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(54) **STRING SET, WARP STRING, AND WEFT STRING**

(57) To provide a string set that ensures improving a hairpin performance and a cut smash performance. A string set (20) is a string set strung on a racket as a main string and a cross string, and is configured to include a first string (22) strung as any one of the main string and the cross string and has a small friction force and a small diameter and a second string (21) strung as another one of the main string and the cross string and has a larger friction force and a larger diameter than the diameter and the surface friction force of the first string. This distributes functions to the first string and the second string to obtain both the hairpin performance, which is improved by the large surface friction force and outer diameter of the string, and the cut smash performance, which is improved by the small surface friction force and outer diameter of the string, at the same time.

FIG.3A

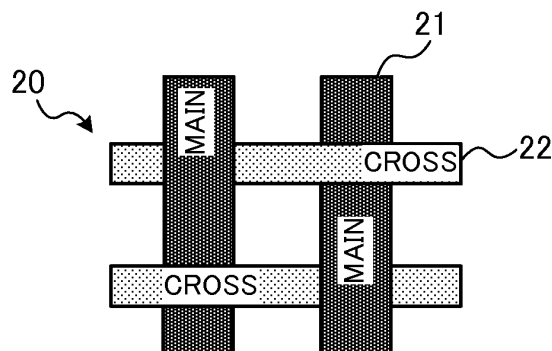
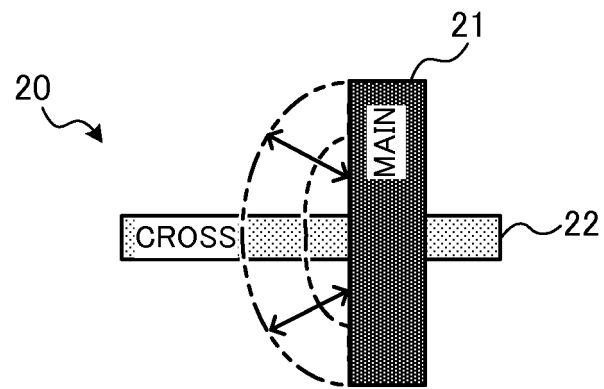


FIG.3B



Description

TECHNICAL FIELD

5 **[0001]** The present invention relates to a string set, a main string, and a cross string strung on a racket.

BACKGROUND ART

10 **[0002]** Generally, a badminton racket has a main string and a cross string strung such that the main string and the cross string intersect to form a face on which a shuttlecock is hit back. For each of the strings, there is known a string made by winding or braiding a side string around a multifilament core string and coating an outer surface. Various proposals to improve functions, such as durability, are made for such a string (for example, see Patent Document 1). For example, a string described in Patent Document 1 has improved string durability by adding a metal powder, such as titanium, in a coating agent.

15 **[0003]** Patent Document 1: Japanese Patent No. 3166031

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

20 **[0004]** As shots in badminton, there are known a shot called a hairpin and a shot called a cut smash. The hairpin is a shot that lightly repels a shuttle (shuttlecock) that is dropped near a net back into an opponent's court. The cut smash is a shot that uses a face of a racket to cut the shuttlecock that flies over the head so as to drop the shuttlecock near the net in the opponent's court. These shots require different functions in the string, and thus, it has been difficult to
25 improve a hairpin performance (spinning performance) and a cut smash performance at the same time.

[0005] The present invention has been made in consideration of such a point, and it is an objective of the present invention to provide a string set, a main string, and a cross string that ensure improving a hairpin performance and a cut smash performance.

30 SOLUTIONS TO THE PROBLEMS

[0006] A string set of the present invention is a string set strung on a racket as a main string and a cross string. The string set includes a first string and a second string. The first string is strung as any one of the main string and the cross string. The first string has a small surface friction force and a small diameter. The second string is strung as another
35 one of the main string and the cross string. The second string has a larger surface friction force and a larger diameter than the surface friction force and the diameter of the first string.

[0007] With this configuration, the second string has the large surface friction force and the large diameter, and thus, a friction force as well as a contacted area with a shuttlecock increases. Accordingly, a spin is easily applied to the shuttlecock repelled when a hairpin is shot, thereby improving the hairpin performance. The first string has the small
40 surface friction force and the small diameter, and thus, a friction force as well as a contacted area between the first string and the second string decreases. Accordingly, the first string and the second string easily moves relatively when a cut smash is shot, thereby improving the cut smash performance. Thus, distributing functions to the first string and the second string ensures obtaining both the hairpin performance, which is improved by the large surface friction force and outer diameter of the string, and the cut smash performance, which is improved by the small surface friction force and
45 outer diameter of the string, at the same time.

[0008] In the string set of the present invention, the first string is the cross string, and the second string is the main string. With this configuration, in addition to obtaining both the hairpin performance and the cut smash performance at the same time, it is possible to compensate the shortage of a feeling of shuttlecock hitting (repulsion) caused by the increased outer diameter of the main string by decreasing the outer diameter of the cross string. Increasing the outer
50 diameter of the main string, which is susceptible to an edge breakage, ensures lowering an edge breakage probability.

[0009] In the string set of the present invention, a friction force at which the second string moves with respect to the first string is 2.2 [N] or less. With this configuration, the second string easily moves with respect to the first string, thereby ensuring improving the cut smash performance.

[0010] In the string set of the present invention, the first string has an outer diameter that is 94% or less of an outer diameter of the second string. With this configuration, even when the second string is made to have a large diameter and the hairpin performance is improved, the second string can be made to easily move with respect to the first string, thereby ensuring improving the cut smash performance.

[0011] In the string set of the present invention, the first string and the second string form a face of the racket, and the

face has a surface friction force of 9 [N] or more. With this configuration, the surface friction force on the face increases, and therefore, a spin is easily applied to a shuttlecock repelled on the face.

[0012] In the string set of the present invention, the second string includes a coating film, and at least a superficial layer of the coating film of the second string has a property to increase a grip force corresponding to an increase in film thickness. With this configuration, the film thickness of at least the superficial layer of the coating film of the second string increases the grip force, thereby ensuring the increased surface friction force of the second string.

[0013] In the string set of the present invention, at least the superficial layer of the coating film of the second string is formed of polyurethane or rubber. With this configuration, a simple configuration ensures the increased surface friction force of the second string.

[0014] A cross string of the present invention is a cross string strung on a racket while intersecting with a main string, and the cross string has a smaller surface friction force and a smaller diameter than a surface friction force and a diameter of the main string.

[0015] With this configuration, the cross string is made to have a smaller surface friction force and a smaller diameter than the surface friction force and the diameter of the main string, thereby decreasing a friction force as well as a contacted area between the strings. Accordingly, the main string easily moves with respect to the cross string when a cut smash is shot, thereby improving the cut smash performance. Even when the main string having the large surface friction force and the large diameter makes it easy to apply a spin, and thus, the hairpin performance is improved, the main string sufficiently moves with respect to the cross string, and thus, the cut smash performance is not lowered. Thus distributing the functions to the main string and the cross string ensures obtaining both the hairpin performance, which is improved by the large surface friction force and outer diameter of the string, and the cut smash performance, which is improved by the small surface friction force and outer diameter of the string, at the same time.

[0016] A main string of the present invention is a main string strung on a racket while intersecting with a cross string, and the main string has a larger surface friction force and a larger diameter than a surface friction force and a diameter of the cross string.

[0017] With this configuration, the main string is made to have a larger surface friction force and a larger diameter than the surface friction force and the diameter of the cross string, thereby increasing a friction force as well as a contacted area between the shuttlecock and the main string. Accordingly, a spin is easily applied to the shuttlecock repelled when a hairpin is shot, thereby improving the hairpin performance. Even when the cross string having the small surface friction force and the small diameter makes it easy for the main string to move, and thus, the cut smash performance is improved, the surface friction force of the main string is sufficiently large, and thus, the hairpin performance is not lowered. Thus distributing the functions to the main string and the cross string ensures obtaining both the hairpin performance, which is improved by the large surface friction force and outer diameter of the string, and the cut smash performance, which is improved by the small surface friction force and outer diameter of the string, at the same time.

EFFECTS OF THE INVENTION

[0018] According to the present invention, using the first string having the small surface friction force and the small diameter in combination with the second string having the large surface friction force and the large diameter ensures improving the hairpin performance and the cut smash performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a front view of a racket on which a string is strung.

FIG. 2 includes explanatory diagrams of a hairpin performance and a cut smash performance according to a comparative example.

FIG. 3 includes explanatory diagrams of a hairpin performance and a cut smash performance according to an embodiment.

FIG. 4 is a cross-sectional schematic diagram of a string according to the embodiment.

FIG. 5 is a drawing showing a relation between a film thickness of polyurethane and a string gauge according to the embodiment.

FIG. 6 is a drawing showing a relation between a cross string gauge and a main string moving amount according to the embodiment.

FIG. 7 is a drawing showing a relation between the cross string gauge and a friction force when the main string moves according to the embodiment.

FIG. 8 is a drawing showing a relation between a friction force of the cross string and the friction force when the main string moves according to the embodiment.

FIG. 9 includes explanatory diagrams of a feeling of shuttlecock hitting and an edge breakage probability according to the embodiment.

FIG. 10 is a drawing showing a relation between the cross string gauge and a friction force when the cross string is threaded through according to the embodiment.

FIG. 11 is an explanatory diagram of a measuring method for a surface friction force according to the embodiment.

FIG. 12 is an explanatory diagram of a measuring method for a friction force when the main string moves according to the embodiment.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0020] The following describes a string set according to an embodiment with reference to the accompanying drawings. FIG. 1 is a front view of a racket on which a string is strung. FIG. 2 includes explanatory diagrams of a hairpin performance and a cut smash performance according to a comparative example. FIG. 3 includes explanatory diagrams of a hairpin performance and a cut smash performance according to an embodiment. It should be noted that an identical string is used for a main string and a cross string in the comparative example, and different strings are used for a main string and a cross string in the embodiment.

