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(54) **Racket frame**

(57) A head 4 of a racket frame has a gut groove 20. The head 4 includes side reinforcing layers 18. Each side reinforcing layer 18 is formed from a prepreg including carbon fibers and a matrix resin. The compressive elastic modulus of the prepreg is equal to or less than 100 GPa. The tensile elastic modulus of the prepreg is equal to or less than 100 GPa. The tensile elastic modulus of the carbon fibers is equal to or less than 160 GPa. Preferably, the prepreg includes amorphous carbon fibers.

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Description

[0001] This application claims priority on Patent Application No. 2013-16360 filed in JAPAN on January 31, 2013. The entire contents of this Japanese Patent Application are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The present invention relates to racket frames used for tennis and the like. Specifically, the present invention relates to improvement of reinforcing layers for gut grooves of racket frames.

Description of the Related Art

[0003] The frame of a tennis racket is formed from a fiber reinforced resin. The matrix resin of the fiber reinforced resin is an epoxy resin. The reinforcing fibers of the fiber reinforced resin are carbon fibers. The reinforcing fibers are long fibers. The frame is formed by winding a plurality of prepregs and curing the epoxy resin included in each prepreg. A racket frame formed from a fiber reinforced resin is disclosed in JP2011-15885.

[0004] A racket frame has a gut groove. A portion of a string that is located at an outer side of the frame is received in the gut groove. Damage of the string is prevented by the gut groove.

[0005] A general frame includes a reinforcing layer. The reinforcing layer is formed from a matrix resin and a large number of carbon fibers extending in substantially a thickness direction. When hitting a ball, a great force is applied to a gut groove through a string. Breakage of the frame caused by the force is prevented by the reinforcing layer.

[0006] When a ball is hit at or near the sweet spot of a racket, the ball is launched at a high speed. When the ball is hit at or near the sweet spot of the racket, the impact force transmitted to the player is small.

[0007] With an existing racket, when a ball is hit at a position away from the sweet spot of the racket, the ball is launched at a low speed. In the racket, an impact force transmitted to the player when the ball is hit at the position away from the sweet spot is great. Thus, the player cannot swing the racket completely when the ball is hit at the position away from the sweet spot. In addition, the player cannot maintain the direction of the ball-hitting face when the ball is hit at the position away from the sweet spot.

[0008] Players aim at hitting a ball at or near the sweet spot when making a stroke. However, in a competition, a player sometimes has to hit a ball at a position away from the sweet spot. A racket is desired which is excellent in resilience when a ball is hit at a position away from the sweet spot.

[0009] An object of the present invention is to provide a racket frame which is excellent in resilience when a ball is hit at a position away from the sweet spot of a racket.

SUMMARY OF THE INVENTION

[0010] A racket frame according to the present invention includes a head formed from a fiber reinforced resin. The head includes a reinforcing layer for a gut groove. The reinforcing layer is formed from a prepreg including fibers and a matrix resin. A compressive elastic modulus of the prepreg is equal to or less than 100 GPa.

[0011] Preferably, a tensile elastic modulus of the prepreg is equal to or less than 100 GPa.

[0012] A racket frame according to another invention includes a head formed from a fiber reinforced resin. The head includes a reinforcing layer for a gut groove. The reinforcing layer is formed from a prepreg including fibers and a matrix resin. A tensile elastic modulus of the fibers is equal to or less than 160 GPa.

[0013] A racket frame according to still another invention includes a head formed from a fiber reinforced resin. The head includes a reinforcing layer for a gut groove. The reinforcing layer includes amorphous carbon fibers and a matrix resin.

[0014] In a racket in which the frame according to the present invention is used, a resilience coefficient is high when a ball is hit at a position away from the sweet spot. The frame is excellent in operability when a ball is hit at a position away from the sweet spot.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a front view of a racket frame according to one embodiment of the present invention;
FIG. 2 is a side view of the racket frame in FIG. 1;

FIG. 3 is an enlarged cross-sectional view taken along a line III-III in FIG. 1;
FIG. 4 is a cross-sectional view taken along a line IV-IV in FIG. 3; and
FIG. 5 is a cross-sectional view showing the racket frame in FIG. 3 together with a grommet and a string.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] The following will describe in detail the present invention based on preferred embodiments with reference to the accompanying drawings.

[0017] A racket frame 2 shown in FIGS. 1 and 2 includes a head 4, two throats 6, a shaft 8, and a grip 10. A grommet, a grip tape, an end cap, and the like are attached to the racket frame 2, and a string is stretched on the racket frame 2, whereby a racket for regulation-ball tennis is obtained. In FIG. 1, the up-down direction is the axial direction of the racket frame 2, and the right-left direction is the width direction of the racket frame 2.

