



(11) **EP 4 043 626 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
17.08.2022 Bulletin 2022/33

(51) International Patent Classification (IPC):
D02G 3/04 (2006.01)

(21) Application number: **20893709.4**

(52) Cooperative Patent Classification (CPC):
D02G 3/04

(22) Date of filing: **24.11.2020**

(86) International application number:
PCT/JP2020/043598

(87) International publication number:
WO 2021/106842 (03.06.2021 Gazette 2021/22)

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(30) Priority: **26.11.2019 JP 2019212975**

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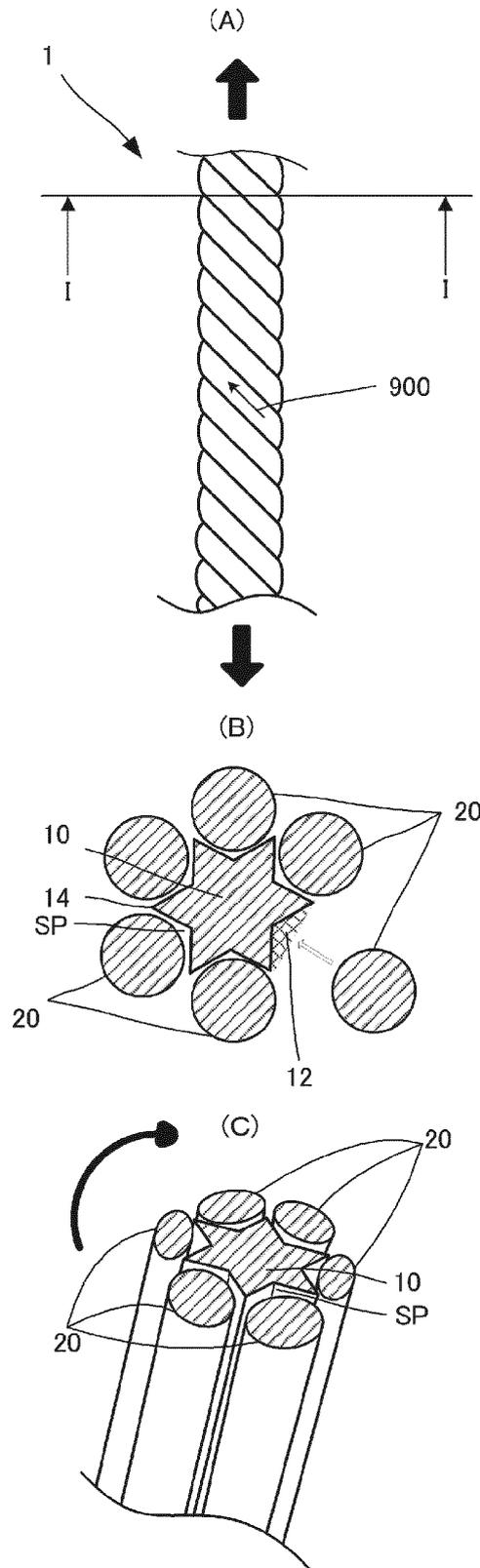
(54) **THREAD**

(57) A thread includes a first fiber having at least one groove extending in a length direction, and at least one second fiber in which potential is generated by external energy. The thread is characterized in that the second

fiber is disposed in a region formed in the groove of the first fiber, and a space is formed between the groove of the first fiber and the second fiber disposed to fit the groove.

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FIG. 1



Description

TECHNICAL FIELD

[0001] The present invention relates to a thread formed by twisting different fibers.

BACKGROUND ART

[0002] In recent years, in order to realize a comfortable and healthy life style, various daily life products with improved comfort, health, or hygiene are devised. In particular, clothing made of fibers having antifungal properties is devised. The fiber having antifungal properties is, for example, charge generating fiber that exhibits antifungal properties by charge generated by a piezoelectric effect. The piezoelectric thread disclosed in Patent Document 1 is an example of charge generating fiber. When tension is applied to the piezoelectric thread, charge is generated on the surface of the piezoelectric thread, and an electric field is generated in a space formed between fibers by the charge. The piezoelectric thread exerts an effect such as an antifungal effect by the generated electric field.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0003] Patent Document 1: International Publication No. 2017/212836

SUMMARY OF THE INVENTION

Problem to be solved by the invention

[0004] There is room for improvement in a conventional charge generating fiber in terms of constraining a fungus in the vicinity of the space where an electric field is generated.

[0005] Therefore, an object of the invention is to provide a thread having a better antifungal effect than a conventional charge generating thread having antifungal properties.

Means for solving the problem

[0006] A thread of the invention includes a first fiber having at least one groove extending in a length direction, and at least one second fiber in which potential is generated by external energy. The thread is characterized in that the second fiber is disposed in a region formed in the groove of the first fiber, and a space is formed between the first fiber and the second fiber.

[0007] In the thread of the invention, the second fiber is disposed in the region formed in the groove of the first fiber, and a space is formed between the first fiber and the second fiber, so that an electric field can be generated

in the space. In addition, since the groove is formed in the first fiber, the surface area of the first fiber increases, and a fungus easily adhere to the first fiber. Thus, the thread including the first fiber and the second fiber exhibits a good antifungal effect.

Advantageous effect of the invention

[0008] According to the present invention, a thread that gives a space in which a good electric field is generated can be realized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1(A) is a view illustrating a configuration of a thread according to one embodiment of the present invention. FIG. 1(B) is a sectional view taken along the line I-I in FIG. 1(A). FIG. 1(C) is a view illustrating applying a twist to a first fiber and second fibers of the thread.

