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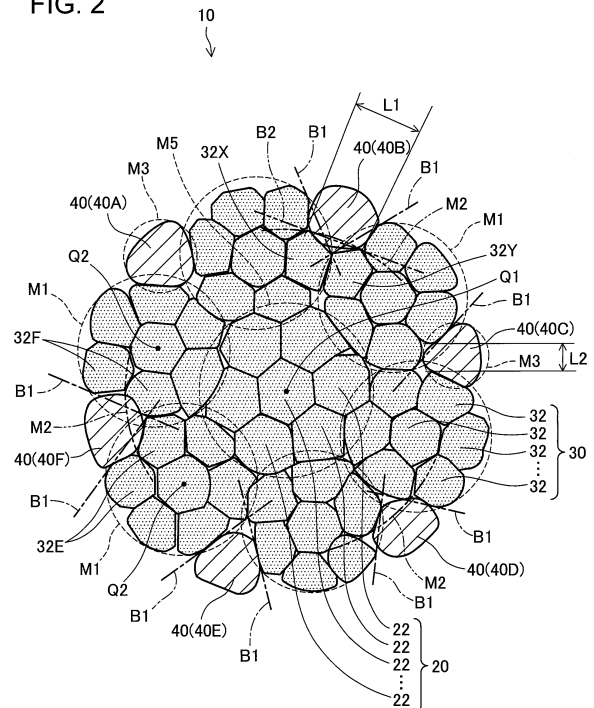
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(54) **WIRE ROPE**

(57) This wire rope is provided with a plurality of strands that are twisted with each other, and the plurality of strands each have a configuration in which a plurality of element wires are twisted with each other. The wire rope is further provided with a single wire that is disposed in a recess section formed on the outer peripheral side of the wire rope by two strands that are adjacent to each other along the peripheral direction of the wire rope. In a transverse cross-section of the wire rope, a portion of the single wire is positioned inside a virtual circumscribed circle of one of the two strands.

FIG. 2



Description**TECHNICAL FIELD**

[0001] The technique disclosed in the present specification relates to a wire rope.

BACKGROUND ART

[0002] Wire ropes can take forms such as so-called single-twisted and multi-twisted forms. A single-twisted form is a form in which a plurality of single wires are twisted with each other, and a multi-twisted form is a form in which a plurality of strands are twisted with each other, where each strand is constituted by a plurality of element wires that are twisted with each other. Single-twisted wire ropes have a higher rigidity than multi-twisted wire ropes, which provides advantages such as a high elongation resistance of the wire rope, an example of which is a low initial elongation. Here, the initial elongation of a wire rope is the elongation that occurs in the initial stages of using a new wire rope. Because the operability of a wire rope can decrease if the initial elongation of the wire rope is large, it is preferable that the initial elongation of the wire rope is small. On the other hand, although multi-twisted wire ropes have a lower rigidity than single-twisted wire ropes, the flexibility of shape changes is correspondingly higher, which provides advantages when the wire rope is used by being inserted inside a bent tube, such as a lower frictional resistance and higher slidability of the wire rope inside the tube.

[0003] Therefore, techniques in which filling wires or Ag strands (hereinafter referred to as "filling wires and the like") are disposed between each of the plurality of strands in a multi-twisted wire rope are conventionally known (for example, see Patent Literature 1 and 2). In these conventional techniques, by interposing the filling wires and the like between two strands that are adjacent to each other, the elongation resistance of the wire rope can be improved due to a higher filling rate of the wire rope (fewer gaps in the transverse cross-section of the wire rope). That is to say, according to these conventional techniques, an improvement in the elongation resistance of the wire rope can be expected while ensuring the flexibility of shape changes.

CITATION LIST**Patent Literature**

[0004]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. H7-138923

Patent Literature 2: United States Patent No. 6,049,042

SUMMARY OF INVENTION**TECHNICAL PROBLEM**

[0005] However, in the conventional techniques described above, because the filling wires and the like are simply twisted alongside the two strands that are adjacent to each other, a cavity exists between the filling wires and the like and the element wires constituting the strands; therefore, the filling rate of the wire rope is insufficient, and the elongation resistance of the wire rope cannot be sufficiently improved.

[0006] A technique capable of solving the problems described above is disclosed herein.

SOLUTION TO PROBLEM

[0007] The technique disclosed herein can be achieved, for example, as the following aspects.

