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(54) Friction-reducing elements for sports racquet strings

(57) A fluoropolymer element for insertion between the strings of a tennis racquet or similar sports device to facilitate the relative movement of the strings under the force of impact of a ball or other object.

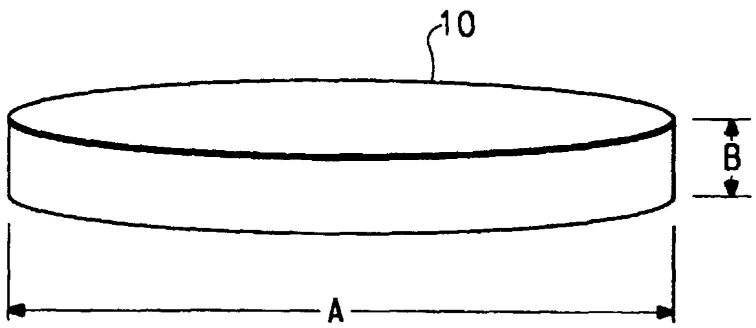

FIG. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention is directed to a friction-reducing element intended to be interposed between sports racquet strings at the contact points thereof, so as to reduce friction between the strings on hitting of a ball during play.

BACKGROUND OF THE INVENTION

[0002] In the woven structures of tennis racquets and similar racquets used in other sports, the strings are arranged at angles to one another, often at right angles, as in the case of tennis racquets. To distinguish the strings running in one direction from those running in the other, one direction will be designated as the "x" direction, and the other direction, the "y" direction. In racquets it is often desirable that the x and y strings move freely with respect to one another. Free movement increases the contact time of the ball with the racquet, which improves control, and decreases the shock felt by the player when the ball contacts the racquet. The response of woven structures to the application of forces not in the plane of the weave depends upon the tensile and elastic properties of the strings and also upon the interaction of the strings with each other. The primary interaction takes place at the points at which the strings cross. These points are referred to as the intersections or contact points. The degree of interaction depends upon the facility with which x and y strings can move with respect to one another at the intersections. At one extreme, that of maximum interaction, the strings may be bonded at the intersections so that no relative movement of the x and y strings is possible. If the strings are not bonded, then the coefficient of friction will determine how much freedom the x and y strings have to move relative to one another under applied force. Strings having very low coefficients of friction, particularly under high load, will have little interaction with intersecting strings.

[0003] The materials used in making strings for sports racquets, such as gut, nylon, and Kapton®, have relatively high coefficients of friction. Various approaches have been proposed to facilitate the relative movement of the strings at their intersections by reducing the friction between the intersecting strings. German Patent no. 3,133,231 describes tennis string coated with fluoropolymer. This has the disadvantage of using expensive fluoropolymer on the entire string to achieve reduced friction in the relatively small area subject to movement under the force of impact by the tennis ball. U.S. Patent no. 3,921,979 describes small elements, grooved on opposite surfaces, the grooves being at right angles to one another. The elements are inserted between the strings of a racquet at the intersections, the strings riding in the grooves. This arrangement allows the strings to move more easily at right angles to one another, and is effective when the force of impact is in the direction of either the x or y strings. In such a case only one set of strings in the area of contact, the x or the y, move laterally. However, when the force is applied at any another angle, both sets of strings must move. The elements can act to resist this movement, in effect locking the string intersections. U.S. Patent no. 4,368,886 describes an absorbent pad, lubricated by the addition of an oil, for insertion at string intersections. The pad is be held in place by a retainer that is much like the elements of U.S. Patent no. 3,921,979. It is to be expected that the oil will be lost in the course of time and in use, and the effectiveness of the pads will decrease. The oil will also attract dirt and dust.

SUMMARY OF THE INVENTION

[0004] An object of the present invention is to provide better and more permanent friction-reducing devices to facilitate the relative movement of sports racquet strings at their intersections under the force of impact from all angles.

[0005] In one embodiment, the present invention is directed to a composite of a reinforcing material covered on at least one side with a polymer film, wherein said composite is conformable to the shape of said strings.

[0006] In another embodiment of the invention, a friction-reducing element is provided for insertion between a contact point of sports racquet strings, comprising a polymeric fabric, wherein said element has a surface area exceeding a surface area of said point of contact between said strings.

[0007] In another embodiment of the invention, a friction-reducing element is provided for insertion between a contact point of sports racquet strings, comprising a composite of a reinforcing material covered on at least one side with a polymer film, wherein said element has a surface area exceeding a surface area of said point of contact between said strings.

[0008] Another embodiment of the invention is directed to a friction-reducing element for insertion between a contact point of sports racquet strings, comprising a polymeric fabric interposed between polymer films, wherein said element has a surface area exceeding a surface area of said point of contact between said strings.

[0009] Another embodiment of the present invention is directed to a friction-reducing element for insertion between contact a point of sports racquet strings comprising two layers of fluoropolymer fabric disposed at about 45° to each other with a layer of fluoropolymer film between them, interposed between fluoropolymer films

[0010] Another embodiment of the present invention is directed to a tennis racquet incorporating any one or all of the embodiments set forth above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The above and other objects, features and advantages of the present invention will be better understood from the following detailed descriptions, taken in conjunction with the accompanying drawings, all of which are given by way of illustration only, and are not limitative of the present invention.