[0021] As illustrated in FIG. 1, a racket 50 of badminton includes a frame 53 on which a main string 21 and a cross string 22 are strung such that the main string 21 and the cross string 22 intersect to form a face 54 on which a shuttlecock is hit back. The main string 21 and the cross string 22 intersect such that relative positions of the strings are exchanged at intersecting positions. Only at these intersecting positions, the main string 21 and the cross string 22 are in contact. When the shuttlecock hits the face 54, an impact disperses on the main string 21 and the cross string 22 via the intersecting positions, and repulsion forces of the respective strings 21 and 22 repel the shuttlecock back.

[0022] As shots in badminton, there are known a shot called a hairpin and a shot called a cut smash. The hairpin is a shot that uses the face 54 of the racket 50 to lightly repel the shuttlecock back to near a net in an opponent's court. In this case, the shuttlecock is repelled with the face 54 of the racket 50 in an approximately horizontal, and when the shuttlecock is hit as if being scuffed, a spin is applied to the repelled shuttlecock, and thus, the shuttlecock is returned to the opponent's court along a nearly vertical trajectory. The cut smash is a shot that uses the face 54 to hit the shuttlecock as if cutting the shuttlecock so as to drop the shuttlecock near the net in the opponent's court. In this case, the face 54 obliquely hits the shuttlecock. The main string 21 is moved by the shuttlecock, and the main string 21 gives a rotation to the shuttlecock when returning, and thus, the shuttlecock is returned to the opponent's court along a sharply dropping trajectory.

[0023] As the comparative example illustrated in FIG. 2A, identical strings 41 and 42 are typically used for a main string and a cross string of a racket. In this case, a spin capability when a hairpin is shot is important as a factor to determine the hairpin performance. The spin is affected by a friction force between a surface of the strings 41 and 42 and a cork leather of the shuttlecock. In view of this, in order to improve the hairpin performance, it is important to increase string gauges (outer diameter) of the strings 41 and 42 and a surface friction force. Accordingly, increasing the string gauges of the strings 41 and 42 and the surface friction force in order to improve the hairpin performance causes a difficulty for the main string 41 to move, thereby lowering the cut smash performance.

[0024] Meanwhile, as illustrated in FIG. 2B, a mobility of the main string 41 is important as a factor to determine the cut smash performance. The mobility of the main string 41 is affected by a friction force and a contacted area between the strings. In view of this, in order to improve the cut smash performance, it is important to decrease the string gauges of the strings 41 and 42 and the surface friction force. Accordingly, decreasing the string gauges of the strings 41 and 42 and the surface friction force in order to improve the cut smash performance makes it difficult to apply a spin to the shuttlecock, thereby lowering the hairpin performance.

[0025] Thus, increasing the string gauges of the strings 41 and 42 and the friction force improves the hairpin performance but lowers the cut smash performance. Decreasing the string gauges of the strings 41 and 42 and the surface friction force improves the cut smash performance but lowers the hairpin performance. Since the hairpin performance and the cut smash performance are in a trade-off relationship, it has been difficult to improve the hairpin performance and the cut smash performance at the same time when the identical strings 41 and 42 are used for the main string and the cross string. In addition, there have occurred disadvantages, such as increasing the string gauges degrades the feeling of shuttlecock hitting, but conversely, decreasing the string gauges causes an easy edge breakage, and further, increasing the surface friction force makes it hard to string.

[0026] Therefore, in the embodiment, functions of the hairpin performance and the cut smash performance are distributed to the main string 21 (second string) having a large surface friction force and a large diameter and the cross string 22 (first string) having a small surface friction force and a small diameter. Then, the disadvantage caused by the increased string gauge of the main string 21 and surface friction force is improved by decreasing the string gauge of the cross string 22 and the surface friction force. Conversely, the disadvantage caused by the decreased string gauge of the cross string 22 and surface friction force is improved by increasing the string gauge of the main string 21 and the

surface friction force.

[0027] Specifically, as illustrated in FIG. 3A, a string set 20 of the embodiment includes the main string 21 and the cross string 22. The main string 21 has a larger surface friction force and a larger diameter than those of the cross string 22. The cross string 22 has a smaller surface friction force and a smaller diameter than those of the main string 21. Since the main string 21 is formed into the large surface friction force and the large diameter, a friction force and a contacted area between a surface of the main string 21 and the shuttlecock increase, and thus, a spin is easily applied to the shuttlecock. Thus, using the string 21 having the large surface friction force and the large diameter for the main string ensures improving the hairpin performance even though the string 22 having the small surface friction force and the small diameter is used for the cross string.

[0028] Meanwhile, as illustrated in FIG. 3B, since the cross string 22 is formed to have the small surface friction force and the small diameter, a contacted area and a surface friction force between the strings 21 and 22 decrease, and thus, the main string 21 easily moves with respect to the cross string 22. The main string 21 is significantly moved by the shuttlecock, and then a force of the main string 21 returning to the original state acts on the shuttlecock. Therefore, a cut smash is easily applied to the shuttlecock. Thus, using the string 22 having the small surface friction force and the small diameter for the cross string ensures improving the cut smash performance even though the string 22 having the large surface friction force and the large diameter is used for the main string.

[0029] Furthermore, a shortage of the feeling of shuttlecock hitting (repulsion) caused by the increased string gauge of the main string 21 is compensated by decreasing the string gauge of the cross string 22. Meanwhile, the easy edge breakage caused by the decreased string gauge of the cross string 22 is compensated by increasing the string gauge of the main string 21, which is in particular susceptible to the edge breakage. Furthermore, the difficulty in stringing caused by the increased surface friction force of the main string 21 is compensated by decreasing the surface friction force of the cross string 22.

[0030] The following describes the string set according to the embodiment in detail. FIG. 4 is a cross-sectional schematic diagram of the string according to the embodiment. It should be noted that a cross-sectional structure of the string according to the embodiment is not limited to the configuration illustrated in FIG. 4, and can be changed as necessary.

[0031] As illustrated in FIG. 4, the string 21 is configured by forming a coating film 16 around a structure 13 in a string shape formed of a core string 11 and side strings 12a and 12b. The structure 13 in the string shape is configured by braiding the side strings 12a and 12b around the multifilament core string 11. The side strings 12a and 12b constitute one set with a plurality of side strings, and eight sets in an S direction and eight sets in a Z direction are braided so as to cover the core string 11.

[0032] Around the structure 13 in the string shape, polyamide or the like coats an inner side, and subsequently, polyurethane coats a superficial layer to form the coating film 16 with a predetermined film thickness. That is, the coating film 16 is configured of a two-layer structure of a coating layer inside (inner layer) and a coating layer outside (superficial layer). The coating layer outside has a friction force (friction coefficient) higher than that of the coating layer inside. It should be noted that the coating film 16 may be formed only of the polyurethane. It should be noted that in the following description, a film thickness t of the coating film 16 of the main string 21 indicates a thickness from an outermost surface of the structure 13 in the string shape.

[0033] While it is not illustrated in detail, the cross string 22 is formed approximately similarly to the main string 21 except that a coating film is formed only of the polyamide and an outer diameter of a structure in the string shape is small. Unlike the main string 21, the cross string 22 has a superficial layer of the coating film formed of the polyamide as well, thereby having the surface friction force smaller than that of the main string 21. It should be noted that, while a material of the core string and the side string of the main string 21 and the cross string 22 is not limited, for example, the polyamide, polyester, and the like are used.

[0034] Next, the hairpin performance will be described. FIG. 5 is a drawing showing a relation between the film thickness of the polyurethane and the string gauge according to the embodiment. It should be noted that in FIG. 5, the horizontal axis indicates the film thickness of the polyurethane on the superficial layer of the coating film and the vertical axis indicates the string gauge. It should be noted that the coating film is formed of the polyurethane and the polyamide as described above. Decreasing a film thickness of the polyamide inside ensures increasing a film thickness of the polyurethane on the superficial layer. The indicated gauge is an outer diameter at a tension of 25 pounds.

[0035] As illustrated in FIG. 5, by repeating test hitting of a hairpin while the surface friction force of the string is changed, it was found that a player felt it was easy to apply a spin to a shuttlecock when a surface friction force of the string was at 9 [N] or more and it was much easier to apply a spin to the shuttlecock when it was at 12 [N] or more. Then, examining a relation between the film thickness of the coating film and the string gauge where the surface friction force of the string became 9 [N] or more and 12 [N] or more obtained the results illustrated in the drawing. Here, where the surface friction force of the string is 9 [N] or more is described as a spin region and where the surface friction force of the string is 12 [N] or more is described as a high spin region.

[0036] When the film thickness of the polyurethane indicated on the horizontal axis in FIG. 5 is 0 [μ m], a range R1 where the string gauge has approximately 0.80 [mm] to 0.94 [mm] is the spin region, and a range R2 where the string

gauge has approximately 0.94 [mm] or more is the high spin region. When the film thickness of the polyurethane is 8 [μm], a range R3 where the string gauge has approximately 0.50 [mm] to 0.65 [mm] is the spin region and a range R4 where the string gauge has approximately 0.65 [mm] or more is the high spin region. That is, in association with the increased film thickness of the polyurethane, the region where a spin is easily applied expands, and it is possible to obtain the surface friction force of 9 [N] or more even when the string gauge is small. It should be noted that the indicated gauge is the outer diameter at a tension of 25 pounds.

