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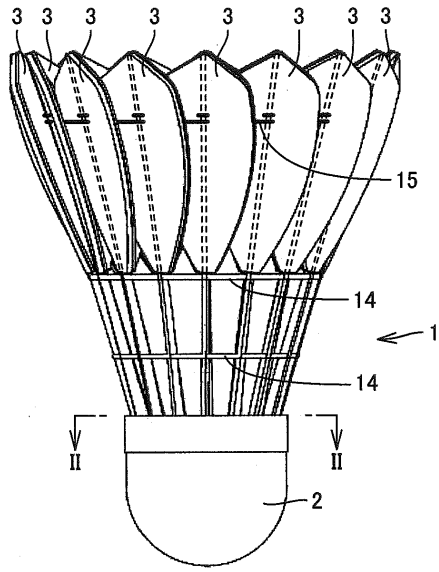
## (54) ARTIFICIAL FEATHER FOR SHUTTLECOCK, SHUTTLECOCK FOR BADMINTON AND MANUFACTURING METHOD FOR ARTIFICIAL FEATHER AND SHUTTLECOCK

(57) An artificial feather for a shuttlecock and a badminton shuttlecock achieving suppressed degradation of flight performance and having high durability, and methods of manufacturing the same are provided. An artificial feather (3) for a shuttlecock includes a feather portion, and a shaft connected to the feather portion. The shaft has a rectangular shape in cross section in a plane perpendicular to a direction in which the shaft extends, and the shaft includes a uniaxially stretched material. With this structure in which the shaft includes the uniaxially stretched material, by utilizing the characteristics of the uniaxially stretched material (such characteristics that the material can be elastically deformed within a wider range of distortion than usual materials), even when a shuttlecock (1) employing this artificial feather (3) for a shuttlecock is hit with a racket, the shaft of the artificial feather (3) is temporarily deformed under the impact of hitting, and then returns to its original shape without breaking. Therefore, the durability against hitting with a racket can be improved when compared to a conventional artificial feather.

FIG.1

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to an artificial feather for a shuttlecock, a badminton shuttlecock, and methods of manufacturing the same. More particularly, the present invention relates to an artificial feather for a shuttlecock and a badminton shuttlecock having excellent flight performance and durability, and methods of manufacturing the same.

### BACKGROUND ART

**[0002]** A shuttlecock employing waterfowl feathers as the feathers thereof (natural shuttlecock) and a shuttlecock employing feathers artificially manufactured using nylon resin and the like (artificial shuttlecock) are conventionally known as badminton shuttlecocks. A natural shuttlecock is more expensive than a shuttlecock employing artificial feathers since it requires time and effort to obtain natural feathers of a certain level of quality. Further, the supply of waterfowl feathers has recently been reduced drastically due to changes in food situation in countries supplying waterfowl feathers, mass culling of waterfowl resulting from the spread of bird influenza, and so on, making natural shuttlecocks even more expensive. Therefore, shuttlecocks employing artificial feathers which are inexpensive and of stable quality have been proposed (see, for example, PTD 1 (Japanese Utility Model Laying-Open No. 54-136060) to PTD 3 (Japanese Utility Model Publication No. 36-20919)).

**[0003]** PTD 1 discloses arranging a thin piece to protrude from a side surface of a shaft (a shaft having a substantially rectangular cross section) of an artificial feather made of an injection molded soft plastic material, to improve flight performance of an artificial shuttlecock. PTD 2 (Japanese Utility Model Publication No. 2-29974) discloses a shaft of a feather for an artificial shuttlecock made of synthetic resin such as polyamide resin and configured such that the shaft has a cross-sectional shape of a deformed rhombus and the long axis of the rhombus is inclined with respect to a circumference on which the artificial feather is arranged, to generate rotational force while the shuttlecock is flying. Further, PTD 3 discloses an artificial feather for an artificial shuttlecock configured such that a plurality of feather shafts made of synthetic resin such as nylon or polyethylene and having an oblong shape in cross section are annularly arranged, formed integrally with a circular substrate at bottom portions of the feather shafts, and coupled to one another with an annular reinforcing member at a central portion of the feather shafts. PTD 4 (Japanese Patent Laying-Open No. 2008-206970) discloses an artificial feather for an artificial shuttlecock configured such that non-woven fabric serving as a feather is partially embedded inside a shaft made of resin.

### CITATION LIST

### PATENT DOCUMENTS

**[0004]**

PTD 1: Japanese Utility Model Laying-Open No. 54-136060
PTD 2: Japanese Utility Model Publication No. 2-29974
PTD 3: Japanese Utility Model Publication No. 36-20919
PTD 4: Japanese Patent Laying-Open No. 2008-206970

### SUMMARY OF INVENTION

### TECHNICAL PROBLEM

**[0005]** However, in the artificial shuttlecocks described in PTD 1 to PTD 4, the artificial feathers thereof still do not have sufficient strength when compared to natural feathers. On the other hand, it is difficult to take a countermeasure such as increasing the thickness of a shaft of an artificial feather to improve strength, in order to satisfy the standard and required flight performance of a shuttlecock (flight performance equal to that of a natural shuttlecock). That is, taking a countermeasure such as merely increasing the thickness of a shaft of an artificial feather to improve strength results in an increase in mass of the entire shuttlecock. Consequently, it has been difficult to achieve an artificial shuttlecock having flight performance equal to that of a natural shuttlecock.

**[0006]** The present invention was made to solve the above-described problems, and an object of the present invention is to provide an artificial feather for a shuttlecock and a badminton shuttlecock achieving suppressed degradation of flight performance and having high durability, and methods of manufacturing the same.

### SOLUTION TO PROBLEM

**[0007]** The present inventors completed the present invention based on research on materials for an artificial feather for a shuttlecock. That is, a great impact is applied to an artificial feather for a shuttlecock during a smash and the like with a racket, often causing breakage of a shaft of the artificial feather. As described above, however, a countermeasure such as increasing the thickness of the shaft to improve strength of the shaft cannot be taken. As such, instead of attempting to develop a highly rigid shaft that is not deformed under the impact, the present inventors considered the possibility of a shaft that returns to its original shape even after being temporarily deformed under the impact received during hitting with a racket (i.e., that is elastically deformed under the impact and returns again to its original shape after the deformation).

**[0008]** As a result of making prototype shafts from various materials and examining them, the following new findings were obtained. Specifically, when PET (polyethylene terephthalate) resin uniaxially stretched (e.g., by a factor of two or more (more preferably a factor of four or more)) from uniaxially stretched rein is used as a material for a shaft, although the shaft is temporarily deformed under the impact received during a smash and the like, the shaft can return to its substantially original shape after the deformation and maintain the shape, because the uniaxially stretched rein can be elastically deformed within a wider range of distortion than usual materials. Based on such findings, an artificial feather for a shuttlecock according to the present invention includes a feather portion, and a shaft connected to the feather portion. The shaft has a rectangular shape in cross section in a plane perpendicular to a direction in which the shaft extends (longitudinal direction), and the shaft includes a uniaxially stretched material.

**[0009]** With this structure in which the shaft includes the uniaxially stretched material, even when a shuttlecock employing this artificial feather for a shuttlecock is hit with a racket, the shaft of the artificial feather is temporarily deformed under the impact of hitting, and then returns to its original shape without breaking. In addition, by utilizing the characteristics of such a uniaxially stretched material (such characteristics that the material can be elastically deformed within a wider range of distortion than usual materials), the shaft can have a rectangular shape in cross section and the mass of the shaft can be set to a value close to that of a feather for a natural shuttlecock. Therefore, the durability against hitting with a racket can be improved when compared to a conventional artificial feather, while the mass of the artificial feather for a shuttlecock can be set substantially equal to that of a feather for a natural shuttlecock.

**[0010]** A badminton shuttlecock according to the present invention includes a hemispherical base body, and the artificial feather for a shuttlecock described above connected to the base body. With this structure, an artificial shuttlecock 1 achieving suppressed degradation of flight performance and having flight performance equal to that of a natural shuttlecock employing natural feathers, and having sufficient durability can be achieved.

**[0011]** A method of manufacturing an artificial feather for a shuttlecock according to the present invention includes the steps of preparing a shaft, and connecting a feather portion to the shaft. The step of preparing a shaft includes the steps of forming a stretched sheet member by uniaxially stretching (preferably drawing and stretching) a raw material molded object by a factor of two or more, and cutting the shaft from the stretched sheet member. An artificial feather 3 for a shuttlecock according to the present invention can be thus manufactured. The uniaxial stretching is performed more preferably by a factor (stretch factor) of four or more. Examples of materials for the shaft include thermoplastic polyester-based resins such as polyethylene terephthalate, polybutylene terephthalate, polyethylene naphthalate, polytrimethylene terephthalate, polyglycolic acid, poly(L-lactic acid), poly(3-hydroxybutyrate), poly(3-hydroxybutyrate/hydroxyvalerate), poly($\varepsilon$-caprolactone), polyethylene succinate, polybutylene succinate, polybutylene succinate adipate, polybutylene succinate/lactic acid, polybutylene succinate/carbonate, polybutylene succinate/terephthalate, polybutylene adipate/terephthalate, polytetramethylene adipate/terephthalate, polybutylene succinate/adipate/terephthalate, and an $\alpha$-olefin alone such as ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 1-octene, 1-decene, 4-methyl-1-pentene, or a polymer of two or more of such olefins. For the thermoplastic polyester-based resin, the stretch factor is preferably two or more and ten or less, and preferably four or more and eight or less (more preferably about six). For the $\alpha$-olefin alone or the polymer of two or more of such olefins, the stretch factor may be 15 or more. For the thermoplastic polyester-based resin, it is preferable to perform drawing and stretching at $\pm$20°C of a glass transition temperature (which is measured from the viscoelastic property) of the material, and then to further perform uniaxial stretching (e.g., roll stretching) at a temperature higher than the drawing and stretching temperature, preferably at between 120°C and 230°C, by a factor of 1.1 to 3. It is to be noted that the stretch factor as used herein is obtained by dividing the cross-sectional area of the sheet before the stretching by the cross-sectional area of the sheet after the stretching.

**[0012]** Moreover, since the shaft is cut from the stretched sheet member as described above, the manufacturing process is easier with lower cost than when the shaft is formed by injection molding using a mold.