Figure 1 is a perspective view of the friction-reducing element of the present invention in the form of a circular disk, illustrating the measurements of A and B, defining the aspect ratio.
Figure 2 is a perspective view of an alternate embodiment of the friction-reducing element of the present invention, in the form of a parallelogram.
Figure 3 is a cross sectional view illustrating the conformance of a friction-reducing element according to the present invention to the shape of a racquet string.
Figure 4 is a side view of Fig. 3.
Figure 5 is a greatly exaggerated plane view of a series of y racquet strings intersecting an x racquet string, with friction-reducing elements of the present invention interposed at the contact points between the strings.
Figures 6a and 6b are respectively a top view and a cross-section of a preferred embodiment of the present invention, illustrating a fabric interposed between polymeric films.
Figure 7 is a perspective view of a prior art ABS plastic spacer or saddle of Comparative Example A.
Figure 8 is a perspective view of a PTFE spacer or saddle of Comparative Example B.

DETAILED DESCRIPTION

[0012] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

[0013] This invention provides a friction-reducing element that is inserted between the x and y strings of a sports racquet to facilitate the movement of the strings with respect one another in response to force applied from any angle. The element may be made of any polymer having a low coefficient of friction, but fluoropolymers are preferred, perfluoropolymers are more preferred, and tetrafluoroethylene homopolymer (PTFE) is most preferred. It is recognized that the term "coefficient of friction" embraces the coefficient of static friction and the coefficient of kinetic friction, and that these generally do not have identical values. The term is used here in a qualitative sense and estimates are based on tactile determinations that do not require making the distinction between static and kinetic friction. The word "point" is used herein to designate the area or region where an x and a y string intersect and come in contact. It is understood that this "point" is not the dimensionless point of geometry. It has a finite area.

[0014] In one embodiment, the present invention is directed to a friction-reducing element for insertion between a contact point of sports racquet strings comprising a polymeric shape conformable to the shape of said strings, wherein said element has a surface area exceeding a surface area of said point of contact between said strings.

[0015] The friction-reducing element according to the present invention may be in the form of a relatively thin, flat shape such as a circular disk 10 (Fig. 1), an oval-shaped disk or a parallelogram, including a flat square shape or a flat rectangular shape 10 (Fig. 2). However, in all cases, the friction-reducing element of the present invention is flexible enough to conform to the circumferential surface of the racquet string to which it will be applied. Fig. 3 is a cross-sectional view which illustrates the conformance of the friction-reducing element 10 to the shape of racquet string 20. Fig. 4 is a side view of the illustration of Fig. 3, which shows the friction-reducing element 10 of the present invention in place and conforming to the surface of string 20.

[0016] Fig. 5 is an overall view of a small portion of intersecting x and y racquet strings 20a and 20b respectively, which illustrates the placement of friction-reducing elements 10 at the intersection of the x and y strings and between the contact points thereof.

[0017] A surprising characteristic of elements made according to this invention is that they do not have to be molded into a precise shape, such as the elements described in U.S. Patent no. 3,921,979. The elements need only have an aspect ratio A/B of greater than about 3, preferably greater than about 5, more preferably greater than about 10, and most preferably greater than about 15, but in all cases no greater than about 50. The aspect ratio is ratio of the length of the longest linear measurement of the element, A, to its thickness, B, i.e. aspect ratio = A/B . The measurements defining the aspect ratio are illustrated for two different embodiments of the present invention in Figs. 1 and 2.

[0018] In order to provide for adequate friction reduction from impacts in all directions, the area of friction-reducing element should at least slightly exceed the surface area of the point of contact between the strings and preferably has a ratio of the surface area of the element to the surface area of a point of contact of the strings greater than about 1.01; i.e., the area of one surface of the element contacting one of the strings is preferably at least about 1% greater than the area of contact at the intersection of the x and y strings. More preferably, the area of the friction reducing element is no more than about 75% greater than the area of a point of contact of the strings. It has been found that elements with an A of about 3 mm and a B of about 0.1 to 0.5 mm work well, being of convenient size for easy insertion between the strings on the order of 50 mils (1.25 mm) in diameter in a racquet. For strings of other diameters, it is preferable that the thickness of the elements be from 0.01 to 0.4 times the diameter of the strings of the article to which the element will be applied. It is more preferable that the thickness of the elements be from 0.02 to 0.2 times the diameter of the strings of the article to which the element will be applied. In cases in which the x and y strings are of different diameters, the thickness of the friction-reducing element is primarily related to the diameter of the smaller string.

[0019] As stated above, the friction-reducing element may be in the form of a circular disk, in which case the diameter is A (Fig. 1), or an oval or elliptical disk, in which case the major axis is A, or a parallelogram, in which case the diagonal is A (Fig. 2), or any other regular or irregular polygon or curved figure, in which case the longest linear dimension is A. In each case the thickness of the element is B (Figs 1 and 2). Because of the variety and simplicity of the shapes which are suitable for the element, the element may be easily made by direct molding in simple dies, or by cutting from sheet stock or rolls, with little or no waste. The polymer element may be in the form of a knit, woven, or nonwoven fabric, a skived, extruded, or cast film, an expanded polymer, which, for the purposes of this invention is considered a film, or an open or closed cell foam sheet, which, for the purposes of this invention is considered a film, or a composite comprising two or more of these. These, especially the films, may be oriented, either uniaxially or biaxially. One or more fillers may be included in any of these forms to reduce wear or to reduce friction, or both.