[0037] When the string gauge indicated on the vertical axis in FIG. 5 is 0.50 [mm], a range R5 where the film thickness is 8 [μm] or more is the spin region. When the string gauge is 0.80 [mm], a range R6 where the film thickness of the polyurethane is 0 [μm] to 2 [μm] is the spin region, and a range R7 where the film thickness of the polyurethane is 2 [μm] or more is the high spin region. That is, in association with the increased string gauge, the region where a spin is easily applied expands, and it is possible to obtain the surface friction force of 9 [N] or more even when the film thickness of the polyurethane is small. Thus, as the film thickness of the polyurethane and the string gauge increase, the region where a spin is easily applied expands. The surface friction force of the face 54 of the racket 50 formed of the cross string 22 and the main string 21 is susceptible to the surface friction force of the string (second string) with the larger surface friction force.

[0038] When the film thickness of the polyurethane is large, increasing a grip force to the shuttlecock increases the surface friction force of the string. When the string gauge is large, increasing a contacted area between the surface of the string and the cork leather of the shuttlecock increases the surface friction force of the string. Thus, in the embodiment, by adjusting the film thickness of the polyurethane and the string gauge, an appropriate friction force is given to the surface of the string. It should be noted that, the above-described string friction force is measured using Autograph AG-IS (made by SHIMADZU CORPORATION), for example, by sliding a weight having a cork leather attached on a contact surface on the string surface strung on a racket.

[0039] Specifically, as illustrated in FIG. 11, the racket 50 on which the strings 21 and 22 are longitudinally and vertically strung is placed on a horizontal table 60, and a plate-shaped weight 32 (1 [kg]) with a cork leather 31 is placed. One end of a wire rod 33 is attached to the weight 32, and the other end of the wire rod 33 is attached to a chuck 72 of a tension testing machine 70 (Autograph AG-IS) via a pulley 71. An elevation of the chuck 72 pulls the weight 32 on the surface of the string 21. A friction force generated between the strings 21 and 22 and the cork leather 31 is measured as a tensile force of the tension testing machine 70. That is, the surface friction force of the string 21 is a friction force generated when the weight 32 weighing 1 [kg] with the cork leather 31 slides with respect to the strings 21 and 22.

[0040] Next, in order to select an optimum material, superficial layers of the coating film were formed using three kinds of materials, polyamide to which a terpene resin is added, polyurethane with an excellent production stability, and rubber with an excellent friction. Then, surface friction forces of the strings were measured, and the surface friction forces were compared with the surface friction force of the string whose superficial layer of the coating film 16 was formed of the polyamide. Common condition was that the string gauge was 0.67 [mm] and the film thickness of the superficial layer of the coating film 16 was 10 [μm]. As a result, a result illustrated in Table 1 was obtained. The terpene resin is a tackifying resin made by processing turpentine and an orange oil as a raw material.

[Table 1]

SUPERFICIAL LAYER OF COATING FILM	SURFACE FRICTION FORCE
POLYAMIDE	REFERENCE (6.3 N)
POLYAMIDE + TERPENE RESIN	FAIR (7.6 N)
POLYURETHANE	GOOD (12.5 N)
RUBBER	GOOD (21.4 N)

[0041] The surface friction force of the string that used the polyamide to which the terpene resin is added was 7.6 [N] and was greater than 6.3 [N] of the surface friction force of the string that used the polyamide, but was less than 9 [N] where a spin is easily applied. In contrast to this, the surface friction forces of the strings that used the polyurethane and the rubber were 12.5 [N] and 21.4 [N], respectively, and were greater than 6.3 [N] of the surface friction force of the string that used the polyamide, and further, were equal to or more than 9 [N] where a spin is easily applied. From this, it was found that a sufficient friction force can be obtained by using the polyurethane and the rubber as the coating agent.

[0042] Accordingly, upon applying a spin to the shuttlecock with the string, it is preferred that the polyurethane or the rubber is used as the material of the superficial layer of the coating film 16. Furthermore, from the aspect of processing stability, it is more preferred to use the polyurethane. It should be noted that the material of the superficial layer of the coating film is not limited to the above-described materials, and any materials may be used as long as the surface friction force of the string becomes 9 [N] or more. For example, it is possible to even use the polyamide and the polyamide to

which the terpene resin is added as the material of the coating film by adjusting the film thickness of the coating film 16 and a size of the string gauge to make the surface friction force of the string 9 [N] or more. When the surface friction force of the string is 9 [N] or more, a material identical to that of an inside of the coating film, for example, the polyamide may form the superficial layer.

[0043] Next the cut smash performance will be described. FIG. 6 is a drawing showing a relation between the cross string gauge and the main string moving amount according to the embodiment. FIG. 7 is a drawing showing a relation between the cross string gauge and a friction force when the main string moves according to the embodiment. FIG. 8 is a drawing showing a relation between a friction force of the cross string and the friction force when the main string moves according to the embodiment. It should be noted that, in FIG. 6, the horizontal axis indicates a size of the cross string gauge and the vertical axis indicates a moving amount of the main string. In FIG. 7, the horizontal axis indicates the size of the cross string gauge and the vertical axis indicates the friction force when the main string moves. In FIG. 8, the horizontal axis indicates the friction force of the cross string and the vertical axis indicates the friction force when the main string moves. The following describes the main string as a warp string, cross string as a weft string, the string gauge for main string as a main string gauge, and the string gauge for cross string as a cross string gauge.

[0044] As illustrated in FIG. 6, the cut smash performance was checked by changing the cross string gauge with respect to the main string having the main string gauge of 0.67 [mm] and the film thickness of the polyurethane of 10 [μ m]. Here, the main string and the cross string were strung at 25 pounds on a racket, ARC8DX (made by YONEX CO., LTD.), and then hitting was performed with a hitting angle of 30 degrees and a swinging speed of 200 [km/h] using a shooting machine. When the cross string gauge is 0.65 [mm], the main string moving amount is approximately 5.50 [mm], and when the cross string gauge is 0.63 [mm], for main string moving amount is approximately 6.00 [mm] or more. From this, it was confirmed that as the cross string gauge decreased, the main string moving amount increased, and thus, a cut smash was easily applied to the shuttlecock.

[0045] Here, by repeating test hitting while the cross string gauge was changed, it was found that the player felt it was easy to apply a cut smash when the main string moving amount was 6.0 [mm] or more. Measurement of the friction force when the main string at this time moved was 2.2 [N] or less. Therefore, the friction force of the cross string gauge and the cross string at which the friction force when the main string moved became 2.2 [N] or less was checked. Then, the results illustrated in FIG. 7 and FIG. 8 were obtained. It should be noted that the friction force when the main string moves is measured by, for example, weaving the cross string into the main string secured by applying a load of 1000 g, applying a load of 300 g to the cross string, mounting the cross string on a force gauge FG-5005 (made by Sato Shoji Corporation), and moving the force gauge with a ROBO Cylinder RCP2 (made by IAI Corporation) as an electric slider.

[0046] Specifically, as illustrated in FIG. 12, a 60 [cm] long main string 82 is wound to a plurality of roller pins 91a so as to meander, one end of the main string 82 is secured to a securing pin 91b, and the other end of the main string 82 is attached to a weight 94 of 1000 [g] via a pulley 92. A 90 [cm] long cross string 81 is wound to a plurality of roller pins 91c so as to thread through the main string 82, one end of the cross string 81 is attached to a hook 96 of a force gauge 97, and the other end of the cross string 81 is attached to a weight 95 of 300 [g] via a pulley 93. This brings the cross string 81 and the main string 82 in contact at a plurality of intersecting positions 85 (fifteen positions in the embodiment).

[0047] The force gauge 97 is mounted to an electric slider 98, and is slid at a tension speed of 600 [mm/min] and for a movement distance of 100 [mm]. Then, slidability is measured. That is, the friction force when the main string moves is a relative friction force generated when the cross string 81 to which the weight weighing 300 [g] is attached is slid with respect to the main string 82 to which the weight weighing 1000 [g] is attached in a state where the cross string 81 is in contact with the main string 82 at the plurality of intersecting positions 85 (fifteen positions in the embodiment).

[0048] As illustrated in FIG. 7, a friction force when the main string moved was checked by changing the cross string gauge with respect to the main string having the main string gauge of 0.67 [mm] and the film thickness of the polyurethane of 10 [μ m]. When the cross string gauge is 0.65 [mm], a friction force when the main string moves is approximately 2.6 [N], and therefore, the main string is difficult to move and it is difficult to apply a cut smash. When the cross string gauge is 0.63 [mm] or less, a friction force when the main string moves is 2.2 [N] or less, and therefore, the main string is easy to move and it is easy to apply a cut smash. Thus, it was confirmed that 0.63 [mm] or less of the cross string gauge with respect to 0.67 [mm] of the main string gauge, that is, cross string gauge having 94% or less of the main string gauge improved the cut smash performance.

[0049] As illustrated in FIG. 8, a friction force when the main string moved was checked by changing a surface friction force of the cross string having the cross string gauge of 0.61 [mm] with respect to the main string having the main string gauge of 0.67 [mm] and the surface friction force of 4.3 [N]. When the surface friction force of the cross string is 2.3 [N], the friction force when the main string moves is approximately 2.8 [N], and therefore, the main string is difficult to move and it is difficult to apply a cut smash. When the friction force of the cross string is 2.0 [N] or less, the friction force when the main string moves is 2.2 [N] or less, and therefore, the main string is easy to move and it is easy to apply a cut smash. Thus, it was confirmed that 2.0 [N] or less of the surface friction force of the cross string with respect to 4.3 [N] of the surface friction force of the main string improved the cut smash performance.

[0050] Next, the feeling of shuttlecock hitting and the edge breakage probability will be described. FIG. 9 includes

explanatory diagrams of the feeling of shuttlecock hitting and the edge breakage probability according to the embodiment. FIG. 9A is the explanatory diagram of the feeling of shuttlecock hitting. FIG. 9B is the explanatory diagram of the edge breakage probability.