FIGS. 2(A) to 2(C) are views showing a sectional shape of the first fiber, respectively.

FIGS. 3(A) and 3(B) are views showing a relation among deformation, a uniaxial stretching direction, and an electric field direction of a second fiber when the second fiber is a polylactic acid (PLLA) uniaxially stretched.

FIG. 4(A) is a view illustrating a configuration of a thread according to one embodiment of the invention. FIG. 4(B) is a sectional view taken along the line II-II of FIG. 4(A). FIG. 4(C) is a view illustrating applying a twist to a first fiber and a second fiber of the thread.

FIG. 5 is a view illustrating an electric field in a thread. FIG. 6 is a sectional view of a thread according to one embodiment of the invention.

FIG. 7 is a sectional view of a thread according to one embodiment of the invention.

MODE FOR CARRYING OUT THE INVENTION

[0010] FIG. 1(A) is a view illustrating a configuration of a thread 1 according to one embodiment of the invention. FIG. 1(B) is a sectional view taken along the line I-I in FIG. 1(A). FIG. 1(C) is a view illustrating applying a twist to a first fiber 10 and second fibers 20 of the thread 1.

[0011] The thread 1 is composed of a first fiber 10 and second fibers 20. The first fiber 10 has at least one a groove 12 extending in a length direction, and is surrounded by a plurality of second fibers 20. When energy is applied to the second fibers 20, charge is generated. In the thread 1 of the present embodiment, the second fibers 20 are disposed to fit the groove 12 of the first fiber 10, and are twisted together with the first fiber 10. In FIG. 1(B), as an example, a cross section of one first fiber 10 and six second fibers 20 is illustrated in a cross section

taken along the line I-I, but the number of first fibers 10 and the number of second fibers 20 are not limited to this, and are actually set as appropriate in consideration of the application and the like.

[0012] Conventionally, it has been known that proliferation and metastasis of a bacterium, a fungus, and the like can be suppressed by an electric field (See, for example, Tetsuaki Tsuchido, Hiroki Kourai, Hideaki Mat-suoka, Junichi Koizumi, Kodansha: Microbial Control - Science and Engineering. In addition, see, for example, Koichi Takaki, Application of High Voltage and Plasma Technology to Agricultural and Food Field, J. HTSJ, Vol. 51, No. 216). In addition, a potential generating the electric field may cause a current to flow through a current path formed by moisture or a circuit formed by a micro discharge phenomenon. It is considered that this current weakens a fungus and suppresses proliferation and metastasis of the fungus.

[0013] When the thread 1 of the embodiment receives external energy (for example, when a tension is applied in an axial direction of the thread 1), charge is generated, and an electric field is generated. Alternatively, when the thread 1 receiving external energy is brought close to a thing having a predetermined potential (including a ground potential) such as a human body, an electric field is also generated between the thread 1 and the thing. When the thread 1 receives external energy and is close to a thing having a predetermined potential (including a ground potential) such as a human body, a current flows between the thread 1 of the present invention and the thing through a liquid such as sweat.

[0014] Disruption of a cell of a fungus and degeneration of the cytoplasm occur by an electric field or an electric current. Therefore, the cell of the fungus and the electron transmission system for maintaining the life of the fungus are disturbed, and the fungus is killed or the fungus itself is weakened. In addition, oxygen contained in a liquid such as sweat or water may be changed into an active oxygen species by an electric field or a current. Active oxygen species includes an oxygen radical, and these effects kill or weaken a fungus. Thus, the thread 1 has a remarkable antifungal effect. In the invention, the "anti-fungal effect" is a concept including both an effect of killing a fungus and an effect of weakening a fungus.

[0015] In the embodiment, the first fiber 10 is a modified cross-section fiber (modified filament) made of a fiber material such as a polyester, a nylon, or an acrylic. FIGS. 2(A) to 2(C) are views showing a sectional shape of the first fiber 10, respectively. As illustrated in FIGS. 2(A) to 2(C), the sectional shape of the first fiber 10 is a cross shape, a star polygon, or a concave polygon. In any example, the first fiber 10 has the groove 12 and protrusion 14 extending in the longitudinal direction.

[0016] Furthermore, in the embodiment, the second fiber 20 is made of, for example, a piezoelectric polymer. Examples of the piezoelectric polymer include a polyvinylidene fluoride (PVDF) and a polylactic acid (PLA), and any of them can be used as a raw material of the second

fiber 20. Among them, the polylactic acid (PLA) is a piezoelectric polymer having no pyroelectricity. The polylactic acid is uniaxially stretched to generate piezoelectricity. The polylactic acid includes PLLA having a right-handed helical structure obtained by polymerizing an L-form monomer and PDLA having a left-handed helical structure obtained by polymerizing a D-form monomer and having a polarity of a piezoelectric constant opposite to that of PLLA.

[0017] FIGS. 3(A) and 3(B) are views showing a relation among deformation, a uniaxial stretching direction, and an electric field direction of the second fiber 20 when the second fiber 20 is a polylactic acid (PLLA) uniaxially stretched. FIGS. 3(A) and 3(B) are views when the second fiber 20 is assumed to have a film shape as a model case. In the embodiment, the second fiber 20 is a circular cross section fiber (circular filament).

[0018] The polylactic acid (PLA) is a chiral polymer, and its main chain has a helical structure. When the polylactic acid is uniaxially stretched and molecules are oriented, piezoelectricity appears. When heat treatment is further performed to increase the crystallinity, the piezoelectric constant increases. The second fiber 20 made of a uniaxially stretched polylactic acid has a tensor component of d_{14} and d_{25} as the piezoelectric strain constant when a thickness direction is defined as a first axis, a stretching direction 900 is defined as a third axis, and a direction orthogonal to both the first axis and the third axis is defined as a second axis. Therefore, when the second fiber 20 made of a uniaxially stretched polylactic acid is distorted in a direction of 45 degrees with respect to the uniaxially stretched direction, charge is generated.