[0018] The racket frame 2 is formed from a fiber reinforced resin. The matrix resin of the fiber reinforced resin is a thermosetting resin. The thermosetting resin is typically an epoxy resin. The fibers of the fiber reinforced resin are typically carbon fibers. The fibers are long fibers. As is obvious from Fig. 3, the racket frame 2 is hollow. The racket frame 2 is formed by winding a plurality of prepregs and curing the thermosetting resin included in the prepregs.

[0019] The head 4 forms the contour of a ball-hitting face. The front shape of the head 4 is substantially an ellipse. The major axis direction of the ellipse coincides with the axial direction of the racket frame 2. The minor axis direction of the ellipse coincides with the width direction of the racket frame 2. One end of each throat 6 is connected to the head 4. Each throat 6 is connected at the vicinity of the other end thereof to the other throat 6. The throats 6 extend from the head 4 to the shaft 8. The shaft 8 extends from the location where the two throats 6 are connected to each other. The shaft 8 is formed so as to be integrally connected to the throats 6. The grip 10 is formed so as to be integrally connected to the shaft 8. A portion of the head 4 that is sandwiched between the two throats 6 is a yoke 12.

[0020] As shown in FIGS. 1 and 2, the head 4 includes a top reinforcing layer 14, a yoke reinforcing layer 16, and two side reinforcing layers 18. In FIGS. 1 and 2, a reference sign P1 indicates a boundary point between the top reinforcing layer 14 and each side reinforcing layer 18, and a reference sign P2 indicates a boundary point between the yoke reinforcing layer 16 and each side reinforcing layer 18.

[0021] FIG. 3 is an enlarged cross-sectional view taken along a line III-III in FIG. 1. FIG. 4 is a cross-sectional view taken along a line IV-IV in FIG. 3. In FIG. 3, the left side is the outer side of the head 4, and the right side is the inner side of the head 4. As shown in FIG. 3, the head 4 has a gut groove 20. The gut groove 20 is formed on an outer surface of the head 4. The gut groove 20 has two side surfaces 22 and one bottom surface 24. As shown in FIG. 2, the gut groove 20 extends along the circumferential direction of the head 4.

[0022] FIGS. 3 and 4 show the side reinforcing layer 18. The side reinforcing layer 18 is formed from a prepreg. The matrix resin of the prepreg is an epoxy resin. The prepreg includes a large number of carbon fibers. Each carbon fiber extends in substantially the thickness direction of the racket frame 2 (the right-left direction in FIG. 2). The side reinforcing layer 18 is formed by heating the prepreg to cure the epoxy resin. The top reinforcing layer 14 and the yoke reinforcing layer 16 are formed by curing epoxy resins of other prepregs.

[0023] FIG. 5 shows the head 4 together with a grommet 26 and a string 28. The grommet 26 includes a flange 30 and a pipe 32. The flange 30 is in contact with the bottom surface 24 of the gut groove 20. The pipe 32 extends through the head 4. A portion of the string 28 is arranged on the flange 30 and along the circumferential direction. In addition, the string 28 extends through the pipe 32.

[0024] When a tennis ball is hit with the racket, a force is applied to the gut groove 20 through the string 28. The side reinforcing layer 18 is arranged so as to surround the gut groove 20. Near the bottom surface 24 of the gut groove 20, the carbon fibers of the side reinforcing layer 18 extend in the thickness direction of the racket frame 2. The side reinforcing layer 18 reinforces the gut groove 20. The side reinforcing layer 18 prevents breakage of the head 4 when a tennis ball is hit with the racket. Similarly, the carbon fibers of the top reinforcing layer 14 and the yoke reinforcing layer 16 also extend in the thickness direction of the racket frame 2 near the bottom surface 24 of the gut groove 20. The top reinforcing layer 14 and the yoke reinforcing layer 16 also prevent breakage of the head 4 when a tennis ball is hit with the racket.

[0025] The compressive elastic modulus of the prepreg of the side reinforcing layer 18 is lower than the compressive elastic modulus of a prepreg of a reinforcing layer of an existing racket frame. The head 4 including the side reinforcing layer 18 is excellent in deformability.

[0026] When a tennis ball is hit at or near the sweet spot, the string 28 sufficiently stretches. By the stretch, the impact is absorbed. After the stretch, the string 28 returns to its original shape. By the return, the tennis ball is launched at a high speed.

