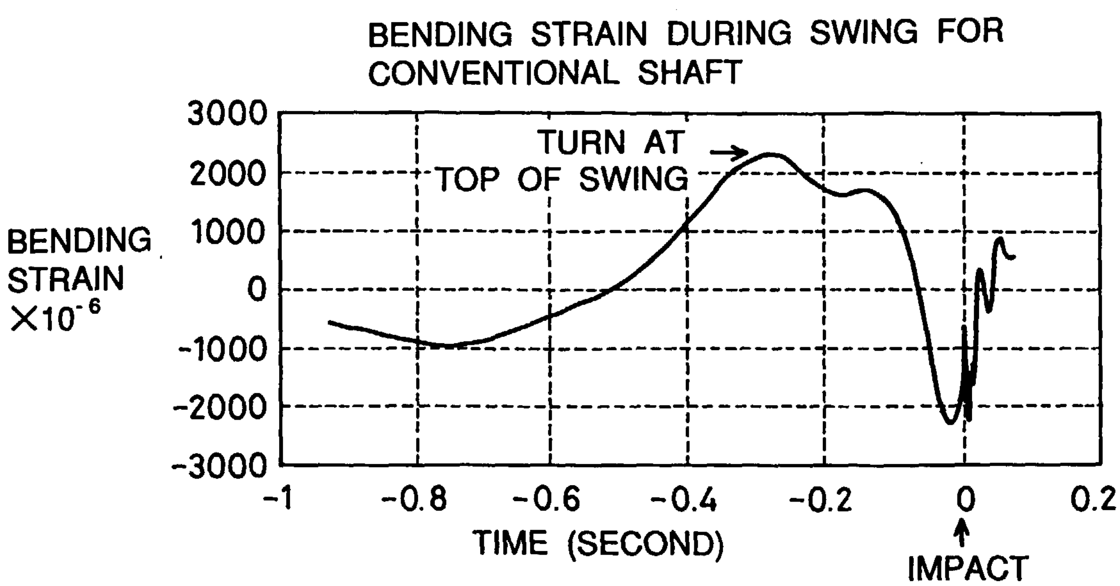
2000
1000
0
-1000
-2000
-3000
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
TIME (SECOND)
IMPACT

FIG. 3B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CONVENTIONAL SHAFT
TURN AT
TOP OF SWING