(1) A wire rope disclosed herein is provided with a plurality of strands that are twisted with each other, the plurality of strands each having a configuration in which a plurality of element wires are twisted with each other, the wire rope including: a single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by two strands that are adjacent to each other along a peripheral direction of the wire rope; wherein in a transverse cross-section of the wire rope, a portion of the single wire is positioned inside a virtual circumscribed circle of one of the two strands. In this wire rope, the single wire is disposed in a recess section formed on the outer peripheral side of the wire rope by two strands that are adjacent to each other. Further, the gap that exists between the two strands is filled such that a portion of the single wire is positioned inside the virtual circumscribed circle of one of the two strands that are adjacent to each other. Therefore, according to this wire rope, compared to a configuration in which the single wire is interposed between two strands that are adjacent to each other, or a configuration in which the single wire is positioned outside the virtual circumscribed circle of the two strands that are adjacent to each other, the filling rate of the wire rope can be increased, which enables the elongation resistance of the wire rope to be improved.

(2) The wire rope described above may be configured such that, in the transverse cross-section, an element wire of one of the two strands and an element wire of the other of the two strands are adjacently disposed further inward of the single wire in a radial direction of the wire rope, and a portion of the single wire is positioned between the element wire of the one strand and the element wire of the other strand in the peripheral direction. In this wire rope, the gap that exists between the two strands is filled such that the single wire is positioned between ele-

ment wires that constitute each of the two strands that are adjacent to each other, and which are disposed adjacent to each other. Therefore, according to this wire rope, compared to a configuration in which the single wire is not positioned between element wires that are disposed adjacent to each other, the filling rate of the wire rope can be increased, which enables the elongation resistance of the wire rope to be more effectively improved.

(3) The wire rope described above may be configured such that, in the transverse cross-section, the single wire makes contact with each of the element wire of the one of the two strands and the element wire of the other strand. In this wire rope, the gap that exists between the two strands is filled such that the single wire makes contact with the element wires constituting each of the two strands that are adjacent to each other. Therefore, according to this wire rope, compared to a configuration in which the single wire is separated from the element wires constituting the strands, the filling rate of the wire rope can be increased, which enables the elongation resistance of the wire rope to be more effectively improved.

(4) The wire rope described above may be configured such that, in the transverse cross-section, a cross-sectional area of the single wire is larger than a cross-sectional area of each of the element wires constituting the strands. In this wire rope, compared to a configuration in which the cross-sectional area of the single wire is smaller than the cross-sectional area of each of the element wires of the strands, the strength of the wire rope can be improved by the single wire.

(5) The wire rope described above may be configured such that a tensile strength of the single wire is lower than a tensile strength of each of the element wires constituting the strands. According to this wire rope, compared to a configuration in which the tensile strength of the single wire is greater than or equal to the tensile strength of the element wires constituting the strands, the single wire enters between the element wires of the two strands more easily, which enables the elongation resistance of the wire rope to be more effectively improved.

(6) The wire rope described above may be configured such that a tensile strength of the single wire is within a range of $\pm 5\%$ of a tensile strength of each of the element wires constituting the strands. According to this wire rope, the tensile strength of the wire rope as a whole can be made uniform.

(7) The wire rope described above may be configured such that an area of the virtual circumscribed circle is smaller than an area of a virtual circumscribed circle of a virtual strand in a case where all of the element wires constituting the one strand are perfectly circular (are perfect circles circle having the same area as the area of the element wires). According to this wire rope, compared to a configuration

in which the area of the virtual circumscribed circle of the strand is the same as that of the virtual circumscribed circle of the virtual strand, the elongation resistance of the wire rope can be more effectively improved by an amount corresponding to the extent that the gap between the element wires of the strand is reduced.

(8) The wire rope described above may be configured such that, in the transverse cross-section, an area of a virtual circumscribed circle of the single wire is larger than an area of the single wire (area of a perfect circle) when being perfectly circular (a perfect circle having the same area as the area of the single wire). According to this wire rope, it is possible to effectively fill (block) the recess section (gap) formed on the outer peripheral side of the wire rope by the two strands that are adjacent to each other with the single wire. As a result, the gaps between the plurality of element wires inside each of the side strands (each individual side strand) can be more effectively filled (blocked) by the plurality of element wires. Therefore, the elongation resistance of the wire rope can be more effectively improved.

(9) The wire rope described above may be configured such that the single wire includes a first single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a first group of strands that are adjacent to each other, and a second single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a second group of strands that are adjacent to each other, and in the transverse cross-section, a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction is larger than a distance between a pair of element wires positioned so as to sandwich the second single wire in the peripheral direction, and further, the number of element wires of the first group of strands making contact with the first single wire is larger than the number of element wires of the second group of strands making contact with the second single wire. According to this wire rope, the larger the distance between the pair of element wires sandwiching the single wire, the larger the number of element wires that make contact with the single wire. As a result, as the gap that exists between the two strands that are adjacent to each other becomes larger, the gap that exists between the two strands is filled such that the single wire makes contact with a larger number of element wires. Therefore, according to this wire rope, compared to a configuration in which the number of element wires making contact with the single wire is the same regardless of the size of the gap that exists between the two strands, the filling rate of the wire rope can be increased, which enables the elongation resistance of the wire rope to be improved.