[0027] When a tennis ball is hit at a position away from the sweet spot, stretch of the string 28 is not sufficient. As described above, the compressive elastic modulus of the prepreg of the side reinforcing layer 18 is low. Therefore, when a tennis ball is hit at a position away from the sweet spot, the head 4 deforms together with the string 28. By the deformation, the impact is absorbed. A player can swing the racket completely with the direction of the ball-hitting face maintained. After the deformation, the head 4 returns to its original shape. By the return, the tennis ball is launched at a high speed.

[0028] In the racket, deformation of the head 4 compensates for insufficient deformation of the string 28 when a tennis ball is hit at a position away from the sweet spot. The racket frame 2 is excellent in impact absorption, operability, and resilience when a tennis ball is hit at a position away from the sweet spot. The sweet area of the racket frame 2 is wide.

[0029] As described above, when a tennis ball is hit at or near the sweet spot, the string 28 sufficiently stretches. Therefore, a force applied to the racket frame 2 by the hitting is small. Deformation of the head 4 by the hitting is small. In the racket, excessive deformation does not occur when a tennis ball is hit at or near the sweet spot.

[0030] In the present embodiment, the compressive elastic modulus of the prepreg of the top reinforcing layer 14 is higher than the compressive elastic modulus of the prepreg of each side reinforcing layer 18, and the compressive elastic modulus of the prepreg of the yoke reinforcing layer 16 is higher than the compressive elastic modulus of the prepreg of each side reinforcing layer 18. The compressive elastic modulus of the prepreg of the top reinforcing layer 14 may be equal to the compressive elastic modulus of the prepreg of each side reinforcing layer 18. The compressive elastic modulus of the prepreg of the yoke reinforcing layer 16 may be equal to the compressive elastic modulus of the prepreg of each side reinforcing layer 18.

[0031] Longitudinal strings and lateral strings are formed from the string 28. As described above, the front shape of the head 4 is substantially an ellipse, and the major axis direction of the ellipse coincides with the axial direction of the racket frame 2. Therefore, the length of the average longitudinal string is larger than the length of the average lateral string. In general, the longitudinal strings stretch more easily than the lateral strings. For the purpose of compensating for lateral strings' difficulty in stretching, it is preferred that: a prepreg having a low compressive elastic modulus is used for each side reinforcing layer 18; a prepreg having a high compressive elastic modulus is used for the top reinforcing layer 14; and a prepreg having a high compressive elastic modulus is used for the yoke reinforcing layer 16.

[0032] The ratio of the compressive elastic modulus of the prepreg of each side reinforcing layer 18 to the compressive elastic modulus of the prepreg of the top reinforcing layer 14 is preferably equal to or less than 75%, more preferably equal to or less than 50%, and particularly preferably equal to or less than 25%. In light of strength of the racket frame 2, the ratio is preferably equal to or greater than 10%.

[0033] The ratio of the compressive elastic modulus of the prepreg of each side reinforcing layer 18 to the compressive elastic modulus of the prepreg of the yoke reinforcing layer 16 is preferably equal to or less than 75%, more preferably equal to or less than 50%, and particularly preferably equal to or less than 25%. In light of strength of the racket frame 2, the ratio is preferably equal to or greater than 10%.

[0034] In light of impact absorption, operability, and resilience, the compressive elastic modulus of the prepreg of each side reinforcing layer 18 is preferably equal to or less than 100 GPa, more preferably equal to or less than 65 GPa, and particularly preferably equal to or less than 35 GPa. In light of strength of the racket frame 2, the compressive elastic modulus is preferably equal to or greater than 10 GPa. The compressive elastic modulus is measured according to the standards of "JIS K 7076".

[0035] A prepreg having a low compressive elastic modulus can be obtained by incorporating carbon fibers having a low tensile elastic modulus. A specific example of carbon fibers having a low tensile elastic modulus is amorphous carbon fibers. A prepreg having a low compressive elastic modulus may also be obtained by setting a fiber area weight (FAW) of the carbon fibers to be small.

[0036] Specific examples of carbon fibers suitable for each side reinforcing layer 18 include trade names "XN-05", "XN-10", and "XN-15" manufactured by Nippon Graphite Fiber Co., Ltd. A particularly preferable carbon fiber is "XN-05".

[0037] In light of impact absorption, operability, and resilience, the tensile elastic modulus of the prepreg of each side reinforcing layer 18 is preferably equal to or less than 100 GPa, more preferably equal to or less than 75 GPa, and particularly preferably equal to or less than 35 GPa. In light of strength of the racket frame 2, the tensile elastic modulus is preferably equal to or greater than 10 GPa. The tensile elastic modulus is measured according to the standards of "JIS K 7073".