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STRAIN
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-1000
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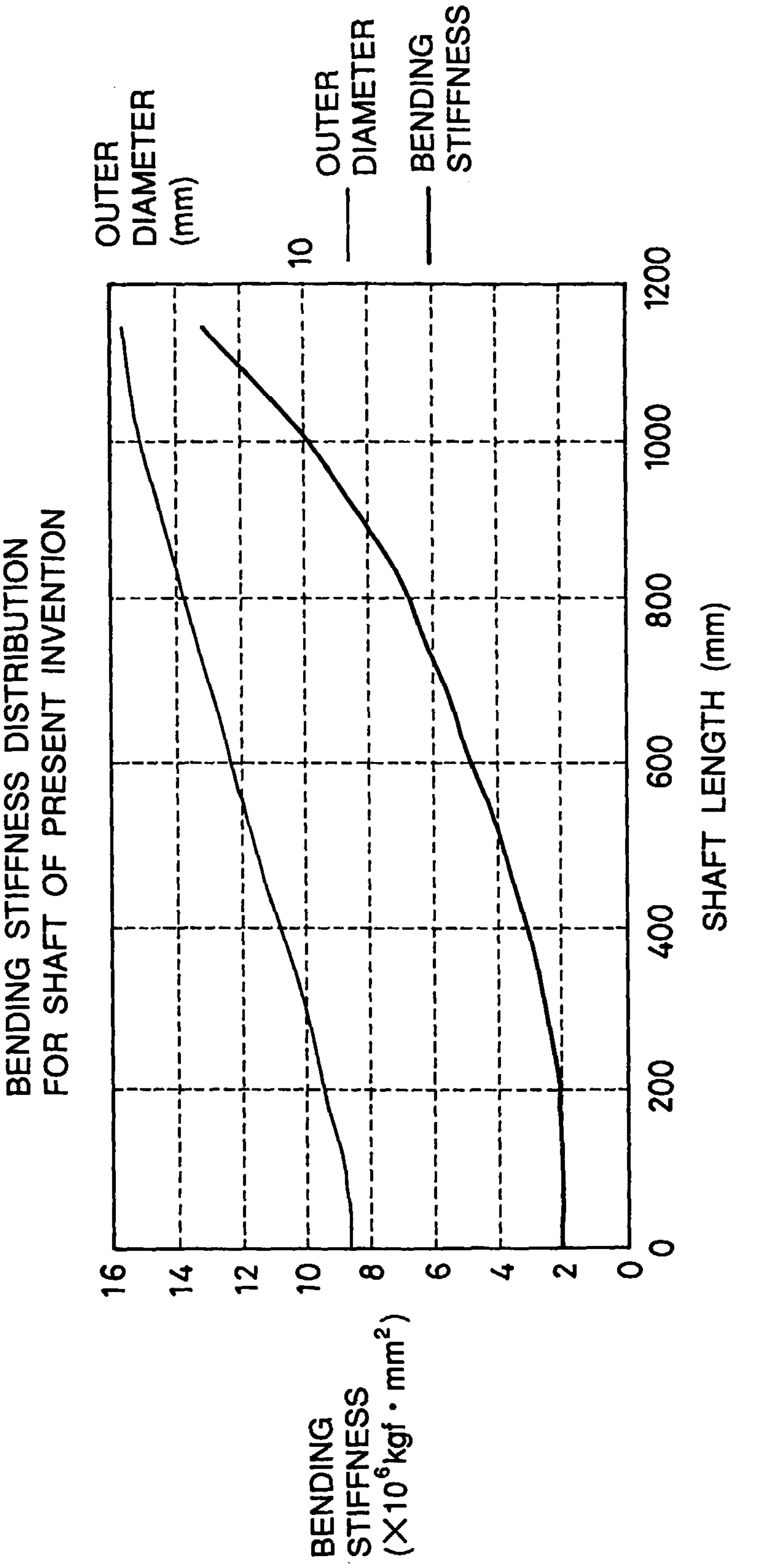
0.2
TIME (SECOND)
IMPACT