**[0013]** A method of manufacturing a badminton shuttlecock according to the present invention includes the steps of preparing a hemispherical base body, manufacturing an artificial feather for a shuttlecock using the method of manufacturing an artificial feather for a shuttlecock described above, and connecting the artificial feather for a shuttlecock to the base body. Badminton shuttlecock 1 according to the present invention can be thus manufactured.

## ADVANTAGEOUS EFFECTS OF INVENTION

**[0014]** According to the present invention, an artificial feather for a shuttlecock and a badminton shuttlecock achieving suppressed degradation of flight performance and having high durability can be obtained.

## BRIEF DESCRIPTION OF DRAWINGS

**[0015]**

Fig. 1 is a schematic side view showing an embodiment of a shuttlecock according to the present invention.

Fig. 2 is a schematic cross-sectional view taken along a line II-II in Fig. 1.

Fig. 3 is a schematic top view of the shuttlecock shown in Fig. 1.

Fig. 4 is a schematic plan view showing an embodiment of an artificial feather for a shuttlecock according to the present invention, which constitutes the shuttlecock shown in Figs. 1 to 3.

Fig. 5 is a schematic cross-sectional view taken along a line V-V in Fig. 4.

Fig. 6 is a schematic cross-sectional view taken along a line VI-VI in Fig. 4.

Fig. 7 is a schematic cross-sectional view taken along a line VII-VII in Fig. 4.

Fig. 8 is a schematic perspective view of a shaft which constitutes the artificial feather for a shuttlecock shown in Fig. 4.

Fig. 9 is a schematic side view of the shaft shown in Fig. 8.

Fig. 10 is a side view showing a modification of the shaft shown in Fig. 8.

Fig. 11 is a fragmentary schematic cross-sectional view showing the structure of a portion of the shuttlecock shown in Figs. 1 and 2 where an intermediate thread is arranged.

Fig. 12 is a flowchart for illustrating a method of manufacturing the artificial feather shown in Figs. 4 to 7.

Fig. 13 is a flowchart for illustrating a shaft formation step included in a constituent member preparation step (S10) shown in Fig. 12.

Fig. 14 is a schematic view for illustrating a processing step (S12) shown in Fig. 13.

Fig. 15 is a flowchart for illustrating a method of manufacturing the shuttlecock shown in Figs. 1 to 3.

Fig. 16 is a schematic cross-sectional view showing a first modification of the artificial feather which constitutes the embodiment of the shuttlecock according to the present invention.

Fig. 17 is a schematic cross-sectional view of a stacked sheet member used for forming a shaft which constitutes the artificial feather shown in Fig. 16.

Fig. 18 is a schematic view for illustrating a sample used in a tensile test.

Fig. 19 is a schematic view for illustrating a testing method of a bending test.

Fig. 20 is a schematic view for illustrating a testing method of a bending test.

## DESCRIPTION OF EMBODIMENTS

**[0016]** Embodiments of the present invention will be hereinafter described with reference to the drawings, in which the same or corresponding parts are designated by the same reference numbers, and description thereof will not be repeated.

**[0017]** An embodiment of a shuttlecock according to the present invention will be described with reference to Figs. 1 to 3.

**[0018]** Referring to Figs. 1 to 3, a shuttlecock 1 according to the present invention includes a hemispherical base body 2, a plurality of artificial feathers 3 for a shuttlecock connected to a fixing surface portion having a substantially flat surface in base body 2, fixing cord members 14 for fixing the plurality of artificial feathers 3 to one another, and an intermediate thread 15 for maintaining a stacked state of the plurality of artificial feathers 3. The plurality of (e.g. sixteen) artificial feathers 3 are annularly arranged in the fixing surface portion of base body 2, along the outer periphery of the fixing surface portion. Further, the plurality of artificial feathers 3 are fixed to one another by cord members 14. The plurality of artificial feathers 3 are arranged such that the distance among them is increased as the distance from base body 2 increases (i.e., an inner diameter of a cylindrical body formed by the plurality of artificial feathers 3 is increased as the distance from base body 2 increases).

**[0019]** The fixing surface portion of base body 2 is provided in advance with a plurality of insertion holes arranged annularly along the outer periphery of the fixing surface portion. Artificial feather 3 is inserted in the insertion hole at a bottom portion of its shaft 7 (see Fig. 4), to be integrated with base body 2. Here, as shown in Fig. 2, a side in a width direction of the outer periphery of shaft 7 of artificial feather 3 (the long side in cross section of shaft 7 in Fig. 2) intersects a radial direction indicated with an arrow 13 from a center point 12 of the fixing surface of base body 2. Moreover, the sides in the width direction of the outer periphery in cross section of the plurality of shafts 7 intersect the radial direction in the same direction.

**[0020]** Intermediate thread 15 serves as a fixing member for maintaining the stacked state of the plurality of artificial feathers 3. That is, intermediate thread 15 is arranged to define the positional relation of the plurality of artificial feathers 3 as will be described later.

**[0021]** Next, an embodiment of an artificial feather for a shuttlecock according to the present invention will be described with reference to Figs. 4 to 11.

**[0022]** Referring to Figs. 4 to 11, artificial feather 3 constituting shuttlecock 1 shown in Figs. 1 to 3 includes a feather portion 5, and a shaft 7 connected to feather portion 5. Shaft 7 includes a feather shaft portion 8 arranged to protrude from feather portion 5, and a fixed shaft portion 10 connected to feather portion 5 at a substantially central portion of feather portion 5. Feather shaft portion 8 and fixed shaft portion 10 are arranged to extend like an identical line, and constitute one continuous shaft 7. As shown in Figs. 5 and 6, shaft 7 has a rectangular shape (more specifically, an oblong shape) in cross section in a direction substantially perpendicular to a direction in which shaft 7 extends. Moreover, as shown in Figs. 5 and 6, feather portion 5 and shaft 7 are connected to each other such that, in the cross-sectional shape of shaft 7, the side in the width direction of the outer periphery of shaft 7 intersects (e.g., perpendicularly intersects) a main surface of feather portion 5 having a relatively large area (the surface of feather portion 5 shown in Fig. 4, or an upper surface of feather portion 5 shown in Fig. 6). That is, the side in the width direction of shaft 7 refers to sides (two side surfaces opposed to each other) of the surface of shaft 7 extending in a direction intersecting the main surface of feather portion 5. The other sides of the surface of shaft 7 connecting the two sides in the width direction together (or two sides of shaft 7 extending in a direction along the main surface of feather portion 5) are also referred to as a side in a thickness direction.

**[0023]** A length W of the side in the width direction of the outer periphery of shaft 7 in cross section (see Fig. 5) gradually decreases from the bottom portion (end portion of the side connected to base body 2) toward a tip of shaft 7. A length T of the side in the thickness direction of the outer periphery of shaft 7 in cross section (see Fig. 5) is constant over the entire length of shaft 7. In addition, as can be seen from Figs. 7 and 9, shaft 7 is warped toward one side when viewed from the side surface (from the side in the width direction of the outer periphery in cross section). In shuttlecock 1, artificial feathers 3 are connected to base body 2 such that a direction of warping of shafts 7 (direction of convex protrusion formed by the warping of shafts 7) faces toward the inner periphery of the shuttlecock, to gradually increase the distance among annularly arranged artificial feathers 3 as the distance from base body 2 increases (to extend shafts 7 outward).

**[0024]** Shaft 7 is made of polyethylene terephthalate, for example, which has been drawn and stretched in the vicinity of a glass transition temperature by a factor of about 5, then uniaxially stretched (roll stretched) at a higher temperature (e.g., about 170°C) by a factor of about 1.2, and then further subjected to heat treatment at a predetermined temperature. A direction of the stretching is along the extension direction of shaft 7. The extension direction of shaft 7 is defined as follows. Namely, referring to Fig. 9, on a side surface seen from the side in the width direction of shaft 7 in cross section, a midpoint of a line a-b connecting an upper end corner portion a and a lower end corner portion b on the tip side together is represented as a point e. In addition, a curve (upper curve) obtained by extending an upper curved surface of shaft 7 in Fig. 9 toward the bottom of shaft 7, and a curve (lower curve) obtained by extending a lower curved surface of shaft 7 toward the bottom of shaft 7 are imagined. Then, a line (bottom side line) parallel to line a-b is imagined on the bottom side of shaft 7. A point of intersection of the bottom side line and the upper curve is represented as a point c, and a point of intersection of the bottom side line and the lower curve is represented as a point d. The middle (midpoint) of a line c-d is represented as a point f. The position of the bottom side line is determined such that the distance between point e and point f serves as a designed length of shaft 7. In Fig. 9, the bottom side of shaft 7 has a wedge shape in which the side surface has a height decreasing toward the end portion. A tip corner portion of the wedge shape corresponds to point f. A straight line connecting point e and point f together is defined as the extension direction of shaft 7.

**[0025]** The stretch direction of the material for shaft 7 is along the extension direction of shaft 7 described above, and the stretch direction is preferably parallel to the extension direction of shaft 7. Alternatively, the stretch direction of the material for shaft 7 may intersect the extension direction of shaft 7 at an angle (intersection angle) of ±15° or less. Furthermore, the intersection angle is preferably 10° or less, and more preferably 5° or less.

**[0026]** The designed length of shaft 7 (the length of a line e-f in Fig. 9) may be set to 76 mm or more and 79 mm or less. This is due to the rules of the game of Nippon Badminton Association stipulating that the length of a feather must be constant within the range of 62 mm and 70 mm between its tip and the top of a base (a fixing surface of a base body). For example, if the length between the tip of the feather and the top of the base is to be 63 mm or more and 65 mm or less, and the length of a portion (embedded portion) at the bottom portion of shaft 7 that is inserted into the insertion hole of base body 2 is to be 13 mm or more and 14 mm or less, the designed length of shaft 7 is set to 76 mm or more and 79 mm or less as described above.

**[0027]** The upper curved surface and the lower curved surface of shaft 7 shown in Fig. 9 may have a radius of curvature of 600 mm or more, and more preferably 800 mm or more. This is because if the radius of curvature of the upper curved surface and the lower curved surface is too small, an oriented structure of orientated molecules is cut in the upper surface and lower surface by the stretching in the uniaxially stretched material, thus reducing the strength of shaft 7 which will then be easily plastically deformed. It is to be noted that the radii of curvature of the upper surface and the lower surface may have different values or the same value.