[0038] In light of impact absorption, operability, and resilience, the tensile elastic modulus of the carbon fibers of each side reinforcing layer 18 is preferably equal to or less than 160 GPa, more preferably equal to or less than 120 GPa, and particularly preferably equal to or less than 60 GPa. In light of strength of the racket frame 2, the tensile elastic modulus is preferably equal to or greater than 20 GPa. The tensile elastic modulus of the carbon fibers is measured according to the standards of "JIS L 1069".

[0039] The carbon fibers of each side reinforcing layer 18 may be of a pitch-type or a PAN-type. In light of impact absorption, operability, and resilience, pitch-type carbon fibers are preferred. The prepreg of each side reinforcing layer 18 may include fibers other than the carbon fibers. The prepreg may include a thermosetting resin other than the epoxy resin.

[0040] As described above, a portion of the racket frame 2 other than the reinforcing layers 14, 16, and 18 is also formed from a prepreg. In light of strength of the racket frame 2, the compressive elastic modulus of the prepreg is preferably higher than the compressive elastic modulus of the prepreg of each side reinforcing layer 18. The compressive elastic modulus of the prepreg of the portion other than the reinforcing layers 14, 16, and 18 is preferably equal to or greater than 110 GPa and particularly preferably equal to or greater than 130 GPa.

[0041] In FIG. 1, a reference sign Pmax indicates a point at which the width of the racket frame 2 is at its maximum. An arrow L1 indicates the distance in the axial direction between a top-side end P1 of the side reinforcing layer 18 and the point Pmax. An arrow L2 indicates the distance in the axial direction between a yoke-side end P2 of the side reinforcing layer 18 and the point Pmax.

[0042] In light of impact absorption, operability, and resilience, the distance L1 is preferably equal to or greater than 4 cm, more preferably equal to or greater than 6 cm, and particularly preferably equal to or greater than 8 cm. The distance L1 is preferably equal to or less than 15 cm.

[0043] In light of impact absorption, operability, and resilience, the distance L2 is preferably equal to or greater than 4 cm, more preferably equal to or greater than 6 cm, and particularly preferably equal to or greater than 8 cm. The distance L2 is preferably equal to or less than 15 cm.

[0044] As is obvious from FIGS. 3 and 4, each side reinforcing layer 18 is located at the outer side of the center of the thickness. In other words, each side reinforcing layer 18 is located near the bottom surface 24 of the gut groove 20. Each side reinforcing layer 18 contributes to deformation of the head 4.

[0045] In FIG. 4, an arrow T1 indicates the thickness of the head 4, and an arrow T2 indicates the thickness from the bottom surface 24 of the gut groove 20 to the side reinforcing layer 18. In light of impact absorption, operability, and resilience, the ratio of the thickness T2 to the thickness T1 is preferably equal to or less than 50%, more preferably equal to or less than 40%, and particularly preferably equal to or less than 30%. The ratio may be zero.

EXAMPLES

[Example 1]

[0046] The racket frame shown in FIGS. 1 to 4 was produced. The compressive elastic modulus of each prepreg used for the racket frame is as follows.

Side reinforcing layer: 32 GPa
Top reinforcing layer: 129 GPa
Yoke reinforcing layer: 129 GPa
Other portion: 129 GPa

[0047] The tensile elastic modulus of the carbon fibers of the prepreg of each side reinforcing layer is 54 GPa. The fiber area weight of the carbon fibers in the prepreg is 100 g/m^2.

[Example 2]

[0048] A racket frame of Example 2 was obtained in the same manner as Example 1, except a prepreg having a compressive elastic modulus of 64 GPa was used for each side reinforcing layer. The tensile elastic modulus of the carbon fibers of the prepreg is 110 GPa. The fiber area weight of the carbon fibers in the prepreg is 100 g/m^2.

[Example 3]

[0049] A racket frame of Example 3 was obtained in the same manner as Example 1, except a prepreg having a compressive elastic modulus of 85 GPa was used for each side reinforcing layer. The tensile elastic modulus of the carbon fibers of the prepreg is 155 GPa. The fiber area weight of the carbon fibers in the prepreg is 100 g/m^2.

[Comparative Example 1]

[0050] A racket frame of Comparative Example 1 was obtained in the same manner as Example 1, except a prepreg having a compressive elastic modulus of 129 GPa was used for each side reinforcing layer. The tensile elastic modulus of the carbon fibers of the prepreg is 230 GPa. The fiber area weight of the carbon fibers in the prepreg is 100 g/m^2.