FIG. 4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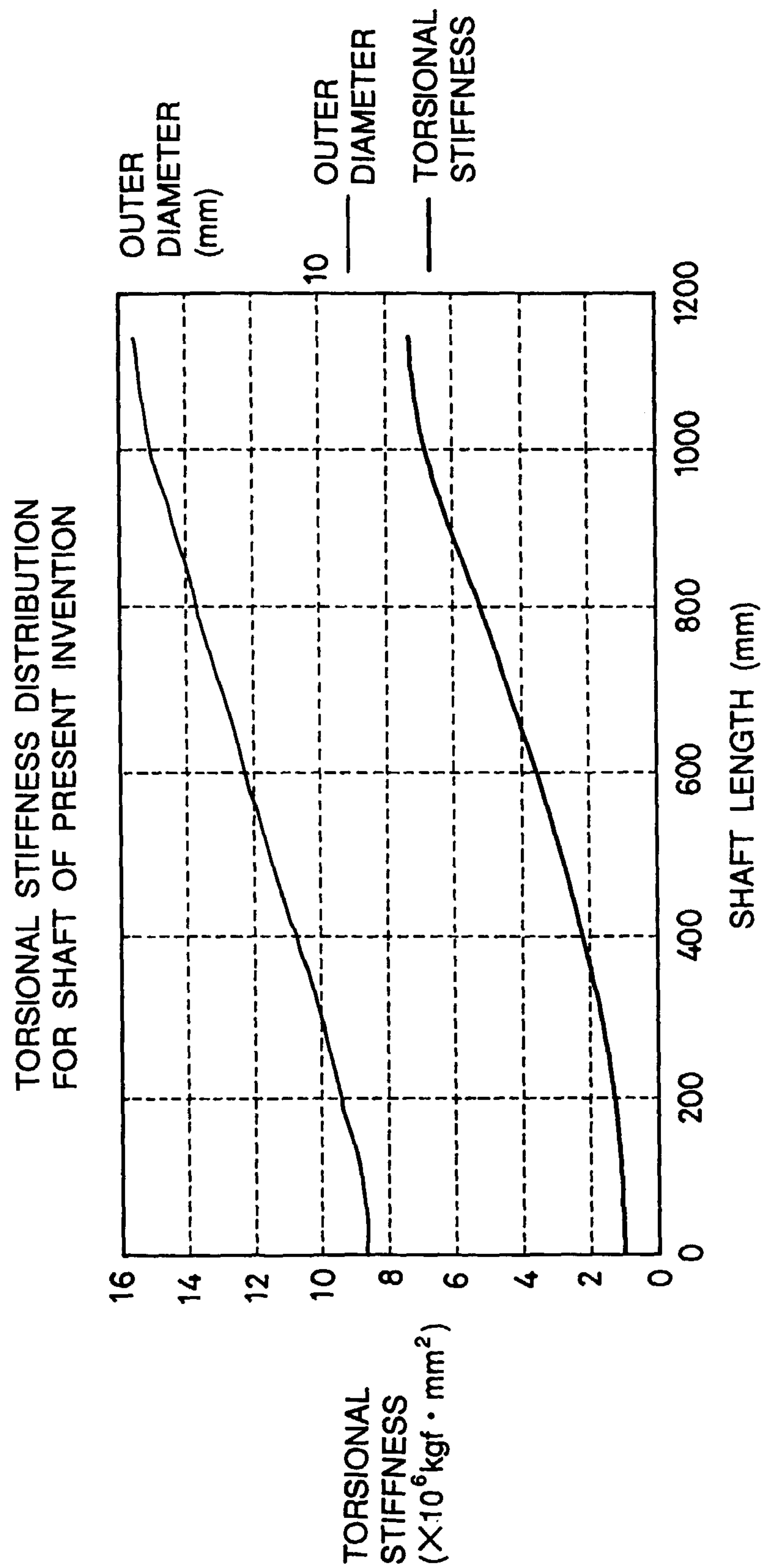
FOR SHAFT OF PRESENT INVENTION
BENDING
STIFFNESS
(×10⁶kgf · mm²)
OUTER
DIAMETER
(mm)
16
14
12
10
8
6
4
2
0
10
0
200
400
600
800
1000
1200
SHAFT LENGTH (mm)
OUTER
DIAMETER
BENDING
STIFFNESS