**[0028]** The shape of the side surface of shaft 7 may be other than the warped shape when viewed from the side surface as shown in Fig. 9. For example, as shown in Fig. 10, the shape may be such that shaft 7 extends straight without being warped when viewed from the side surface of shaft 7. In this case, point a, point b and point e can be defined in a manner similar to point a, point b and point e of shaft 7 shown in Fig. 9. In addition, a straight line (upper straight line) obtained by extending an upper straight surface of shaft 7 in Fig. 10 toward the bottom of shaft 7, and a straight line (lower straight line) obtained by extending a lower straight surface of shaft 7 toward the bottom of shaft 7 are imagined. Then, a line (bottom side line) parallel to line a-b is imagined on the bottom side of shaft 7. A point of intersection of the bottom side line and the upper straight line is represented as a point c, and a point of intersection of the bottom side line and the lower straight line is represented as a point d. The middle (midpoint) of a line c-d is represented as a point

f. The position of the bottom side line is determined such that the distance between point e and point f serves as a designed length of shaft 7. In Fig. 10, as with shaft 7 shown in Fig. 9, the bottom side of shaft 7 has a wedge shape in which the side surface has a height decreasing toward the end portion. A tip corner portion of the wedge shape corresponds to point f. A straight line connecting point e and point f together (center line of shaft 7) is defined as the extension direction of shaft 7. For shaft 7 having such a shape, it is again preferable that the stretch direction of the material for shaft 7 be along the extension direction of shaft 7.

**[0029]** Shaft 7 made of such a uniaxially stretched material is anisotropic in tensile strength, tensile modulus of elasticity and the like. Specifically, if the extension direction of shaft 7 is along the stretch direction of the uniaxially stretched material, the values of the tensile strength and tensile modulus of elasticity in the extension direction of shaft 7 are much higher, for example, three times or more higher (more specifically, three to seven times in the tensile modulus of elasticity, five to ten times in the tensile strength) than the values of the tensile strength and tensile modulus of elasticity in a direction perpendicular to the extension direction of shaft 7. If uniaxially stretched polyethylene terephthalate is used as a material for shaft 7, a glass transition temperature measured from its viscoelastic property is about 130°C, which is much higher than a glass transition temperature of usual polyethylene terephthalate (75°C).

**[0030]** It is to be noted that whether or not shaft 7 is made of a uniaxially stretched material can be determined by measuring its characteristic values such as a tensile modulus of elasticity, tensile strength and a coefficient of linear expansion, and comparing the characteristic values with characteristic values of the same material which has not been stretched (non-stretched material). For example, if a material for shaft 7 to be inspected has a tensile modulus of elasticity whose value is 1.5 times or more of that of the non-stretched material, a tensile strength whose value is 1.5 times or more of that of the non-stretched material, and a coefficient of linear expansion whose value is 0.5 times or less of that of the non-stretched material, it can be determined that the material for this shaft 7 is a uniaxially stretched material, and that this shaft 7 corresponds to shaft 7 constituting the shuttlecock according to the present invention.

**[0031]** As shown in Figs. 6 and 7, feather portion 5 includes a foam layer 92 and a shaft fixing layer 91 arranged to sandwich fixed shaft portion 10 therebetween, and adhesion layers 93, 94 for fixing these foam layer 92 and shaft fixing layer 91 to each other. That is, in feather portion 5, foam layer 92 and shaft fixing layer 91 are stacked to sandwich fixed shaft portion 10 therebetween. Further, in feather portion 5, adhesion layers 93, 94 are arranged to connect foam layer 92 and shaft fixing layer 91 with each other, and to connect and fix these foam layer 92 and shaft fixing layer 91 to fixed shaft portion 10. From a different viewpoint, in feather portion 5, adhesion layer 93 is stacked on foam layer 92 located on an outer peripheral side when shuttlecock 1 is configured. On adhesion layer 93, fixed shaft portion 10 is arranged to be located at a substantially central portion of adhesion layer 93 and foam layer 92. The other adhesion layer 94 is arranged to extend from above fixed shaft portion 10 to above adhesion layer 93. Shaft fixing layer 91 is arranged on adhesion layer 94.

**[0032]** As can be seen from Fig. 7, in artificial feather 3, shaft 7 is warped toward foam layer 92 (i.e., the outer peripheral side of shuttlecock 1). From a different viewpoint, shaft 7 is warped to be convex toward shaft fixing layer 91. Further, although Fig. 7 shows a state where artificial feather 3 is warped toward foam layer 92 in the extension direction of shaft 7, feather portion 5 may be warped toward foam layer 92 (i.e., feather portion 5 may be warped to be convex toward shaft fixing layer 91) in a direction intersecting the extension direction of shaft 7 (e.g., a width direction perpendicular to the extension direction of shaft 7 and along a surface of feather portion 5). In this case, warping of artificial feather 3 in the extension direction of shaft 7 and warping of feather portion 5 in the direction intersecting the extension direction of shaft 7 as described above may occur simultaneously, or only one of the warpings may occur. Such warping can be formed by performing cutting (e.g., laser beam machining or punching) in such a manner that shaft 7 will be warped when cut from a sheet member of a material, as can be understood from a method of manufacturing shaft 7 to be described later. Alternatively, the warped shape may be formed by performing heat treatment after the cutting. The warped shape of feather portion 5 can be implemented by a conventionally well-known method, such as subjecting a constituent material for feather portion 5 to heat treatment, or originally forming a constituent material for feather portion 5 in a warped state.

**[0033]** Here, as a material for foam layer 92, for example, a resin foam, and more specifically, for example, a polyethylene foam (a foam of polyethylene) can be used. For shaft fixing layer 91, a resin foam can be used as well. Further, for shaft fixing layer 91, for example, any material such as a film made of resin or the like, or nonwoven fabric can be used, other than a polyethylene foam.

**[0034]** Further, for adhesion layers 93, 94, for example, a double-faced tape can be used. In artificial feather 3 shown in Figs. 4 to 7, a polyethylene foam is used as foam layer 92 and shaft fixing layer 91. A direction in which this polyethylene foam is extruded is preferably a direction indicated with an arrow 95 in Figs. 4 and 6. In this case, shaft 7 is connected and fixed to feather portion 5 so as to intersect the extrusion direction of the polyethylene foam indicated with arrow 95, thus reducing the probability of occurrence of faults such as splitting of feather portion 5 in a direction along the extension direction of shaft 7.

**[0035]** Next, the arrangement of intermediate thread 15 will be specifically described with reference to Fig. 11.

**[0036]** As shown in Fig. 11, intermediate thread 15 is arranged to encircle shafts 7 of artificial feathers 3, and to pass through regions where feather portions 5 of adjacent artificial feathers 3 are opposed to each other (i.e., to pass through the spaces between stacked feather portions 5) in parts of feather portions 5 in a stacked state in adjacent artificial feathers 3. Intermediate thread 15 passes through the spaces between stacked feather portions 5 in the parts where feather portions 5 are thus stacked, whereby occurrence of such a problem that the order of stacking of feather portions 5 is changed during use of shuttlecock 1 (e.g., the order of stacking of feather portions 5 is changed under the impact of hitting with a racket) can be suppressed.

**[0037]** Intermediate thread 15 described above is circumferentially arranged to fix all of the plurality of annularly arranged artificial feathers 3 to one another, as shown in Figs. 1 and 3. Intermediate thread 15 can be arranged as shown in Figs. 1 and 3, for example, by being sewn by an operator using a needle or the like. With this arrangement, shuttlecock 1 exhibiting excellent durability can be achieved by suppressing occurrence of the problem that the order of stacking of feather portions 5 is changed during use of shuttlecock 1.

**[0038]** It is to be noted that a sewing start end portion and a sewing finish end portion of circumferentially arranged intermediate thread 15 are connected with each other, and the remaining portions of the thread are cut in the vicinity of a knot and removed. A protective layer is preferably formed on the surface of the knot by applying an adhesive or the like. Such a protective layer is so formed that the knot can be prevented from coming loose when shuttlecock 1 is hit with a racket.

**[0039]** While any material such as cotton or resin can be employed for intermediate thread 15, a polyester thread is preferably employed. Further, a thread as lightweight as possible is preferably employed as intermediate thread 15 in order to minimize the influence on the center of gravity and the like of shuttlecock 1. For example, a polyester thread No. 30 may be employed as the thread. In this case, the mass of the thread used as intermediate thread 15 is about 0.02 g. If the mass is at about this level, it is conceivable that flight performance is hardly influenced, although the position of the center of gravity of shuttlecock 1 is slightly influenced. Further, to arrange intermediate thread 15, the distance from base body 2 can be arbitrarily set.

**[0040]** Next, methods of manufacturing shuttlecock 1 shown in Figs. 1 to 3 and artificial feather 3 for a shuttlecock will be described with reference to Figs. 12 to 15.

**[0041]** Firstly, referring to Fig. 12, a method of manufacturing artificial feather 3 for a shuttlecock according to the present invention will be described. As shown in Fig. 12, in the method of manufacturing artificial feather 3, a constituent member preparation step (S10) is firstly performed. In this step (S10), shaft 7, sheet-like materials for foam layer 92 and shaft fixing layer 91, and the double-faced tape which will be adhesion layers 93, 94 shown in Figs. 6 and 7, which constitute artificial feather 3, are prepared. The sheet-like members and the double-faced tape may have any planar shapes as long as they are larger than the size of feather portion 5 shown in Fig. 4. As the sheet-like member which will be foam layer 92, for example, a material such as a polyethylene foam (a foam of polyethylene formed in the shape of a sheet) having a thickness of 1.0 mm and a basis weight of 24 $g/m^2$ can be used. As the sheet-like member which will be shaft fixing layer 91, a material such as a polyethylene foam having a thickness of 0.5 mm and a basis weight of 20 $g/m^2$ can be used. The double-faced tape which will be adhesion layers 93, 94 can have a basis weight of 10 $g/m^2$.

**[0042]** Further, as a step of manufacturing shaft 7 described above, a base material preparation step (S11) is firstly performed, as shown in Fig. 13. In this step (S11), first, a raw material molded object is prepared by molding a material (e.g., a resin material) for shaft 7 into a sheet form. As the material for the raw material molded object, polyethylene terephthalate (PET) can be used, for example, or other materials (e.g., resins such as an $\alpha$-olefin alone such as ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 1-octene, 1-decene, 4-methyl-1-pentene, or a polymer of two or more of such olefins) can be used. The raw material molded object in a sheet form can be obtained by a conventionally well-known method. An extrusion method can be used, for example. The raw material molded object may have a thickness of 2 mm or more and 5 mm or less, for example.