[Example 4]

[0051] A racket frame of Example 4 was obtained in the same manner as Comparative Example 1, except the fiber area weight of the carbon fibers in the prepreg was 70 g/m^2. The tensile elastic modulus of the carbon fibers of the prepreg is 230 GPa.

[Evaluation]

[0052] A grommet, a grip tape, an end cap, and a string were mounted to each racket frame to produce a tennis racket. The tennis racket was fixed, a tennis ball of a speed of 30 m/s was caused to hit at each of first to eighteenth points on a ball-hitting face, and a resilience coefficient was measured. The coordinate (X, y) of each point is as follows.

First point: (0, 12)
Second point: (0, 15)
Third point: (0, 18)
Fourth point: (0, 21)
Fifth point: (0, 24)
Sixth point: (0, 27)
Seventh point: (0, 30)
Eighth point: (3, 12)
Ninth point: (3, 15)
Tenth point: (3, 18)
Eleventh point: (3, 21)
Twelfth point: (3, 24)
Thirteenth point: (3, 27)
Fourteenth point: (6, 12)
Fifteenth point: (6, 15)
Sixteenth point: (6, 18)
Seventeenth point: (6, 21)
Eighteenth point: (6, 24)

[0053] The origin for the coordinates is at the top of the ball-hitting face, x is a distance (cm) in the width direction from the origin, and y is the distance (cm) in the axial direction from the origin. The average e1 of the resilience coefficients at the first to seventh points, the average e2 of the resilience coefficients at the eighth to thirteenth points, and the average e3 of the resilience coefficients at the fourteenth to eighteenth points were calculated. The results are shown in Table 1 below.

Table 1 Results of Evaluation

	Example 1	Example 2	Example 3	Example 4	Comp. Example 1
Fiber					
Tensile elastic modulus (GPa)	54	110	155	230	230
Prepreg					
FAW (g/m^2)	100	100	100	70	100
Tensile elastic modulus (GPa)	34	72	93	95	137
Compressive elastic modulus (GPa)	32	64	85	90	129
e1	0.38	0.38	0.38	0.38	0.38
e2	0.33	0.33	0.32	0.32	0.31
e3	0.23	0.22	0.22	0.22	0.21

[0054] As shown in Table 1, in the racket frame of each Example, the resilience coefficients at points away from the central point in the width direction are high. In other words, the sweet area of the racket frame of each Example is wide. From the results of evaluation, advantages of the present invention are clear.

[0055] The above descriptions are merely illustrative examples, and various modifications can be made without departing from the principles of the present invention.

Claims

1. A racket frame comprising a head formed from a fiber reinforced resin, wherein
the head includes a reinforcing layer for a gut groove,
the reinforcing layer is formed from a prepreg including fibers and a matrix resin, and
a compressive elastic modulus of the prepreg is equal to or less than 100 GPa.

2. The racket frame according to claim 1, wherein a tensile elastic modulus of the prepreg is equal to or less than 100 GPa.

3. The racket frame according to claim 1 or 2, wherein a tensile elastic modulus of the fibers is equal to or less than 160 GPa.

4. The racket frame according to any one of claims 1 to 3, wherein a material of the fibers is amorphous carbon.

5. A racket frame comprising a head formed from a fiber reinforced resin, wherein
the head includes a reinforcing layer for a gut groove,
the reinforcing layer is formed from a prepreg including fibers and a matrix resin, and
a tensile elastic modulus of the fibers is equal to or less than 160 GPa.

6. A racket frame comprising a head formed from a fiber reinforced resin, wherein
the head includes a reinforcing layer for a gut groove, and
the reinforcing layer includes amorphous carbon fibers and a matrix resin.