[0019] As shown in FIG. 3(A), when the second fiber 20 shrinks in the direction of the first diagonal line 910A and extends in the direction of the second diagonal line 910B orthogonal to the first diagonal line 910A, an electric field is generated in a direction from the back side to the front side of the paper surface. That is, in the state of FIG. 3(A), a negative charge is generated on the front side of the paper surface. As shown in FIG. 3(B), when the second fiber 20 extends in the direction of the first diagonal line 910A and shrinks in the direction of the second diagonal line 910B, charge is also generated. In this case, the polarity is reversed, and an electric field is generated in a direction from the surface to the back side of the paper surface. That is, in the state of FIG. 3(B), a positive charge is generated on the front side of the paper surface.

[0020] The polylactic acid has piezoelectricity due to orientation of molecules by stretching, and thus does not need poling unlike other piezoelectric polymers such as PVDF or piezoelectric ceramics. The piezoelectric constant of the uniaxially stretched polylactic acid is about 5 to 30 pC/N, and has a very high piezoelectric constant among polymers. Furthermore, the piezoelectric constant of the polylactic acid does not vary with time and is extremely stable.

[0021] As illustrated in FIG. 1(C), the second fibers 20

having the characteristics are twisted together with the first fiber 10 to the left to obtain the thread 1. The thread 1 is S-twisted (right-twisted). In FIG. 1(A), since the plurality of second fibers 20 are twisted, the stretching direction (length direction) 900 of each second fiber 20 is inclined obliquely with respect to the stretching direction of the thread 1. In other words, the stretching direction 900 of the second fibers 20 is inclined to the left on the paper surface with respect to the stretching direction of the thread 1.

[0022] Ideally, the angle (twist angle of the second fibers 20) between stretching direction 900 of the second fibers 20 and the stretching direction of the thread 1 is preferably 45 degrees. When such a thread 1 is stretched under tension, the second fibers 20 are stretched along the axial direction of the thread 1, and are shrunk along the width direction of the thread 1. Therefore, the axial direction of the thread 1 corresponds to the second diagonal line 910B illustrated in FIG. 3(A), and the width direction of the thread 1 corresponds to the first diagonal line 910A illustrated in FIG. 3(A). As in the example shown in FIG. 3(A), the second fiber 20 stretches in the direction corresponding to the second diagonal line 910B and shrinks in the direction corresponding to the direction of the first diagonal line 910A. Therefore, a negative charge is generated on the surface of the second fiber 20, and a positive charge is generated on the inner side. That is, in the second fiber 20, charge is generated by external energy.

[0023] Of course, the inclination of the second fiber 20 with respect to the axial direction of the thread 1 is not limited to 45 degrees to the left. When a shearing stress is applied to the second fiber 20, charge is generated. Therefore, the stretching direction 900 of the second fiber 20 may cross at least the axial direction of the thread 1. Considering this, the twist angle of the second fiber 20 may be larger than 0 degrees and smaller than 90 degrees to the left. In general, as the twist angle of the second fiber 20 approaches 45 degrees to the left, the charge generation efficiency is improved. However, usually, the thread is used for knitted fabrics, textile fabrics, and sewing, and the direction in which the thread extends may not be constant. That is, since an external force is not necessarily applied in the long axis direction of the thread, the twist angle of the second fiber 20 is not limited to the above.

[0024] In the embodiment, since the first fiber 10 has the groove 12, the surface area of the first fiber 10 is larger than that of a fiber having no groove, and the possibility that fungus adheres to the first fiber 10 is relatively high. As shown in FIG. 1(C), when the first fiber 10 having the groove 12 in the length direction is twisted, the groove 12 extends helically. The shape of the groove 12 is a shape along a surface of the second fiber 20. In such a configuration, when the second fiber 20 is twisted, the second fiber 20 is twisted along the groove 12 of the first fiber 10. In other words, the second fiber 20 is twisted while being guided by the groove 12 of the first fiber 10.

The opening width of the groove 12 is substantially equal to or larger 20 than the diameter length of the second fiber 20. At this time, by increasing the friction coefficient of one of the first fiber 10 and the second fiber 20, when the first fiber 10 and the second fiber 20 are stressed against each other, stress can be efficiently applied to the other, and generation of charge can be improved.

[0025] Further, as shown in FIG. 1(C), in the embodiment, a space SP is formed between the groove 12 of the first fiber 10 and the second fiber 20 disposed in the region formed in the groove 12. In FIG. 1(C), the cross section of the groove 12 is V-shaped, but the cross section of the second fiber 20 is circular form. Therefore, since the second fiber 20 and the groove 12 are not engaged exactly with each other, the space SP is generated. With such a space SP, a leakage electric field is likely to be formed. Therefore, the thread 1 exerts a good antifungal effect. The shape of the space SP can be changed by changing the shape of the groove 12 of the first fiber 10, and the optimum leakage electric field can be changed in combination with the second fiber 20.

[0026] The cross section of the space SP is smaller than the cross section of the thread 1. The space SP may be smaller than the cross section of the first fiber 10 or smaller than the cross section of the second fiber 20.