[0020] In another embodiment of the invention, a friction-reducing element is provided for insertion between a contact point of sports racquet strings comprising a polymeric fabric. The fabric may be knit, woven, or nonwoven, but is preferably woven, and more preferably woven in a plain weave or other weave with directional characteristics such that the racquet strings can fit at least partly between the yarns of the fabric. The fabric may be woven loosely enough to allow movement of the yarns to accommodate the racquet strings. It is preferable that the fabric be secured to resist unraveling or otherwise coming apart. This may be accomplished with heat and pressure on fabric woven from fiber made from Teflon 303J PTFE Fluoropolymer aqueous dispersion resin. This fabric should be sintered at 700°F (370°C) under moderate pressure 400 psi (2.7 MPa) and then cooled to room temperature while pressure is maintained. Unraveling may also be prevented by bonding the yarns of the fabric at their intersections, by heat and pressure, particularly if the yarns are made from a modified PTFE, or by application of a bonding agent or adhesive at the points at which the yarns contact one another. U.S. Patent no. 5,731,394 describes modified PTFE.

[0021] Another embodiment of the invention is directed to a stringed sports racquet comprising friction reducing elements inserted between a contact point of the strings, said elements comprising a composite of a reinforcing material covered on at least one side with a polymer film, wherein said composite is conformable to the shape of said strings. As illustrated in Figs. 6a and 6b, it is further provided that the polymer element 10 may be a complex structure such as a woven or nonwoven fabric 12 that is coated with polymer from solution or by melt extrusion, or laminated to polymer film 11 or nonwoven polymer structure such as expanded PTFE. A metal foil may also be used as the reinforcing material with a polymer coating, or laminated with polymer film, or with polymer and fabric. The fabric may be of any material, but nylon and polyester are preferred, and fluoropolymer fabric is more preferred, and PTFE fabric is most preferred. The fabric may have polymer on only one side Fig. 6b, 11, but it is preferred that the fluoropolymer be on both sides of the fabric, Fig. 6b, 11 and 13.

[0022] More than one layer of fabric 12 may be used, but it is preferred that two layers be used, and more preferred that the second fabric layer be laid upon the first fabric layer so that the x and y yarns of the second fabric layer do not lay in the same direction as the x and y yarns of the first fabric layer. It is more preferred that the x and y yarns of the first fabric layer are at about a 45° angle (in the same plane) to the x and y yarns of the second fabric layer. If two layers of fabric are used, it is preferable that a layer of polymer film be interposed between the fabric layers.

[0023] Suitable fluoropolymers for use in the present invention include polymers comprised of at least one fluoroolefin monomer. Useful fluoropolymers include homopolymers or copolymers formed from fluoromonomers of, for example, vinyl fluoride; yinylidene fluoride; trifluoroethylene; chlorotrifluoroethylene (CTFE); 1,2-difluoroethylene; tetrafluoroethylene (TFE); hexafluoropropylene (HFP); perfluoro(alkyl vinyl ethers) such as perfluoro(methyl vinyl ether) (PMVE), perfluoro(ethyl vinyl ether) (PEVE), and perfluoro(propyl vinyl ether) (PPVE); perfluoro(1,3-dioxole); perfluoro(2,2-dimethyl-1,3-dioxole) (PDD); perfluoro(butenyl vinyl ether); $F(CF_2)_nCH_2OCF{=}CF_2$ wherein n is 1, 2, 3, 4, or 5; $R_4CH_2OCF{=}CF_2$ wherein R_4 is hydrogen or $F(CF_2)_m$- and m is 1, 2 or 3; and $R_5OCF{=}CH_2$ wherein R_5 is $F(CF_2)_z$- and z is 1, 2, 3, or 4; perfluorobutyl ethylene (PFBE); 3,3,3-trifluoropropene and 2-trifluoromethyl-3,3,3-trifluoro-1-propene. Preferred fluoromonomers include vinyl fluoride, vinylidene fluoride, TFE, HFP, PMVE, PEVE, PPVE, CTFE, and PDD.

[0024] The fluoromonomers may be polymerized with one or more other fluoromonomers or other monomers, such as hydrocarbon monomers that are not fluoromonomers, to form a copolymer. If a copolymer is to be formed, the monomers chosen must be able to copolymerize. Fluorine-free monomers that copolymerize with some combinations of fluoromonomers include propylene and ethylene. One example of such a copolymer is ethylene/tetrafluoroethylene (ETFE).

[0025] The polymers useful in this invention include TFE and CTFE homopolymers; TFE or CTFE polymerized with one or more other fluoromonomers described above such that said other fluoromonomers are less than 1% by weight of the total polymer (wt.%); TFE or CTFE polymerized with 1 to 99 wt.% of one or more other fluoromonomers, preferably 1 to 50 wt.% of one or more other fluoromonomers, more preferably 1 to 20 wt.% of one or more other fluoromonomers, and most preferably 1 to 10 wt.% of one or more other fluoromonomers. In all cases, the wt.% values refer to the amount of comonomer incorporated in the polymer.