FIG. 1

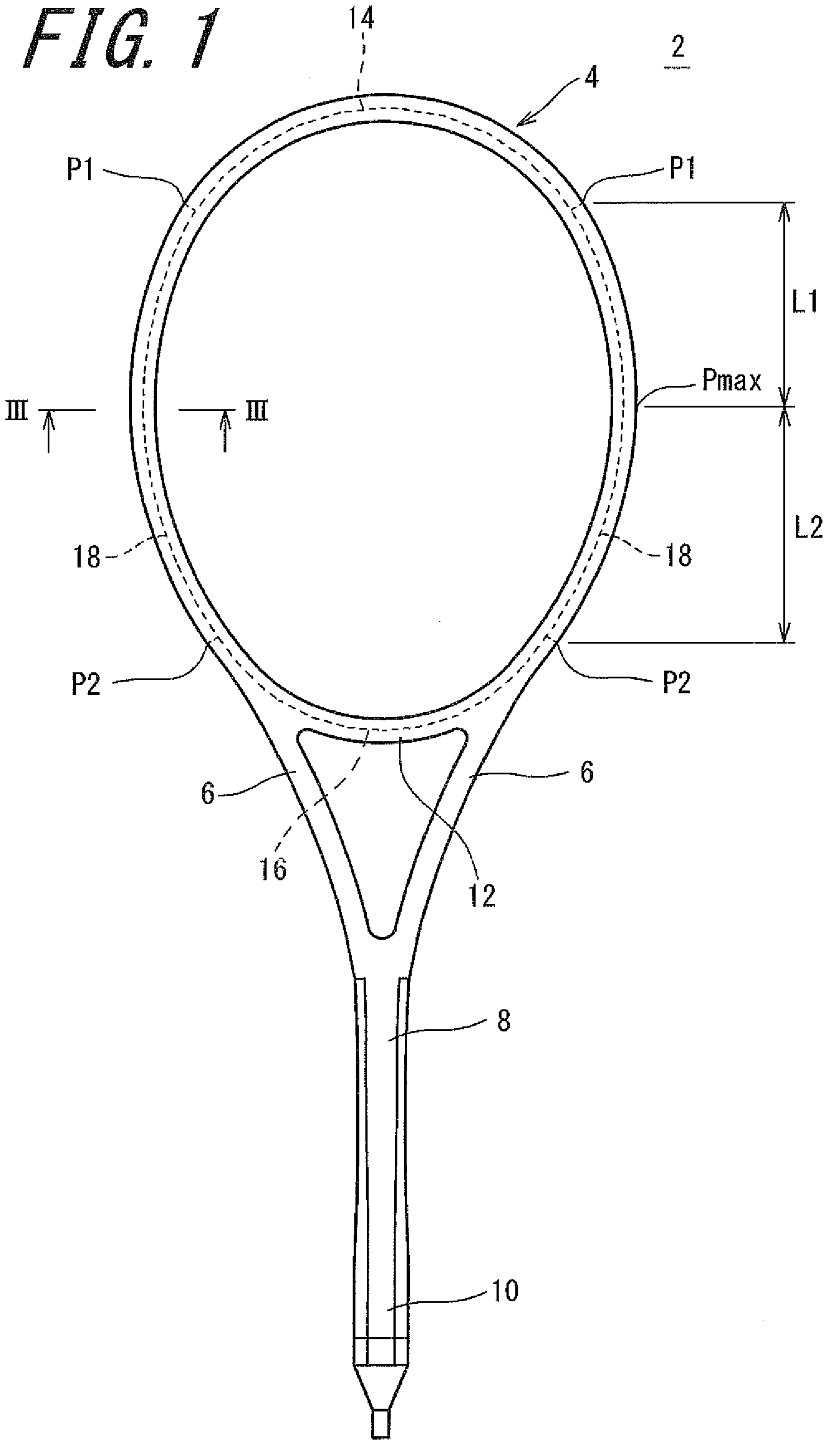
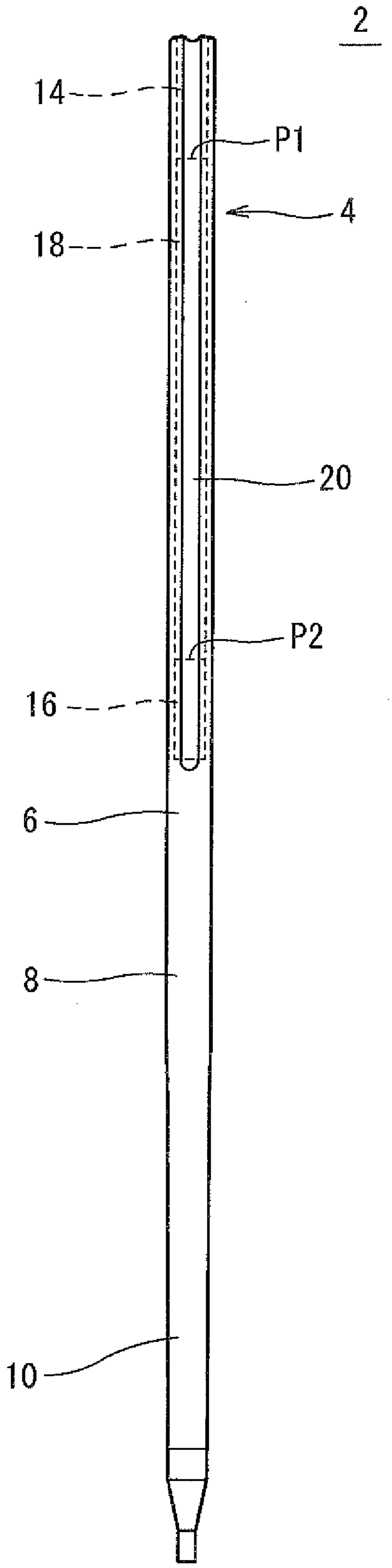