FIG. 5


TORSIONAL STIFFNESS DISTRIBUTION
FOR SHAFT OF PRESENT INVENTION
TORSIONAL
STIFFNESS
(×10⁶kgf · mm²)
OUTER
DIAMETER
(mm)
OUTER
DIAMETER
TORSIONAL
STIFFNESS
SHAFT LENGTH (mm)
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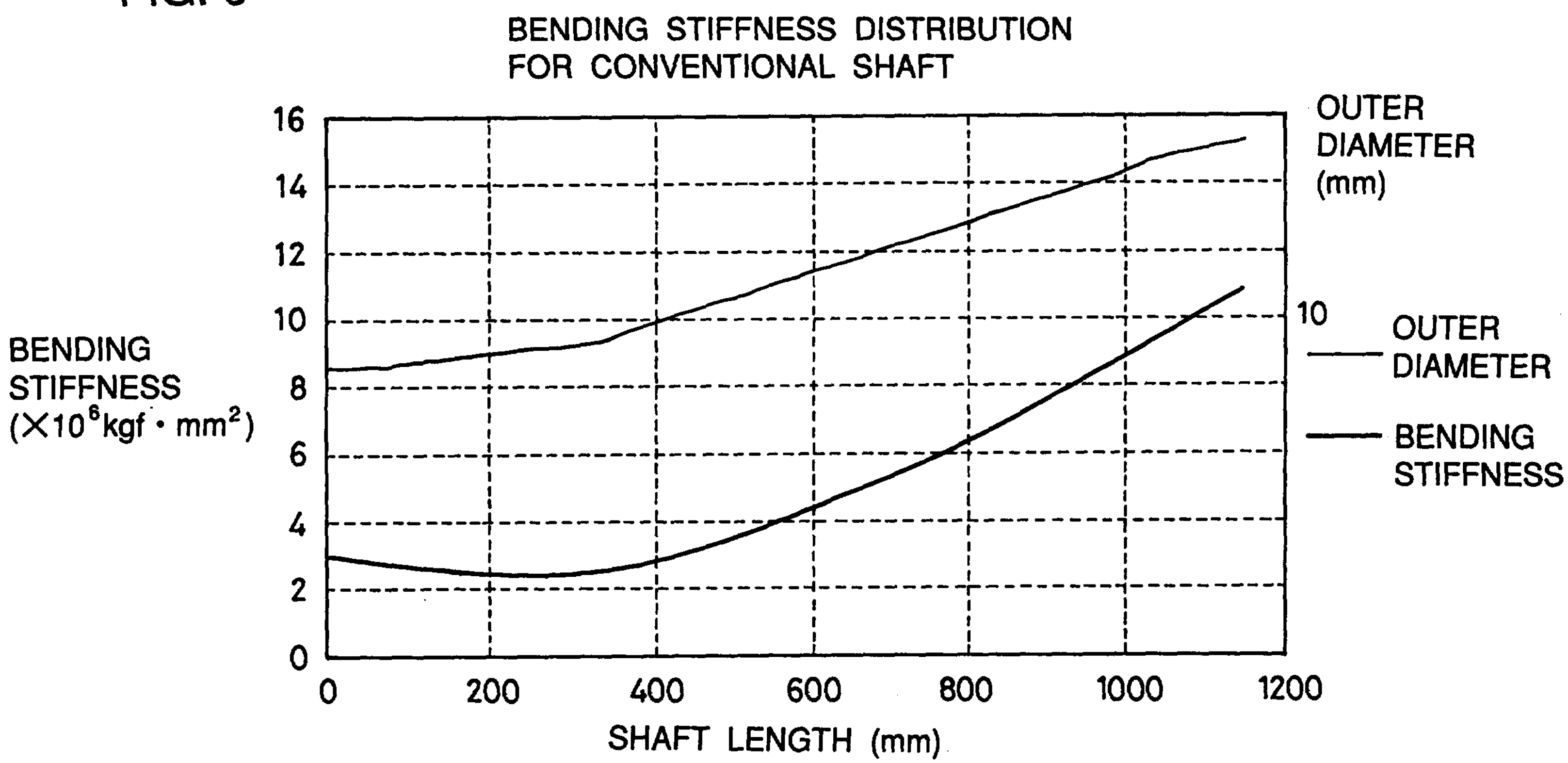
4
6
8
10
12
14
16
0
200
400
600
800
1000
1200