[0027] FIG. 4(A) is a view illustrating a configuration of a thread 2 according to one embodiment of the invention. FIG. 4(B) is a sectional view taken along line II-II of FIG. 4(A). FIG. 4(C) is a view illustrating applying a twist to a first fiber 10 and second fibers 20 of the thread 2. In the thread 2 of the embodiment, the second fibers 20 are twisted rightward together with the first fiber 10. That is, the thread 2 is Z-twisted (left-twisted). In FIG. 4(A), the stretching direction 900 of the second fibers 20 is inclined to the right on the paper surface with respect to the stretching direction of the thread 2.

[0028] As in the thread 1, in the thread 2, the angle between the stretching direction 900 of the second fiber 20 and the stretching direction of the thread 2 is ideally preferably 45 degrees. When such a thread 2 is stretched under tension, the second fibers 20 are stretched along the axial direction of the thread 2, and are shrunk along the width direction of the thread 2. Therefore, the stretching direction of the thread 2 corresponds to the first diagonal line 910A illustrated in FIG. 3(B), and the width direction of the thread 2 corresponds to the second diagonal line 910B illustrated in FIG. 3(B). As in the example shown in FIG. 3(B), the second fiber 20 stretches in the direction corresponding to the first diagonal line 910A and shrinks in the direction corresponding to the direction of the second diagonal line 910B. Therefore, a positive charge is generated on the surface of the thread 2, and a negative charge is generated on the inner side.

[0029] Since charge generates when the shearing stress is applied in the second fiber 20, the inclination with respect to the stretching direction of the thread 2 is not limited to 45 degrees to the right, and may at least intersect with the stretching direction of the thread 2.

However, as the twist angle of the second fiber 20 approaches 45 degrees to the right, the charge generation efficiency is improved. In the embodiment, the groove 12 of the first fiber 10 is a V-shaped groove, and a surface of the second fiber 20 is arcuate. That is, the shape of the groove 12 of the first fiber 10 is a shape that is not along the surface of the second fiber 20. However, in other embodiments, the shape of the groove 12 of the first fiber 10 may be a shape along the surface of the second fiber 20. For example, the groove 12 of the first fiber 10 is a semicircular groove, and the surface of the second fiber 20 is arcuate. Furthermore, usually, the thread is used for knitted fabrics, textile fabrics, and sewing, and the direction in which the thread extends may not be constant. That is, since an external force is not necessarily applied in the long axis direction of the thread, the twist angle of the second fiber 20 is not limited to the above.

[0030] As shown in FIG. 4(C), since there is a space SP between the groove 12 of the first fiber 10 and the second fiber 20 disposed to fit the groove 12, a leakage electric field is easily formed. Therefore, the thread 2 has the same good antifungal effect as the thread 1.

[0031] FIG. 5 is a view illustrating an electric field in the thread 1 and the thread 2. In the thread 1 alone, the surface has a negative potential and the inside has a positive potential when tension is applied. In the thread 2 alone, the surface has a positive potential and the inside has a negative potential when tension is applied. When the thread 1 and the thread 2 are brought close to each other, the close portions (surfaces) tend to have the same potential. In this case, the proximity portion between the thread 1 and the thread 2 becomes 0 V, and the positive potential inside the thread 1 is further increased so as to maintain the original potential difference. Similarly, the negative potential inside the thread 2 is further lowered.

[0032] An electric field directed mainly from the inside to the outside of the thread 1 is formed in the cross section of the thread 1, and an electric field directed mainly from the outside to the inside the thread 2 is formed in the cross section of the thread 2. When the thread 1 and the thread 2 are brought close to each other, these electric fields leak out into the air and are synthesized, and an electric field is formed by a potential difference between the thread 1 and the thread 2 as illustrated in FIG. 5. Alternatively, when the thread 1 (or the thread 2) and a thing having a predetermined potential (including a ground potential) such as a human body are brought close to each other, an electric field is generated between the thread 1 (or the thread 2) and the thing close to the thread 1 (or the thread 2).

[0033] Alternatively, a current may flow through a current path formed by moisture between the thread 1 and the thread 2, or a circuit formed by a micro discharge phenomenon. Even when the thread 1 or the thread 2 and a thing having a predetermined potential close to each other are brought close to each other, a current may flow through a current path formed by moisture, or a cir-

cuit formed by a micro discharge phenomenon.

[0034] Furthermore, the thread 1 and the thread 2 do not need to have potentials of opposite polarity. Even if the thread 1 and the thread 2 have potentials of the same polarity, an electric field or a current is generated if there is a potential difference between them. That is, the thread 1 and the thread 2 may have different potentials when charges are generated.

[0035] As the fiber that generates a negative charge on the surface, a Z thread using PDLA is also conceivable in addition to an S thread using PLLA. Furthermore, as the fiber that generates a positive charge on the surface, the S thread using PDLA is also conceivable in addition to the Z thread using PLLA.

[0036] In the embodiment, only the second fiber 20 contains the polylactic acid. However, in other embodiments, the first fiber 10 may also contain the polylactic acid. Then, when the first fiber 10 is twisted, charge is generated.

[0037] In the embodiment, the number of the first fibers 10 in the thread 1 or the thread 2 is 1, but in other embodiments, the number of the first fibers 10 may be plural. FIG. 6 is a sectional view of a thread according to one embodiment of the invention. As shown in FIG. 6, a plurality of first fibers 10 is disposed so as to be surrounded by second fibers 20. The bundle of first fibers 10 has more grooves 12 than the single first fiber 10. In such a configuration, when the first fibers 10 and the second fibers 20 are twisted, the bundle of the first fibers 10 can guide more the second fibers 20.

