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(71) Applicant: **Mitsubishi Rayon Co., Ltd.**
Tokyo 100-8253 (JP)

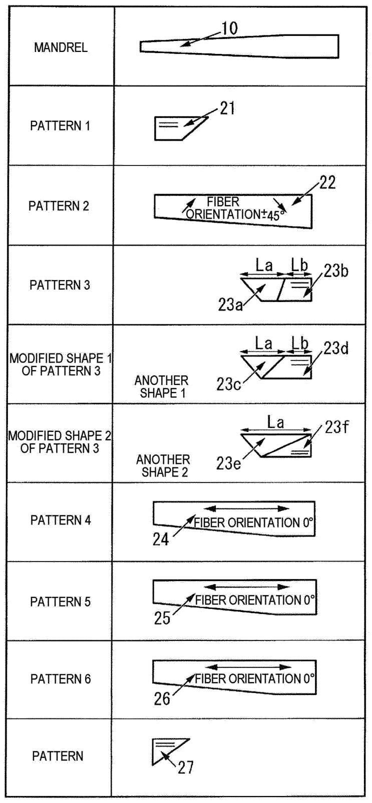
(72) Inventors:
- **ATSUMI, Tetsuya**
  Toyohashi-shi
  Aichi 440-8601 (JP)
- **KANEKO, Takashi**
  Toyohashi-shi
  Aichi 440-8601 (JP)
- **SHIMONO, Satoshi**
  Toyohashi-shi
  Aichi 440-8601 (JP)

(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

(54) **GOLF CLUB SHAFT AND GOLF CLUB**

(57) The purpose of the present invention is to provide a golf club shaft that makes it possible to: maintain ease of swing even when a heavy head is mounted thereto; obtain an agreeable feel whether the golfer using said golf club shaft is a professional golfer or a normal advanced player; and increase the distance that a hit golf ball travels. This golf club shaft is configured from a plurality of fiber-reinforced resin layers and comprises a heavy substance having a specific gravity of 7 or higher within a range of 0-400 mm from the grip-side end of the golf club shaft. When the total length of the golf club shaft is denoted by Ls and the distance from the head-side end to the center of gravity of the golf club shaft is denoted by Lg, Lg/Ls is in the range of 0.54-0.65.

FIG. 1



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Description

Field of the Invention

[0001] The present invention relates to a golf club shaft and to a golf club.

[0002] The present application is based upon and claims the benefit of priority to Japanese Patent Application No. 2014-1896, filed January 8, 2014. The entire contents of the application are incorporated herein by reference.

Background Art

[0003] The behavior of a shaft during the swing of a golfer significantly affects the carry distance of a ball and feel of the golfer. Accordingly, golf club shafts have been studied to improve the carry of a ball and to provide a preferred feel for the golfer. It is generally known that the carry of a golf ball is determined by the initial velocity, launch angle, and spin rate of the ball. To extend the carry, it is necessary to provide an appropriate and stable launch angle and spin rate while increasing the initial velocity of the ball.

[0004] Considering the above, Patent Literature 1 proposes how to gain stable launch angles and spin rates by enhancing the rigidity of a golf club shaft on its tip-end side and lowering the rigidity of the adjacent butt-end side. However, the method does not result in increased carry distance.

[0005] As described above, it is necessary to enhance the initial velocity of a ball to increase the carry distance. To improve the initial ball velocity, it is an option to make the head heavier. However, a heavier head causes an increase in the moment of inertia of the club, and the golf club feels heavier during the swing, thereby reducing the ease of swinging the golf club.

[0006] To solve the aforementioned problems, proposed is a so-called high balance shaft, in which the gravity center is set closer to the grip side.

[0007] When the gravity center of a shaft is designed to be closer to the grip side, a heavy feel of the shaft during the swing is reduced even when a heavier head is mounted. Patent Literature 2 proposes a high balance shaft: when the entire length of a shaft is set as (Ls) and the distance from the tip end to gravity center (G) of the shaft is set as (Lg), the ratio (Lg/Ls) is 0.52-0.65.

[0008] However, it is thought that the high balance shaft in Patent Literature 2 is achieved by arranging thicker layers on the grip side of the shaft. In such a case, since the flexural rigidity increases on the grip side of the shaft, the design flexibility of the shaft is minimized, making it difficult to optimize the feel during the swing. In addition, since such thicker layers increase the shaft weight, it is necessary to decrease the layer thickness on the head side to prevent a heavier shaft. However, such a decrease may cause a reduction in shaft strength.

PRIOR ART LITERATURE

PATENT LITERATURE

[0009]

Patent Literature 1: JP2009-189554A
Patent Literature 2: JP2012-239574A

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0010] The present invention was carried out in consideration of the above-mentioned problems. Its objectives are to provide a golf club shaft that is capable of responding to a wide range of characteristics of a head to be mounted, levels and preferences of golfers, and the like; maintaining the ease of swing even when a heavier head is mounted; providing a preferred feel for a golfer, even when the subject is a professional or low handicap golfer; and increasing the carry of a ball.

SOLUTIONS TO THE PROBLEMS

[0011] To achieve the above objectives, embodiments of the present invention are as follows:

(1) A golf club shaft made of multiple fiber-reinforced resin layers, containing a heavy substance with a specific gravity of 7 or greater positioned between 0 and 400 mm from the grip end (butt end) of the golf club shaft; in such

a golf club shaft, when the entire length of the golf club shaft is set as (Ls) and the distance from the head end (tip end) to the gravity center of the golf club shaft is set as (Lg), the ratio (Lg/Ls) is 0.54-0.65.

(2) The golf club shaft described in (1) above, the golf club shaft being made of multiple fiber-reinforced resin layers, further containing a 20~400 mm-long filler-containing resin layer (W) which contains the above heavy substance as a filler.

(3) The golf club shaft described in (2) above, the golf club shaft being made of multiple fiber-reinforced resin layers, in which the weight per unit area of the filler-containing resin layer (W) is 500 g/m^2 or greater.

(4) The golf club shaft described in any of (1)~(3) above, the golf club shaft being made of multiple fiber-reinforced resin layers, in which the outer diameter of the grip-end portion is set at 14.5 mm~15.7 mm.

(5) The golf club shaft described in any of (2)~(4) above, in which the filler-containing resin layer (W) is set at less than 10 mass% of the entire mass of the golf club shaft.

(6) The golf club shaft described in any of (2)~(5) above, in which the filler-containing resin layer (W) is set at 4 mass% or greater of the entire mass of the golf club shaft.

(7) The golf club shaft described in any of (2)~(6) above, having a fiber-reinforced resin layer (X) which is positioned on the grip-end (butt-end) side to be adjacent to the filler-containing resin layer (W) and set to have a thickness difference of-70 μm~+110 μm with the filler-containing resin layer (W).

(8) The golf club shaft described in any of (1)~(7) above, in which the heavy substance is tungsten.

(9) The golf club shaft described in any of (1)~(8) above, in which the kickpoint obtained by the formula below is less than 45.0%.

$$\text{kickpoint } (\%) = (LK/LB) \times 100$$

LK: when a shaft is curved by a compression load applied on both ends of the shaft so that the straight-line distance between both ends is 98.5~99.5% of the entire shaft length, the distance from the tip end of the shaft to the intersection of the straight line connecting both ends and a vertical line drawn from the apex of the curve.
LB: when a shaft is curved by a compression load applied on both ends of the shaft so that the straight-line distance between both ends is 98.5~99.5% of the entire shaft length, the straight-line distance between both ends of the shaft.

(10) The golf club shaft described in (9) above, in which the kickpoint is less than 44.0%.

(11) A golf club having a golf club shaft made of multiple fiber-reinforced resin layers, in which the golf club shaft contains a heavy substance with a specific gravity of 7 or greater positioned between 0 and 400 mm from the grip end, and when the entire length of the golf club shaft is set as (Ls) and the distance from the head end to the gravity center of the golf club shaft is set as (Lg), the ratio (Lg/Ls) is 0.54-0.65.

(12) The golf club described in (11) above, in which the filler-containing resin layer (W) is set to have a length of 20~355 mm and to be present between 0 and 355 mm from the grip end of the golf club shaft.

EFFECTS OF THE INVENTION

[0012] When a golf club shaft related to the present invention is used, the ease of swing is maintained even when a heavier head is mounted, a preferred feel is gained even when the subject is a professional or low handicap golfer, and the carry of a ball is increased.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

FIG. 1 shows views, illustrating cut shapes of prepreg sheets and the wrapping order to form a golf club shaft according to an embodiment of the present invention;
FIG. 2 schematically shows a view of a mandrel used in an embodiment of the present invention;
FIG. 3 shows views, illustrating cut shapes of prepreg sheets used for forming a golf club shaft and their order of wrapping on a mandrel according to an embodiment of the present invention; and
FIG. 4 shows views, illustrating cut shapes of prepreg sheets used for forming a golf club shaft and their order of wrapping on a mandrel according to another embodiment of the present invention.

MODE TO CARRY OUT THE EMBODIMENTS

[0014] A golf club shaft according to an embodiment of the present invention is made of multiple fiber-reinforced resin layers, and contains a heavy substance with a specific gravity of 7 or greater positioned between 0 and 400 mm from the grip end of the golf club shaft (corresponding to the butt end in the examples). When the entire length of the golf club shaft is set as (Ls) and the distance from the head end (corresponding to the tip end in the examples) to the gravity center of the golf club shaft is set as (Lg), the ratio (Lg/Ls) is 0.54-0.65.
[0015] Unless otherwise specified, a "golf club shaft" or a "shaft" in the embodiments of the present invention means both a shaft prior to being mounted on a golf club (namely, a part of a golf club) and the shaft portion of a golf club after each part is mounted on the golf club. However, the effects of the present invention are more significantly exhibited in the shaft portion of a golf club.