[0026] The identity and proportion in the polymer of units derived from other monomers, fluorinated and fluorine-free, can have wide ranges depending on the physical or chemical properties sought. Thus, the polymers of this invention can be plastic or elastomeric, generally according to the identity and proportion of units derived from monomers making up the major part of the polymer composition, as known in the art. It is preferable that the polymers be plastic, that is, that their glass transition temperatures (Tg) be greater than 25 to 30°C. It is more preferable that the Tg be greater than 35°C. Having a Tg above the use temperature of the element is more important for the polymer that makes up the surface of the element, than for polymer in the interior of the element.

[0027] Of the fluoropolymers that may be used according to this invention, perfluoropolymers are more preferred as having lower coefficients of friction than incompletely fluorinated polymers. Polytetrafluoroethylene is most preferred as having the lowest coefficient of friction of all fluoropolymers.

[0028] One or more fillers may be used in any of these structures to improve wear resistance or reduce friction, or both. Typical fillers include PTFE powder, graphite, boron nitride, and molybdenum disulfide. Loadings are 0.1-20 wt. %, preferably 1-10 wt.% based on total weight.

[0029] The fact that fluoropolymers can creep, that is, flow slowly under load, is well-known and in many applications is a disadvantage. One of the surprising aspects of the friction-reducing elements made according to this invention is that the creeping of the fluoropolymer is, to an extent, an advantage. The friction-reducing elements inserted between the x and y strings at their intersections are subject to the load of the strings bearing on their surfaces. The partial creep of the fluoropolymer under this load conforms the elements to the shape of the strings, in effect fitting the element to the strings, and acting to hold the elements in position.

[0030] However, creep beyond a certain point is undesirable. It is undesirable that creep leading to cut-through of the element by the strings occur before the strings have otherwise reached the end of their useful life. The beneficial aspects of creep can be obtained without the disadvantages by using composite structures as described above. For example, preferable to elements made of film alone, are elements made from film-fabric laminates (Figs. 6a and 6b), more preferably film-fabric-film laminates. The film stabilizes the fabric against movement of its component filaments or fibers, and the fabric limits the extent to which the film can creep. Any fabric is effective, but fluoropolymer fabrics are more effective, probably because of their greater compatibility with the preferred fluoropolymer films. Fluoropolymer fabrics can be woven from Teflon® multifilament fiber (available from DuPont) or from Goretex® fiber (available from W. L. Gore & Associates, Elkton MD, USA). Fabrics woven from 100 to 400 denier fibers are preferable. The directional characteristics of woven fabrics, that is their maximum strengths, are in two directions, the x- and the y-axes. For multidirectional strength, two layers of fabric may be used, laid one on the other, with the direction of the component fibers at about 45° to one another. Similar multidirectional strength may be obtained from single layers of knit fabrics or with multiaxially woven fabrics.

EXAMPLES

[0031] The elements used in the examples are in the shape of circular disks approximately 0.125 in (3.2 mm) in diameter, and 5-20 mils (0.13-0.51 mm) thick stamped or cut from the stock described in the examples. The contact area for the circular spacer between the 51 mil (1.3 mm) strings is 0.00067 sq. inches (0.935 sq. mm). The contact area of a commercially available spacer or saddle, made of ABS (acrylonitrile-butadiene-styrene) plastic with the strings is 0.0 10 sq. inches (6.4 sq. mm) (Figure 7). The contact area of a saddle made of Teflon® PTFE with the strings is 0.0078 sq. inches (5.0 sq. mm). (Figure 8). Properties measured and measurement methods are given below.

<u>Coefficient of friction</u>: This term is used qualitatively. Literature values are used, and in addition, an estimate is made by firmly placing the index finger on the surface of the element or the stock from which the element is cut, and rubbing. A ranking of 1 to 10 is used, with 10 representing the lowest coefficient of friction.

<u>Resistance to wearing through</u>: This is measured by removing several elements from a tennis racquet from time to time during the period over which the racquet is used, and examining the elements with a magnifying glass or opti-

cal microscope. If the element develops a hole, it is considered to have reached the end of its useful life. The longer the element can be used before developing a hole, the better it is judged to be. A ranking of 1 to 10 is used, with 10 representing elements that do not wear through after a year of use at the rate of three hours of tennis per week.

Softness: This is measured with a fingernail test and in the tennis racquet. An element on which no impression is made receives a ranking of 10. An element which takes a deep impression from light fingernail contact receives a ranking of 1. Intermediate results receive intermediate rankings.

Durability: Measured by how long the spacer remains integral, that is, does not develop a hole at the point where the strings intersect.

Performance in a tennis racquet as determined by casual players and professionals: Measured by a) how much longer the player feels the tennis ball is staying on the racquet and making play easier; b) how well the racquet performs when the ball rebounds from the racquet near the edges; c) the feel when the ball bits the racquet at a relative angle of about 45° to the strings and at an angle of about 40 to about 50° to the plane of the racquet face.

[0032] Elements of various compositions are made and evaluated and ranked according to the tests described above. The compositions of the elements are given in the following examples. The results of the evaluations and rankings of the elements are presented in Table 1.