[0038] In the embodiment, the first fiber 10 and the second fiber 20 are long fibers (filaments), and the thread 1 and the thread 2 are twisted threads made of long fibers. However, the thread 1 and thread 2 are not limited to the twisted threads made of long fibers. In another embodiment, the first fiber 10 and the second fiber 20 may be short fibers (spans), and the thread 1 and the thread 2 may be spun threads made of short fibers. In other embodiments, the first fiber 10 and the second fiber 20 may be long fibers and short fibers (or short fibers and long fibers), respectively, and the thread 1 and the thread 2 may be twisted threads made of two types of fibers.

[0039] In the embodiment, the first fibers 10 are heteromorphic modified cross-section fibers (modified filaments) and the second fibers 20 are circular cross-section fibers (circular filaments). However, the second fibers 20 are not limited to the circular cross-section fibers. In another embodiment, the second fibers 20 are a modified cross-section fibers like the first fibers 10.

[0040] In other embodiments, both the first fiber 10 and the second fiber 20 may be charge generating fibers that generate charge. Furthermore, when both the first fiber 10 and the second fiber 20 are charge generating fibers, either one may have a lower elastic modulus than the other, and when only one of the first fiber 10 and the second fiber 20 is charge generating fiber, the other may have a lower elastic modulus than the one. In this case, since the fiber has a low elastic modulus, the thread tends

to stretch, and the shearing stress tends to be applied to the charge generating fiber. Furthermore, when both of the first fiber 10 and the second fiber 20 are charge generating fibers, either one may have a lower coefficient of static friction than the other, and when only one of the first fiber 10 and the second fiber 20 is charge generating fiber, the other may have a higher coefficient of static friction. In this case, the shearing stress tends to be applied to the charge generating fiber.

[0041] FIG. 7 is a sectional view of a thread 3 according to one embodiment of the invention. In this embodiment, a thread 3 is composed of the first fiber 10 and the second fiber 20 which are modified cross-section fibers, and the first fiber 10 and the second fiber 20 have the same sectional shape. However, in other embodiments, the first fiber 10 and the second fibers 20 in the thread 3 may have different sectional shapes.

[0042] As illustrated in FIG. 7, the second fiber 20 has at least one protrusion 24 extending in the length direction. The second fiber 20 is disposed such that the protrusion 24 of the second fiber 20 engages with the groove 12 of the first fiber 10. In such a configuration, when the second fiber 20 is twisted, the protrusion 24 of the second fiber 20 is twisted along the groove 12 of the first fiber 10, and extends helically. That is, the second fiber 20 is twisted while being guided by the groove 12 of the first fiber 10.

[0043] The thread 3 is S-twisted or z-twisted depending on the direction of twisting. In the embodiment, by using the groove 12 of the first fiber 10 and the protrusion 24 of the second fiber 20, the twist angle of the second fiber 20 can be made close to a desired angle (45 degrees to the left or 45 degrees to the right), and the thread 3 can be made into a medium twisted thread or a hard twisted thread. Since the shape and size of the internal space of the groove 12 do not exactly fit the shape and size of the protrusion 24, the space SP exists between the first fiber 10 and the second fiber 20. Therefore, a leakage electric field is easily formed. Such a thread 3 has the same good antifungal effect as the thread 1 and the thread 2.

[0044] In the embodiment, the groove 12 of the first fiber 10 is parallel to the length direction of the first fiber 10 as shown in FIG. 1(C). However, the groove 12 is not limited to the linear groove. In another embodiment, the groove 12 of the first fiber 10 is a groove formed in a helical shape with respect to the axial direction of the first fiber 10. When the second fiber 20 is wound along the helical groove, a thread having an appearance similar to that of the twisted thread is obtained. In this embodiment, it is not necessary to twist the first fiber 10. The number of turns and the helical angle of the second fiber 20 are determined by the installation state of the helical groove. Therefore, if the number of turns and the helical angle are appropriate, the thread obtained in this embodiment can also exhibit a good antifungal effect.

[0045] The above-mentioned threads (thread 1, thread 2, thread 3, etc.) can be applied to daily life products such as medical parts and clothing. For example, the thread

(thread 1, thread 2, thread 3, etc.) can be applied to a mask, underwear (in particular, socks), a towel, insoles such as shoes and boots, sportswear in general, a hat, bedding (bedclothes, a mattress, a sheet, a pillow, a pillow cover, and the like), a toothbrush, a froth, a water purifier, a filter for an air conditioner or an air cleaner, a stuffed toy, a pet-related product (a mat for a pet, clothing for a pet, and an innerwear for a pet), various mat products (a foot, a hand, and a toilet seat), s curtain, s kitchen utensil (s sponge or s cloth), seats (a seats for a car, a train, an airplane, etc.), a cushioning material for a motorbike helmet and an exterior material thereof, a sofa, a bandage, a gauze, a suture, clothes for a doctor and a patient, a supporter, a sanitary product, a sporting good (an inner of a wear and a glove, an arm guard used in a martial art, or the like), a filter for an air conditioner or an air cleaner, a packaging material, and a screen door.

[0046] Of the clothing, in particular, socks (or supporters) always expand and contract along a joint by movement such as walking, and thus the thread (thread 1, thread 2, thread 3, etc.) generates charge with high frequency. In addition, socks absorb moisture such as sweat and become a hotbed for proliferation of a fungus, but the threads (thread 1, thread 2, thread 3, etc.) can suppress proliferation of a fungus, and thus exert a remarkable effect as a fungus-countermeasure application for odor prevention.

[0047] Finally, description of this embodiment should be considered to be exemplary in all respects and not restrictive. The scope of the present invention is defined not by the embodiments but by the claims. Furthermore, the scope of the invention is intended to include all modifications within the meaning and scope equivalent to the claims.