[Heavy Substance with Specific Gravity of 7 or Greater]

[0016] In the present invention, it is necessary for a golf club shaft to contain a heavy substance with a specific gravity of 7 or greater. By so setting, the position of a gravity center of the golf club shaft is controlled without overly increasing the total weight of the golf club shaft, or without constraining the design flexibility of bending (flexural rigidity) and strength. On the other hand, even when a substance has a specific gravity smaller than 7, the position of gravity center may be controlled by using a greater amount of such a substance. However, such a structure causes the shaft to have a locally increased flexural rigidity and an unnecessarily large diameter, and may impair the flexibility of shaft design. The specific gravity of a heavy substance is preferred to be 10 or greater, more preferably 15 or greater.
[0017] Here, the specific gravity means the value obtained when the density of a target substance at 4°C is compared to the density of water at 4°C.
[0018] In the golf club shaft of the present embodiment, the heavy substance having a specific gravity of 7 or greater is not limited specifically; examples are metals such as chromium (specific gravity: 7), zinc (specific gravity: 7.1), manganese (specific gravity: 7.2), iron (specific gravity: 7.9), cobalt (specific gravity: 8.9), nickel (specific gravity: 8.9), copper (specific gravity: 8.9), bismuth (specific gravity: 9.8), molybdenum (specific gravity: 10. 2), silver (specific gravity: 10.5), lead (specific gravity: 11.3), mercury (specific gravity: 13.6), tungsten (specific gravity: 19.3), gold (specific gravity: 19.3), and platinum (specific gravity: 21.4), alloys of those metals, rubber, resin and the like.
[0019] Those listed above may be used alone or in combination thereof. When costs, impact on the human body, regulations and the like are considered, iron and tungsten are preferred, especially preferably tungsten.
[0020] In addition, the shape of such a heavy substance is not limited specifically, and may be selected appropriately from among the shapes of particles, powders, needles, fibers, fabrics, plates, liquids and the like. However, the shape of particles with an average outer diameter of 0.4 μm~10 μm is preferred, more preferably particles with an average outer diameter of 2 μm~4 μm, because such a shape disperses well in the resin for forming a shaft and is capable of providing excellent strength and durability for the shaft.
[0021] Moreover, at least part of, preferably the entire portion of, the heavy substance needs to be present between 0 and 400 mm from the grip end of a shaft.
[0022] That is because, if the position where the heavy substance is present is far from the grip end of a shaft, the gravity center of the shaft cannot be positioned sufficiently closer to the grip end, making it difficult to achieve the effects of the present embodiment. The position is preferred to be no farther than 360 mm, more preferably no farther than 320 mm, from the grip end of the shaft.
[0023] Yet furthermore, it is better for the heavy substance with a specific gravity of 7 or greater to be positioned somewhat away from the grip end, because this will likely result in a stable swing, while excellent feel is gained by the golfer. Namely, when a golfer grips a golf club, the heavy substance is preferred to be positioned near the right hand if the golfer is right-handed.
[0024] Therefore, the heavy substance is preferred to be positioned at least 50 mm, more preferably at least 70 mm, from the grip end of the shaft.

[Lg/Ls]

[0025] In the present embodiment, when the entire length of a golf club shaft is set as (Ls) and the distance from the head end to the gravity center of the shaft is set as (Lg), the ratio (Lg/Ls) needs to be at 0.54-0.65. If (Lg/Ls) is less than 0.54 and a heavier head is mounted, the head feels even heavier, making it harder to swing the club. The ratio is preferred to be 0.55 or greater, more preferably 0.56 or greater. Also, if (Lg/Ls) exceeds 0.65, it is hard to maintain the swing balance approximately the same as that of a conventional balance unless the head weight is overly increased. As a result, the total club weight increases and the ease of swinging the club is reduced. The ratio is preferred to be 0.61 or lower, more preferably 0.60 or lower.

[Filler-containing Resin Layer (W)]

[0026] A filler-containing resin layer (W) contains a heavy substance described above as the filler. When the layer (W) is set to be located between 0 and 400 mm from the grip end, the gravity center of a golf club shaft can be set to be positioned sufficiently closer to the grip end. Accordingly, such a shaft is preferably used to achieve the effects of the present embodiment.

[0027] A filler-containing resin layer (W) is preferred to be 20~400 mm long. When the length of a filler-containing resin layer (W) is at least 20 mm, the gravity center of a golf club shaft is more likely to be positioned sufficiently closer to the grip end. The length is more preferred to be 50 mm or greater, especially preferably 100 mm or greater. In addition, when the length of a filler-containing resin layer (W) is 400 mm or less, the shaft tends not to be overly heavy. The length is more preferred to be 355 mm or less, even more preferably 300 mm or less, especially preferably 200 mm or less. Here, the length of a filler-containing resin layer (W) means the maximum length in a longitudinal direction when wound on a shaft.

[0028] Moreover, the weight per unit area of a filler-containing resin layer (W) is preferred to be 500 g/m^2 or greater. When the weight per unit area is 500 g/m^2 or greater, the gravity center of a golf club shaft is more likely to be positioned sufficiently closer to the grip end. The weight per unit area is more preferred to be 550 g/m^2 or greater, even more preferably 600 g/m^2 or greater

[0029] In addition, the weight per unit area of a filler-containing resin layer (W) is preferred to be 900 g/m^2 or less. When the weight per unit area is 900 g/m^2 or less, a heavier shaft or a greater outer diameter of the shaft is more likely to be prevented. The weight per unit area is more preferred to be 800 g/m^2 or less, even more preferably 750 g/m^2 or less.

[0030] As for a filler-containing resin layer (W), it is not limited specifically as long as it contains the heavy substance described above as the filler under the conditions above, and if it is 20~400 mm long. A matrix resin to be used in a filler-containing resin layer (W) is not limited to any specific type, and epoxy resin is usually used; examples of epoxy resin are bisphenol-A epoxy resins, bisphenol-F epoxy resins, bisphenol-S epoxy resins, epoxy phenol novolak resins, epoxy cresol novolak resins, glycidyl amine epoxy resins, isocyanate modified epoxy resins, and alicyclic epoxy resins. They may be liquid or solid. They may be used alone or by blending two or more epoxy resins. In addition, a curing agent may be combined with the epoxy resin.

[0031] Examples of the shape of a filler-containing resin layer (W) is a trapezoid such as **23a** or a triangle such as **23c** or **23e** in FIG. 1. A trapezoidal shape is preferred since the anisotropy in a shaft circumferential direction is prevented, and the gravity center is effectively positioned closer to the grip end.

[0032] In the present embodiment, the range "having a filler-containing resin layer (W)" includes the entire range in a longitudinal direction of the shaft where even part of the filler-containing resin layer (W) exists regardless of the number of its layers. The thickness of a filler-containing resin layer (W) is preferred to be set at 70~160 μm, more preferably 80~130 μm, even more preferably 85~110 μm.

[0033] Moreover, relative to the entire mass of the golf club shaft of the present embodiment, the above filler-containing resin layer (W) is preferred to be contained at less than 10 mass%. By setting the rate of content of the filler-containing resin layer (W) at less than 10 mass%, a heavier shaft is prevented, while the ease of swinging the club and long carry of a ball are both achieved. The rate of content is preferred to be 9 mass% or less, even more preferably 8 mass% or less.

[0034] Yet furthermore, relative to the entire mass of the golf club shaft of the present embodiment, the above filler-containing resin layer (W) is preferred to be 4 mass% or greater. By setting the rate of content of the filler-containing resin layer (W) at 4 mass% or greater, the gravity center of a golf club shaft is likely to be positioned sufficiently closer to the grip end. The rate of content is preferred to be 5 mass% or greater, even more preferably 6 mass% or greater.

[0035] Therefore, the content of the filler-containing resin layer (W) in a golf club shaft of the present embodiment is preferred to be, for example, 4~10 mass%, more preferably 5~9 mass%, even more preferably 6~8 mass%, relative to the entire mass of the golf club shaft.

[Outer Diameter of Butt End Portion]

[0036] In the present embodiment, the outer diameter of the grip-end portion of a golf club shaft is preferred to be 14.5 mm~15.7 mm. Here, the outer diameter of the grip-end portion means the maximum outer diameter in the area of the grip-end portion. When the outer diameter at the grip-end portion is 14.5 mm or greater, a sufficient flexural rigidity is obtained and the club is made easier for a golfer to grip even if the subject is a professional or low handicap golfer. The outer diameter is more preferred to be 14.8 mm or greater, even more preferably 15.0 mm or greater. In addition, when the outer diameter of the grip-end portion is 15.7 mm or less, the club is more likely to be easier to grip. The outer diameter is more preferred to be 15.6 mm or less, even more preferably 15.5 mm or less.

[Fiber-reinforced Resin Layer (X)]

[0037] In the present embodiment, a golf club shaft is preferred to have a fiber-reinforced resin layer (X) which is positioned on the butt-end side to be adjacent to the filler-containing resin layer (W) and has a thickness difference of -70 μm~+110 μm with filler-containing resin layer (W), since a golfer can gain an excellent feel without sensing the difference in outer diameters or in rigidities in the area where the golfer grips the shaft.

[0038] A fiber-reinforced resin layer (X) is preferred to contain a matrix resin and reinforcing fiber.