FIG. 6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FOR CONVENTIONAL SHAFT
BENDING
STIFFNESS
(×10⁶kgf · mm²)
16
14
12
10
8
6
4
2
0
0
200
400
600
800
1000
1200
SHAFT LENGTH (mm)
OUTER
DIAMETER
(mm)
10
OUTER
DIAMETER
BENDING
STIFFNESS

FIG. 7

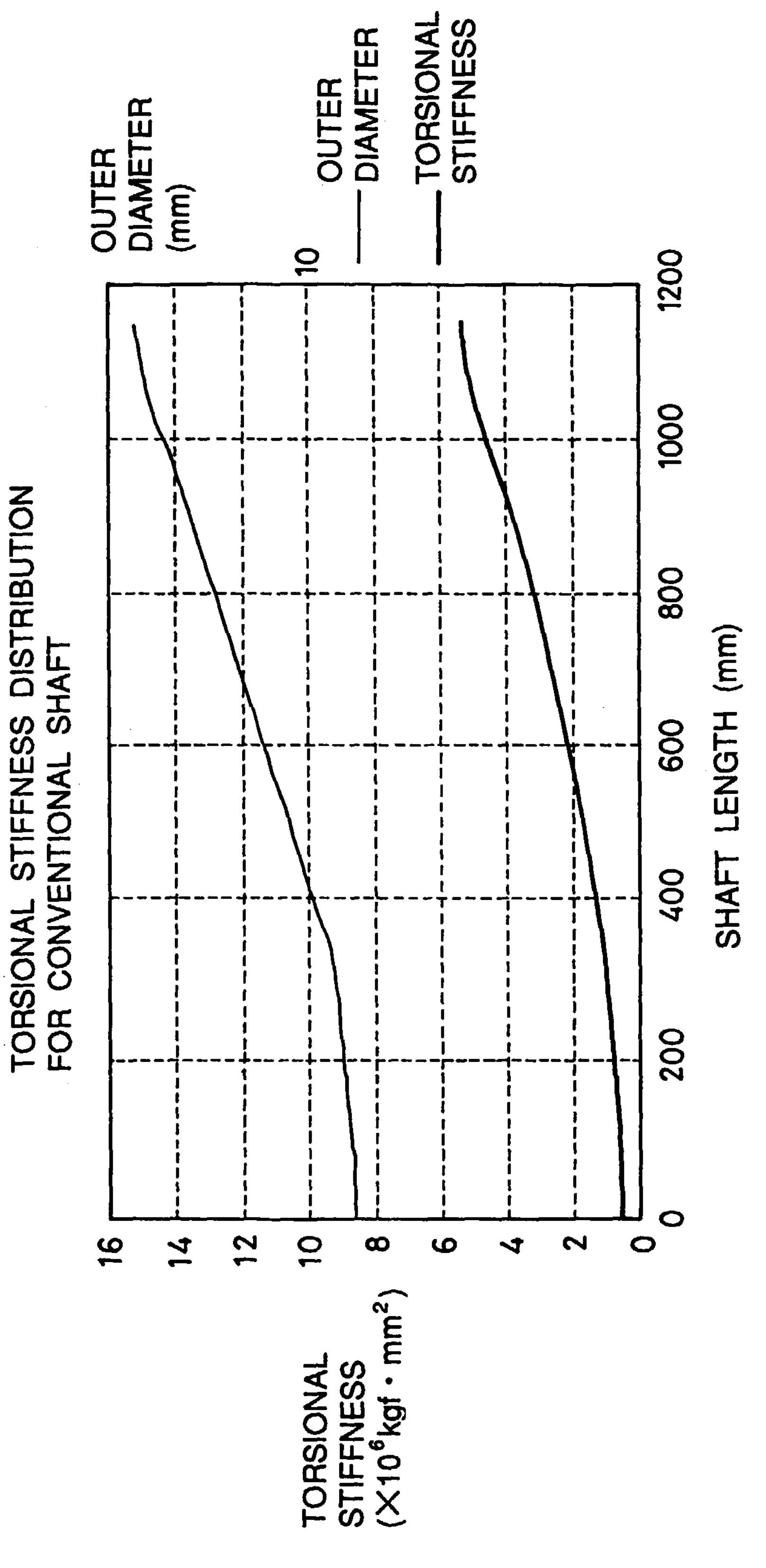

TORSIONAL STIFFNESS DISTRIBUTION
FOR CONVENTIONAL SHAFT
TORSIONAL
STIFFNESS
(×10⁶kgf · mm²)
OUTER
DIAMETER
(mm)
OUTER
DIAMETER
TORSIONAL
STIFFNESS
SHAFT LENGTH (mm)
0
200
400
600
800
1000
1200
2
4
6
8
10
12
14
16