(10) The wire rope described above may be config-

ured such that the single wire includes a first single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a first group of strands that are adjacent to each other, and in the transverse cross-section, a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction is larger than a distance between a pair of element wires positioned so as to sandwich the first single wire in another transverse cross-section different from the transverse cross-section, and further, the number of element wires of the first group of strands making contact with the first single wire in the transverse cross-section is larger than the number of element wires making contact with the first single wire in the another transverse cross-section. According to this wire rope, of the common first group of strands, the distance between the pair of element wires positioned so as to sandwich the first single wire in the peripheral direction differs between the transverse cross-section of the wire rope and the another transverse cross-section, and the number of element wires making contact with the first single wire becomes larger as the distance between the pair of element wires sandwiching the first single wire becomes larger. As a result, with respect to the common first group of strands and the first single wire, as the gap that exists between the two strands becomes larger in the transverse cross-section, the gap that exists between the two strands is filled such that the first single wire makes contact with a larger number of element wires. Therefore, according to this wire rope, compared to a configuration in which the number of element wires making contact with the single wire is the same despite the gap that exists between the two strands being different depending on the axial direction position in the wire rope, the filling rate of the wire rope can be increased, which enables the elongation resistance of the wire rope to be improved.

(11) The wire rope described above may be configured such that the single wire includes a first single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a first group of strands that are adjacent to each other, and a second single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a second group of strands that are adjacent to each other, in the transverse cross-section, a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction is larger than a distance between a pair of element wires positioned so as to sandwich the second single wire in the peripheral direction, and further, the number of element wires of the first group of strands making contact with the first single wire is larger than the number of element wires of the second group of strands making contact with the

second single wire, and in the transverse cross-section, a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction is larger than a distance between a pair of element wires positioned so as to sandwich the first single wire in another transverse cross-section different from the transverse cross-section, and further, the number of element wires of the first group of strands making contact with the first single wire in the transverse cross-section is larger than the number of element wires making contact with the first single wire in the another transverse cross-section. According to this wire rope, the filling rate of the wire rope can be increased, which enables the elongation resistance of the wire rope to be improved.

(12) The wire rope described above may be configured such that a shape of the element wires in a transverse cross-section is a shape which is different from a perfect circle, an ellipse, or an oval. According to this wire rope, the gap that exists between the two strands is filled by the shape of the element wires in the transverse cross-section being different from that of a perfect circle, an ellipse, or an oval, which enables the elongation resistance of the wire rope to be improved.

(13) The wire rope described above may be configured such that a shape of the single wire in a transverse cross-section is a shape which is different from a perfect circle, an ellipse, or an oval. According to this wire rope, the gap that exists between the two strands is filled by the shape of the single wire in the transverse cross-section being different from that of a perfect circle, an ellipse, or an oval, which enables the elongation resistance of the wire rope to be improved.

[0008] The technique disclosed herein can be achieved in various aspects including, for example, a wire rope and a method of manufacturing a wire rope.

BRIEF DESCRIPTION OF DRAWINGS

[0009]

FIG. 1 is a cross-sectional perspective view schematically showing a configuration of a wire rope 10 of an embodiment.

FIG. 2 is an explanatory view showing a transverse cross-sectional configuration of the wire rope 10 of an embodiment.

FIG. 3 is an explanatory view partially showing different transverse cross-sectional configurations of the wire rope 10.

FIG. 4 is an explanatory view showing transverse cross-sectional configurations of a side strand 30 and a virtual strand 30P.

EMBODIMENTS OF THE INVENTION

A. Embodiment:

A-1. Configuration of Wire Rope 10:

[0010] FIG. 1 is a cross-sectional perspective view schematically showing the configuration of a wire rope 10 according to the present embodiment, and FIG. 2 is an explanatory view showing a transverse cross-sectional configuration of the wire rope 10 according to the present embodiment. The wire rope 10 of the present embodiment may be used in various applications (such as in bicycle brakes, and for operating an endoscope).

[0011] As shown in FIG. 1 and FIG. 2, the wire rope 10 includes a core material 20, a plurality (or more specifically, six) side strands 30, and a plurality (or more specifically, six) single wires 40 (40A to 40F).

[0012] The core material 20 has a plurality of metallic element wires 22 that are twisted with each other. More specifically, the core material 20 has a configuration in which six metallic element wires 22 are twisted around one metallic element wire 22. For example, each of the metallic element wires 22 constituting the core material 20 is formed of stainless steel (such as SUS 304).