[0039] The matrix resin used for a fiber-reinforced resin layer (X) is not limited specifically, and epoxy resin is usually used. Examples of epoxy resin are bisphenol-A epoxy resins, bisphenol-F epoxy resins, bisphenol-S epoxy resins, epoxy phenol novolak resins, epoxy cresol novolak resins, glycidyl amine epoxy resins, isocyanate modified epoxy resins, and alicyclic epoxy resins. Liquid or solid types of those epoxy resins may be used. In addition, they may be used alone or by blending two or more epoxy resins. Also, a curing agent may be combined with the epoxy resin.

[0040] Examples of reinforcing fiber used in a fiber-reinforced resin layer (X) are inorganic fibers such as metallic fibers, boron fibers, carbon fibers, glass fibers and ceramic fibers; aramid fibers, and other highly strong synthetic fibers. Considering the flexibility of designing flexural rigidity, glass fibers, boron fibers and carbon fibers are preferred, especially preferably carbon fibers.

[0041] In the present embodiment, "to have a fiber-reinforced resin layer (X) positioned on the grip-end side to be adjacent to a filler-containing resin layer (W)" means to position a fiber-reinforced resin layer (X) on the grip-end side of a filler-containing resin layer (W) in such a way that the layer (X) abuts the layer (W) without overlapping, or without creating a gap with the layer (W). When a fiber-reinforced resin layer (X) is positioned on the grip-end side to be adjacent to the filler-containing resin layer (W), the golf club shaft related to the present invention provides an excellent feel for a golfer without giving the golfer the sense of an uneven touch derived from the thickness difference between the layers when the golfer grips the shaft.

[0042] The thickness difference between a fiber-reinforced resin layer (X) and filler-containing resin layer (W) indicates the thickness of the fiber-reinforced resin layer (X) relative to the thickness of the filler-containing resin layer (W). When a golfer grips the shaft, he may experience uneasiness if the thickness of the fiber-reinforced resin layer (X) is either too thin or too thick relative to the thickness of the filler-containing resin layer (W). The difference in the thickness of the fiber-reinforced resin layer (X) and the thickness of the filler-containing resin layer (W) is preferred to be -50 μm~+90 μm, more preferably -30 μm~+60 μm.

[0043] In the following, the present embodiment is described in further detail. However, the present embodiment is not limited to the following descriptions.

[0044] The golf club shaft according to the present embodiment is structured to have multiple reinforced-fiber layers, made by laminating prepreg sheets **21~27** with cut shapes illustrated in patterns **1~7** of FIG. 1, which are wrapped onto mandrel **10** in the order of patterns **1~7,** and then thermoset. The shaft has at least a filler-containing resin layer (W), and preferably a fiber-reinforced resin layer (X) positioned on the grip-end side to be adjacent to the filler-containing resin layer (W).

[0045] In the example above, the filler-containing resin layer (W) is made of filler-containing resin layer **23a,** and is located between 0 and 400 mm from the grip end of the shaft and is 20~400 mm long. Positioned on the grip-end side to be adjacent to the filler-containing resin layer (W), a fiber-reinforced resin layer (X) **23b** is formed to have a thickness difference of -70 μm~-1-110 μm with the filler-containing resin layer (W).

[0046] In the following, layers to be laminated on a golf club shaft of the present embodiment are each described below.

[Filler-containing Resin Layer (W)]

[0047] A filler-containing resin layer (W) is set to have a length **La** of 20~400 mm. The length of filler-containing resin layer (W) is preferred to be 20 mm or greater, more preferably 50 mm or greater, especially preferably 100 mm or greater, but is preferred to be 355 mm or less, more preferably 300 mm or less, especially preferably 200 mm or less. The shape of a filler-containing resin layer (W) is, for example, a trapezoid **23a,** or triangle **23c** or **23e** as shown in FIG. 1. A trapezoidal shape is preferred since the anisotropy in a shaft circumferential direction is prevented, and the gravity center is effectively positioned closer to the grip end.

[0048] The filler-containing resin layer (W) is required to be positioned between 0 and 400 mm from the grip end of the shaft. **La+Lb** is set to be 400 mm or less.

[Fiber-reinforced Resin Layer (X)]

[0049] In the present embodiment, to achieve excellent feel in the area where a golfer grips without sensing the difference in outer diameters or in rigidities, the shaft is preferred to include a fiber-reinforced resin layer (X) which is positioned on the grip-end side to be adjacent to the filler-containing resin layer (W), and has a thickness difference of -70 μm~+110 μm with the filler-containing resin layer (W). The shape of a fiber-reinforced resin layer (X) may be a trapezoid such as **23b** or a triangle such as **23d** and **23f** as shown in FIG. 1. The direction of fibers may be set appropriate to usage purposes. Layers may be arranged to have a gap inevitable in the production process as long as they do not overlap each other.

[0050] The golf club shaft of the present embodiment may have another layer by employing a fiber-containing resin layer (W) described above, for example, as long as the layer contains the aforementioned heavy substance. For example, as shown in the example shown in FIG. 1, a preferred example of a shaft is structured by forming a tip-end reinforcing layer, bias layer and straight layer in that order from the inner side, and by further forming multiple other straight layers.

[0051] As described above, such a golf club shaft is structured with multiple fiber-reinforced resin layers, including a bias layer where carbon fibers are arranged relative to the shaft axis direction at an orientation angle of +30 ~ +70 degrees in one layer and at an orientation angle of -30 ~ -70 degrees in another layer; and a straight layer where carbon fibers are arranged in the shaft axis direction. The filler-containing resin layer (W) is positioned between 0 and 400 mm from the grip end of the golf club shaft to have a length of 20~400 mm. To alleviate uneven touch, the shaft is preferred to include a fiber-reinforced resin layer (X) positioned on the grip-end side to be adjacent to the filler-containing resin layer (W), having a thickness difference of -70 μm ~ +110 μm with the filler-containing resin layer (W).

[0052] When the structure of the present embodiment is employed in a golf club shaft, a so-called wood, having a length of 1041 mm~1291 mm and a shaft mass of 40~85 grams, the effects of the present invention are achieved even more significantly.

[0053] The golf club shaft of the present embodiment is also suitable to be used in combination with a larger head. Examples of a larger head are those having a volume of 380 cm^3~460 cm^3 and a moment of inertia of 3500 $g{\cdot}cm^2$~5900 $g{\cdot}cm^2$. Even when a larger head is mounted, the golf club shaft of the present embodiment provides preferred feel and is capable of extending the carry of a ball.

[0054] For the fiber-reinforced resin used in the golf club shaft of the present embodiment, a so-called fiber prepreg, formed by impregnating in advance a matrix resin into fibers in a sheet shape, may be used.

[0055] For the matrix resin to form fiber-reinforced resin of the present embodiment, thermoplastic resins or thermosetting resins, preferably thermosetting resins, are used. Examples of thermoplastic resins are polyamide resins, polyacrylate resins, polystyrene resins, polyethylene resins, and combined resins thereof. Examples of thermosetting resins are epoxy resins, unsaturated polyester resins, phenol resins, urea resins, melamine resins, diallyl phthalate resins, urethane resins, polyimide resins, and combined resins thereof. Among those listed above, epoxy resins are most preferred since they have smaller contraction rates when cured while exhibiting higher rigidity and plasticity properties.

[0056] The fibers of fiber-reinforced resins used in the present embodiment are inorganic fibers such as metallic fibers, boron fibers, carbon fibers, glass fibers and ceramic fibers; aramid fibers, and other highly strong synthetic fibers. Among those, inorganic fibers are preferred because they are lightweight and significantly strong, and carbon fibers are especially preferred because of their excellent specific strength and specific rigidity.

[0057] Those fibers listed above may be used alone or in combination thereof. In addition, fibers of any length such as long fibers, short fibers, mixed fibers and the like may be used.

[0058] The golf club shaft of the present embodiment is formed by laminating fiber-reinforced resins. The layer structure is described below.

[0059] The golf club shaft of the present embodiment is preferred to have a filler-containing resin layer (W), and further preferably to have a fiber-reinforced resin layer adjacent to the filler-containing resin layer (W). The filler-containing resin layer (W) and its adjacent fiber-reinforced resin layer are capable of providing preferred feel and an increase in the carry of a ball especially when the subject is a professional or low handicap golfer. A filler-containing resin layer (W) is preferred to be present between 0 and 400 mm from the butt end of a shaft so as to position the gravity center closer to the grip end. When the filler-containing resin layer (W) is positioned far away from the grip end of a shaft, it is difficult to position the gravity center of the shaft sufficiently closer to the grip end. The position of a filler-containing resin layer (W) is preferred to be at least 50 mm, more preferably at least 70 mm from the grip end of a shaft. When the layer (W) is positioned at least 70 mm from the grip end, a stable swing is obtained during the swing, thereby providing excellent feel for the golfer. The length of the filler-containing resin layer (W) is preferred to be 360 mm or less, more preferably

320 mm or less. Next, a fiber-reinforced resin layer (X) adjacent to the filler-containing resin layer (W) is useful to eliminate the uneven feel caused by different outer diameters at the grip held by a golfer. Positioned on the grip-end side to be adjacent to the filler-containing resin layer (W), a fiber-reinforced resin layer (X) is preferred to have a thickness difference of -70 μm~+110 μm with the filler-containing resin layer (W). By positioning a fiber-reinforced resin layer (X) to be adjacent to the filler-containing resin layer (W), the sense of an uneasy touch is eliminated when the golfer grips the shaft, thereby providing excellent feel.

[0060] It is sufficient for the golf club shaft of the present embodiment to include at least one layer, usually 1~3 layers, preferably 1~2 layers, of filler-containing resin layer (W) at a position described above. Too many layers make it hard to mold a shaft, and result in a heavier shaft. Accordingly, desired feel and increased carry are less likely to be achieved. When two or more layers of filler-containing resin layer (W) and fiber-reinforced resin layer (X) are laminated, filler-containing resin layers (W) and its adjacent fiber-reinforced resin layers (X) are separately prepared in advance and are later laminated respectively.