[0051] As illustrated in FIG. 9A, feelings of shuttlecock hitting were checked by hitting the shuttlecock and comparing the feelings of shuttlecock hitting between when the main string gauge and the cross string gauge were identical and when the main string gauge was increased and the cross string gauge was decreased. When both the main string gauge and the cross string gauge were 0.67 [mm], a repulsion of the shuttlecock decreased. When both the main string gauge and the cross string gauge were 0.63 [mm], the repulsion of the shuttlecock increased. Thus, when the main string gauge and the cross string gauge are identical, the repulsion improves by decreasing both the main string gauge and the cross string gauge.

[0052] In contrast to this, when the main string gauge was 0.67 [mm] and the cross string gauge was 0.61 [mm], a repulsion similar to that of when both the main string gauge and the cross string gauge were 0.63 [mm] was obtained. That is, the repulsion better than that of when both the main string gauge and the cross string gauge were 0.67 [mm] was obtained. Thus, it was confirmed that even when the main string gauge was increased, decreasing the cross string gauge ensured obtaining a sufficient repulsion.

[0053] As illustrated in FIG. 9B, edge breakage probabilities were checked by hitting the shuttlecock and comparing the edge breakage probabilities between when the main string gauge and the cross string gauge were identical and when the main string gauge was increased and the cross string gauge was decreased. Here, test hitting examinations were executed by stringing the main string and the cross string at 30 to 32 pounds on a racket. It should be noted that, the edge breakage means that a string is cut off at an edge of a frame, and the edge breakage probability means a probability of the edge breakage of the main string or the cross string strung on the racket. When both the main string gauge and the cross string gauge were 0.63 [mm], the edge breakage probability was approximately 68%.

[0054] In contrast to this, when the main string gauge was 0.67 [mm] and the cross string gauge was 0.61 [mm], the edge breakage probability decreased down to approximately 32%. Increasing the main string gauge and decreasing the cross string gauge tremendously lowers the edge breakage probability. This is considered because the edge breakage is typically more likely to occur in the main string, and the size of the main string gauge affects the edge breakage probability easier than the size of the cross string gauge affects the edge breakage probability. Thus, it was confirmed that even when the cross string gauge was decreased, increasing the main string gauge ensured lowering the edge breakage probability.

[0055] From the results in FIG. 9A and FIG. 9B described above, it was confirmed that decreasing the cross string gauge while increasing the main string gauge enabled to lower the edge breakage probability without deteriorating the feeling of shuttlecock hitting to the shuttlecock. Accordingly, it is possible to compensate the shortage of repulsion caused by the increased main string gauge in order to improve the hairpin performance by decreasing the cross string gauge. It is possible to decrease the increase in the edge breakage probability caused by the decreased cross string gauge in order to improve the cut smash performance by increasing the main string gauge.

[0056] Next, a stringability will be described. Usually, when the main string and the cross string are strung on a racket, the main string is strung on the racket, and then, the cross string is strung so as to thread through the main string. In view of this, the stringability changes depending on a threadability of the cross string through the main string in a state where the main string is strung on the racket. FIG. 10 is a drawing illustrating a relation between the cross string gauge and a friction force when the cross string is threaded through according to the embodiment. It should be noted that in FIG. 10, the horizontal axis indicates the size of the cross string gauge and the vertical axis indicates the friction force when the cross string is threaded through. It is not smooth when the friction force when the cross string is threaded through is 3.0 [N] or more, and thus, it is in a region where a difficulty in stringing is felt.

[0057] As illustrated in FIG. 10, threadabilities of the cross string through the main string having a main string gauge of 0.67 [mm] and a thickness of polyurethane of 10 [μ m] were checked when a cross string having a polyurethane coating (film thickness of 10 [μ m]) was used and when a cross string having a nylon coating was used. When the cross string with the polyurethane coating was used, a friction force when the cross string was threaded through the main string was 3.0 [N] or more with the cross string gauge in a range of 0.55 to 0.70 [mm], and thus, slidability of the cross string was poor. Accordingly, when both the main string and the cross string are coated with the polyurethane to enhance the surface friction, the stringability lowers.

[0058] In contrast to this, when the cross string with the nylon coating was used, a friction force when the cross string was threaded through the main string was 3.0 [N] or less with the cross string gauge in a range of 0.55 to 0.70 [mm], and thus, slidability of the cross string was good. Accordingly, when the cross string is coated with ordinary nylon to reduce the surface friction force, the stringability improves. Thus, it is possible to compensate the lowered stringability caused by the increased surface friction force of the main string in order to improve the hairpin performance by decreasing the surface friction force of the cross string.

(Working Examples)

[0059] While the following further describes the present invention in detail based on working examples, these are described for explanation, and the scope of the present invention is not limited to the following working examples.

[0060] Strings having a string gauge of 0.67 [mm] and film thicknesses of the polyurethane of 0 [μm], 4 [μm], and 6 [μm] were prepared, and actual test hitting evaluations of a hairpin were executed. Ten intermediate to advanced players in the age group of twenties to fifties evaluated spin capabilities into six levels of "excellent," "good," "slightly good," "normal," "slightly poor," and "poor." As a result, the result illustrated in Table 2 was obtained.

[Table 2]

POLYURETHANE FILM THICKNESS [μm]	SPIN CAPABILITY					
	EXCELLENT	GOOD	SLIGHTLY GOOD	NORMAL	SLIGHTLY POOR	POOR
0	0	0	0	10	0	0
4	0	9	0	0	0	1
6	4	3	2	0	1	0

[0061] The string with the film thickness of the polyurethane of 0 [μm] was evaluated as a reference (normal). In contrast to this, when the film thickness of the polyurethane was 4 [μm], nine players evaluated as "good," and only one player evaluated as "poor." When the film thickness of the polyurethane was 6 [μm], four players evaluated as "excellent," three players evaluated as "good," two players evaluated as "slightly good," and only one player evaluated as "slightly poor." That is, nine out of ten players evaluated that it spun better than "normal" with both strings with the polyurethane film thicknesses of 4 [μm] and 6 [μm]. Thus, it was obtained the evaluation that a spin was easily applied with the polyurethane film thicknesses of 4 [μm] and 6 [μm], that is, the surface friction force of 9 [N] or more (see FIG. 5).

[0062] Next, cross strings having cross string gauges of 0.65 [mm], 0.63 [mm], 0.61 [mm], and 0.58 [mm] and a main string having a main string gauge of 0.67 [mm] and a polyurethane film thickness of 10 [μm] were prepared, and actual test hitting evaluations of a cut smash were executed. Here, the main string and the cross string were strung at 23 pounds on a racket, NR900 (made by YONEX CO., LTD.). Ten intermediate to advanced players in the age group of twenties to fifties evaluated cut smash capabilities into five levels of "good," "slightly good," "normal," "slightly poor," and "poor." As a result, the result illustrated in Table 3 was obtained.

[Table 3]

CROSS STRING GAUGE [mm]	GOOD	SLIGHTLY GOOD	NORMAL	SLIGHTLY POOR	POOR
0.65	2	2	2	4	0
0.63	2	4	3	1	0
0.61	2	5	2	1	0
0.58	7	3	0	0	0

[0063] When the size of the cross string gauge was 0.65 [mm], two players evaluated as "good," two players evaluated as "slightly good," two players evaluated as "normal," and four players evaluated as "slightly poor." When the size of the cross string gauge was 0.63 [mm], two players evaluated as "good," four players evaluated as "slightly good," three players evaluated as "normal," and one player evaluated as "slightly poor." When the size of the cross string gauge was 0.61 [mm], two players evaluated as "good," five players evaluated as "slightly good," two players evaluated as "normal," and one player evaluated as "slightly poor." When the size of the cross string gauge was 0.58 [mm], seven players evaluated as "good," and three players evaluated as "slightly good." That is, equal to or more than the half evaluated any of the strings with the cross string gauges sized 0.63 [mm], 0.61 [mm], and 0.58 [mm] as higher than "normal."

[0064] As described above, in the string set 20 according to the embodiment, using the main string 21 having a larger surface friction force and a larger diameter than those of the cross string 22 increases the friction force as well as the contacted area between the shuttlecock and the main string 21. Accordingly, a spin is easily applied to the shuttlecock repelled when a hairpin is shot, thereby improving the hairpin performance. Using the cross string 22 having a smaller surface friction force and a smaller diameter than those of the main string 21 decreases the friction force as well as the contacted area between the main string 21 and the cross string 22. Accordingly, the main string 21 is easily moved with

respect to the cross string 22 when a cut smash is shot, thereby improving the cut smash performance. Thus, distributing functions to the main string 21 and the cross string 22 ensures obtaining both the hairpin performance, which is improved by the large surface friction force and outer diameter of the string, and the cut smash performance, which is improved by the small surface friction force and outer diameter of the string, at the same time.

[0065] It should be noted that, the present invention is not limited to the above-described embodiment, and can be variously changed to embody. In the above-described embodiment, size, shape, direction, and the like illustrated in the attached drawings are not limited to those, and may be appropriately changed in a range that can provide the effects of the present invention. Moreover, the present invention may be appropriately changed to embody without departing from a scope of the object of the present invention.

[0066] For example, in the embodiment, while the structure 13 in the string shape is configured by braiding the side strings 12a and 12b around the core string 11, the structure 13 in the string shape may be configured only of the core string 11. While it is configured such that the side strings 12a and 12b are braided around the core string 11, it may be configured such that only one layer of the side string is wound around the core string 11. Furthermore, two layers of the side string may be wound around and string gauges (outer diameter) of the first layer and the second layer of the side strings may be different.

[0067] In the embodiment, the core string 11 and the side strings 12a and 12b may be configured of any of a multifilament and a monofilament, and a count is not limited. When the core string 11 is the monofilament, the cross-sectional surface is not limited to a circular shape, and the cross-sectional surface may be polygonal (such as a pentagonal shape). Furthermore, a hollow thread may be used for the core string 11 and the side strings 12a and 12b.