DESCRIPTION OF REFERENCE SYMBOLS

[0048]

1, 2, 3: Thread
 10: First fiber
 20: Second fiber
 12: Groove
 14, 24: Protrusion
 SP: Space
 900: Stretching direction
 910A: First diagonal line
 910B: Second diagonal line

Claims

1. A thread comprising:

a first fiber having at least one groove extending in a length direction; and
 at least one second fiber in which potential is generated by external energy,

- the second fiber being disposed in a region formed in the groove of the first fiber, and a space being formed between the groove of the first fiber and the second fiber disposed to fit the groove. 5
2. The thread according to claim 1, wherein a cross section of the space formed between the first fiber and the second fiber is smaller than a cross section of the thread. 10
 3. The thread according to claim 1 or 2, wherein a shape of the groove of the first fiber is a shape along a surface of the second fiber. 15
 4. The thread according to claim 1 or 2, wherein a shape of the groove of the first fiber is a shape that is not along a surface of the second fiber.
 5. The thread according to claim 1 or 2, wherein the first fiber and the second fiber are modified cross-section fibers, the second fiber has at least one protrusion extending in the length direction, and the second fiber is disposed such that the protrusion engages with the groove of the first fiber. 20
25
 6. The thread according to any one of claims 1 to 5, wherein the first fiber has a lower elastic modulus than the second fiber. 30
 7. The thread according to any one of claims 1 to 6, wherein the first fiber has a higher coefficient of static friction than the second fiber.
 8. The thread according to any one of claims 1 to 7, wherein an opening width of the groove substantially matches a diameter length of the second fiber. 35
 9. The thread according to any one of claims 1 to 7, wherein an opening width of the groove is larger than a diameter length of the second fiber. 40
 10. The thread according to any one of claims 1 to 9, wherein the second fiber contains a polylactic acid. 45
 11. The thread according to any one of claims 1 to 10, wherein the first fiber or the second fiber is a long fiber. 50
 12. The thread according to any one of claims 1 to 10, wherein the first fiber or the second fiber is a short fiber. 55

FIG. 1

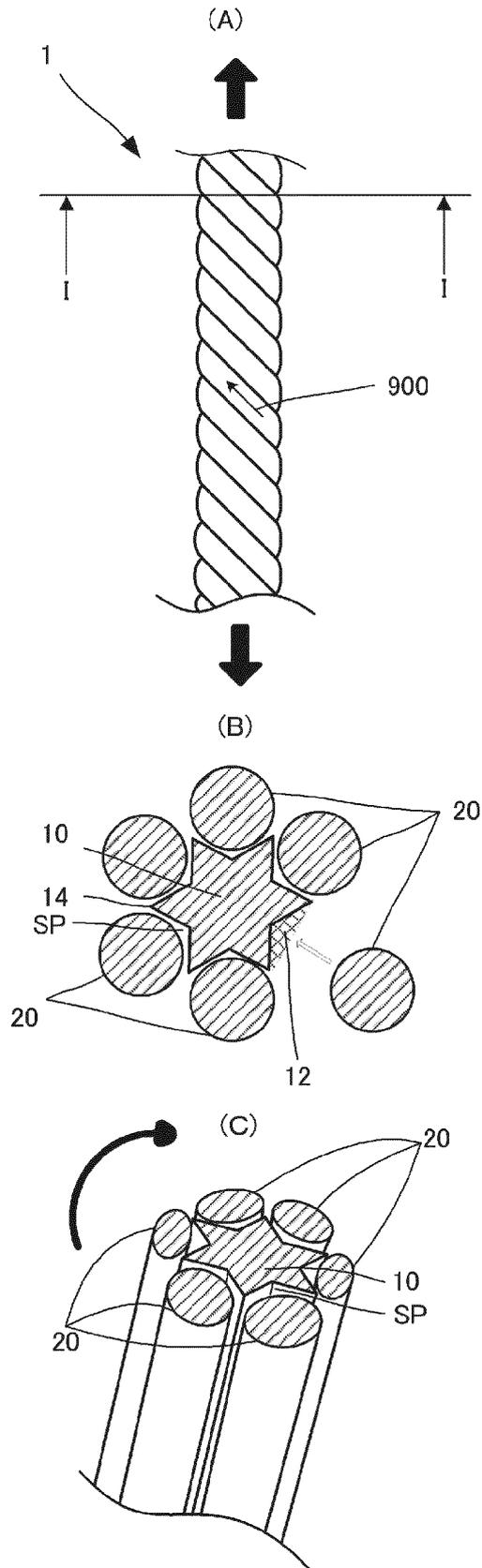
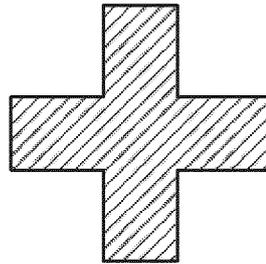
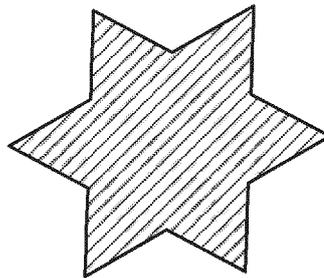


FIG. 2

(A)



(B)



(C)