[0061] The filler-containing resin layer (W) and its adjacent fiber-reinforced resin layer (X) are preferred to be laminated on at least one layer toward the inner side from the outermost layer. If positioned outermost, they will be shaved away during the process of surface polishing a shaft. Therefore, both layers (W) and (X) are laminated appropriately as layers that are not positioned outermost.

[0062] The weight per unit area of a filler-containing resin layer (W) is preferred to be 550 g/m^2 or greater, more preferably 600 g/m^2 or greater, but also is preferred to be 800 g/m^2 or less, more preferably 750 g/m^2 or less. Examples of filler-containing resin layer (W) may be any resin layer as long as it satisfies the above weight per unit area. The matrix resin to be used for a filler-containing resin layer (W) is not limited specifically, and epoxy resins are usually employed. In addition, examples of a filler are preferred to be iron or tungsten, especially preferably tungsten. A particulate filler, for example, may be used, but for homogeneous dispersion in the matrix resin, powdered filler is preferred.

[0063] The modulus of elongation of fibers for forming a fiber-reinforced resin layer (X) is not limited specifically, and may be appropriately selected to control the rigidity of the portion gripped by the golfer. The orientation angle of reinforcing fibers is designed appropriately to suit usage purposes: for example, it is 0 degrees to enhance flexural rigidity, 45 degrees to enhance torsional rigidity, and 90 degrees to enhance compressive rigidity.

[0064] A preferred example of the golf club shaft according to the present embodiment is a shaft formed by laminating fiber-reinforced resin layers, including a filler-containing resin layer (W) and its adjacent fiber-reinforced resin layer (X). When the entire length of the golf club shaft is set as (Ls) and the distance from the tip end to the gravity center of the shaft is set as (Lg), the ratio (Lg/Ls) is 0.54-0.65, and the outer diameter of the butt-end portion is 14.5 mm~15.7 mm.

[0065] Other than a filler-containing resin layer (W) and fiber-reinforced resin layer (X), examples of fiber-reinforced resin layers to form a golf club shaft of the present embodiment are, for example, a bias layer with reinforcing fibers arranged to have an orientation angle of +45 degrees and/or -45 degrees relative to a longitudinal direction of the shaft, a straight layer with reinforcing fibers arranged to have an orientation angle of zero degrees relative to a longitudinal direction of the shaft, and a hoop layer with reinforcing fibers arranged to have an orientation angle of 90 degrees relative to a longitudinal direction of the shaft.

[0066] The matrix resin and fibers for forming a bias layer, straight layer and hoop layer made of fiber-reinforced resin are those as described above. In addition, the allowable tolerance to the shifted degree of fiber orientation angles in a bias layer, straight layer and hoop layer is approximately ±5 degrees.

[0067] The primary effects of a bias layer are to enhance torsional rigidity and torsional strength. The modulus of elongation of the fibers to form a bias layer is preferred to be 240~550 GPa. If the elongation modulus of fibers is too low, torsional rigidity is reduced, thus the rotation of the head face is delayed at the time of ball impact, adversely affecting the direction of ball flight. On the other hand, if the elongation modulus of fibers is too high, torsional strength is lowered.

[0068] The thickness of a bias layer is preferred to be set at 0.05 mm~0.125 mm. When a shaft is relatively heavy, weighing 60 grams or greater when converted to a length of 1168 mm, if a bias layer is too thin, it is necessary to increase the number of laminated layers. Accordingly, wrinkles or the like are likely to occur, making it harder to mold a shaft. On the other hand, if a bias layer is too thick and the bias layer is formed by fractions of a layer, the outer diameter and flexural rigidity may likely be uneven in a circumferential direction.

[0069] The primary effects of a straight layer are to enhance flexural rigidity and flexural strength. The modulus of elongation of fibers to form a straight layer is preferred to be 50~400 GPa. If the fiber elongation modulus is too low, the flexural rigidity is insufficient, making the shaft too soft. Accordingly, the swing rhythm is disturbed. On the other hand, if the fiber elongation modulus is too high, flexural rigidity is enhanced, but flexural strength is lowered.

[0070] The thickness of a straight layer is preferred to be set at 0.05 mm~0.150 mm. If a straight layer is too thin, the number of laminated layers increases, thus lowering productivity and reducing the ease of handling. Accordingly, wrinkles or the like are likely to occur and molding a shaft is thereby made harder. On the other hand, if a straight layer is too thick, the outer diameter and flexural rigidity are uneven in a circumferential direction, thus lowering the quality of the shaft. A hoop layer has the primary effects of enhancing compressive rigidity and compressive strength. The modulus of elongation of fibers to form a hoop layer is preferred to be 240~400 GPa. If the fiber elongation modulus is too low, the compressive rigidity is lowered, causing compressive deformation to occur and to disturb the swing rhythm. On the other hand, if the fiber elongation modulus is too high, compressive rigidity is enhanced but compressive strength is lowered.

[0071] The primary effects of a hoop layer are to enhance compressive rigidity and compressive strength in a shaft circumferential direction. The thickness of a hoop layer is preferred to be set at 0.02 mm~0.100 mm. If a hoop layer is too thick, the ease of handling decreases. Thus, wrinkles or the like tend to occur, making it harder to mold a shaft. On the other hand, if a hoop layer is too thin, compressive rigidity in a circumferential direction is not sufficient.

[0072] Moreover, in addition to the bias layer and straight layer described above, another bias layer or straight reinforcing layer may also be partially formed. By providing a reinforcing layer formed partially, torsional rigidity and flexural rigidity may be controlled locally. The fiber elongation modulus and thickness of such partial layer are preferred to satisfy the aforementioned ranges.

[0073] The method for manufacturing a golf club shaft of the present embodiment is not limited to any specific method. For example, a sheet-wrapping method may be conducted using a sheet type prepreg which is formed by impregnating an uncured matrix resin into reinforcing fibers, by wrapping the prepreg on a rod type core (mandrel) and curing the prepreg, and by pulling out the mandrel.

[0074] In the above sheet-wrapping method, multiple types of prepreg with different sizes and different orientation angles of reinforcing fibers are prepared. Then, prepreg sheets are wrapped one by one on a mandrel to form a multilayer shaft. The shaft according to the present embodiment is formed by adjusting the size of each prepreg, orientation angle of reinforcing fibers contained in each prepreg, modulus of elongation of fibers contained in each prepreg, and the position to wrap each prepreg, and by changing the number of prepreg layers. In addition, during the lamination process, the tapering degree and outer diameter of a shaft may also be adjusted appropriately.

[0075] There are fewer restrictions when the golf club shaft of the present embodiment is designed, and the aforementioned bias layer, straight layer, hoop layer and the like may be combined appropriately to form a shaft. Therefore, while maintaining the ratio (Lg/Ls) at 0.54-0.65, the kickpoint can be set at various values so as to respond to a wide variety of characteristics of the head to be mounted, the level and preference of the golfer, and the like.

[0076] The kickpoint means the most bendable position of a shaft, and is shown as the ratio of the entire length of the shaft to the distance from the head end to the apex of the curve the shaft makes when compressed from both ends. In particular, such a value is obtained from the formula below.

$$\text{kickpoint } (\%) = (LK/LB) \times 100$$

[0077] LK: when a shaft is curved by a compression load applied on both ends of the shaft so that the straight-line distance between both ends is 98.5~99.5% of the entire shaft length, the distance from the tip end of the shaft to the intersection of the straight line connecting both ends and a vertical line drawn from the apex of the curve.

[0078] LB: when a shaft is curved by a compression load applied on both ends of the shaft so that the straight-line distance between both ends is 98.5~99.5% of the entire shaft length, the straight-line distance between both ends of the shaft.

[0079] Based on the value of the kickpoint, shafts are generally sorted in three types described below.

low kickpoint: less than 44.0%
middle kickpoint: 44.0% or greater but less than 45.0%
high kickpoint: 45.0% or greater

[0080] According to the present embodiment, shafts of high kickpoint, in addition to those of low kickpoint and middle kickpoint, are obtained.

EXAMPLES

[0081] In the following, the embodiments of the present invention are described in further detail by referring to the examples.

[0082] Table 1 shows the materials used for preparing golf club shafts in the Examples and Comparative Examples.

Table 1

Name	Product Name
Prepreg 1	TR350E125S, made by Mitsubishi Rayon Co., Ltd. (CF elastic modulus: 235 GPa, CF weight per unit area: 125 g/m^2, resin content: 30%, prepreg thickness: 0.113 mm)

(continued)

Name	Product Name
Prepreg 2	HRX350C100S, made by Mitsubishi Rayon Co., Ltd. (CF elastic modulus: 395 GPa, CF weight per unit area: 92 g/m^2, resin content: 25%, prepreg thickness: 0.076 mm)
Prepreg 3	MRX350C125R, made by Mitsubishi Rayon Co., Ltd. (CF elastic modulus: 295 GPa, CF weight per unit area: 125 g/m^2, resin content: 25%, prepreg thickness: 0.106 mm)
Prepreg 4	TR350E100R, made by Mitsubishi Rayon Co., Ltd. (CF elastic modulus: 235 GPa, CF weight per unit area: 100 g/m^2, resin content: 30%, prepreg thickness: 0.095 mm)
Prepreg 5	MRX350C100R, made by Mitsubishi Rayon Co., Ltd. (CF elastic modulus: 295 GPa, CF weight per unit area: 100 g/m^2, resin content: 25%, prepreg thickness: 0.084 mm)
Prepreg 6	TR350C150S, made by Mitsubishi Rayon Co., Ltd. (CF elastic modulus: 235 GPa, CF weight per unit area: 150 g/m^2, resin content: 25%, prepreg thickness: 0.127 mm)
Filler-containing Resin Layer	TP013G-E3417, made by Mitsubishi Rayon Co., Ltd. (tungsten-containing prepreg, prepreg weight per unit area: 670 g/m^2, prepreg thickness: 0.090 mm)

[0083] In the filler-containing resin layer above, tungsten powder (specific gravity: 19.3) with an average outer diameter of 3 μm is dispersed homogeneously.