FIG. 2



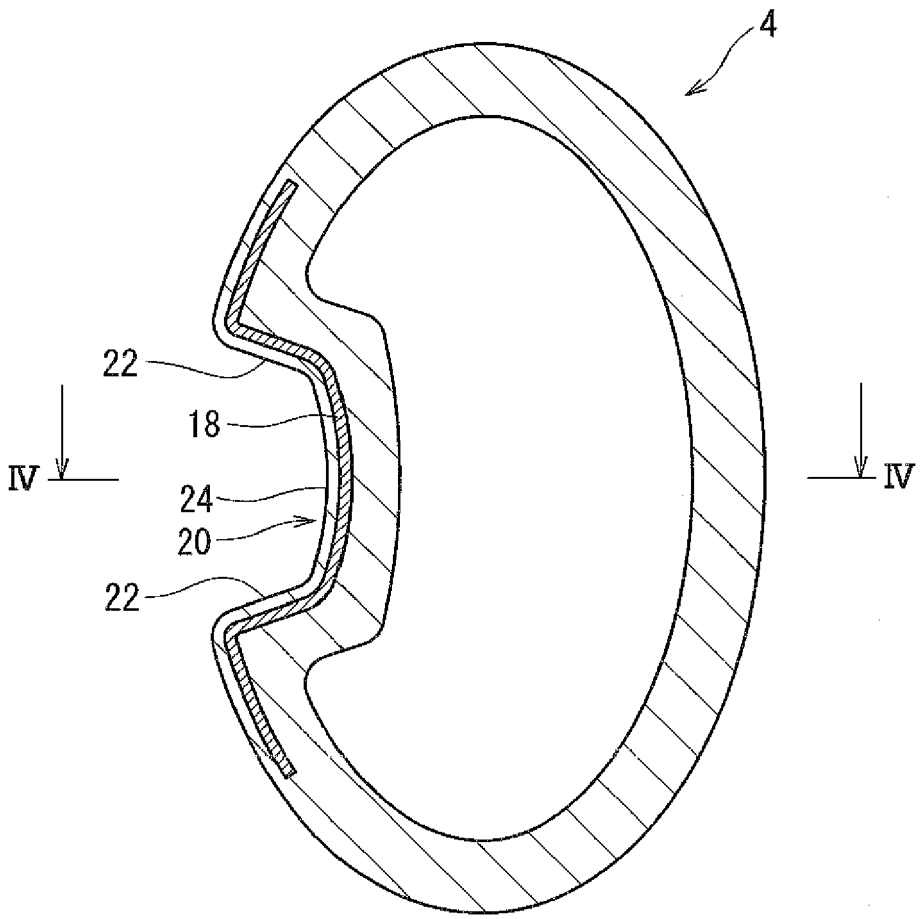


FIG. 3

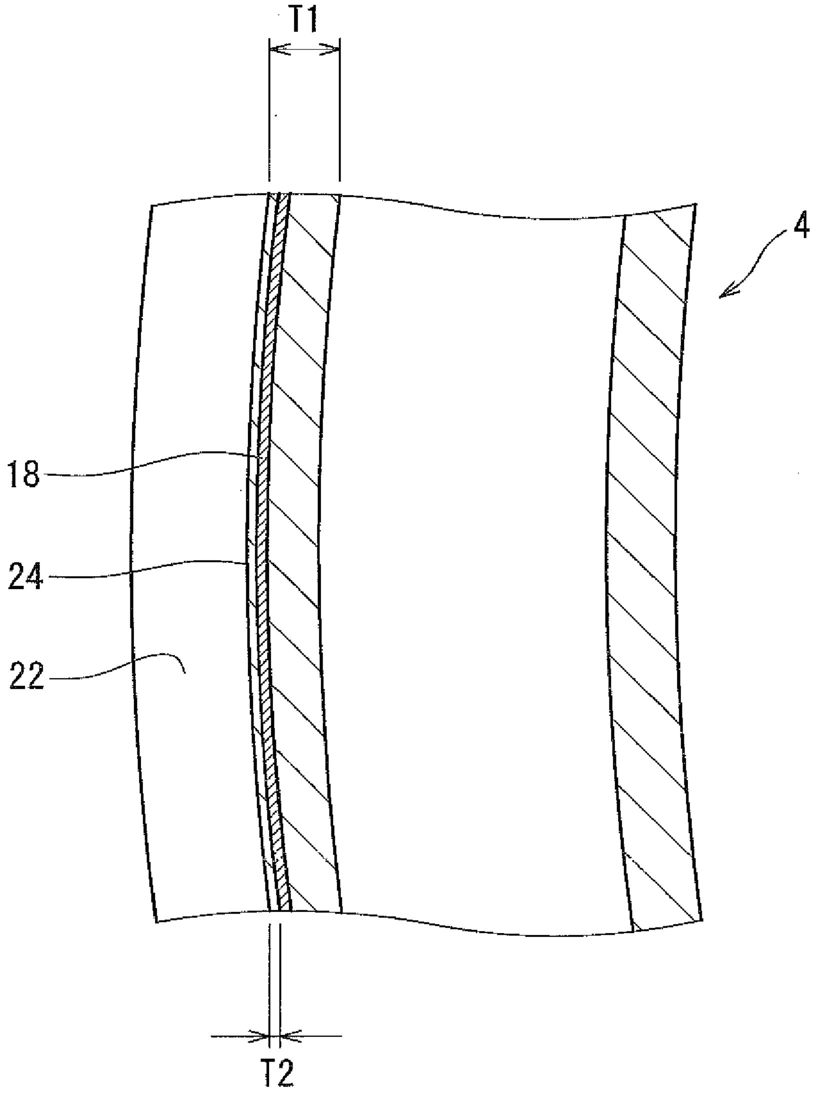


FIG. 4

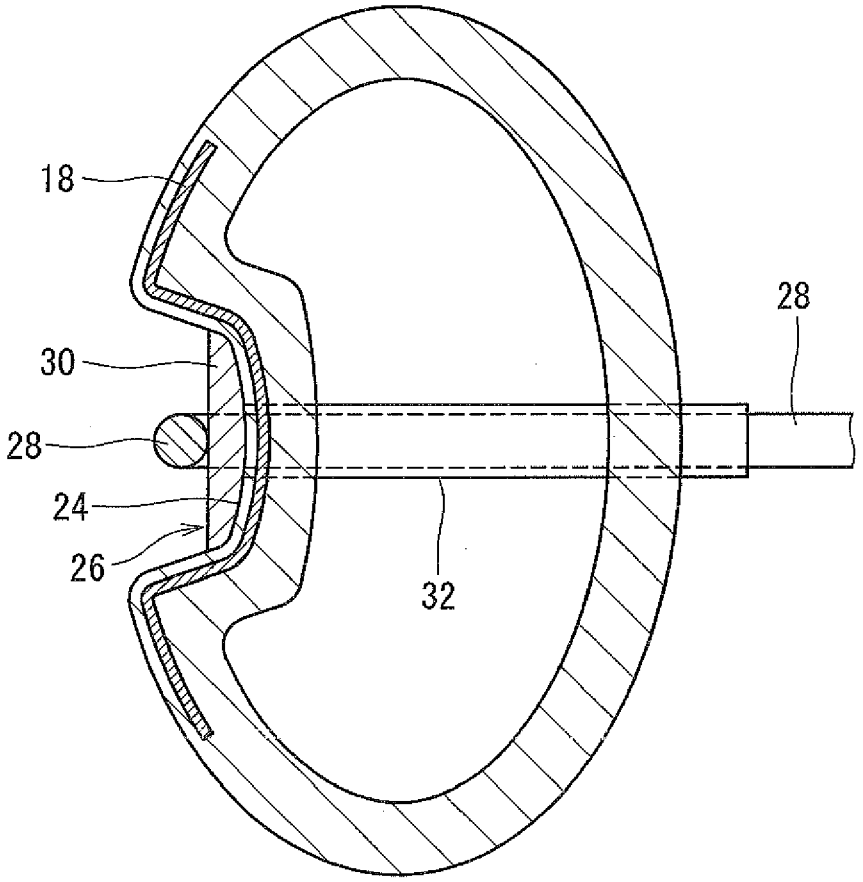


FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 14 15 2466

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 April 2014	Tejada Biarge, Diego

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

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