FIG. 8

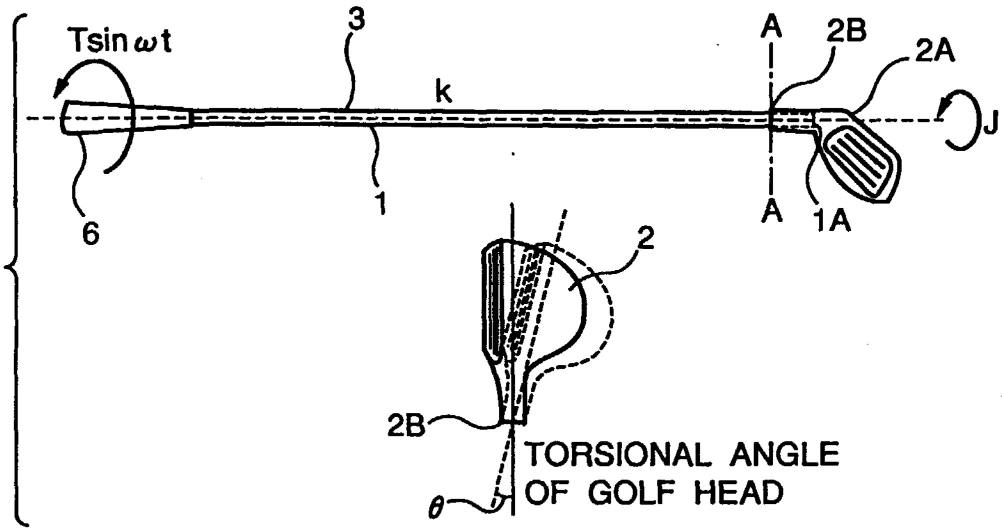

Tsin ωt
3
k
1
6
A
2B
2A
J
A
1A
2
2B
θ
TORSIONAL ANGLE OF GOLF HEAD

FIG. 9

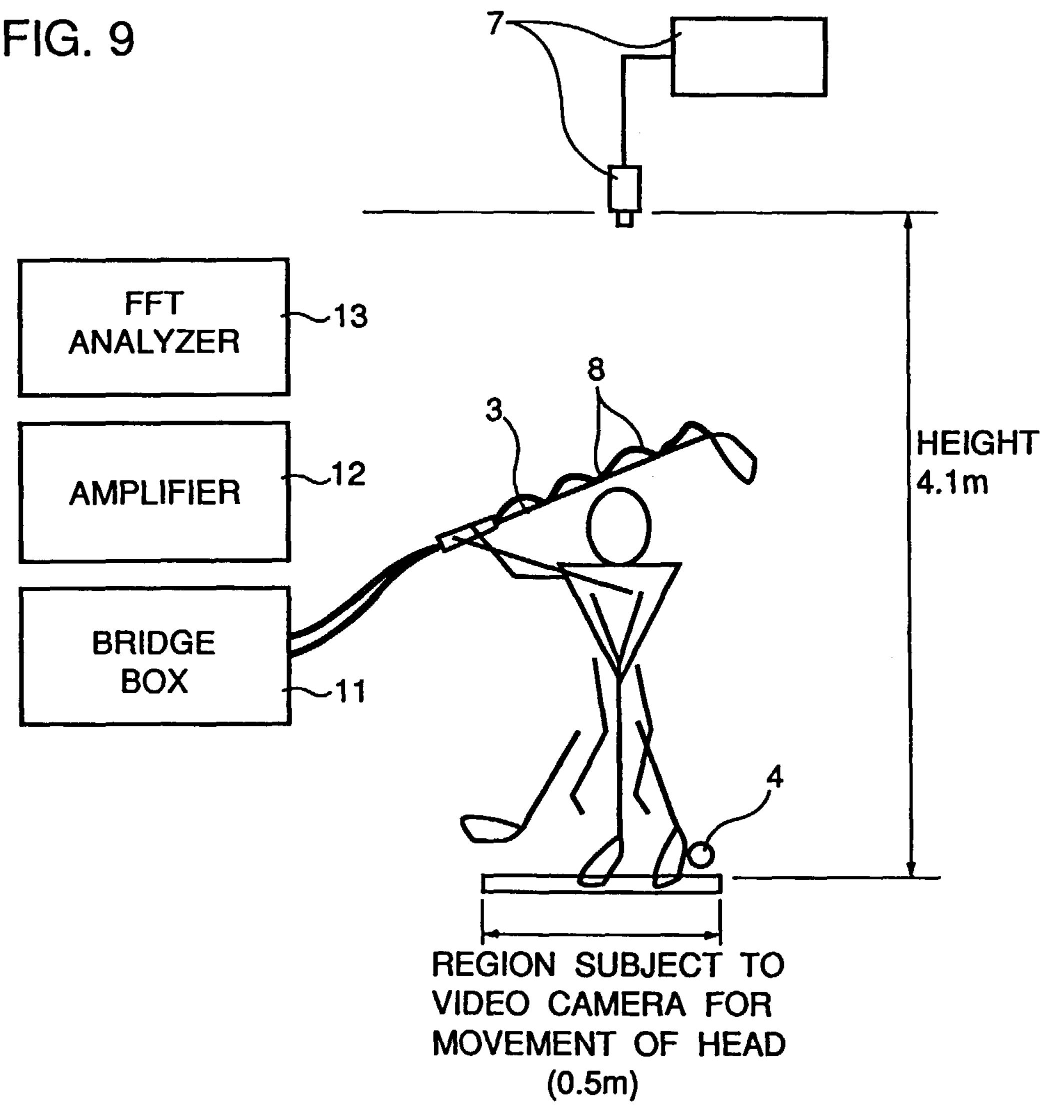

7
FFT ANALYZER
13
AMPLIFIER
12
BRIDGE BOX
11
3
8
4
HEIGHT 4.1m
REGION SUBJECT TO VIDEO CAMERA FOR MOVEMENT OF HEAD (0.5m)