(Example 1)

<Mandrel>

[0084] A mandrel (H) shown in FIG. 2 was prepared. The mandrel (H) is in a cylindrical shape made of iron, having the outer diameter, length and tapering degree as follows: outer diameter at **P1**=5.10 mm, outer diameter at **P2**=6.10 mm, outer diameter at **P3**=8.00 mm, outer diameter at **P4** and **P5**=13.40 mm, distance from **P1** to **P2** (ℓ**1**)=200 mm, distance from **P2** to **P3** (ℓ**2**)=120 mm, distance from **P1** to **P4** (ℓ**3**)=975 mm, distance from **P1** to **P5** (ℓ**4**)=1500 mm, tapering degree from **P1** to **P2**=5.00/1000, and tapering degree from **P3** to **P4**=8.24/1000.

<Cutting and Wrapping Prepreg>

[0085] The portion of the mandrel to wrap prepreg sheets was set at 70 mm to 1260 mm measured from the tip end. Next, sheets of prepreg cut into the shapes shown in FIG. 3 (patterns **1**~**8**) are wrapped on mandrel (H) in the order of patterns **1~8.** Then, a 20 mm-wide polypropylene shrink tape was wound on the prepreg layers at a pitch of 2 mm.

[0086] The length of each portion in the patterns shown in FIG. 3 is as follows: α1=250 mm, α2=53 mm, α3=130 mm, α4=65 mm, α5=1190 mm, α6=145 mm, α7=65 mm, α8=300 mm, α9=29 mm, α10=200 mm, α11=22 mm, α12=150 mm, α13=150 mm, α14=46 mm, α15=200 mm, α16=50 mm, α17=1190 mm, α18=113 mm, α19=45 mm, α20=1190 mm, α21=57 mm, α22=23 mm, α23=1190 mm, α24=58 mm, α25=24 mm, α26=130 mm, and α27=80 mm.

[0087] Pattern **1** used prepreg **1** shown in Table 1 and was made into a tip-reinforcing layer by being positioned at the head-end portion and arranging carbon fibers with an orientation angle of zero degrees relative to the mandrel axis. Pattern **2** used prepreg **2** shown in Table 1 and was made into a bias layer. The bias layer was formed by layering two sheets of prepreg **2,** one with carbon fibers arrayed at an orientation angle of +45 degrees and another with carbon fibers arrayed at an orientation angle of -45 degrees. In addition, two sheets of pattern **2** are overlapped by wrapping them in such a way that two starting edges (upper end of prepreg in FIG. 3) are 10 mm off from each other at the left side of pattern **2** in FIG. 3 (tip-end side), while the two starting edges are 22 mm off from each other at the right side in FIG. 3 (butt-end side). Prepreg **3** in Table 1 was used as pattern **3** which was wrapped to form a tip-end reinforcing layer, the same as pattern **1.** Pattern **4,** formed with the tungsten filler-containing resin layer (W) shown in Table 1 and its adjacent fiber-reinforced resin layer (X) made of prepreg **4** in Table 1, was positioned at the butt-end side with carbon fibers of fiber-reinforced resin layer (X) arrayed at an orientation angle of zero degrees relative to the mandrel axis, and then the layers (W) and (X) were wrapped without any overlapping portion. Patterns **5~7** made of the prepreg shown in Table 1 were used to form straight layers that were arranged along the entire length of the mandrel with carbon fibers arrayed at an orientation angle of zero degrees relative to the mandrel axis. Using prepreg **1** in Table 1, pattern **8** was formed to be a tip-end reinforcing layer, positioned at the head-end portion with carbon fibers arrayed at an orientation angle of zero degrees relative to the mandrel axis.

<Curing Resin, and Polishing Surface of Material Tube for Golf Club Shaft >

[0088] The prepreg-wrapped body obtained above was placed in a curing oven, and heat was applied at 145°C for two hours so that the prepreg resins were cured. Then, the polypropylene tape and the mandrel (H) were removed.

[0089] At each of both ends of the shaft material tube, a length of 10 mm was cut to make the entire length of 1170 mm.

[0090] The cantilever flex (the bending degree at the shaft tip end when a position 920 mm away from the tip end was fixed and a 3-kg weight was exerted at a position 10 mm away from the shaft tip end) of the shaft prior to being polished was 140 mm. Also, regarding the shaft material tube prior to being polished, the outer diameter at the tip end was 8.75 mm and the outer diameter at the butt end was 15.4 mm.

[0091] The surface of the shaft material tube was polished using a cylinder polishing machine so that a golf club shaft is obtained having an entire length of 1168 mm, outer diameter of 8.50 mm at the tip end, outer diameter of 15.45 mm at the grip end, and cantilever flex of 150 mm.

[0092] The golf club shaft prepared for Example 1 had a weight of 61.5 grams, a ratio (Lg/Ls) of 0.553, shaft torsional angle of 3.7 degrees (a torsional angle of the shaft when a position 1035 mm away from the tip end of the shaft was fixed and a torque of 138.5 kgf·mm was exerted in areas from the shaft head end to a point 50 mm away from the shaft head end).

[0093] The shaft included a filler-containing resin layer which was positioned between 140 and 290 mm from the grip end, had a length of 150 mm, a weight per unit area of 670 g/m^2 and a mass of 4.4% relative to the total mass of the shaft, and contained tungsten powder as a filler homogeneously dispersed therein. The shaft also included a fiber-reinforced resin layer (X) between the grip end and the filler-containing resin layer (W) to have a thickness difference of +5μm with the filler-containing resin layer (W).

[0094] The kickpoint of the shaft was 44.5%.

(Example 2)

[0095] Sheets of prepreg (patterns **1**~**8**) cut in shapes as shown in FIG. 4 were wrapped in that order on mandrel (H), and a golf club shaft was prepared the same as in Example 1.

[0096] Here, the length of each portion in the patterns shown in FIG. 4 is as follows, and the filler-containing resin layer (W) in pattern **4** is positioned to have a distance of 150 mm from the grip end: α1=250 mm, α2=53 mm, α3=130 mm, α4=65 mm, α5=1190 mm, α6=145 mm, α7=65 mm, α8=300 mm, α9=29 mm, α10=200 mm, α11=22 mm, α12=150 mm, α14=45 mm, α16=50 mm, α17=1190 mm, α18=113 mm, α19=45 mm, α20=1190 mm, α21=57 mm, α22=23 mm, α23=1190 mm, α24=58 mm, α25=24 mm, α26=130 mm, and α27=80 mm.

[0097] The evaluation results of the golf club shaft are shown in Table 2.

(Example 3)

[0098] A golf club shaft was prepared the same as in Example 2 except that the lengths of α12 and α16 of pattern **4** were changed to α12=200 mm and α16=100 mm, and the distance from the grip end was set at 100 mm.

[0099] The evaluation results of the golf club shaft are shown in Table 2.

(Example 4)

[0100] A golf club shaft was prepared the same as in Example 2 except that the lengths of α12 and α16 of pattern **4** were changed to α12=250 mm and α16=150 mm, and the distance from the grip end was set at 50 mm.

[0101] The evaluation results of the golf club shaft are shown in Table 2.

(Example 5)

[0102] In Example 2, the type of prepreg **3** for pattern **3** was changed to TR350E100R, which is the same as prepreg **4,** and the lengths of α8 and α10 were changed to α8=180 mm and α10=100 mm. Accordingly, a golf club shaft with a kickpoint of 43.5% was obtained

[0103] The characteristics of the golf club shaft are shown in Table 2.

(Example 6)

[0104] In Example 2, the lengths of $\alpha 8$ and $\alpha 10$ in pattern **3** were changed to $\alpha 8$=480 mm and $\alpha 10$=380 mm. Accordingly, a golf club shaft with a kickpoint of 45.5% was obtained.
[0105] The characteristics of the golf club shaft are shown in Table 2.

(Comparative Example 1)

[0106] A golf club shaft was prepared the same as in Example 2 except that the lengths of $\alpha 12$ and $\alpha 16$ in pattern **4** were changed to $\alpha 12$=430 mm and $\alpha 16$=380 mm, and the distance from the grip end was set at 0 mm.
[0107] The evaluation results of the golf club shaft are shown in Table 2.

(Comparative Example 2)

[0108] A golf club shaft was prepared the same as in Example 2 except that a filler-containing resin layer (W) made of pattern **4** was not used.
[0109] The evaluation results of the golf club shaft are shown in Table 2.

(Comparative Example 3)

[0110] A golf club shaft was prepared the same as in Example 2 except that the filler-containing resin layer (W) formed with pattern **4** was positioned to have a distance of 430 mm from the grip end.
[0111] The evaluation results of the golf club shaft are shown in Table 2.

(Comparative Example 4)

[0112] A golf club shaft was prepared the same as in Example 2 except that the filler-containing resin layer (W) formed with pattern **4** was replaced with glass fiber-containing prepreg (GE352G135S, made by Mitsubishi Rayon, prepreg weight per unit area of 200 g/m^2 and prepreg thickness of 0.110 mm).
[0113] The evaluation results of the golf club shaft are shown in Table 2.