[0068] In the embodiment, while the strings 21 and 22 have a configuration of being formed of the synthetic fiber, the configuration is not limited to this. The structure 13 in the string shape of the strings 21 and 22 may be formed of a natural string made of a natural fiber, such as a sheep casing and a whale's muscle.

[0069] In the embodiment, while there has been described the configuration in which the polyamide is coated on the cross string 22, it is not limited to this configuration. The coating film of the cross string 22 may be formed in any way as long as it is possible to improve the cut smash performance by having a friction force smaller than that of the main string 21 so as to cause the main string 21 to easily move.

[0070] In the embodiment, while it is configured to use the string having the small friction force and the small diameter for cross string and the string having the large friction force and the large diameter for main string, the configuration is not limited to this. It is possible to obtain both the hairpin performance and the cut smash performance at the same time even when a string having a small friction force and a small diameter is used for main string and a string having a large friction force and a large diameter is used for cross string.

[0071] This application is based on Japanese Patent Application No. 2016-089286 filed on April 27, 2016, and the disclosure of which is incorporated herein.

Claims

1. A string set strung on a racket as a main string and a cross string, the string set comprising:

a first string strung as any one of the main string and the cross string, the first string having a small surface friction force and a small diameter; and
a second string strung as another one of the main string and the cross string, the second string having a larger surface friction force and a larger diameter than the surface friction force and the diameter of the first string.

2. The string set according to claim 1, wherein
the first string is the cross string, and
the second string is the main string.

3. The string set according to claim 1 or 2, wherein
a friction force at which the second string moves with respect to the first string is 2.2 [N] or less.

4. The string set according to any one of claims 1 to 3, wherein
the first string has an outer diameter that is 94% or less of an outer diameter of the second string.

5. The string set according to any one of claims 1 to 4, wherein
the first string and the second string form a face of the racket, the face having a surface friction force of 9 [N] or more.

6. The string set according to claim 5, wherein

the second string includes a coating film, and
at least a superficial layer of the coating film of the second string has a property to increase a grip force corresponding
to an increase in film thickness.

- 5 7. The string set according to claim 6, wherein
the at least the superficial layer of the coating film of the second string is formed of polyurethane or rubber.
- 10 8. A cross string strung on a racket while intersecting with a main string, wherein
the cross string has a smaller surface friction force and a smaller diameter than a surface friction force and a diameter
of the main string.
- 15 9. A main string strung on a racket while intersecting with a cross string, wherein
the main string has a larger surface friction force and a larger diameter than a surface friction force and a diameter
of the cross string.