Comparative Example A

[0033] A hard plastic spacer or saddle similar to that described in U.S. Patent no. 3,921,979 is obtained from the local tennis pro shop (Fig. 7). It is a right quadrangular prism 30 with two opposite surfaces grooved 35 by shaping. The spacer is made of injection molded ABS (acrylonitrile-butadiene-styrene copolymer) plastic, sold by Guterman International, Inc., Worcester, MA, USA. The contact area for a single string in the longer groove of this element is 0.0099 sq. in (6.36 sq. mm). The results show that ABS has a high coefficient of friction, lacks sofiness, and relative play performance is not exceptional.

Comparative Example B

[0034] A second spacer similar to that of Comparative Example A is made of Teflon® tetrafluoroethylene homopolymer (Fig. 8). A groove 35 is made on one face of the spacer 30 and a notch 36 of regular triangular cross section is made on the opposite face at a right angle to the groove 35. The contact area for a single string in the groove of this element is 0.0079 sq. in (5.06 sq. mm). As expected for PTFE, the coefficient of friction is greatly superior to ABS. This, however, only modestly improves performance relative to Comparative Example A.

Example 1

[0035] The element is a skived tape of PTFE, such as that available from Norton Co. of Wayne, NJ. Plain film is an improvement over the structures of the Comparative Examples, but the pressure of the strings leads to wear through in a short time.

Example 2

[0036] The element is made from unsintered Goretex® G18 (0.125 in (3.17 mm) thick). The sheet can be delaminated to the desired thickness by hand. It lacks wear-through resistance.

Example 3

[0037] The element is made from HS-10 porous PTFE, made according to U.S. Patent no. 3,556,161 Example V. It is similar to Goretex® and like it in performance. It also has poor wear resistance, and as a result lacks durability.

Example 4

[0038] The element is made from PTFE filled with polyphenylene sulfide (PPS), available from Teleflex Co., Sheffield, CT. The added PPS slightly improves wear-through resistance but at the expense of an increase in the coefficient of friction.

Example 5

[0039] The element is made from NXT70, a chemically-modified polytetrafluoroethylene, made into a skived tape, available from the Norton Co., Wayne NJ. Results are similar to those of Example 1.

Example 6

[0040] The element is prepared as described in Example 5 but before use is "coined", that is pressed to compact and harden it, at 350°C and 2000 psi (13 MPa), and then cooled to 3 00°C while the pressure is maintained. Coining makes an improvement in wear-through resistance. As in Examples 1 and 5, the element composed of nonporous PTFE shows excellent performance until creep or wear through ends its useful life.

Example 7

[0041] The element is cut from a film of FEP (copolymer of tetrafluoroethylene and hexafluoropropylene, available from the DuPont Co., Wilmington, Delaware, USA, as FC01) which had been coextruded with 5 wt.% of boron nitride (BN). Its thickness is 18 mils (460 µm). The coefficient of friction is higher than that of the PTFE samples. This is expected, since it is known that PTFE has the lowest coefficient of friction of all fluoropolymers. The increased friction is reflected in the lower performance of the elements made according to this example compared to those using PTFE.

Example 8

[0042] The element is cut from a film of Teflon® PFA 340 (copolymer of tetrafluoroethylene and perfluoro(alkyl vinyl ether), available from the DuPont Co.). Performance is identical to that of FEP.

Example 9

[0043] The element is prepared from HS-10 sintered PTFE, made free of voids, according to the conditions of Example 6. Eliminating voids increases wear resistance, resulting in a structure that performs as well as PTFE film but with better wear-through resistance.

Example 10

[0044] The element is cut from a film of Teflon® PFA 340 (available from the DuPont Co.) that had been heated to 235°C for 24 hours. Heat aging did not improve performance. Performance was similar to Example 8.

Example 11

[0045] The element is cut from a film of Teflon® PFA 340 filled with carbon (an experimental film made by extrusion of PFA with carbon black). Carbon filling does not improve the performance of PFA film. Performance was similar to Examples 8 and 10.

Example 12

[0046] The element is cut from tubing made from Teflon® 6C (DuPont Company) and has a thickness of 18 mils (450 µm) This PTFE sample has excellent performance, and wear-through resistance is adequate for long term play.

Example 13

[0047] The element is cut from Teflon® 6C wire insulation, made by extruding Teflon® 6C, at 40 ft/min (12.2 m/min) on solid copper AWG 16 wire (0.051 inch, 1.30 mm diameter). The insulation is cut lengthwise on both sides of the wire and removed. Spacers are cut to 0.075 inch (1.90 mm) lengths and are 19 mils (480 µm) thick. Because the racquet string is about the same diameter as the copper wire, the spacer fits the string well. Figures 3 and 4 show how the element is fitted to the string. This PTFE sample is slightly better than that of Example 12.

Example 14

[0048] The element is cut from Teflon® 62 wire insulation, available as tubing from Atlantic Tubing, Chestnut Ridge, NY. It is cut as in Example 12. Its thickness is 16 mils (410 μm). Figures 3 and 4 show how the element is fitted to the string. This is PTFE with different properties than Teflon® 6C. However, the differences in polymer do not affect the behavior of the sample in the tests compared to that of Example 12.

Example 15

[0049] The element is cut from Zamaxx® matting of carbon fiber reinforced Teflon® PFA fluoropolymer resin available from DuPont. The element is processed according to the conditions of Example 6. Coining improves wear-through resistance, but the elements tend to be lost easily from the racquet in the course of play.