**[0043]** Next, the prepared raw material molded object is uniaxially stretched to form a stretched sheet member as the base material. The uniaxial stretching may be performed by a stretch factor of two or more, for example, and more preferably four or more. While a conventionally well-known method can be employed as a method for the uniaxial stretching, for example, a drawing and stretching method of drawing a sheet that has been passed between rolls at predetermined intervals from each other, or a roll stretching method of pinching a raw material molded body between two pairs of pinch rolls having different rotation speeds and applying tension to the raw material molded body by the rotation of the pinch rolls to thereby stretch the raw material molded body uniaxially (in the direction of a line connecting the two pairs of pinch rolls together) can be used. Here, the raw material molded body may be heated. The uniaxially stretched sheet member is thus obtained. More preferably, the obtained stretched sheet is further subjected to heat treatment at a predetermined temperature.

**[0044]** Next, a processing step (S12) is performed. In this step (S12), shaft 7 is cut from the stretched sheet member. Specifically, shaft 7 may be cut from the stretched sheet member with a laser beam machine, for example, or any other method may be used. As a result, shaft 7 constituting artificial feather 3 can be obtained.

**[0045]** As shown in Fig. 14, when cutting shaft 7 from a stretched sheet member 20, it is preferable that the upper curve (see Fig. 9) and the lower curve (see Fig. 9) of shaft 7 have the same radius of curvature. This allows the cutting of a plurality of shafts 7 arranged without any gaps therebetween from stretched sheet member 20, as shown in Fig. 14. Consequently, shafts 7 can be cut from stretched sheet member 20 without waste. It is also preferable that the extension direction of shaft 7 be along a direction indicated with an arrow 24 in Fig. 14 in which the stretched sheet member is stretched.

**[0046]** Next, an affixation step (S20) is performed as shown in Fig. 12. In this step (S20), the double-faced tape which will be adhesion layer 93 is affixed to a main surface of the sheet-like member which will be foam layer 92. Then, fixed shaft portion 10 of shaft 7 is arranged on the double-faced tape. Further, on fixed shaft portion 10, the sheet-like member which will be shaft fixing layer 91, which has the double-faced tape which will be adhesion layer 94 affixed on a surface facing fixed shaft portion 10, is stacked and affixed. Consequently, a structure can be obtained in which fixed shaft portion 10 of shaft 7 is sandwiched and fixed between the sheet-like member which will be foam layer 92 and the sheet-like member which will be shaft fixing layer 91.

**[0047]** Next, a post-treatment step (S30) is performed. Specifically, an unnecessary portion of the stacked sheet-like members which will be feather portion 5 (i.e., a region other than a portion which will be feather portion 5) is cut and removed. Consequently, artificial feather 3 as shown in Figs. 4 to 7 can be obtained.

**[0048]** Here, warped shaft 7 is originally formed as shown in Fig. 14 to obtain warped artificial feather 3 as shown in Fig. 7. Alternatively, the warping of artificial feather 3 may be implemented with another method. For example, heat treatment such as application of heat from the foam layer 92 side may be performed on artificial feather 3 to constrict foam layer 92 and the like. Consequently, feather portion 5 can be warped as shown in Fig. 7.

**[0049]** Next, a method of manufacturing shuttlecock 1 shown in Figs. 1 to 3 will be described with reference to Fig. 15. As shown in Fig. 15, a preparation step (S 100) is firstly performed. In this preparation step (S100), the constituent members of shuttlecock 1 such as base body 2 (tip member) and artificial feather 3 described above of shuttlecock 1 are prepared.

**[0050]** Base body 2 can be manufactured with any conventionally known method. For example, a natural material such as cork can be used as a material for base body 2. Alternatively, an artificial resin or the like may be used as a material for base body 2. When an artificial resin is used as a material for base body 2, base body 2 can be formed using any conventionally well-known processing method. For example, a block of the material for base body 2 is firstly prepared and cut to have a rough shape. On this occasion, cutting is performed in consideration of the height of the hemispherical portion at the tip portion. Then, cutting may be further performed to form insertion holes for inserting artificial feathers 3. Further, when the artificial resin described above is used, for example, an ionomer resin foam, EVA (ethylene-vinyl acetate copolymer), polyurethane, PVC (polyvinyl chloride), polyethylene, polypropylene, or the like can be used. In addition, artificial feather 3 can be manufactured with the manufacturing method shown in Fig. 12 described above.

**[0051]** Next, an assembly step (S200) is performed. In the assembly step (S200), the bottoms of shafts 7 of the plurality of artificial feathers 3 described above are inserted and fixed in the insertion holes provided in advance in the fixing surface portion of the base body. Further, the plurality of artificial feathers 3 are fixed to one another by the cord members. In addition, sewing is performed such that intermediate thread 15 for maintaining the stacked state of the feather portions is arranged as shown in Fig. 11. Thus, shuttlecock 1 shown in Figs. 1 to 3 can be manufactured. It is to be noted that the fixing member for fixing the plurality of artificial feathers 3 to one another is not limited to the cord members as described above, and any member such as a ring-shaped member may be used.

**[0052]** Further, as a material for the fixing member described above, for example, any material such as resin and fiber can be used. For example, a fixing member made of FRP (Fiber-Reinforced Plastic) prepared by impregnating aramid fiber or glass fiber with a resin (e.g., a thermosetting resin) and curing the resin may be used as the cord members. Such a fixing member made of FRP can have improved strength and rigidity. As the thermosetting resin, for example, epoxy resin or phenolic resin can be used. By using the thermosetting resin for FRP in this manner, the fixing member can be readily made of FRP using the thermosetting resin simultaneously during a heating step and the like in a process for fixing the fixing member to shaft 7.

**[0053]** A modification of the artificial feather constituting the embodiment of the shuttlecock according to the present invention will now be described with reference to Figs. 16 and 17. It is to be noted that Fig. 16 corresponds to Fig. 6.

**[0054]** An artificial feather shown in Fig. 16 has a structure which is basically similar to that of artificial feather 3 shown in Figs. 4 to 7, but is different in the structure of shaft 7. Specifically, fixed shaft portion 10 of the shaft shown in Fig. 16 includes a shaft body portion 32 made of a stretched sheet member, and an auxiliary member 31 fixed to shaft body portion 32. It is to be noted that the entire shaft including fixed shaft portion 10 has a stacked structure formed of two layers, i.e., shaft body portion 32 and auxiliary member 31. For auxiliary member 31, a material having a density lower than that of shaft body portion 32, for example, a foam resin sheet can be used. As the foam resin sheet, for example, a sheet of polyethylene terephthalate foamed by a factor of four can be used. This foam resin sheet may have a specific gravity of 0.35, for example.

**[0055]** With this structure, the rigidity of shaft 7 can be increased while an increase in mass of the shaft is suppressed, when compared to an example where the shaft is made only of the stretched sheet member. Consequently, the durability of artificial feather 3 can be improved. Moreover, the width of shaft 7 (the width in the width direction of feather portion 5 as indicated with arrow 95 in Fig. 16) is increased to also increase air resistance of shaft 7, leading to such effects as improved rotational force of the shuttlecock and milder feeling and sound of hitting the shuttlecock.

**[0056]** Shaft body portion 32 in the structure shown in Fig. 16 may have a width of 0.2 mm or more and 0.5 mm or less, for example. Auxiliary member 31 may have a width of 0.8 mm or more and 2.0 mm or less, for example.

**[0057]** A method of manufacturing artificial feather 3 including shaft 7 having the stacked structure described above is basically similar to the manufacturing method shown in Figs. 12 and 13, but is partly different in the base material preparation step (S11) shown in Fig. 13. Specifically, after uniaxially stretched sheet member 20 is obtained, an auxiliary member 21 is fixed to the surface of stretched sheet member 20 as shown in Fig. 17. By cutting shaft 7 from a stacked sheet member 22 having auxiliary member 21 stacked on the surface of stretched sheet member 20 in the processing step (S12), a shaft having the cross-sectional shape shown in Fig. 16 can be obtained. Then, using this shaft, with the manufacturing method shown in Figs. 12 and 15, the modification of artificial feather 3 and the shuttlecock employing this artificial feather 3 according to the present invention can be obtained.

**[0058]** It is to be noted that the stacked structure of auxiliary member 31 and shaft body portion 32 is not limited to the arrangement as shown in Fig. 16. A multilayered structure in which auxiliary member 31 is sandwiched between two shaft body portions 32 (three-layer structure), or a multilayered structure in which shaft body portion 32 is sandwiched between two auxiliary members 31 in an opposite manner may be employed. Furthermore, shaft 7 may be formed of two or more auxiliary members 31 and two or more shaft body portions 32 stacked on one another.

**[0059]** Characteristic features of the invention of the present application will be listed below, although the description thereof partially overlaps the description of the embodiment described above.

**[0060]** Artificial feather 3 for a shuttlecock according to the present invention includes feather portion 5, and shaft 7 connected to feather portion 5. Shaft 7 has a rectangular shape in cross section in a plane perpendicular to a direction in which shaft 7 extends, as shown in Fig. 5, and shaft 7 includes a uniaxially stretched material.

**[0061]** With this structure in which shaft 7 includes the uniaxially stretched material, even when shuttlecock 1 employing this artificial feather 3 for a shuttlecock is hit with a racket, shaft 7 of artificial feather 3 is temporarily deformed under the impact of hitting, and then returns to its original shape without breaking. In addition, by utilizing the characteristics of such a uniaxially stretched material (such characteristics that the material can be elastically deformed within a wider range of distortion than usual materials), shaft 7 can have a rectangular shape in cross section and the mass of shaft 7 can be set to a value close to that of a feather for a natural shuttlecock. Therefore, the durability against hitting with a racket can be improved when compared to a conventional artificial feather, while the mass of artificial feather 3 for a shuttlecock can be set substantially equal to that of a feather for a natural shuttlecock.