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FIG.1

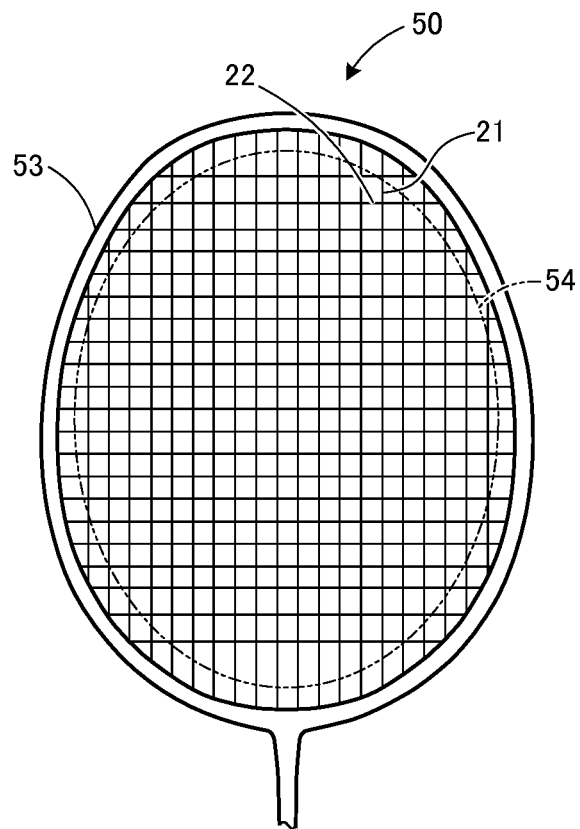


FIG.2A

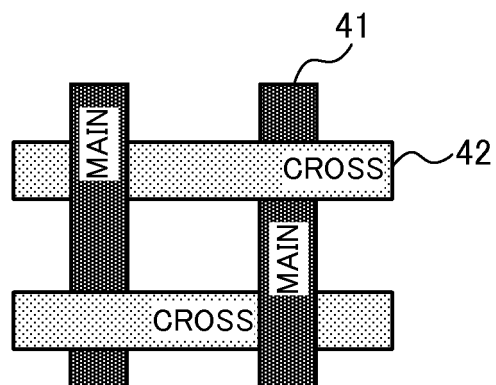


FIG.2B

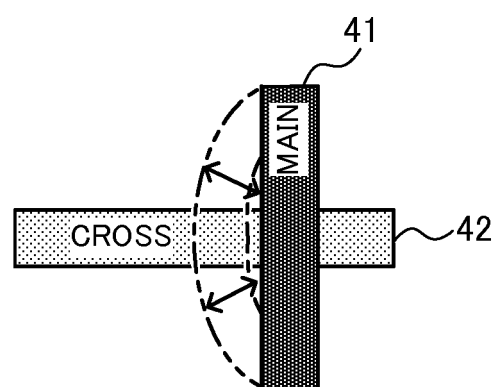


FIG.3A

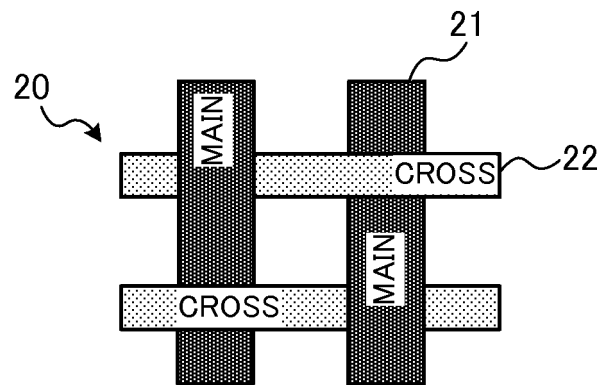


FIG.3B

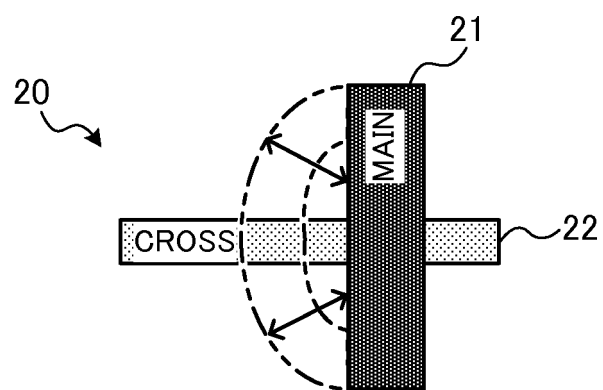


FIG.4

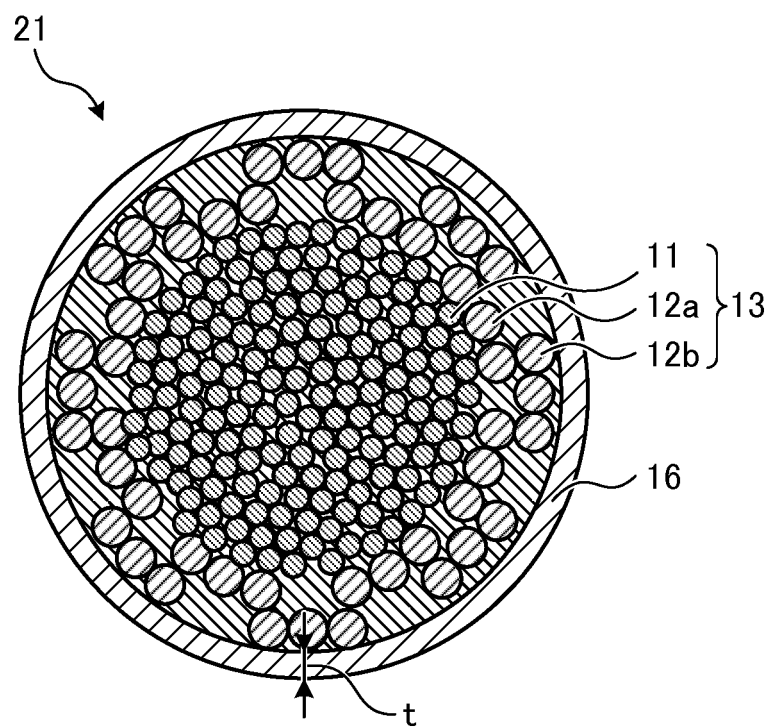


FIG.5

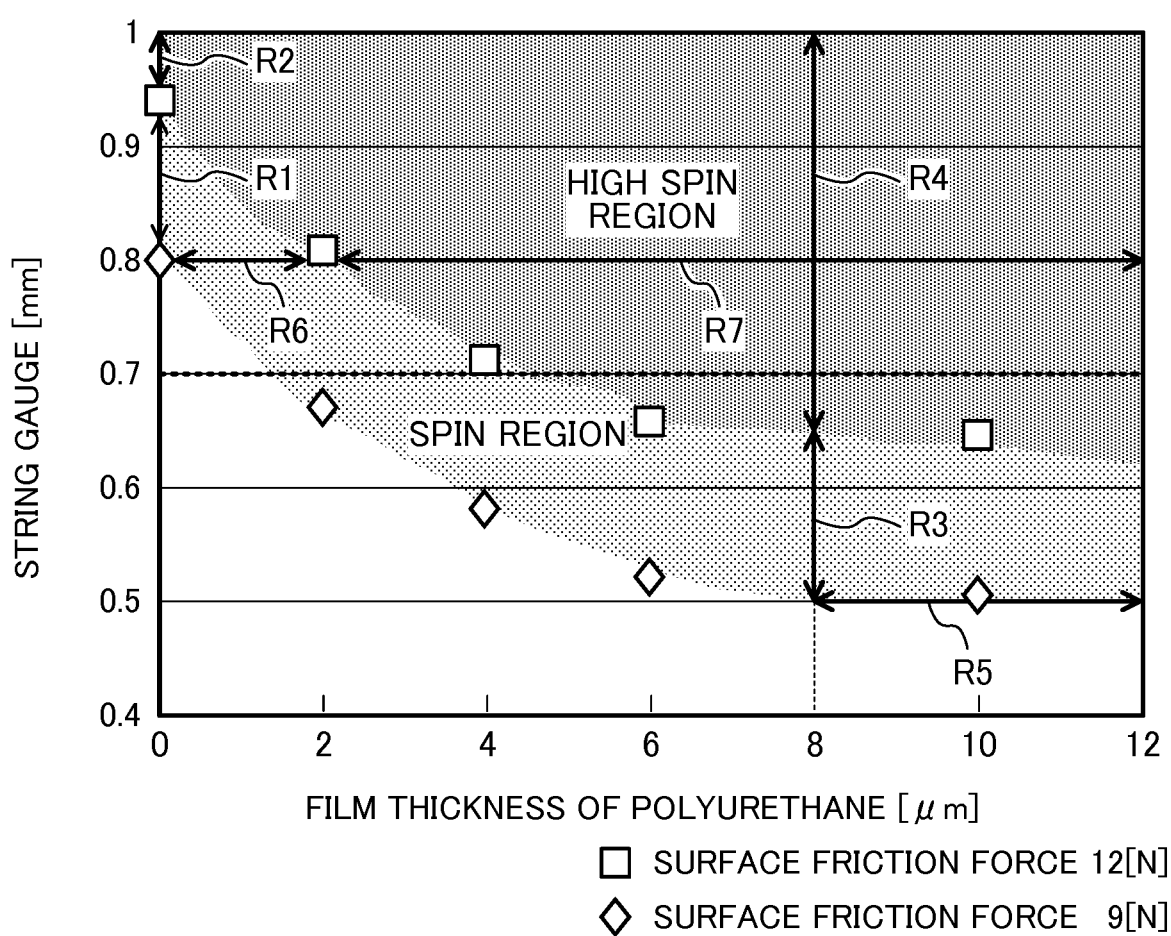


FIG.6

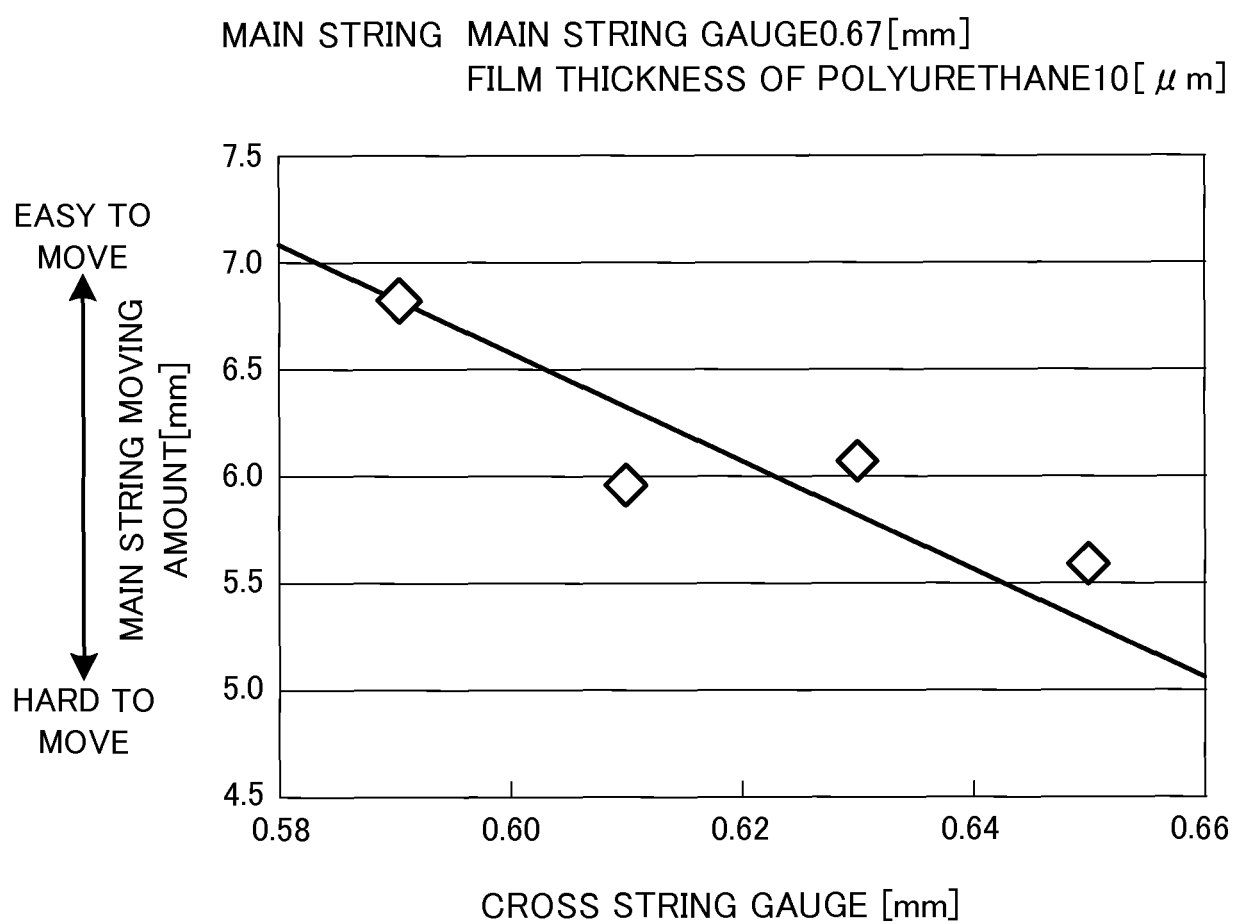


FIG.7

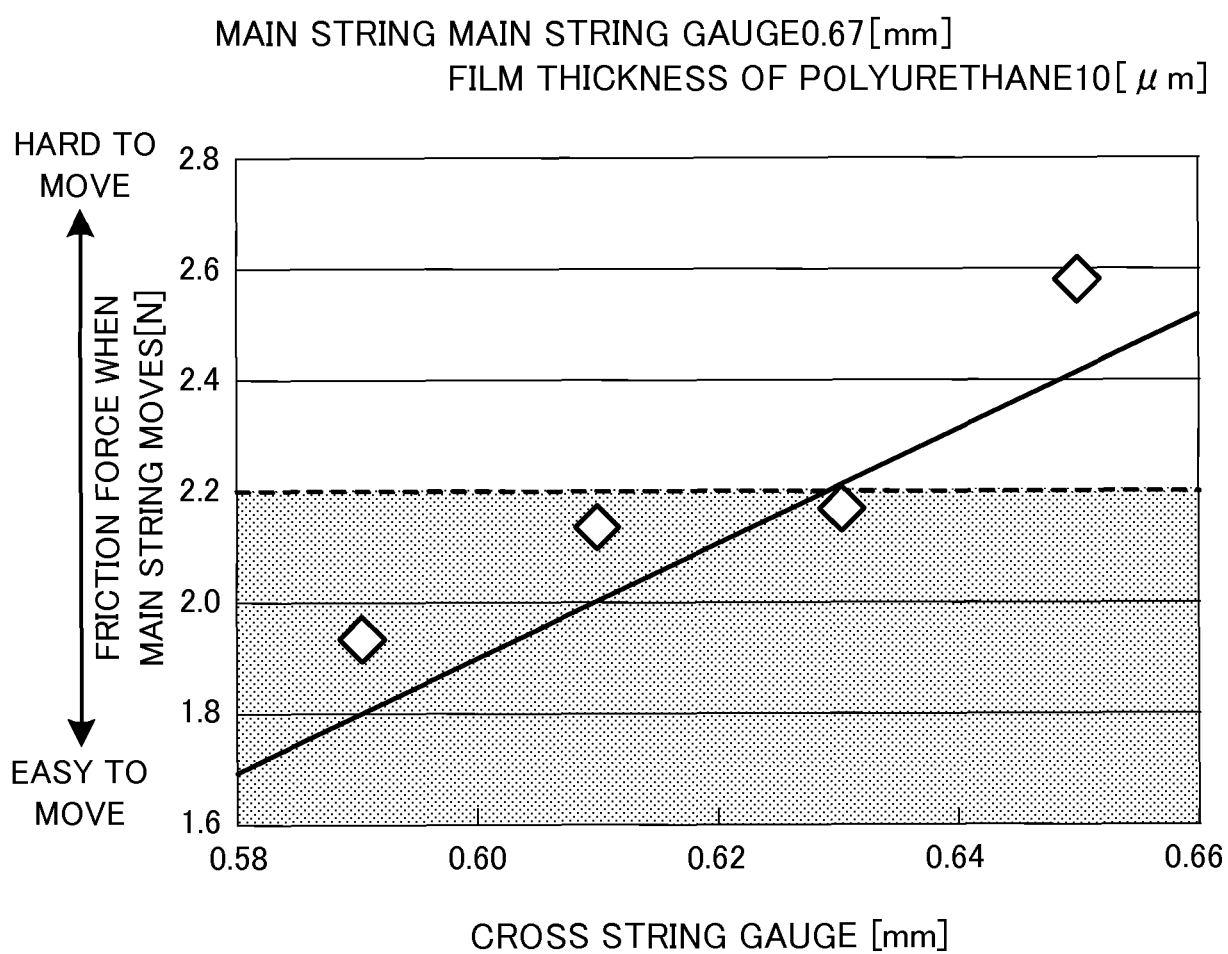


FIG.8

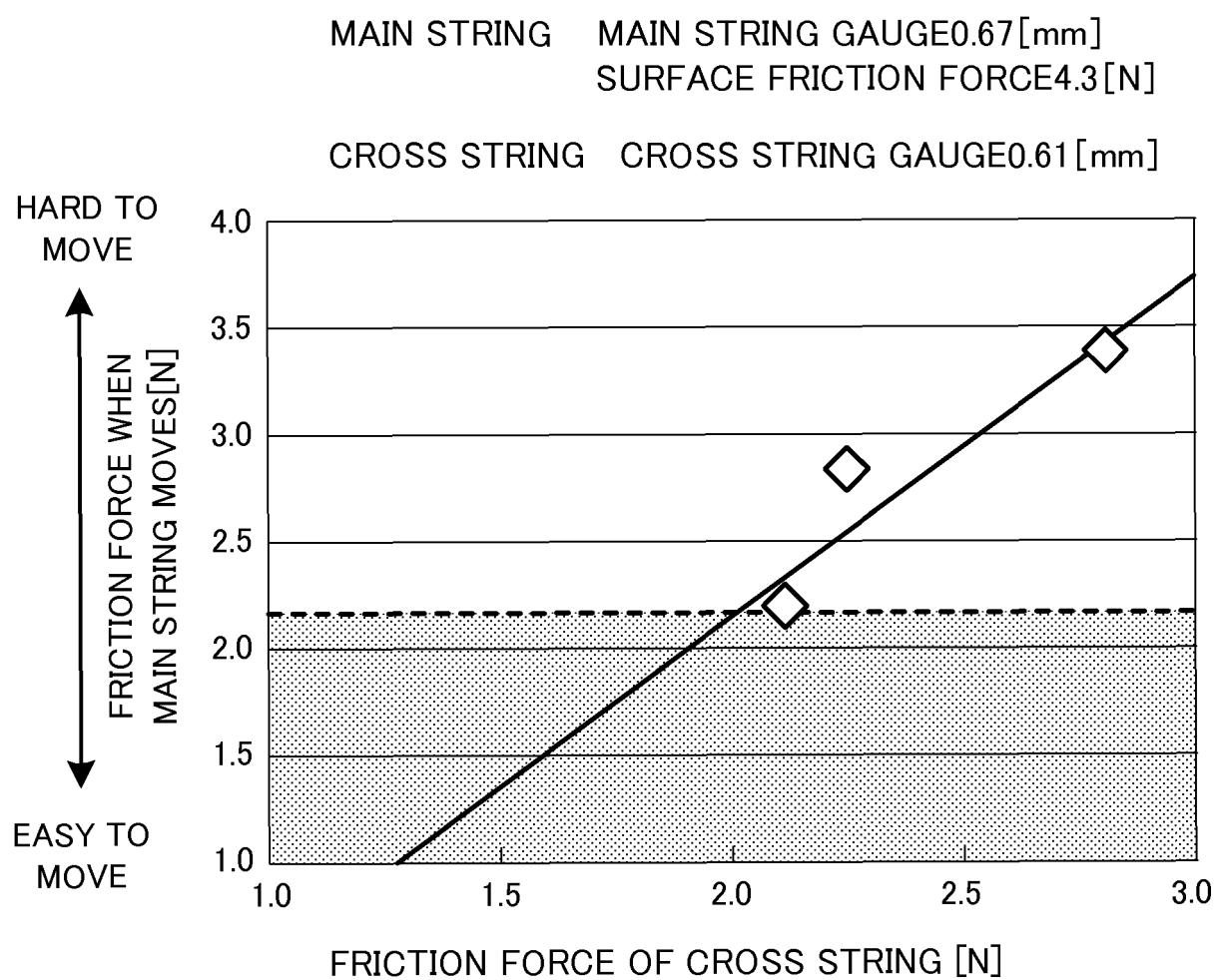


FIG.9A

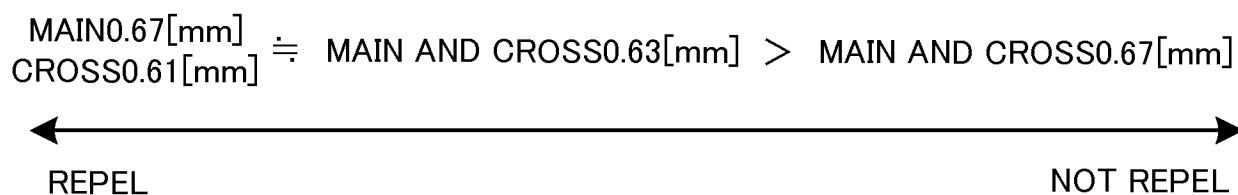


FIG.9B

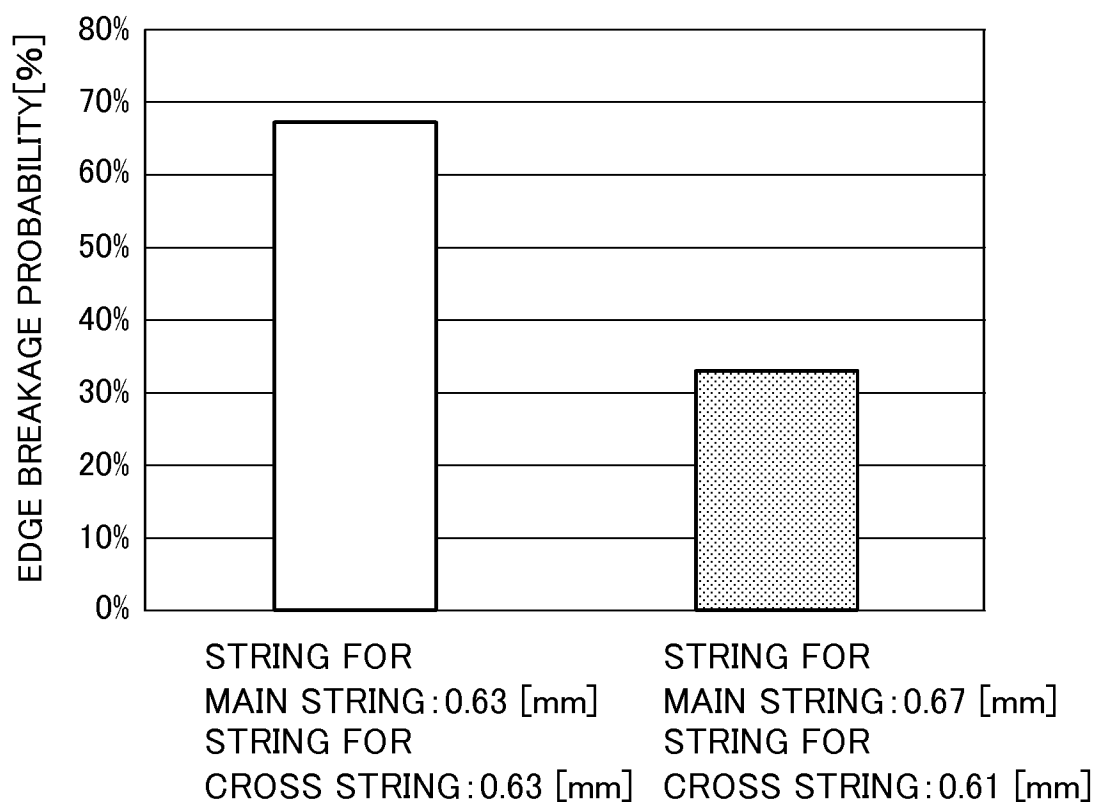


FIG.10

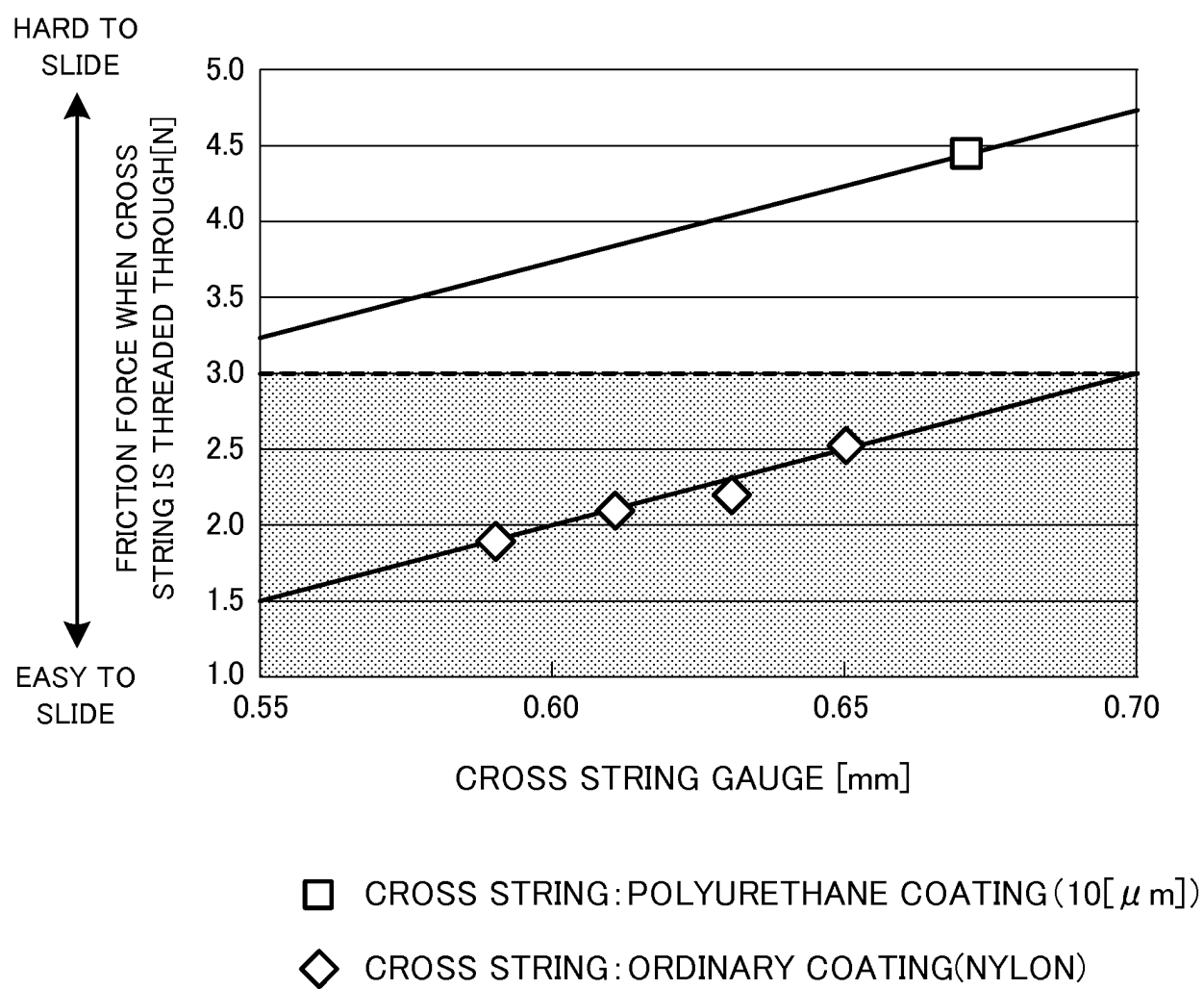


FIG.11

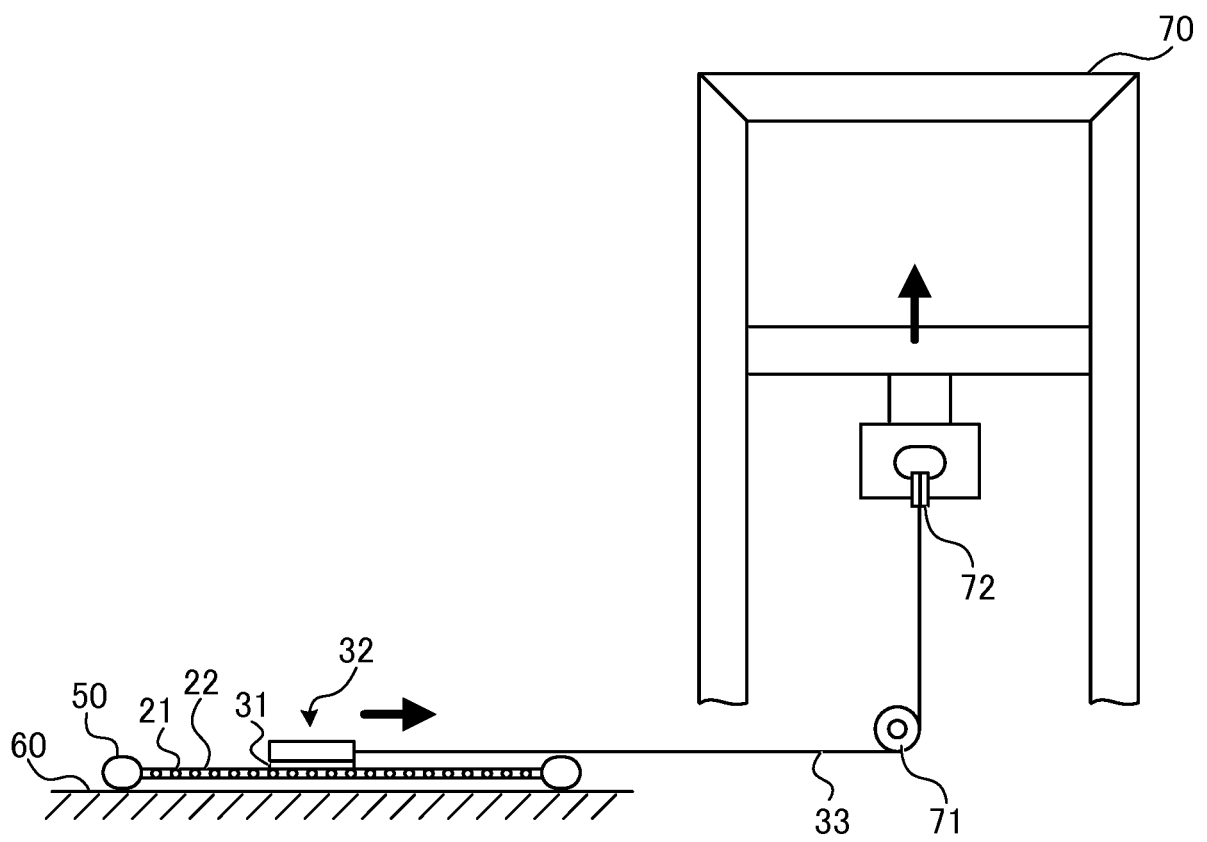
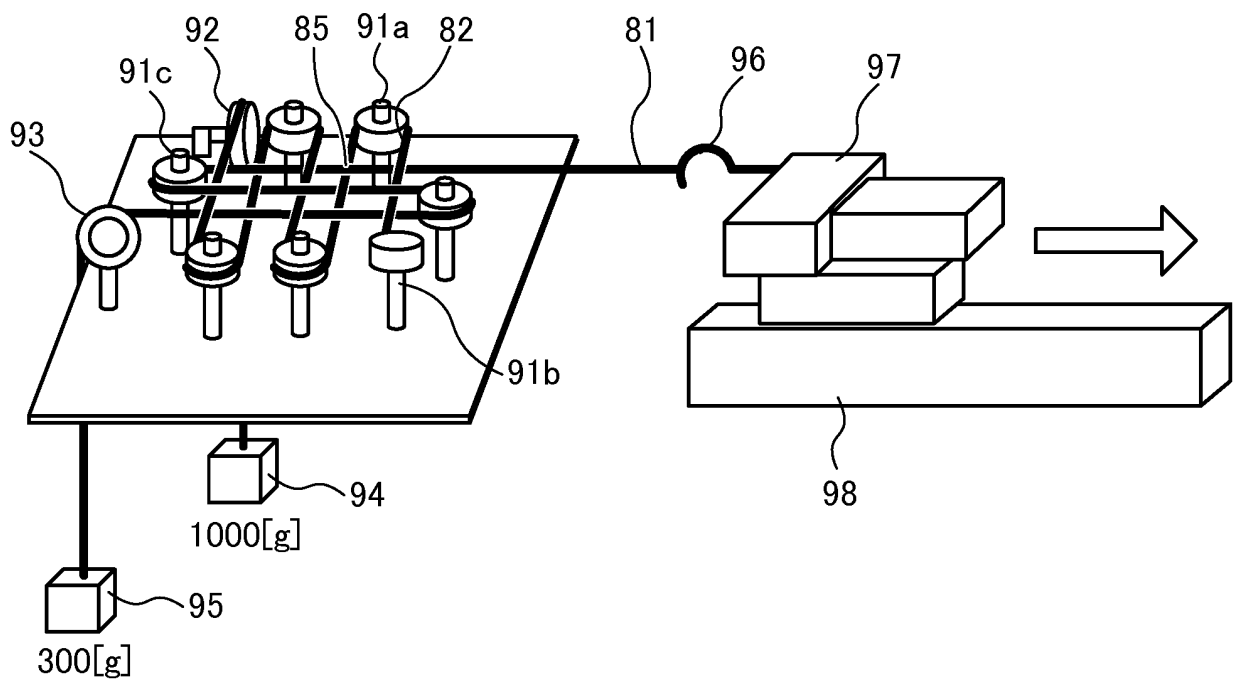