Table 2

	Entire Length (mm)	Outer Dia. at Head End (mm)	Outer Dia. at Grip End (mm)	Cantilever Flex (mm)	Weight (g)	Lg/Ls	Torsional Angle (º)	Position of W (mm)	Length of W (mm)	Weight per unit area (g/m²)	Rate of W (wt%)	Fiber-reinforced Resin Layer X	Kickpoint (%)
Example 1	1168	8.50	15.45	150	61.5	0.553	3.7	140~290	150	670	4.4	formed	44.5
Example 2	1168	8.50	15.30	150	61.0	0.546	3.8	140~290	150	670	4.4	none	44.4
Example 3	1168	8.50	15.30	150	62.5	0.555	3.8	90~290	200	670	6.5	none	44.5
Example 4	1168	8.50	15.30	150	64.5	0.563	3.7	40~290	250	670	8.4	none	44.6
Comp. Example 1	1168	8.50	15.45	151	68.5	0.578	3.7	0~420	420	670	15.4	none	44.6
Comp. Example 2	1168	8.50	15.30	150	59.5	0.535	3.8	-	-	-	-	none	44.5
Comp. Example 3	1168	8.50	15.25	151	61.0	0.537	3.7	420~570	150	670	4.1	none	44.4
Comp. Example 4	1168	8.50	15.30	151	59.0	0.538	3.7	140~290 (GF)	150	200	1.3	none	44.4
Example 5	1168	8.50	15.30	150	60.5	0.545	3.8	140~290	150	670	4.4	none	43.8
Example 6	1168	8.50	15.30	150	62.0	0.542	3.7	140~290	150	670	4.2	none	45.3

<Mounting Golf Club Head and Grip>

[0114] The grip end of each shaft prepared in Examples 1~4 and Comparative Examples 1~4 was cut off to make an entire shaft length of 1100 mm. Then, a head (195.7 g, 440 mL, loft 9.5°) and socket (5.7 g) were mounted on the head side of each shaft, and a commercially available grip (50 g) was attached to the grip end. Accordingly, a 45.25 inch-long (1149 mm-long) golf driver was prepared for testing. Next, on the head sole portion of each golf club, an appropriate amount of lead was attached so as to gain the same swing balance in each golf club.

[0115] The properties of the golf clubs are shown in Table 3.

[0116] In addition, the amounts of lead described in Table 3 were respectively attached to golf drivers formed from the shafts prepared in Examples 5 and 6. Accordingly, properties shown in Table 3 are provided for the golf clubs.

Table 3

	Total Weight of Club (g)	Number of Oscillations in Club (cpm)	Club Balance	Amount of Attached Lead (g)
Example 1	311.5	258	C9	1.93
Example 2	311.6	260	C9	0.94
Example 3	312.6	257	C9	0.82
Example 4	316.2	255	C9	2.43
Comp. Example 1	317.9	259	C9	2.42
Comp. Example 2	308.0	260	C9	0
Comp. Example 3	309.3	258	C9	0
Comp. Example 4	308.0	257	C9	0
Example 5	311.1 .1	260	C9	0.92
Example 6	312.0	260	C9	0.85

<Sensory Evaluation>

[0117] Five balls each were hit by five low handicap golfers using the golf clubs prepared in Examples 1~4 and Comparative Examples 1~4 to obtain their comments. A swing that was easiest, most stable and most preferable was evaluated as 5 on a scale of 1 to 5. Then, the average value of the five test golfers was obtained. The results are shown in Table 4.

[0118] In addition, when the same sensory evaluation was conducted on golf clubs prepared using the shafts in Examples 5 and 6, the results are as shown in Table 4.

Table 4

	Ease of Swing	Stability	Preference	Comments
Example 1	4.3	4.5	4.5	excellent feel when gripped since unevenness derived from tungsten is not sensed
Example 2	3.8	3.5	3.4	
Example 3	3.9	3.5	3.6	
Example 4	4.0	3.7	3.5	
Comp. Example 1	3.0	3.2	2.8	hard to swing, since the entire club weight is increased

(continued)

	Ease of Swing	Stability	Preference	Comments
Comp. Example 2	3.5	3.2	3.2	average
Comp. Example 3	2.8	2.8	2.7	flexural rigidity is adversely affected
Comp. Example 4	3.6	3.1	3.3	average
Example 5	3.9	3.5	3.2	launch angle is slightly high
Example 6	4.0	3.7	4.3	launch angle is low

<Measuring and Evaluating Trajectory>

[0119] Golf clubs prepared using the shafts in Examples 1~4 and Comparative Examples 1~4 were each test hit by a tester (human) to measure the trajectory. Five balls each were hit using each club and employing a trajectory measuring machine "TrackMan Pro 2" made by TrackMan Golf. The average value obtained from the five test hit data was used as the trajectory result.

[0120] The trajectory was measured by using a trajectory measuring machine "TrackMan Pro 2" made by TrackMan Golf. The results are shown in Table 5. The evaluation details in Table 5 are as follows:

Club Speed: speed at impact
Ball Speed: ball velocity after impact
Vertical Angle: launch angle relative to a horizontal direction the ball makes to take off shortly after impact (vertical launch angle)
Horizontal Angle: launch angle relative to the target line the ball makes to take off shortly after impact (horizontal launch angle), "+" is to the right, and "-" is to the left.
Spin Rate: the number of rotations shortly after impact.
Spin Axis: the axis of the spinning ball, "+" is a slice, and "-" is a hook.
Vertical Carry Distance: total distance of ball flight.
Horizontal Carry Distance: difference from the target line in a horizontal direction, "+" is off to the right, and "-" is off to the left.

[0121] In addition, when the same trajectory measurement and evaluation were conducted on golf clubs prepared using the shafts in Examples 5 and 6, the results are as shown in Table 5.

Table 5

	Club Speed (m/sec)	Ball Speed (m/sec)	Vertical Angle (deg)	Horizontal Angle (deg)	Spin Rate (rpm)	Spin Axis (deg)	Vertical Carry Distance (yds)	Horizontal Carry Distance (yds)
Example 1	45.7	68.7	8.5	-1.2	2434	-1.3	272.2	-8.1
Example 2	47.0	70.6	8.4	0.5	1534	2.7	281 .8	6.2
Example 3	46.7	69.7	9.9	2.3	2484	15.9	277.3	40.8
Example 4	47.1	69.2	8.7	0.0	2701	5.7	273.8	22.0

(continued)

	Club Speed (m/sec)	Ball Speed (m/sec)	Vertical Angle (deg)	Horizontal Angle (deg)	Spin Rate (rpm)	Spin Axis (deg)	Vertical Carry Distance (yds)	Horizontal Carry Distance (yds)
Comp. Example 1	46.2	67.9	12.2	0.6	3460	4.4	263.0	13.1
Comp. Example 2	45.9	67.9	11.0	4.1	3362	9.1	263.5	39.5
Comp. Example 3	46.1	69.3	8.1	-1.6	4627	2.0	249.0	-2.1
Comp. Example 4	46.1	68.8	8.4	-1.8	3189	-3.1	267.1	-14.8
Example 5	45.7	68.9	11.0	0.8	2900	3.0	273.0	-2.0
Example 6	47.0	69.3	8.1	0.3	2300	2.0	278.0	8.0

[0122] As shown in Tables 2-5, using golf clubs formed with golf club shafts prepared in Examples, low handicap golfers gain excellent feel during the swing and achieve an increase in the carry of a ball.

INDUSTRIAL APPLICABILITY

[0123] When golf club shafts related to the present invention are used, the ease of swing is maintained even when a heavier head is mounted, preferred feel is provided even the subject is a professional or low handicap golfer, and the carry distance is increased.

DESCRIPTION OF NUMERICAL REFERENCES

[0124]

10 mandrel
21 prepreg (tip-end reinforcing layer)
22 prepreg (bias layer)
23a filler-containing resin layer
23b fiber-reinforced resin layer
23c filler-containing resin layer (another shape 1)
23d fiber-reinforced resin layer (another shape 1)
23e filler-containing resin layer (another shape 2)
23f fiber-reinforced resin layer (another shape 2)
24 prepreg (first straight layer)
25 prepreg (second straight layer)
26 prepreg (third straight layer)
27 prepreg (tip-end outer diameter adjustment layer)

Claims

1. A golf club shaft made of a plurality of fiber-reinforced resin layers, comprising:

a heavy substance with a specific gravity of 7 or greater positioned between 0 and 400 mm from the grip end

of the golf club shaft,
wherein when the entire length of the golf club shaft is set as (Ls) and the distance from the head end to the gravity center of the golf club shaft is set as (Lg), the ratio (Lg/Ls) is 0.54-0.65.

2. The golf club shaft according to Claim 1, the golf club shaft being made of a plurality of fiber-reinforced resin layers, further comprising a 20~400 mm-long filler-containing resin layer (W) which contains the above heavy substance as a filler.

3. The golf club shaft according to Claim 2, the golf club shaft being made of a plurality of fiber-reinforced resin layers, wherein the weight per unit area of the filler-containing resin layer (W) is 500 g/m^2 or greater.

4. The golf club shaft according to any of Claims 1-3, the golf club shaft being made of a plurality of fiber-reinforced resin layers, wherein the outer diameter of the grip-end portion is set at 14.5 mm~15.7 mm.

5. The golf club shaft according to any of Claims 2-4, wherein the filler-containing resin layer (W) is set at less than 10 mass% of the entire mass of the golf club shaft.

6. The golf club shaft according to any of Claims 2-5, wherein the filler-containing resin layer (W) is set at 4 mass% or greater of the entire mass of the golf club shaft.

7. The golf club shaft according to any of Claims 2-6, further comprising a fiber-reinforced resin layer (X) which is positioned on the grip-end side to be adjacent to the filler-containing resin layer (W) and set to have a thickness difference of-70 μm~+110 μm with the filler-containing resin layer (W).