**[0062]** In artificial feather 3 for a shuttlecock described above, the extension direction of shaft 7 (the direction along line e-f in Figs. 9 and 10) may be along the stretch direction of the uniaxially stretched material (the direction indicated with arrow 24 in Fig. 14). When the extension direction of shaft 7 is along the stretch direction of the material in this manner, the durability of shaft 7 against bending can be securely improved. In particular, the durability of shaft 7 can be maximized when the extension direction of shaft 7 and the stretch direction of the material are parallel to each other.

**[0063]** That the extension direction of shaft 7 is along the stretch direction means that the intersection angle of the extension direction of shaft 7 and the stretch direction is 15° or less. The intersection angle of the extension direction of shaft 7 and the stretch direction is more preferably 10° or less, and still more preferably 5° or less.

**[0064]** In artificial feather 3 for a shuttlecock described above, at an end portion (bottom portion) of shaft 7 opposite to a portion thereof connected to feather portion 5, shaft 7 may have an oblong shape in cross section as shown in Fig. 5, and a side in a width direction of a surface of shaft 7 extending in a direction intersecting a main surface of feather portion 5 having a relatively large area (the surface of feather portion 5 shown in Fig. 4) may constitute a long side of this oblong shape. The main surface of feather portion 5 as used herein may also be defined as a surface of feather portion 5 facing toward the outer periphery (or inner periphery) of shuttlecock 1 employing this artificial feather 3 for a shuttlecock.

**[0065]** In this case, an impact received by shuttlecock 1 from the outer peripheral side during hitting with a racket is applied to the shaft from the side in the thickness direction in cross section of shaft 7 (i.e., the short side of the aforementioned cross-sectional shape (oblong shape) of shaft 7). That is, the impact is applied to shaft 7 in a direction along the side in the width direction in cross section of shaft 7 (e.g., the long side in the vicinity of the bottom portion of shaft 7), thereby increasing an impact resistance value of shaft 7 as compared to an example where the impact is applied from a direction along the side in the thickness direction in cross section of shaft 7 (the short side of the oblong shape). As a result, artificial feather 3 for a shuttlecock having high durability (and shuttlecock 1 employing this artificial feather 3 for a shuttlecock) can be achieved.

**[0066]** Badminton shuttlecock 1 according to the present invention includes hemispherical base body 2, and artificial feather 3 for a shuttlecock described above connected to base body 2. With this structure, artificial shuttlecock 1 achieving suppressed degradation of flight performance and having flight performance equal to that of a natural shuttlecock employing natural feathers, and having sufficient durability can be achieved.

**[0067]** In badminton shuttlecock 1 described above, at the end portion (bottom portion) of shaft 7 of artificial feather 3 for a shuttlecock opposite to the portion thereof connected to feather portion 5, shaft 7 may have an oblong shape in cross section as shown in Fig. 5, and the side in the width direction of the surface of shaft 7 extending in the direction intersecting the main surface of feather portion 5 having a relatively large area may constitute the long side of the oblong shape. In addition, base body 2 and artificial feather 3 for a shuttlecock may be connected to each other such that the side in the width direction of shaft 7 is along the radial direction (the direction indicated with arrow 13 in Fig. 12) extending outward from center point 12 of the surface of base body 2 to which artificial feather 3 for a shuttlecock is connected. That the side in the width direction of shaft 7 is along the radial direction includes both a case where a direction in which the side in the width direction extends is parallel to the radial direction, and a case where the direction in which the side in the width direction extends intersects the radial direction at a certain intersection angle. The intersection angle of the direction in which the side in the width direction extends and the radial direction may be, for example, 45° or less, and more preferably 30° or less.

**[0068]** In this case, when artificial feather 3 receives an impact resulting from hitting with a racket from the outer peripheral side of shuttlecock 1, shaft 7 receives the impact from a direction along the side in the width direction in cross section of shaft 7. Accordingly, shaft 7 can resist a relatively greater impact than when the impact is received from a direction along the side in the thickness direction in cross section of shaft 7. As a result, the durability of shuttlecock 1 can be securely improved.

**[0069]** For example, base body 2 and artificial feather 3 for a shuttlecock may be connected to each other such that the side in the width direction in cross section of shaft 7 is parallel to the radial direction. In this case, the probability that shaft 7 receives an impact resulting from hitting with a racket from a direction parallel to the side in the width direction in cross section of shaft 7 can be increased, thereby maximizing the impact resistance of artificial feather 3 for a shuttlecock.

**[0070]** In badminton shuttlecock 1 described above, base body 2 and artificial feather 3 for a shuttlecock may be connected to each other such that the side in the width direction of shaft 7 intersects the radial direction. In this case, the side in the width direction of the outer periphery of shaft 7 is inclined relative to the radial direction. Thus, a flow of wind that will stabilize the rotation while the shuttlecock is flying can be produced around shaft 7. It is preferable that shafts 7 of the plurality of artificial feathers 3 have the same intersecting direction relative to the radial direction.

**[0071]** A method of manufacturing artificial feather 3 for a shuttlecock according to the present invention includes the steps of preparing shaft 7 (constituent member preparation step (S10)), and connecting a feather portion to shaft 7 (affixation step (S20)). The step of preparing the shaft (S10) includes the steps of forming stretched sheet member 20 by uniaxially stretching a raw material molded object by a factor of 10 or more (base material preparation step (S11)), and cutting shaft 7 from stretched sheet member 20 (processing step (S12)). Artificial feather 3 for a shuttlecock according to the present invention can be thus manufactured. The uniaxial stretching is performed more preferably by a factor of two or more. As a material for the shaft, a thermoplastic polyester-based resin such as polyethylene terephthalate (PET), or resins such as an $\alpha$-olefin alone such as ethylene, propylene, 1-butene, 1-pentene, 1-hexene, 1-octene, 1-decene, 4-methyl-1-pentene, or a polymer of two or more of such olefins can be used.

**[0072]** Moreover, since the shaft is cut from the stretched sheet member as described above, the manufacturing process is easier with lower cost than when the shaft is formed by injection molding using a mold.

**[0073]** A method of manufacturing a badminton shuttlecock according to the present invention includes the steps of preparing a hemispherical base body (preparation step (S 100)), manufacturing an artificial feather for a shuttlecock using the method of manufacturing an artificial feather for a shuttlecock described above (preparation step (S100)), and connecting the artificial feather for a shuttlecock to the base body (assembly step (S200)). Badminton shuttlecock 1 according to the present invention can be thus manufactured.

**[0074]** Next, a description will be given of experiments conducted as described below to confirm the effects of the artificial feather for a shuttlecock and the shuttlecock according to the present invention.

(Experiment 1)

**[0075]** First, relation between an intersection angle of a stretch direction of a stretched sheet member and an extension direction of shaft 7 and strength of the shaft was examined as described below. Specifically, samples extending in directions having predetermined intersection angles relative to the stretch direction were cut from the stretched sheet member, and mechanical characteristics (specifically, a tensile modulus of elasticity, maximum stress and maximum distortion) of the samples were measured.

(Prepared Samples)

**[0076]** As the stretched sheet member, a PET super-stretched sheet (trade name: DUORA (registered trademark)) manufactured by Sekisui Chemical Co., Ltd. was prepared. This super-stretched sheet had a thickness of 700 μm. From this stretched sheet member, a sample 41 having a central axis 42 that has an intersection angle 0 relative to a stretch direction of the stretched sheet member as indicated with an arrow 24 was cut, as shown in Fig. 18. Each sample had a plane size of 175 mm in length and 10 mm in width. There were four levels of 0°, 15°, 30° and 45° as the intersection angle θ. Five samples were prepared for each intersection angle.

(Details of Experiments)

**[0077]** Tensile tests were conducted using Autograph AG-10TB manufactured by Shimadzu Corporation as a test machine, to measure the tensile modulus of elasticity, maximum stress and maximum distortion of each sample. The temperature was set to 23°C and the humidity to 50% in a measurement atmosphere. A measurement speed was set to 10 mm/min, and a distance between chucks fixing the samples was set to 115 mm.

(Results)

**[0078]** As to the tensile modulus of elasticity, an average value of the five samples for each standard of the intersection angle θ was determined. To compare these average values, the tensile modulus of elasticity was 9.0 GPa, 7.0 GPa, 4.3 GPa, and 3.2 GPa for the standards of 0°, 15°, 30° and 45° of the intersection angle θ, respectively. Likewise, the maximum stress was 402 MPa, 189 MPa, 112 MPa and 88 MPa for the standards of 0°, 15°, 30° and 45° of the intersection angle θ, respectively. Likewise, the maximum distortion was 16.6%, 9.9%, 7.1% and 5.8% for the standards of 0°, 15°, 30° and 45° of the intersection angle θ, respectively.

**[0079]** It can thus be seen that the smaller the intersection angle θ, the higher the values of all of the tensile modulus of elasticity, maximum stress and maximum distortion.

(Experiment 2)

**[0080]** Relation between a stretch direction of a stretched sheet member and a bending modulus of elasticity was examined as described below.

(Prepared Samples)

**[0081]** As the stretched sheet member, a PET super-stretched sheet having the same thickness of 700 μm as that of Experiment 1 described above was prepared. Two types of samples having an oblong planar shape were prepared from this stretched sheet. Specifically, the two types of samples were a sample in which a direction between fulcrums of the oblong shape is along a stretch direction of the stretched sheet (sample A), and a sample in which a direction between fulcrums of the oblong shape is perpendicular to the stretch direction of the stretched sheet (sample B). Five samples A and five samples B were prepared. Each sample had a planar shape size of 20 mm in length in the direction between fulcrums and 25 mm in short side length.

(Details of Experiments)

**[0082]** Bending tests were conducted using Autograph AG-10TB manufactured by Shimadzu Corporation as a test machine in a manner similar to Experiment 1. The bending moduli of elasticity were measured with these tests. Figs. 19 and 20 show schematic views for illustrating the bending tests. The temperature was set to 23°C and the humidity to 50% in a measurement atmosphere. A measurement speed was set to 1 mm/min, and a distance between support members 52 supporting the samples was set to 16 mm.

**[0083]** As shown in Fig. 19, a test piece 51 employed as sample A was supported by two support members 52, and was bent by a pressing member 53 from an upper surface of test piece 51. In this case, sample A is bent in a direction orthogonal to the stretch direction. As shown in Fig. 20, sample B was subjected to a bending test under conditions similar to those of the test of sample A shown in Fig. 19. In this case, sample B is bent in a direction along the stretch direction.