Example 16

[0050] The element is cut from tape skived from a billet of carbon-filled PTFE containing 5 % carbon black. The billet is made at the DuPont laboratory at Chestnut Run, Wilmington, Delaware, USA. Similar material is available from the Norton Company. Carbon filling does not improve wear-through resistance. Performance is excellent for the short life of these elements.

Example 17

[0051] The element is cut from tape skived from a billet of PTFE containing 15 % glass fiber. The billet was made at the DuPont laboratory at Chestnut Run, Wilmington, Delaware, USA. Similar material is available from the Norton Company. The presence of glass increases the coefficient of friction. The drop in performance compared to Examples 1 or 10 illustrates how important low coefficient of friction is to performance.

Example 18

[0052] The element is cut from the delaminated Goretex of Example 2. It is sintered and cooled according to the conditions of Example 6. Sintering Goretex® increases its wear resistance, hardness, and durability.

Example 19

[0053] The element is cut from a Goretex/Zamaxx® matting/Goretex laminate, made under the conditions of Example 6. The Goretex layers are 0.001 inch (25 μm) thick. Racquet strings do not retain these elements long enough for performance to be evaluated.

Example 20

[0054] The element is cut from a Goretex/PTFE fabric/Goretex laminate sintered and cooled according to the conditions of Example 6. The Goretex is type G18, 7 mils (175 μm) thick. The Teflon® PTFE fabric is type 187-30 (woven from 225 denier Teflon® yarn) from Stern and Stern, Hornell, NY. This Goretex®-fabric laminate is an improvement over Goretex® alone (Example 18).

Example 21

[0055] The element is cut from a Goretex/PTFE fabric/Goretex/ PTFE fabric /Goretex laminate made using the same conditions as in Example 19. The outer layers of Goretex are 7 mils (175 μm) thick. The inner Goretex layer is 3 mils (75 μm) thick. The fabrics are laid with the weaves at about 45° to one another, that is, cross-plied. This arrangement improves wear-through resistance and durability. Ratings are maximum in all categories.

Example 22

[0056] The element is configured as in Example 21, except that NXT70 is used in place of Goretex®.

Example 23

[0057] The element is cut from a Goretex®/polyester fabric/Goretex laminate made under the conditions of Example 19. The polyester fabric is type 15886 (woven from 220 and 440 denier yams) from Stern & Stern, Hornell, NY. The Goretex layers are 7 mils (175 μm) thick. This element is equivalent in ranking to the PTFE fabric structure of Example

20, though slight delamination is seen.

Example 24

[0058] The element is cut from a 6 mil thick glass fabric impregnated with PTFE. The source is Chemfab, Merrimack, NH. This structure lacks wear-through resistance. The fabric fibers separate easily.

Example 25

[0059] The element is cut from a Goretex®/impregnated glass fabric/Goretex® laminate (Goretex® 75 µm thick), the glass fabric being the same as that used in Example 24, the laminate made as in Example 19. This structure is similar in behavior to that of Example 24.

Example 26

[0060] The element is cut from a NXT70/PTFE fabric/Goretex®/ PTFE fabric /NXT70 laminate made using the same conditions as in Example 21. The fabrics are laid with the weaves at about 45° to one another, that is, cross-plied. Maximum rankings are achieved in all categories. This structure is at least equivalent to that of examples 21 and 22, perhaps slightly better in wear-through resistance.

Example 27

[0061] The element is cut from a laminate of 50 µm Goretex®/Zamaxx®/50 µm Goretex® made as in Example 19, the Zamaxx being coined before lamination. The Goretex thickness is 2 mil (50 µm). As in Example 19, the elements do not stay in the racquet.

Example 28

[0062] The element is cut from a laminate similar to that of Example 27 except that one of the Goretex layers is 7 mil (175 µm) thick. Performance is maximum in all categories.

Example 29

[0063] No element is used in this example. Instead, PTFE micropowder, type MP1100 (made by DuPont) is dusted on the strings of a tennis racquet. This example shows that this treatment of strings with PTFE is not adequate to reduce friction or to give good performance. In addition, the dust is a nuisance.

Table 1.

Example	Type of Element	Coeff. Friction	Wear-through Resistance	Softness	Durability	Performance	Observations
	DISCS OF						
A	ABS prism element	1	10	1	10	1	Coefficient of friction high Tends to lock strings when a ball makes about a 45° impact on the racquet.
B	PTFE prism element	10	10	2	10	3	
1	Skived PTFE film	10	2	10	2	10	
2	Unsintered Goretex®	10	1	1	1	3	
3	HS-10 porous PTFE	10	3	10	2	5	
4	PPS filled PTFE	3	4	7	3	3	
5	NXT70 skived tape	10	3	10	2	10	
6	NXT skived tape, coined	10	4	9	3	10	
7	FEP filled with 5 wt % BN	6	3+	7	4	5	
8	PFA film	6	3+	7	4	5	
9	HS-10 sintered, no voids	10	7	10	6	10	
10	PFA film aged 24 hrs at 235°C	6	3+	7	3	5	
11	PFA film, carbon-filled	6	3+	7	3	5	