FIG.12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/006675

A. CLASSIFICATION OF SUBJECT MATTER

A63B51/02(2015.01)i, A63B102/04(2015.01)n

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)

A63B51/02, A63B102/04

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 1996-2017
 Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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.
X A	JP 44-1749 Y1 (Daishiro NISHIMURA), 23 January 1969 (23.01.1969), page 1, right column, lines 5 to 12; fig. 2 (Family: none)	1, 3-5, 8-9 2, 6-7
A	JP 2007-282661 A (Gosen Co., Ltd.), 01 November 2007 (01.11.2007), paragraphs [0027], [0044] to [0045] (Family: none)	6-7
A	JP 2003-260152 A (Hiroshi UEDA), 16 September 2003 (16.09.2003), paragraphs [0004] to [0006] (Family: none)	6-7

☒ 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
24 April 2017 (24.04.17)Date of mailing of the international search report
16 May 2017 (16.05.17)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/006675

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 133582/1979 (Laid-open No. 50461/1981) (Toyo Tire Cord Kabushiki Kaisha), 06 May 1981 (06.05.1981), specification, page 4, lines 8 to 13 (Family: none)	1-9
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 95055/1988 (Laid-open No. 17155/1990) (Uinza Shoji Kabushiki Kaisha), 05 February 1990 (05.02.1990), specification, page 3, lines 13 to 15; fig. 3 (Family: none)	1-9
A	US 5536005 A (KOFF, Steven G.), 16 July 1996 (16.07.1996), column 5, lines 15 to 21; fig. 4 (Family: none)	1-9

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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- JP 3166031 B [0003]
- JP 2016089286 A [0071]