(Results)

**[0084]** An average value of the bending moduli of elasticity of five samples A was 13.8 GPa. On the other hand, an average value of the bending moduli of elasticity of five samples B was 3.3 GPa. It can thus be seen that the bending modulus of elasticity is higher when the sample is bent in the direction orthogonal to the stretch direction than in the direction along the stretch direction.

(Experiment 3)

**[0085]** A plurality of types of shuttlecocks having shafts extending in directions having different intersection angles relative to a stretch direction of a stretched sheet member were prepared, and actual hitting tests were conducted to examine their durability.

(Prepared Samples)

**[0086]** A plurality of types of shafts having different intersection angles relative to the extension direction of the shaft were prepared using the stretched sheet member used in Experiment 1. Specifically, shafts of five levels of 0°, 5°, 10°, 15° and 30° as the intersection angle were prepared. To accurately measure the effect of inclination of the shaft, the feather shaft was straight-shaped as shown in Fig. 10. The shaft had a width on a tip side (length W of the side in the width direction: i.e., the distance between a and b in Fig. 10) of 0.64 mm and a width on a bottom side (between c and d in Fig. 10) of 2.25

mm. Length T of the side in the thickness direction in cross section of the shaft was set to 0.7 mm.

**[0087]** In addition, a polyethylene foam having a thickness of 0.5 mm and a basis weight of 20 g/$m^2$ was used as a material for shaft fixing layer 91 constituting feather portion 5 of artificial feather 3. A polyethylene foam having a thickness of 1.0 mm and a basis weight of 24 g/$m^2$ was used as a material for foam layer 92. A double-faced tape was used for adhesion layers 93, 94. The double-faced tape used had characteristics such as a thickness of 10 $\mu$m and a basis weight of 10 g/$m^2$. Then, using such artificial feathers, a shuttlecock having the structure shown in Figs. 1 to 3 was prepared. Five shuttlecocks were prepared for each level of the intersection angle described above.

(Details of Experiments)

**[0088]** Actual hitting tests of performing a high clear and a smash were conducted using the prepared shuttlecocks. The "clear" refers to flights in general of deeply hitting a shuttlecock from the center to a rear portion of a badminton court toward a rear portion of the opponent's court. The "high clear" refers to one of the clear moves of hitting a shuttlecock high to move the opponent to the rear portion of the court. The "clear" includes "a driven clear," which refers to an aggressive clear intended to send a shuttlecock flying over the opponent's head by hitting the shuttlecock at a relatively low level. The "smash" refers to the most aggressive flight of hitting a shuttlecock at an overhead stroke at an acute angle with respect to the opponent's court.

(Results)

**[0089]** As a result of the actual hitting tests described above, in the shuttlecocks employing the shafts having intersection angles of 0° and 5°, the artificial feathers did not break. In the shuttlecocks employing the shafts having an intersection angle of 10°, tip portions (narrowed portions of the shafts) of a few artificial features broke. In the shuttlecocks employing the shafts having an intersection angle of 15°, a few artificial features broke. In the shuttlecocks employing the shafts having an intersection angle of 30°, however, the shafts of the artificial features broke in all of the shuttlecocks.

**[0090]** Moreover, in the shuttlecocks employing the shafts having intersection angles of 0° and 5°, their flight performances were also relatively close to that of a natural shuttlecock.

**[0091]** Consequently, it was found that the intersection angle is preferably 15° or less, and more preferably 10° or less, in terms of durability of the shuttlecock. The intersection angle is preferably 5° or less to achieve both good flight performance and durability.

**[0092]** It should be understood that the embodiments and experimental examples disclosed herein are illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims, rather than the description above, and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

INDUSTRIAL APPLICABILITY

**[0093]** The present invention is advantageously applied to a badminton shuttlecock employing artificial feathers, that achieves suppressed degradation of flight performance and has high durability.

REFERENCE SIGNS LIST

**[0094]** 1 shuttlecock; 2 base body; 3 artificial feather; 5 feather portion; 7 shaft; 8 feather shaft portion; 10 fixed shaft portion; 12 center point; 13, 24, 95 arrow; 14 fixing cord member; 15 intermediate thread; 17 shaft tip portion; 18 shaft base side end portion; 20 stretched sheet member; 21 auxiliary member; 22 stacked sheet member; 31 auxiliary member; 32 shaft body portion; 41, 51 test piece; 42 central axis; 52 support member; 53 pressing member; 91 shaft fixing layer; 92 foam layer; 93, 94 adhesion layer.

**Claims**

**1.** An artificial feather for a shuttlecock, comprising:

a feather portion (5); and
a shaft (7) connected to said feather portion (5), said shaft (7) having a rectangular shape in cross section in a plane perpendicular to a direction in which said shaft (7) extends,
said shaft (7) including a uniaxially stretched material.

**2.** The artificial feather for a shuttlecock according to claim 1, wherein
said direction in which said shaft (7) extends is along a direction in which said uniaxially stretched material is stretched.

**3.** The artificial feather for a shuttlecock according to claim 1 or 2, wherein
at an end portion of said shaft (7) opposite to a portion thereof connected to said feather portion (5), said shaft (7) has an oblong shape in said cross section, and
a side in a width direction of a surface of said shaft (7) extending in a direction intersecting a main surface of said feather portion (5) having a relatively large area constitutes a long side of said oblong shape.

**4.** A badminton shuttlecock comprising:

a hemispherical base body (2); and
the artificial feather (3) for a shuttlecock according to claim 1 connected to said base body (2).

**5.** The badminton shuttlecock according to claim 4, wherein
at an end portion of said shaft (7) of said artificial feather (3) for a shuttlecock opposite to a portion thereof connected to said feather portion (5), said shaft (7) has an oblong shape in said cross section, a side in a width direction of a surface of said shaft (7) extending in a direction intersecting a main surface of said feather portion (5) having a relatively large area constitutes a long side of said oblong shape, and
said base body (2) and said artificial feather (3) for a shuttlecock are connected to each other such that said side in said width direction of said shaft (7) is along a radial direction extending outward from a center (12) of a surface of said base body (2) to which said artificial feather (3) for a shuttlecock is connected.

**6.** The badminton shuttlecock according to claim 5, wherein
said base body (2) and said artificial feather (3) for a shuttlecock are connected to each other such that said side in said width direction of said shaft (7) intersects said radial direction.

**7.** A method of manufacturing an artificial feather for a shuttlecock, comprising the steps of:

preparing a shaft (7) (S10); and
connecting a feather portion to said shaft (7) (S20),
said step of preparing a shaft (7) (S10) including the steps of
forming a stretched sheet member (20) by uniaxially stretching a raw material molded object by a factor of two or more (S11), and
cutting said shaft (7) from said stretched sheet member (20) (S12).

**8.** A method of manufacturing a badminton shuttlecock, comprising the steps of:

preparing a hemispherical base body;
manufacturing an artificial feather for a shuttlecock using the method of manufacturing an artificial feather for a shuttlecock according to claim 7 (S100); and
connecting said artificial feather for a shuttlecock to said base body (S200).