8. The golf club shaft according to any of Claims 1-7, wherein the heavy substance is tungsten.

9. The golf club shaft according to any of Claims 1-8, wherein the kickpoint obtained by the formula below is less than 45.0%.

$$\text{kickpoint } (\%) = (LK/LB) \times 100$$

LK: when a shaft is curved by a compression load applied on both ends of the shaft so that the straight-line distance between both ends is 98.5~99.5% of the entire shaft length, the distance from the tip end of the shaft to the intersection of the straight line connecting both ends and a vertical line drawn from the apex of the curve.
LB: when a shaft is curved by a compression load applied on both ends of the shaft so that the straight-line distance between both ends is 98.5~99.5% of the entire shaft length, the straight-line distance between both ends of the shaft.

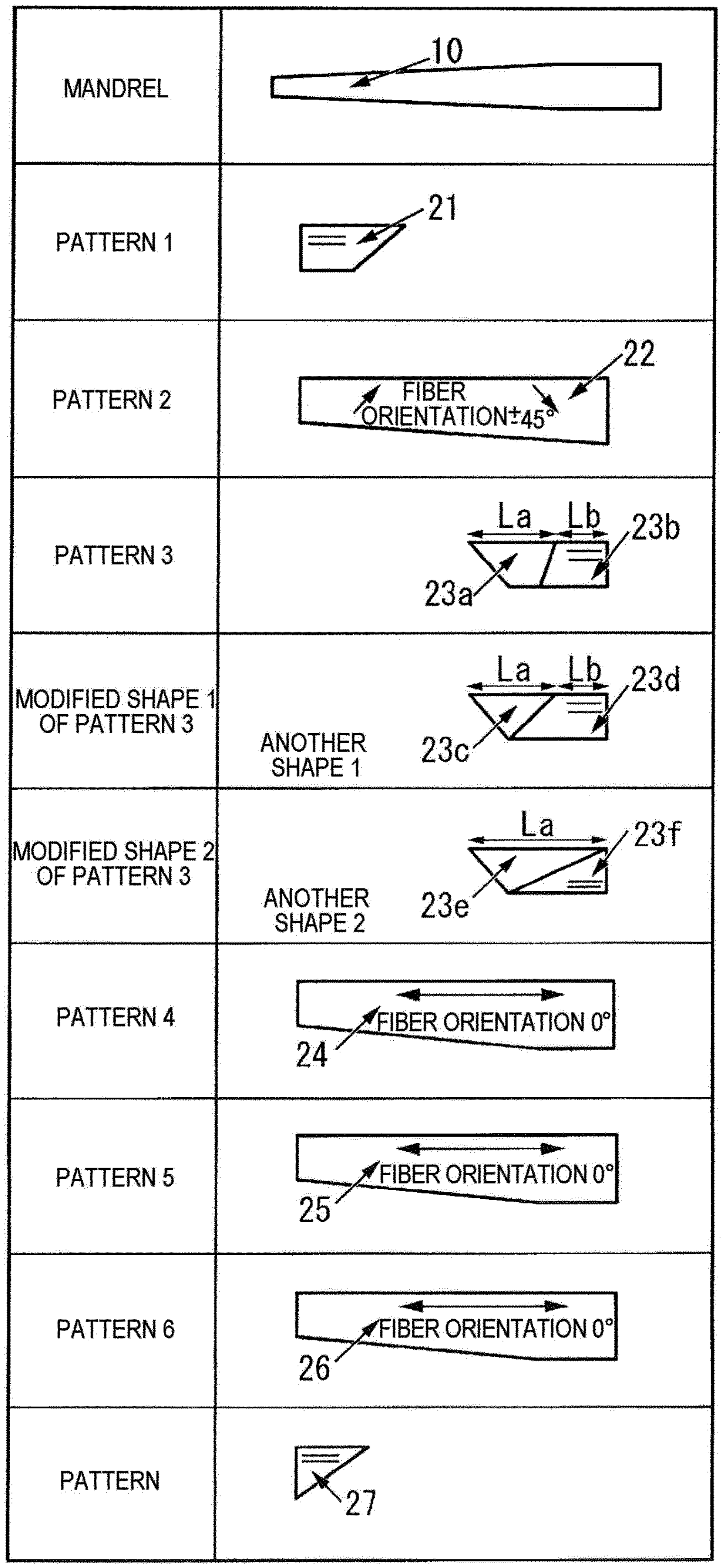
10. The golf club shaft according to Claim 9, wherein the kickpoint is less than 44.0%.

11. A golf club, comprising:

a golf club shaft made of a plurality of fiber-reinforced resin layers,
wherein the golf club shaft comprises a heavy substance with a specific gravity of 7 or greater positioned between 0 and 400 mm from the grip end, and when the entire length of the golf club shaft is set as (Ls) and the distance from the head end to the gravity center of the golf club shaft is set as (Lg), the ratio (Lg/Ls) is 0.54-0.65.

12. The golf club according to Claim 11, wherein the filler-containing resin layer (W) is set to have a length of 20~355 mm and to be present between 0 and 355 mm from the grip end of the golf club shaft.

FIG. 1


MANDREL
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PATTERN 1
21
PATTERN 2
FIBER ORIENTATION±45°
22
PATTERN 3
La
Lb
23b
23a
MODIFIED SHAPE 1 OF PATTERN 3
ANOTHER SHAPE 1
La
Lb
23d
23c
MODIFIED SHAPE 2 OF PATTERN 3
ANOTHER SHAPE 2
La
23f
23e
PATTERN 4
FIBER ORIENTATION 0°
24
PATTERN 5
FIBER ORIENTATION 0°
25
PATTERN 6
FIBER ORIENTATION 0°
26
PATTERN
27

FIG. 2

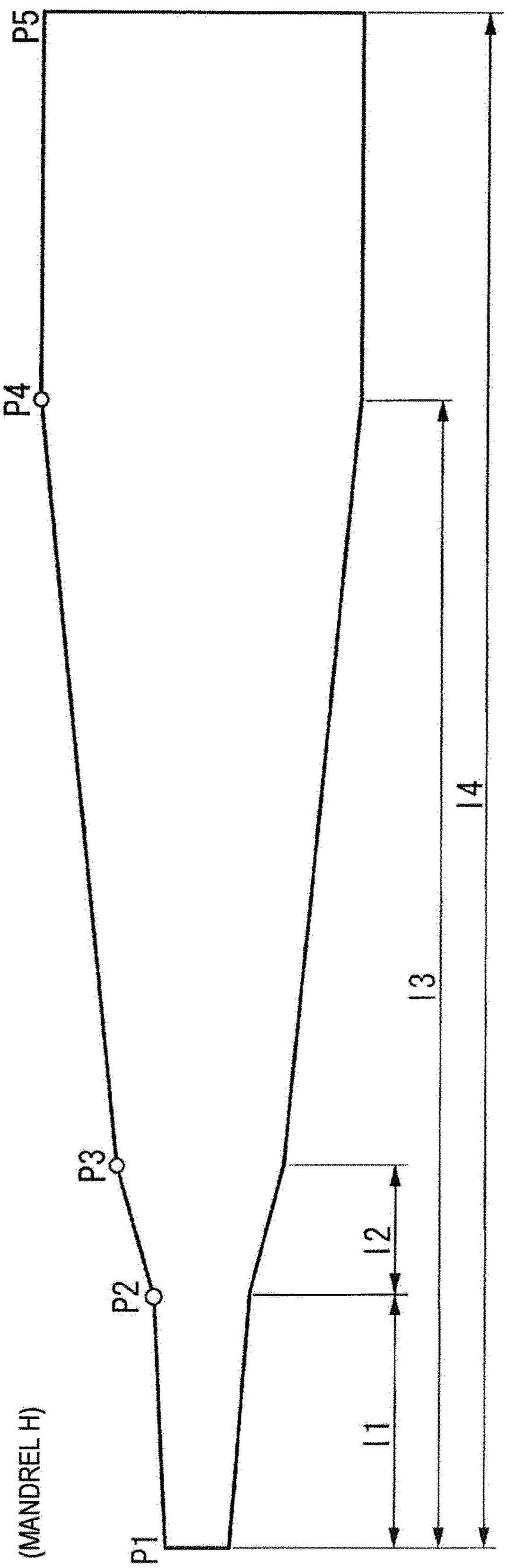
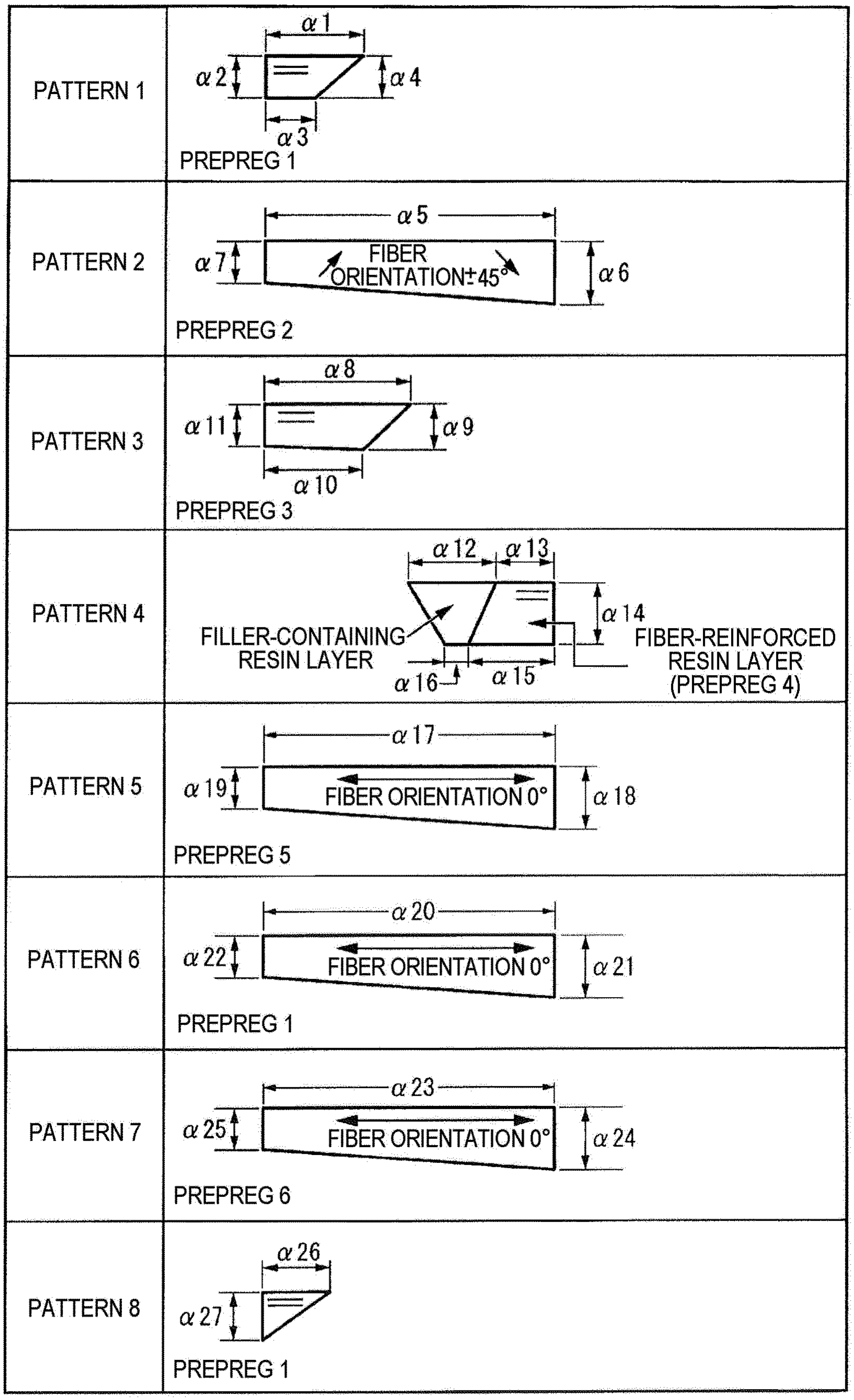