FIG. 10

RATIO OF CHANGE OVER TIME OF LONGITUDINAL CURVATURE OF SHAFT OF PRESENT INVENTION

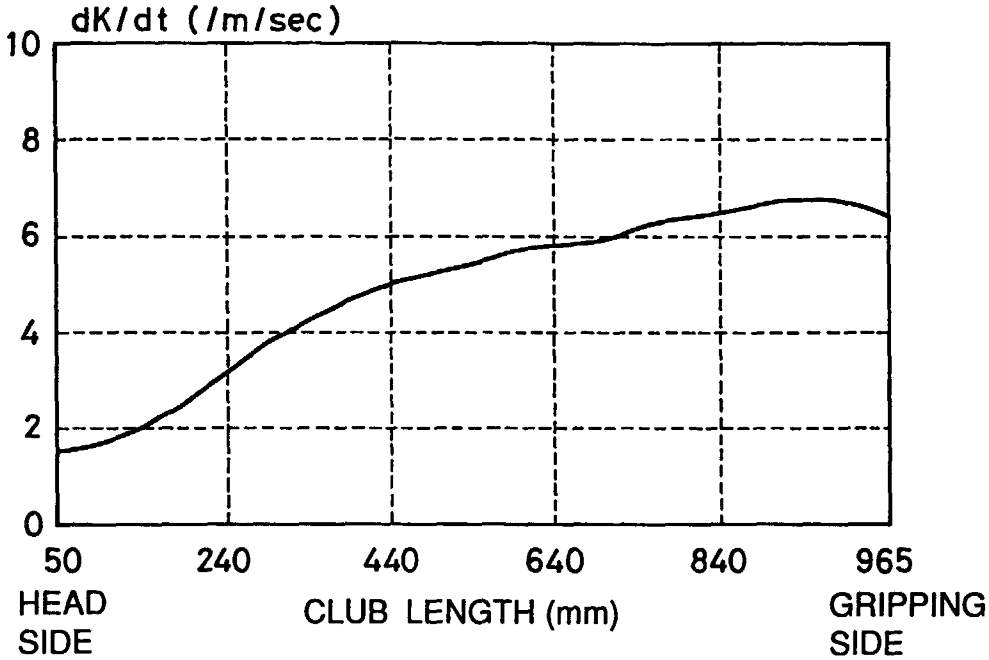


FIG. 11

RATIO OF CHANGE OVER TIME OF LONGITUDINAL CURVATURE OF CONVENTIONAL SHAFT

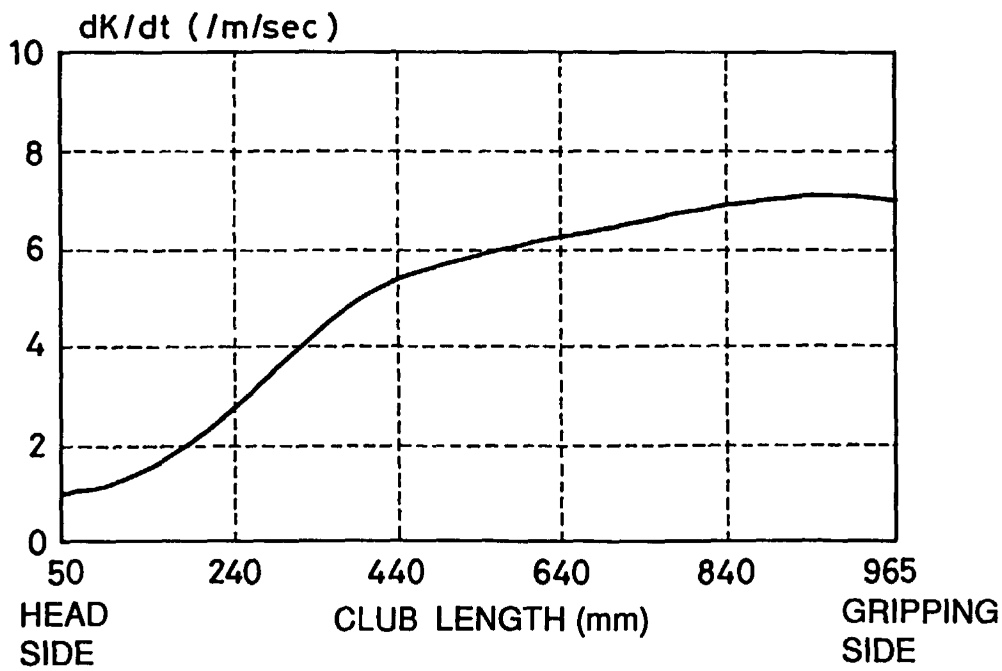


FIG. 12A

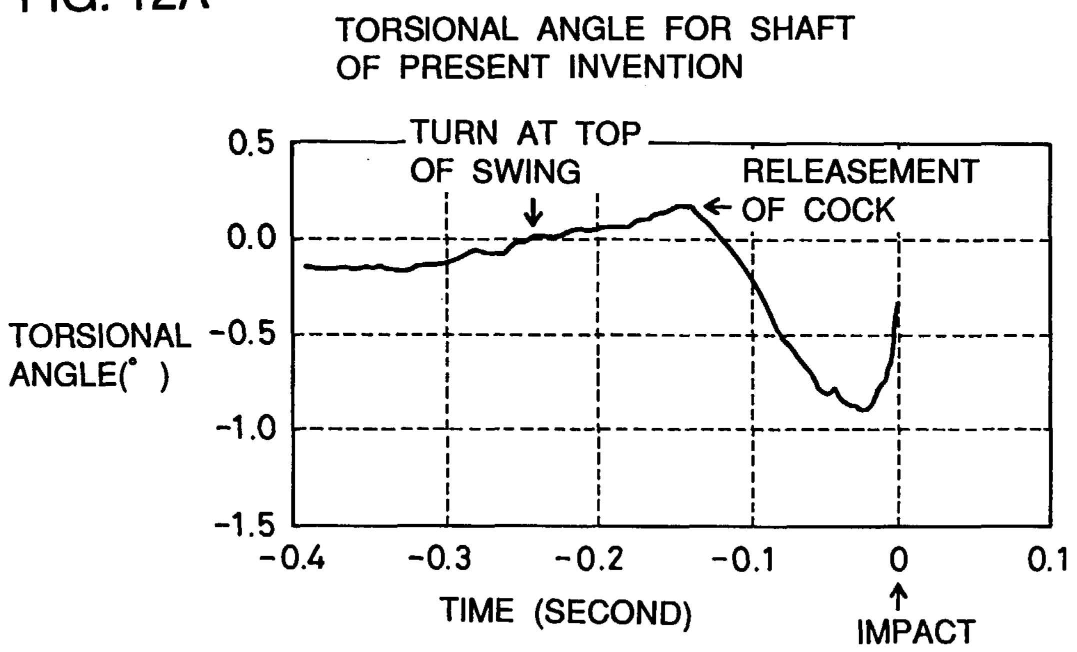
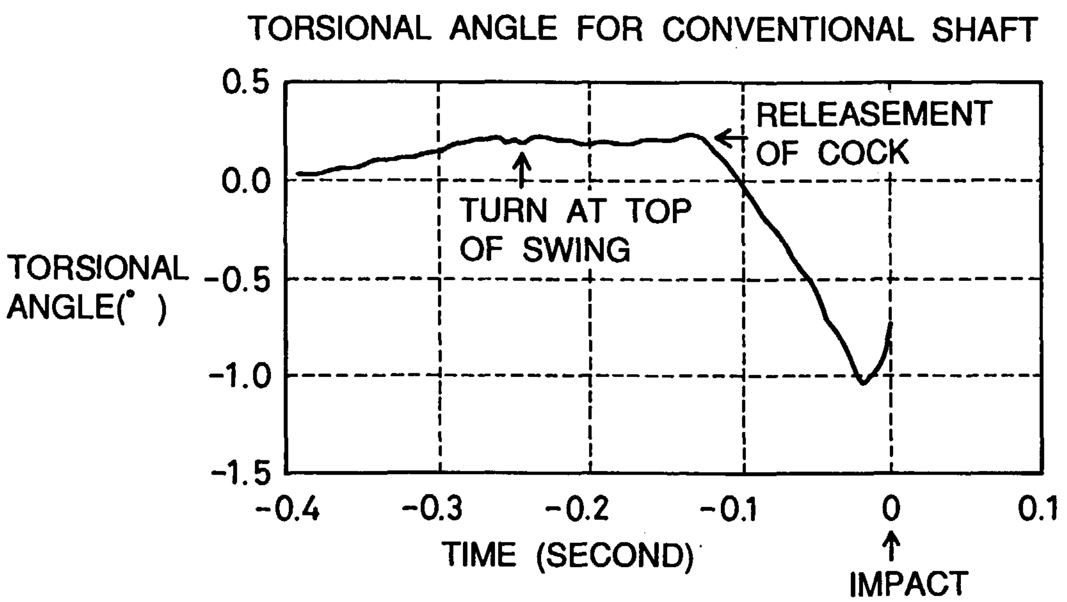


FIG. 12B



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 4952

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	FR 2 706 777 A (TAYLOR MADE GOLF COMPANY) 30 December 1994 * the whole document *	1,7	A63B53/10
A	EP 0 662 329 A (CALLAWAY GOLF COMPANY) 12 July 1995 * column 6, line 3 - column 7, line 36; figures 1,6 *	2,4,6,8	
A	WO 87 07514 A (WSD) 17 December 1987 * the whole document *	1,3,5	
A	US 5 156 396 A (AKATSUKA ET AL.) 20 October 1992 * the whole document *	1,3,5	
A	GB 2 290 238 A (HONMA GOLF CO) 20 December 1995 * page 3, paragraph 2 - page 4, paragraph 2; figures 1,2 *	2,4,6,8	
A	US 5 551 691 A (HARADA ET AL.) 3 September 1996		TECHNICAL FIELDS SEARCHED (Int.Cl.6) A63B
A	WO 91 14480 A (EXEL OY) 3 October 1991		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	28 May 1998	Williams, M

CATEGORY OF CITED DOCUMENTS

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