12	Teflon® 6C tubing	10	7	10	6	10	
13	Teflon® 6C wire insulation	10	7	10	6	10	
14	Teflon® 62 wire insulation	10	7	10	6	10	
15	Zamac coined (PFA)	6	10	1	1	1*	In use, elements pop out
16	Skived PTFE tape, carbon-filled	10	1	10	1	10+	
17	Skived PTFE tape, glass-filled	4	3	10	3	5	
18**	Goretex® sintered, cooled under pressure	10	8	10	6	10	
	LAMINATES OF						
19	Goretex® on each side of Zamac, unsintered, cooled under pressure	10	10	10	1	1*	In use, elements pop out
20**	Goretex on each side of PTFE woven fabric, sintered, cooled under pressure.	10	9	10	8	10	
21***	Like Ex. 20 but with two PTFE fabrics at about 45° to one another with Goretex between the fabric layers	10	10	10	10	10	
22***	Like Ex. 21 but with NXT70, 3 mil (75 μm) thick, in place of Goretex®	10	10	10	8	10	

23	Goretex® on each side of polyester fabric, sintered, and cooled under pressure	10	9	10	Successful in 2 month test. Testing Continues.	9	Slight delamination of Goretex® from the fabric
24	PTFE impregnated glass fabric	10	1	10	1	3	Glass fibers separate from each other, leading to rapid cut through.
25	Goretex® (75 μm thick) on each side of PTFE impregnated glass fabric	10	1	10	2	3	Similar to Example 24.
26***	NXT70 (75 μm thick) on each side of two layers of PTFE woven fabric laid at about 45° to one another with Goretex® between the fabrics	10	10	10	10	10	
27	Zamac coined with 50 μm thick layers of Goretex® on each side, sintered, cooled under pressure	10	10+	10	1	1*	In use, elements pop out

28***	Like Ex. 26 but with 50 µm Goretex® on one side and 175 µm Goretex® on the other	10	10+	10	10	10	
29	PTFE micropowder dusted on strings in tennis racquet	1	10	1	2	2	Dust is a nuisance.

* Easily pops out from between strings during play.

** Very acceptable for the out edge string intersections of the racquet for long term play. If used at or near the center of the racquet, the elements will quickly wear through, giving string-to-string contact.

*** Very acceptable for all string intersections, allowing long-term play, that is, about 1 year.

[0064] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. A friction-reducing element for insertion between a contact point of sports racquet strings comprising a composite of a reinforcing material covered on at least one side with a polymer film, wherein said composite is conformable to the shape of said strings.

2. The friction-reducing element according to claim 1, wherein said polymer film comprises fluoropolymer.

3. The friction-reducing element according to claim 1, wherein said element has a surface area exceeding a surface area of said point of contact between said strings.

4. The friction reducing element of claim 3, wherein a ratio of the surface area of said element to the surface area of said point of contact is between about 1.01 and about 1.75.

5. The friction-reducing element according to claim 1, wherein the aspect ratio of said element ranges from about 3 to about 50.

6. The friction-reducing element according to claim 5, wherein said element is in the shape of a circular disk, an oval disk or a parallelogram.

7. The friction-reducing element according to claim 1, wherein said reinforcing material comprises a layer of polymeric fabric.

8. The friction-reducing element according to claim 1, wherein said element comprises a layer of polymeric fabric and a layer of fluoropolymer film.

9. The friction-reducing element according to claim 1, wherein said element comprises a layer of polymeric fabric interposed between layers of polymeric films.

10. The friction-reducing element according to one of claims 8 or 9, wherein said polymeric fabric comprises two layers of said fabric in the same plane, laid so the direction of component fibers of one of said fabric layers are at an angle of about 45° to component fibers of the other fabric layer.

11. The friction-reducing element according to claim 9, further comprising a layer of polymer film between the fabric layers.

12. The friction-reducing element according to claim 1, wherein both sides of the reinforcing material are covered with polymer films.

13. The friction-reducing element according to claim 11, wherein said polymeric fabric comprises two layers of said fabric in the same plane, laid so the direction of component fibers of one of said fabric layers are at an angle of about 45° to component fibers of the other fabric layer.

14. The friction-reducing element according to claim 1, wherein said reinforcing material comprises metal foil.

15. A friction-reducing element for insertion between a contact point of sports racquet strings comprising two layers of fluoropolymer fabric disposed at about 45° to each other with a layer of fluoropolymer film between them, interposed between fluoropolymer films.

16. A stringed sports racquet comprising friction reducing elements inserted between a contact point of the strings, said elements comprising a composite of a reinforcing material covered on at least one side with a polymer film, wherein said composite is conformable to the shape of said strings.