FIG. 3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α3
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PATTERN 2
α5
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α6
PREPREG 2
PATTERN 3
α8
α11
α9
α10
PREPREG 3
PATTERN 4
α12
α13
α14
FILLER-CONTAINING RESIN LAYER
FIBER-REINFORCED RESIN LAYER (PREPREG 4)
α16
α15
PATTERN 5
α17
α19
FIBER ORIENTATION 0°
α18
PREPREG 5
PATTERN 6
α20
α22
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α21
PREPREG 1
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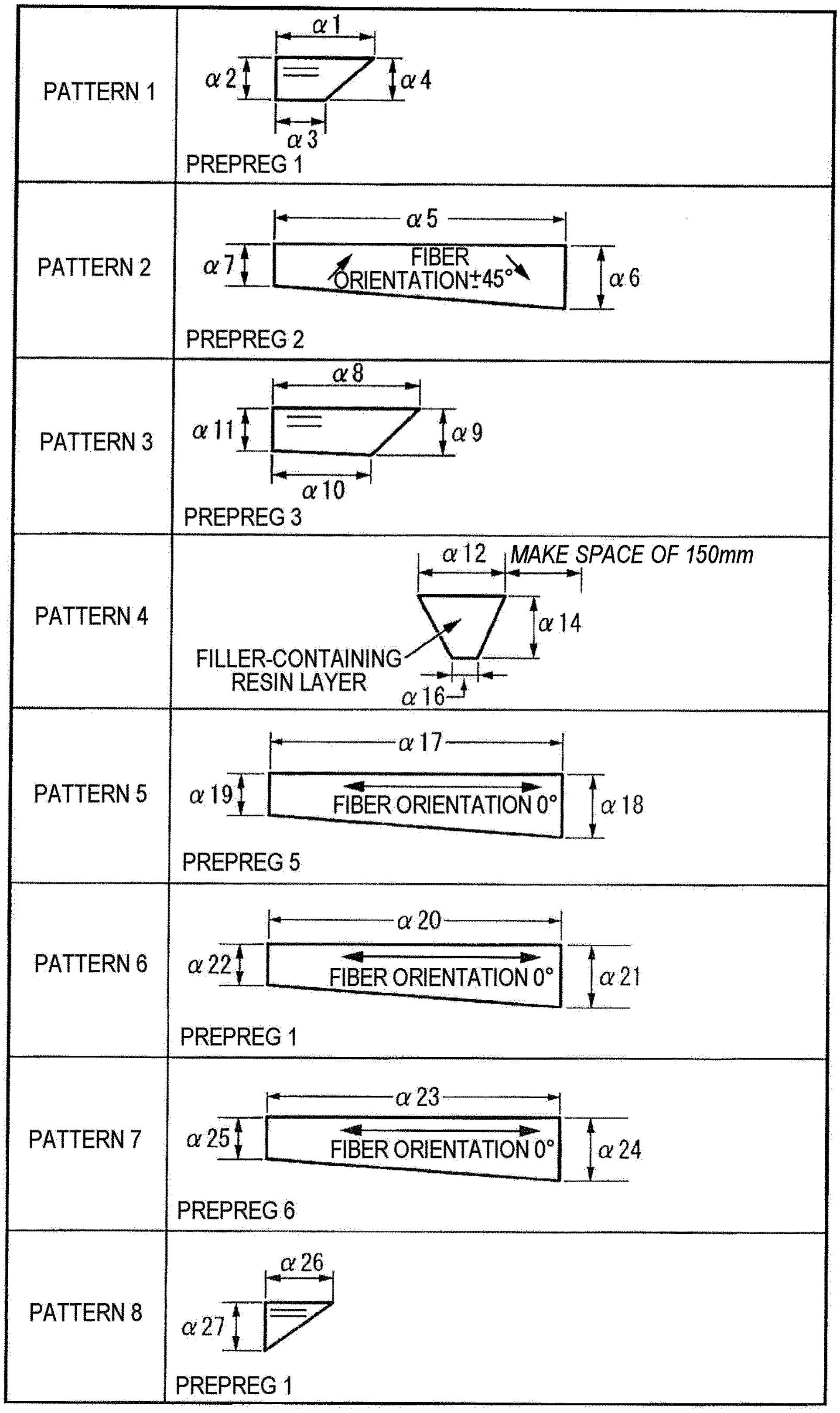
α25
FIBER ORIENTATION 0°
α24
PREPREG 6
PATTERN 8
α26
α27
PREPREG 1

FIG. 4


PATTERN 1
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α4
α3
PREPREG 1
PATTERN 2
α5
α7
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α6
PREPREG 2
PATTERN 3
α8
α11
α9
α10
PREPREG 3
PATTERN 4
α12
MAKE SPACE OF 150mm
α14
FILLER-CONTAINING RESIN LAYER
α16
PATTERN 5
α17
α19
FIBER ORIENTATION 0°
α18
PREPREG 5
PATTERN 6
α20
α22
FIBER ORIENTATION 0°
α21
PREPREG 1
PATTERN 7
α23
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FIBER ORIENTATION 0°
α24
PREPREG 6
PATTERN 8
α26
α27
PREPREG 1

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2014/084475

A. CLASSIFICATION OF SUBJECT MATTER
A63B53/10(2015.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A63B53/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2012-239574 A (Dunlop Sports Co., Ltd.), 10 December 2012 (10.12.2012), claims 1, 3 & US 2012/0295734 A1 & CN 102784464 A & KR 10-2012-0129799 A	1-12
Y	JP 2012-147982 A (Mitsubishi Rayon Co., Ltd.), 09 August 2012 (09.08.2012), entire text; all drawings (Family: none)	1-12
Y	JP 6-344519 A (Mitsubishi Rayon Co., Ltd.), 20 December 1994 (20.12.1994), paragraph [0010] (Family: none)	3

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 March 2015 (13.03.15)	24 March 2015 (24.03.15)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/084475

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 7-116289 A (Hitachi Chemical Co., Ltd.), 09 May 1995 (09.05.1995), claims 1 to 2; paragraph [0019]; fig. 2 (Family: none)	4 8
Y	JP 9-206413 A (Daiwa Seiko Inc.), 12 August 1997 (12.08.1997), claim 1; paragraphs [0003] to [0004] & US 5947839 A	9-10
A	JP 2013-138703 A (Dunlop Sports Co., Ltd.), 18 July 2013 (18.07.2013), claim 1; paragraph [0044]; fig. 1 (Family: none)	1-12
A	JP 10-155952 A (Daiwa Seiko Inc.), 16 June 1998 (16.06.1998), claim 3; paragraphs [0008], [0013] (Family: none)	9
A	JP 2001-346925 A (Daiwa Seiko Inc.), 18 December 2001 (18.12.2001), claims 1 to 2; paragraphs [0014], [0018], [0022]; fig. 1 (Family: none)	1-12
A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 68202/1992(Laid-open No. 29559/1994) (The Yokohama Rubber Co., Ltd.), 19 April 1994 (19.04.1994), entire text; all drawings (Family: none)	1-12

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2009189554 A **[0009]**
- JP 2012239574 A **[0009]**