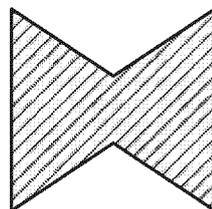


FIG. 3

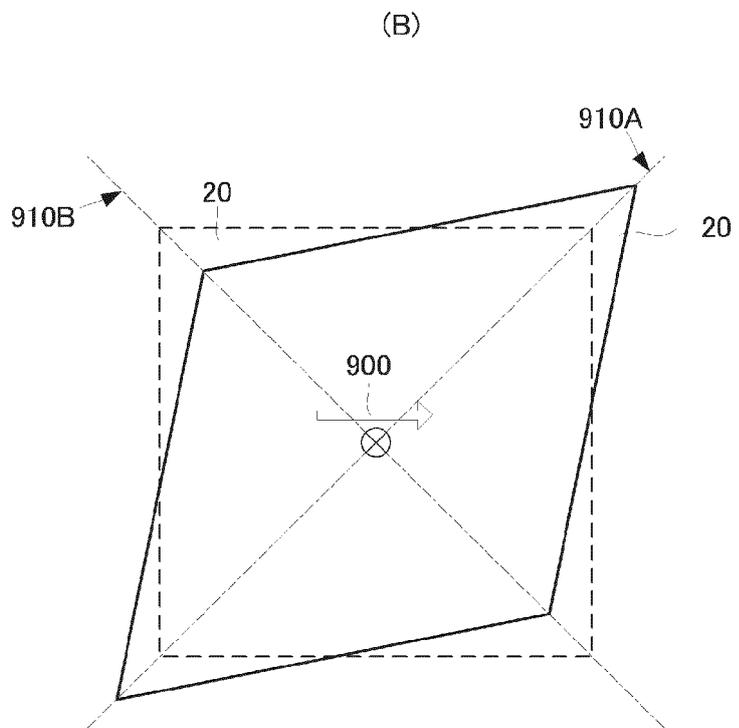
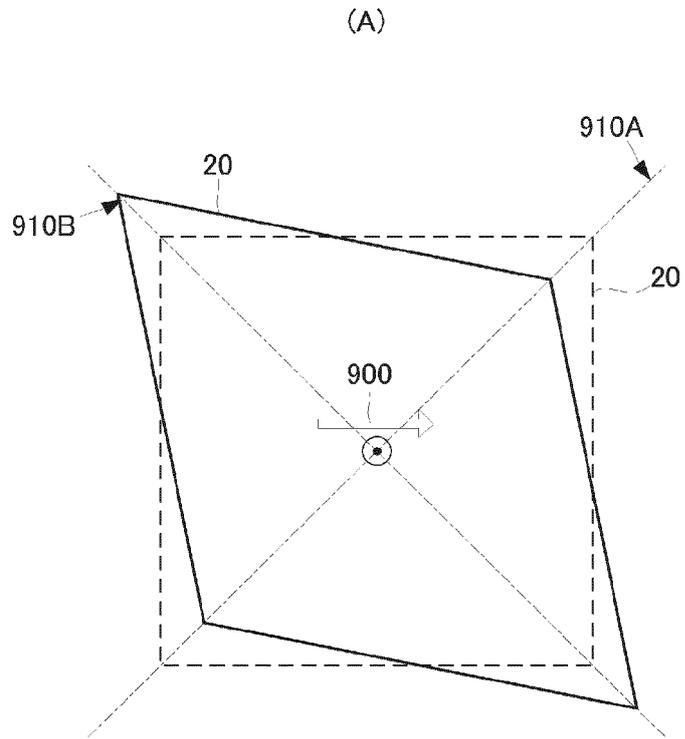