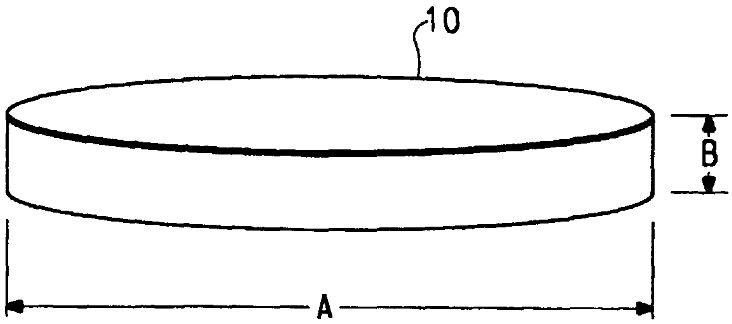

FIG. 1

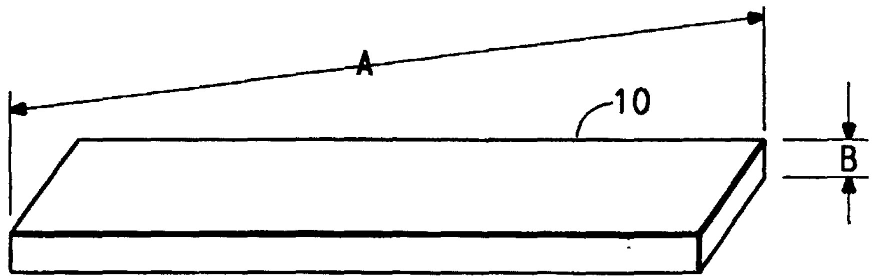

FIG. 2

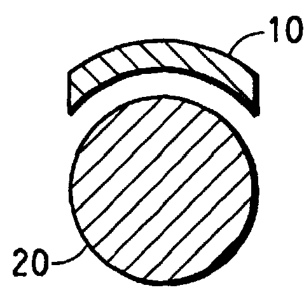

FIG. 3

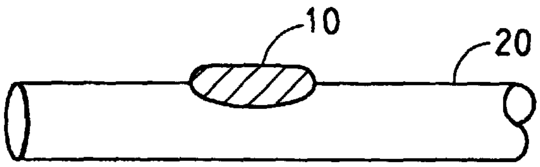

FIG. 4

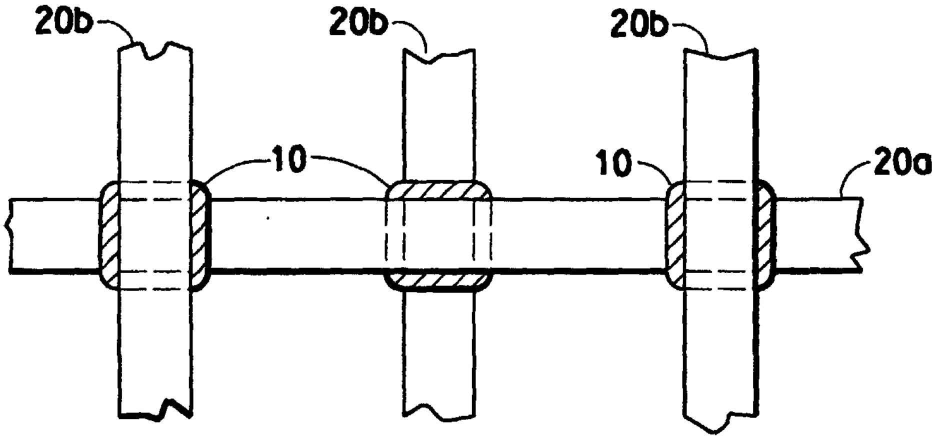

FIG. 5

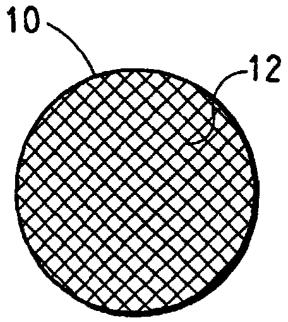

FIG. 6a

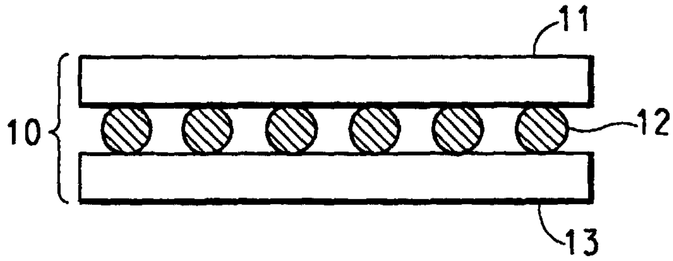

FIG. 6b

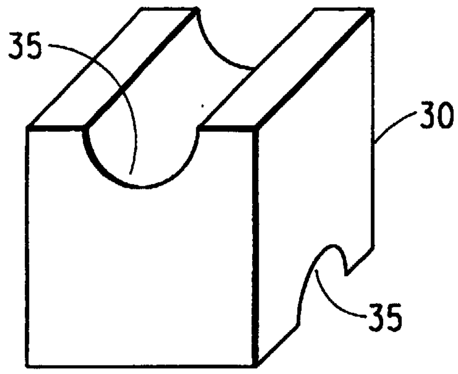

FIG. 7
(PRIOR ART)

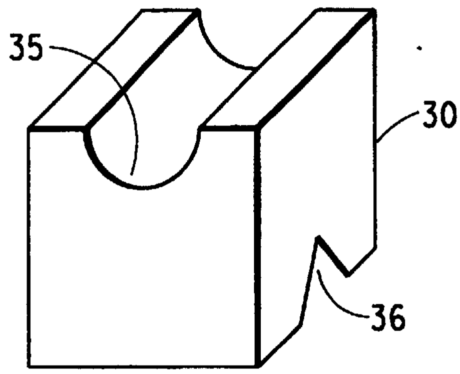

FIG. 8