FIG.1

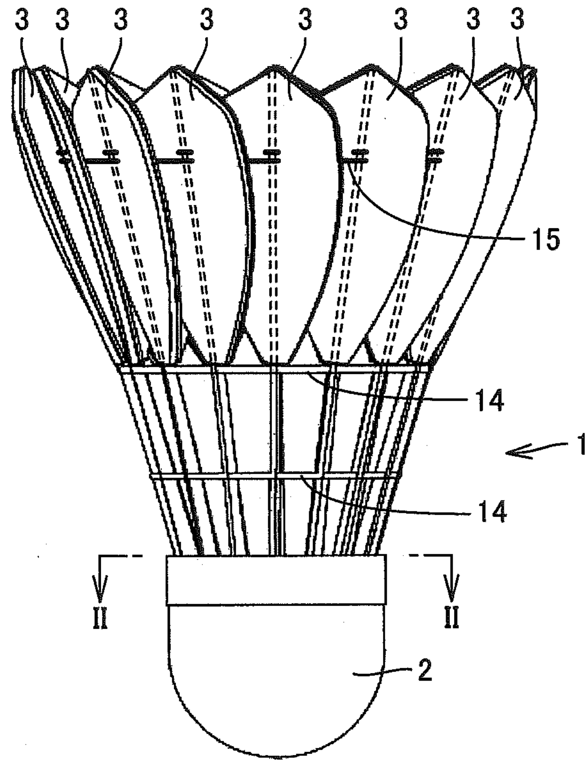



FIG.2

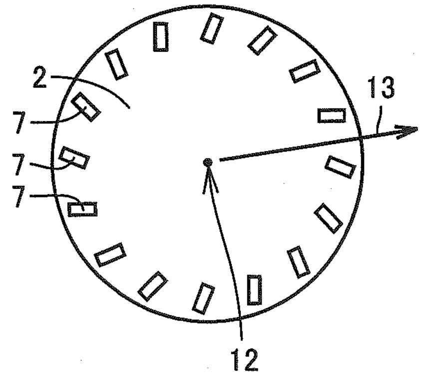


FIG.3

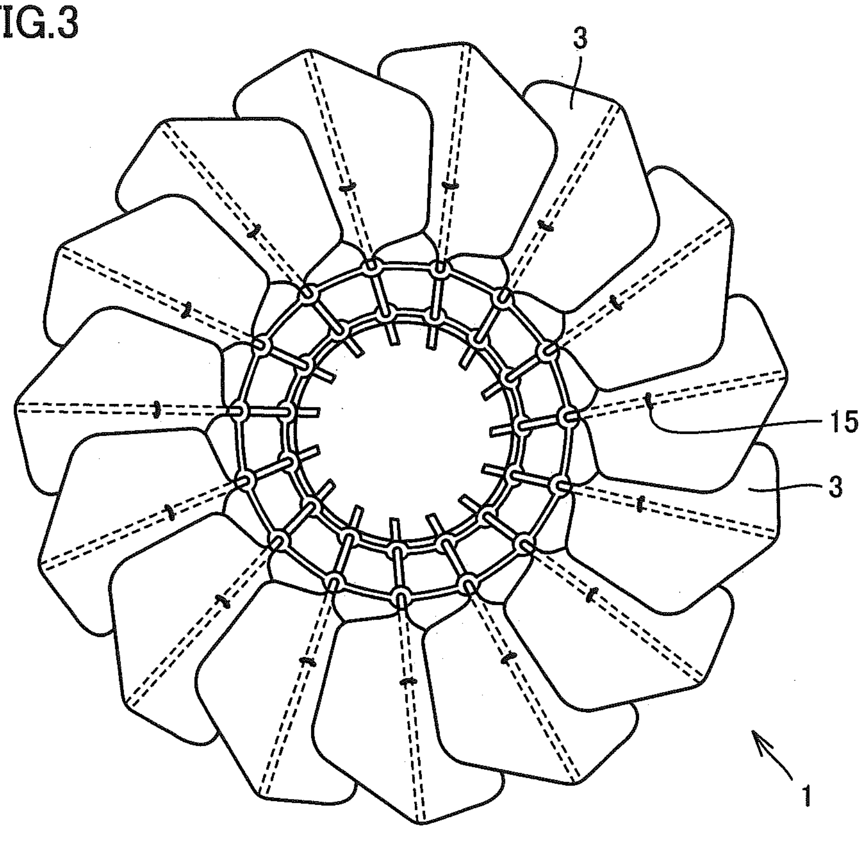


FIG.4

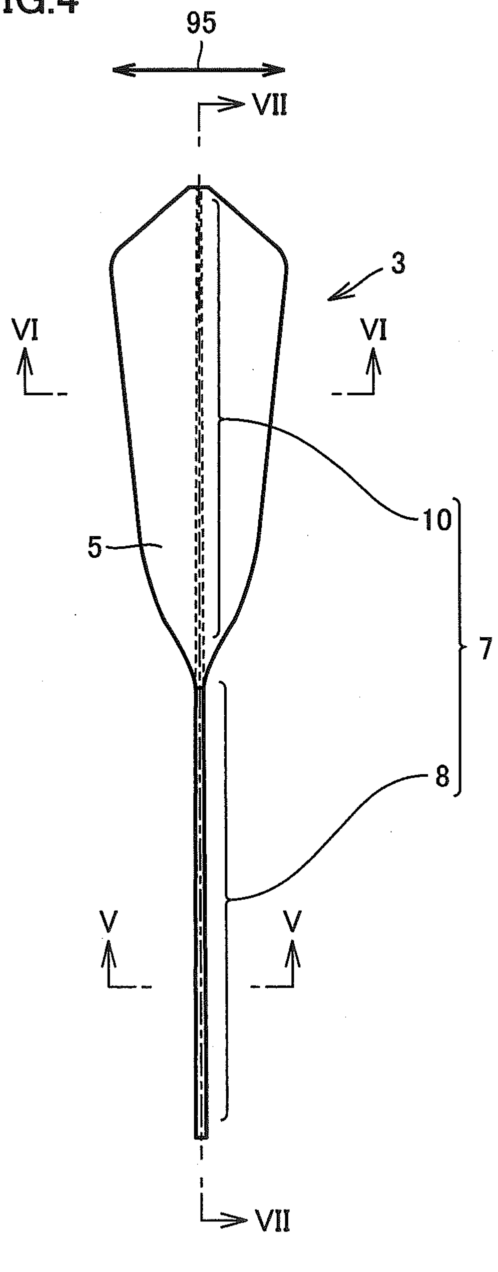


FIG.5

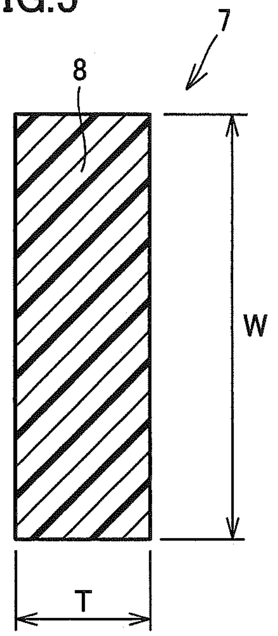



FIG.6

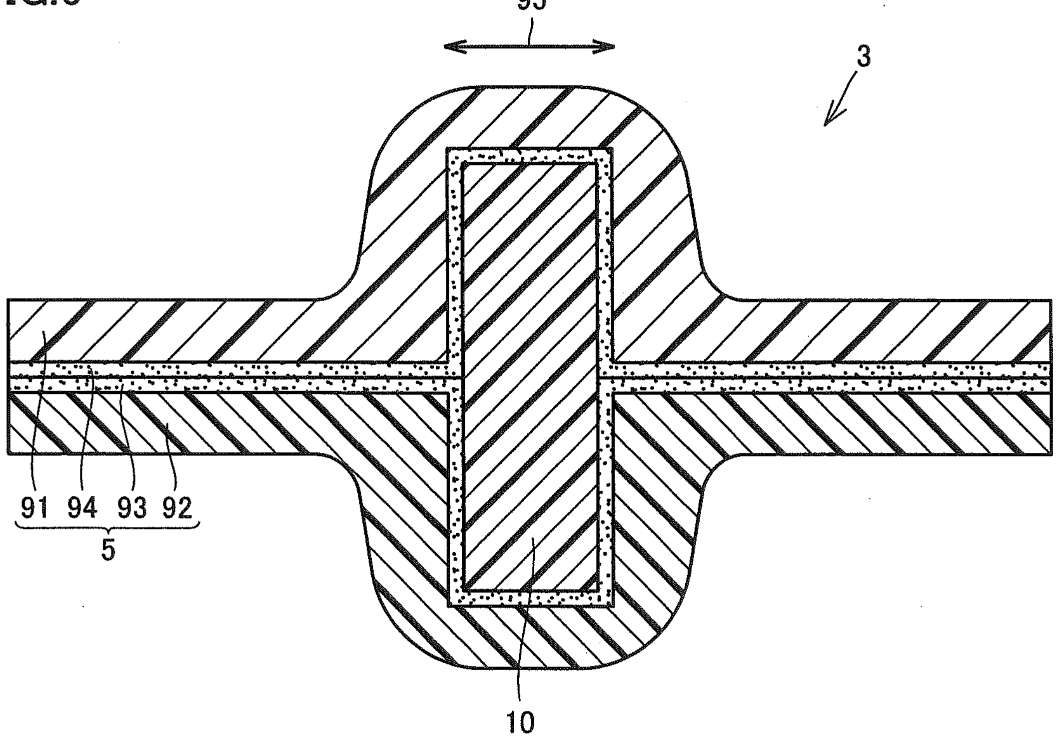


FIG.7

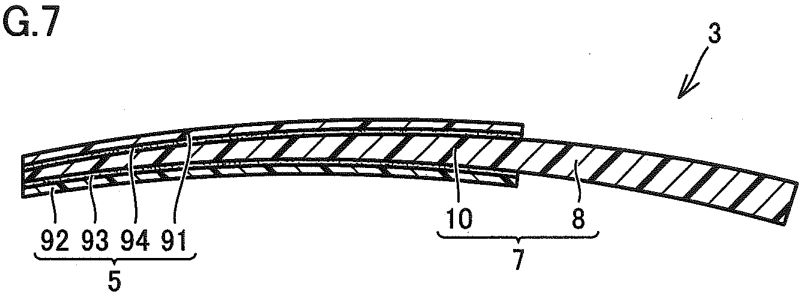



FIG.8

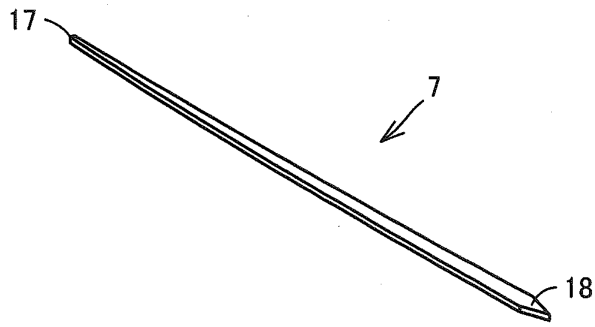



FIG.9

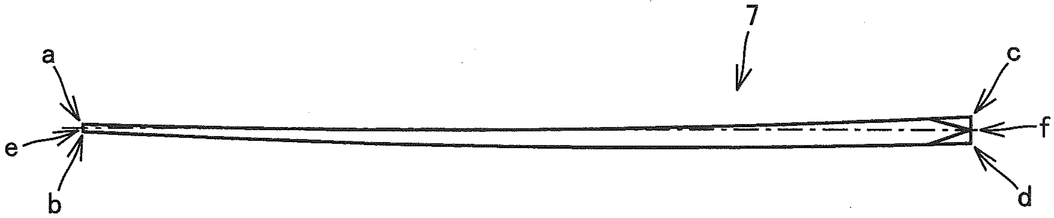


FIG.10

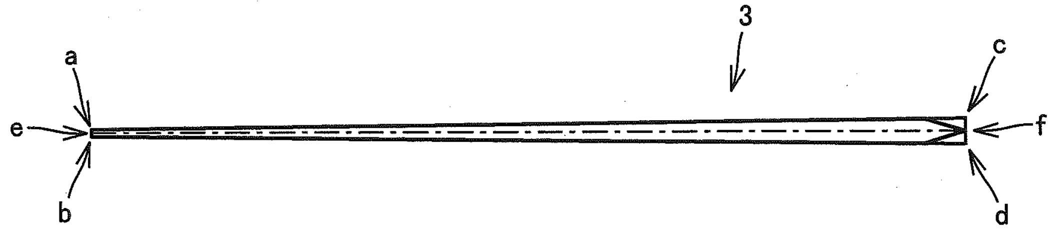



FIG.11

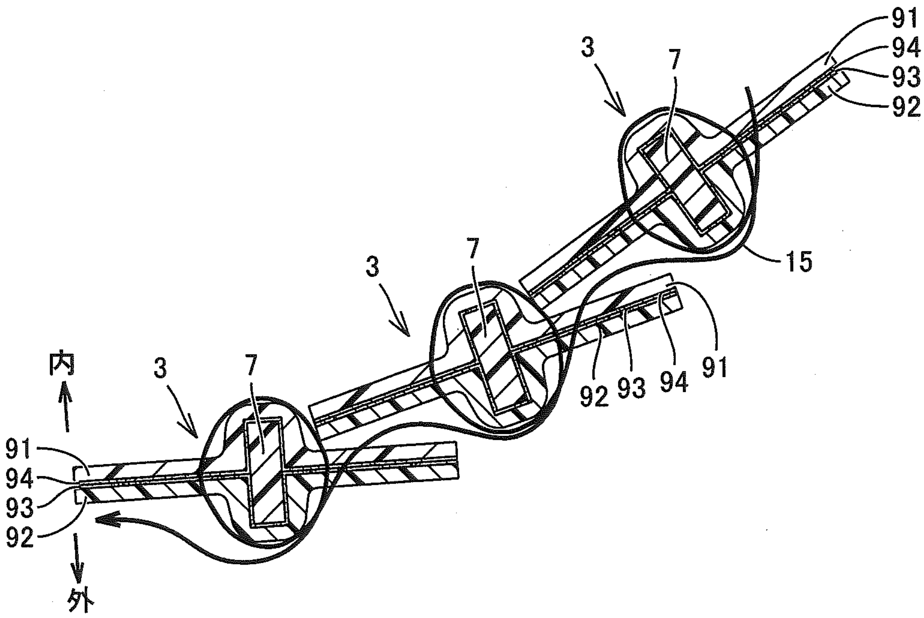


FIG.12

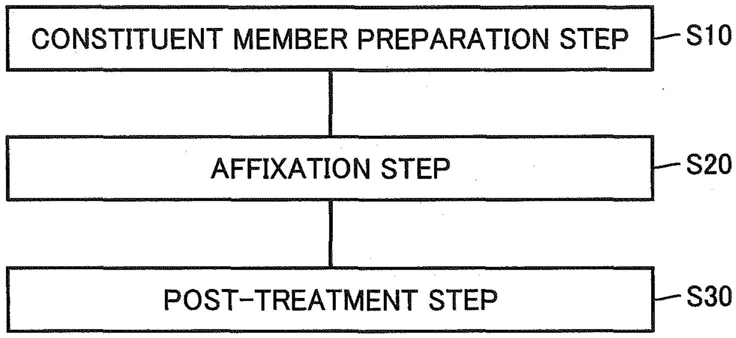



FIG.13

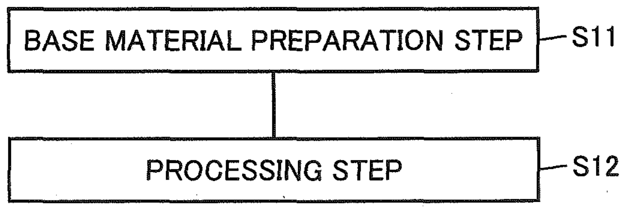



FIG.14

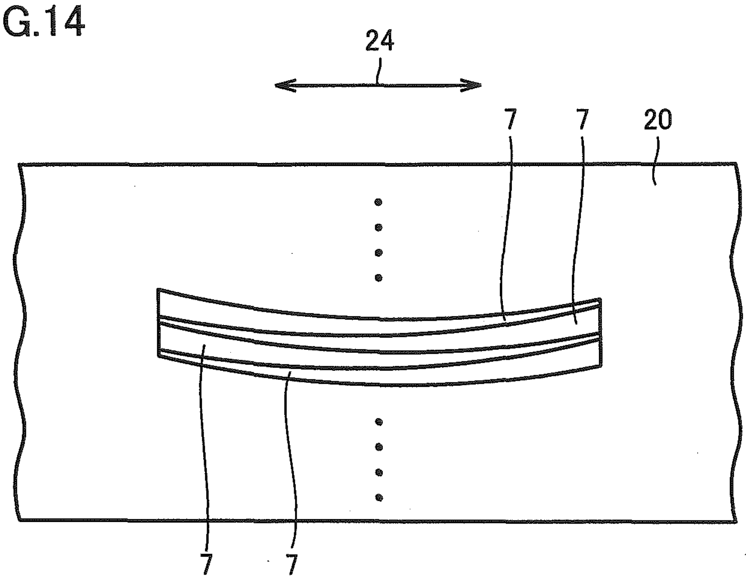


FIG.15

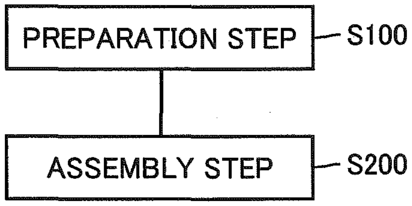



FIG.16

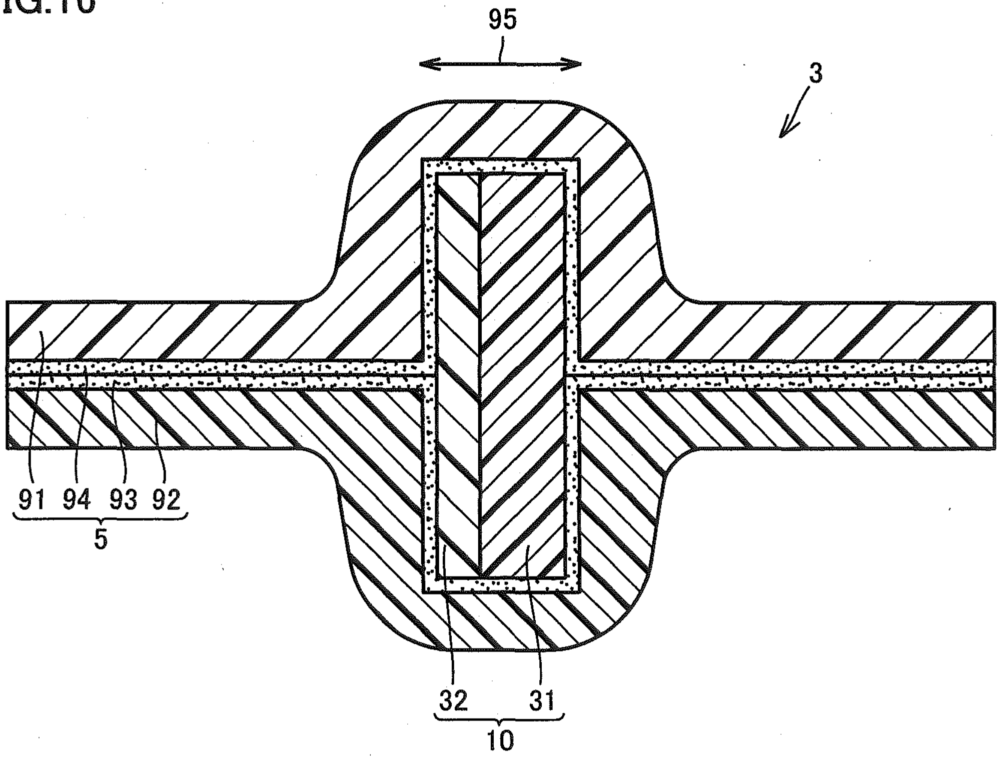



FIG.17

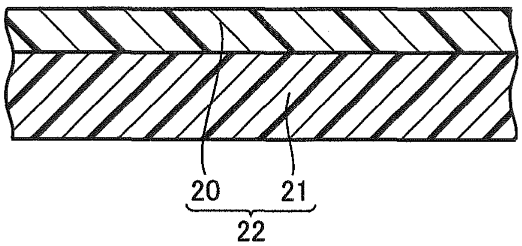


FIG.18

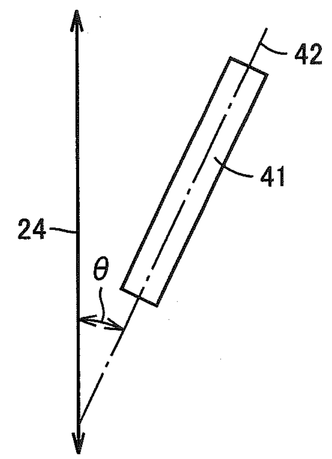



FIG.19

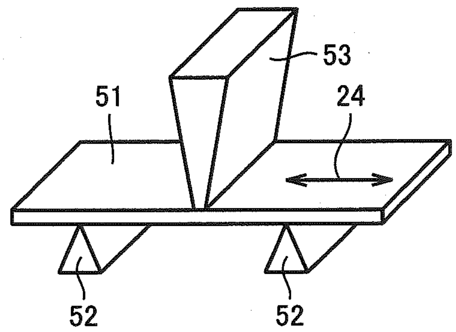
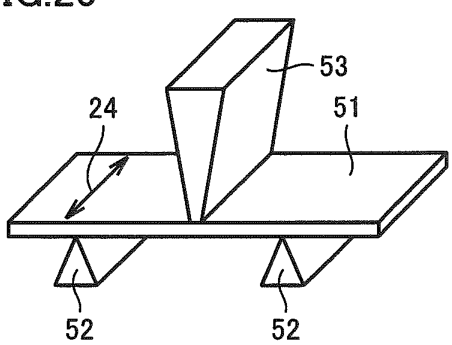



FIG.20



**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2012/058111

A. CLASSIFICATION OF SUBJECT MATTER
*A63B67/18*(2006.01)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)
A63B67/18

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 | 1996-2012 |
| Kokai Jitsuyo Shinan Koho | 1971-2012 | Toroku Jitsuyo Shinan Koho | 1994-2012 |

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. |
|---|---|---|
| A | JP 2010-220997 A (Toray Industries, Inc.), 07 October 2010 (07.10.2010), claim 1; paragraphs [0024], [0050]; fig. 1 (Family: none) | 1-8 |
| A | JP 2008-279179 A (Unitika Ltd.), 20 November 2008 (20.11.2008), claim 1; paragraph [0018]; fig. 1 (Family: none) | 1-8 |
| A | JP 2008-206970 A (Mizuno Inc.), 11 September 2008 (11.09.2008), paragraph [0024]; fig. 2, 12 & WO 2008/093649 A1 & CN 101578121 A | 1-8 |

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

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 07 May, 2012 (07.05.12) | 03 July, 2012 (03.07.12) |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| Japanese Patent Office | |
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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2012/058111

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 2010-82160 A (Mizuno Inc.), 15 April 2010 (15.04.2010), paragraph [0079]; fig. 4, 14, 55 & WO 2010/038657 A1 & CN 102164641 A | 1-8 |

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## REFERENCES CITED IN THE DESCRIPTION

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- JP 54136060 A **[0002] [0004]**
- JP 3620919 B **[0002] [0004]**
- JP 2029974 A **[0003] [0004]**
- JP 2008206970 A **[0003] [0004]**