FIG. 4

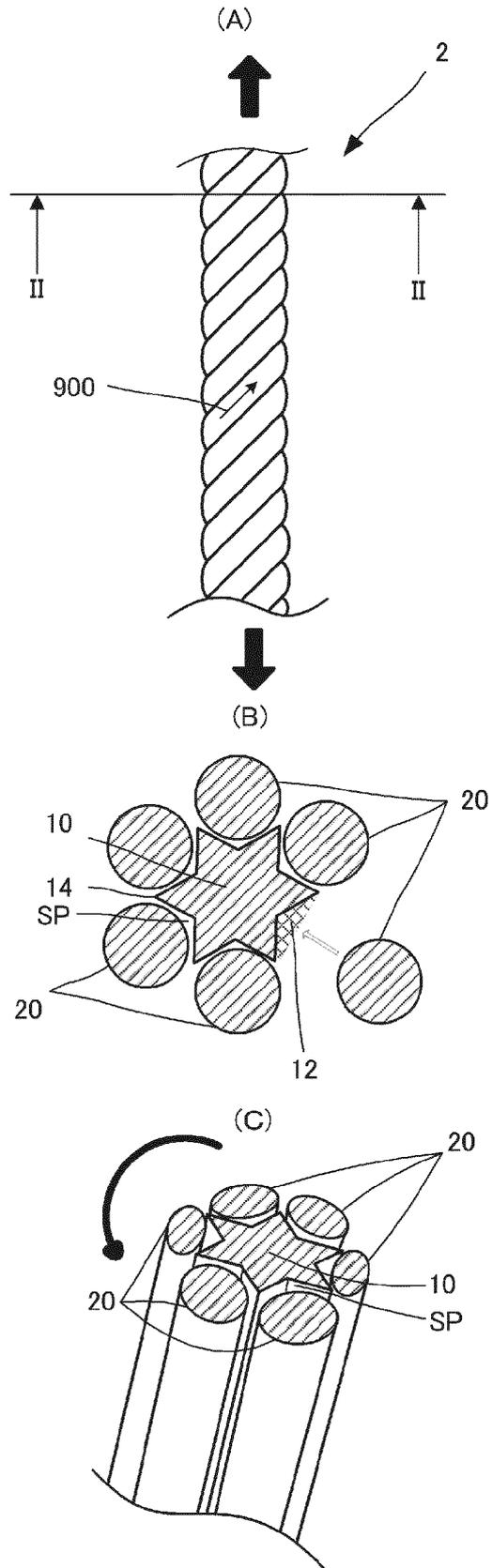


FIG. 5

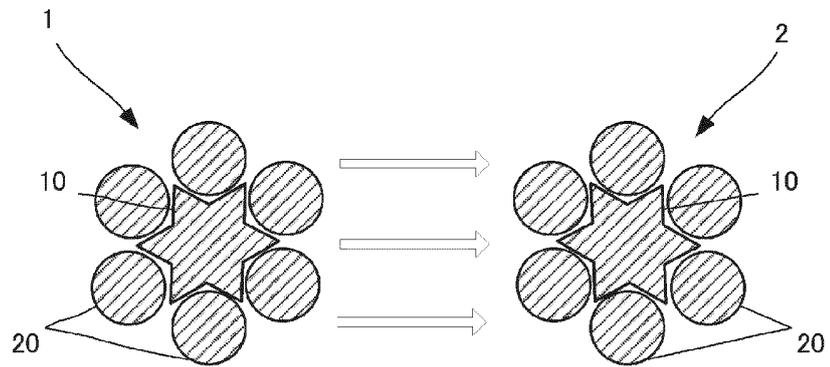


FIG. 6

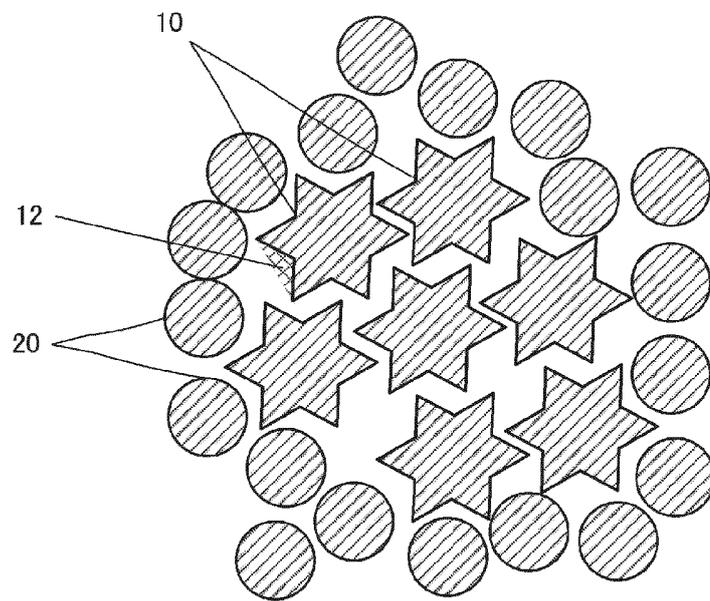
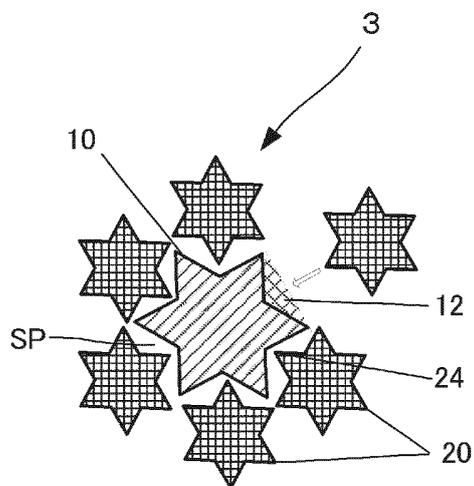


FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/043598

A. CLASSIFICATION OF SUBJECT MATTER

D02G 3/04 (2006.01) i

FI: D02G3/04

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)

D02G1/00-3/48; D02J1/00-13/00

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2021

Registered utility model specifications of Japan 1996-2021

Published registered utility model applications of Japan 1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2019/078143 A1 (MURATA MANUFACTURING CO., LTD.) 25 April 2019 (2019-04-25) claims	1-12
A	WO 2017/212836 A1 (MURATA MANUFACTURING CO., LTD.) 14 December 2017 (2017-12-14) paragraph [0068], fig. 11	1-12
A	JP 63-92741 A (TEIJIN LTD.) 23 April 1988 (1988- 04-23) page 2, lower right column, lines 5-20, fig. 3	1-12
A	JP 4-316624 A (UNITIKA LTD.) 09 November 1992 (1992-11-09) paragraph [0008], fig. 1	1-12



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
06 January 2021 (06.01.2021)Date of mailing of the international search report
19 January 2021 (19.01.2021)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No. PCT/JP2020/043598
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Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
WO 2019/078143 A1	25 Apr. 2019	US 2019/0330771 A1 claims	
WO 2017/212836 A1	14 Dec. 2017	CN 110088367 A EP 3467169 A1 paragraph [0067], fig. 11 JP 2017-220658 A JP 2018-75348 A JP 2018-76629 A JP 2018-90950 A JP 2019-131948 A US 2019/0078239 A1 WO 2017/212523 A1 WO 2017/212666 A1 WO 2018/084054 A1 CN 109312500 A	
JP 63-92741 A	23 Apr. 1988	(Family: none)	
JP 4-316624 A	09 Nov. 1992	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2017212836 A [0003]

Non-patent literature cited in the description

- **TETSUAKI TSUCHIDO ; HIROKI KOURAI ; HIDE-AKI MATSUOKA ; JUNICHI KOIZUMI.** *Kodansha: Microbial Control - Science and Engineering* [0012]
- **KOICHI TAKAKI.** Application of High Voltage and Plasma Technology to Agricultural and Food Field. *J. HTSJ*, vol. 51 (216 [0012]