[0013] The plurality of side strands 30 are twisted with each other around the core material 20. That is to say, the plurality of side strands 30 are disposed side-by-side along the peripheral direction of the wire rope 10 (peripheral direction of a virtual circle centered on a central axis Q1 of the wire rope 10 (core material 20)). The central axis Q1 is the center of a virtual circumscribed circle of the metallic element wire 22 positioned at the center of the core material 20. Furthermore, when the core material 20 is constituted by one element wire, the central axis Q1 is the center of a virtual circumscribed circle of the transverse cross-section of the element wire. Each of the side strands 30 has a plurality of metallic element wires 32 that are twisted with each other. More specifically, each of the side strands 30 has a configuration in which six metallic element wires 32 are twisted around one metallic element wire 32. For example, each of the metallic element wires 32 constituting the side strands 30 is formed of stainless steel (such as SUS 304). The side strands 30 are an example of a strand in the scope of the claims, and each of the metallic element wires 32 constituting the side strands 30 is an example of an element wire in the scope of the claims.

[0014] The plurality of single wires 40 are twisted around the core material 20 together with the side strands 30, and in the same direction as the side strands 30. The single wire 40 is disposed in a recess section formed on the outer peripheral side of the wire rope 10 by two side strands 30 that are adjacent to each other along the peripheral direction of the wire rope 10. That is to say, the wire rope 10 is provided with the same number of single wires 40 as side strands 30. Furthermore, each of the single wires 40 is constituted by one metallic element

wire. For example, each of the single wires 40 is formed of stainless steel (such as SUS 304).

[0015] In addition, in the present embodiment, because the wire rope 10 includes six side strands 30, there are six combinations of two side strands 30 that are adjacent to each other along the peripheral direction of the wire rope 10. In the present embodiment, one single wire 40 is disposed with respect to each of the six combinations. Moreover, in the present embodiment, the core material 20 is Z-twisted, each of the side strands 30 is S-twisted, and the plurality of side strands 30 and single wires 40 around the core material 20 are Z-twisted, but the twisting method and twisting direction of each wire is not limited to this. The details of the cross-sectional configuration of the wire rope 10 will be described below.

A-2. Details of Cross-Sectional Configuration of Wire Rope 10:

(Relationship between one single wire 40 and one side strand 30)

[0016] In the wire rope 10 of the present embodiment, Condition 1 below is satisfied with respect to one single wire 40 and one side strand 30.

<Condition 1>

[0017] In at least one transverse cross-section of the wire rope 10 (a cross-section perpendicular to the axial direction of the wire rope 10 (direction along the central axis Q1 of the wire rope 10)), a portion of at least one single wire 40 is positioned inside a first virtual circumscribed circle M1 of at least one of the side strands 30 among the two side strands 30 that are adjacent to each other along the peripheral direction of the wire rope 10.

[0018] Here, the first virtual circumscribed circles M1 are perfect circles circumscribed on the side strands 30 (group of metallic element wires 32 constituting the side strands 30), and have the smallest radius of the perfect circles that enclose all of the metallic element wires 32 constituting one side strand 30. Condition 1 indicates that one single wire 40 enters so as to be positioned between the metallic element wires 32 constituting one side strand 30. In the wire rope 10, by satisfying Condition 1, the gap that exists between two side strands 30 is filled by a portion of the single wire 40 being positioned inside the first virtual circumscribed circles M1 of the side strands 30. Therefore, according to the present embodiment, compared to a configuration in which the single wire 40 is positioned outside the first virtual circumscribed circles M1 of the side strands 30, the filling rate of the wire rope 10 can be increased, which enables the elongation resistance of the wire rope 10 to be improved (for example, the initial elongation is reduced).

[0019] It is preferable that, in at least one transverse cross-section of the wire rope 10, a portion of one single wire 40 is positioned inside the first virtual circumscribed

circles M1 of each of the two side strands 30 that are adjacent to each other in the peripheral direction of the wire rope 10. This means that, with respect to each of the two side strands 30 that are adjacent to each other, one single wire 40 enters so as to be positioned between the metallic element wires 32 constituting each of the side strands 30. As a result, because the gap that exists between the two side strands 30 that are adjacent to other is further filled, the filling rate of the wire rope 10 can be further increased, which enables the elongation resistance of the wire rope 10 to be more effectively improved.

[0020] In the wire rope 10 of the present embodiment, it is preferable that Condition 1A below is further satisfied with respect to one single wire 40 and one side strand 30.

<Condition 1A>

[0021] In at least one transverse cross-section of the wire rope 10, at least a portion of one single wire 40 is positioned further on the central axis Q2 side of the side strand 30 than a first virtual circumscribed line B 1 that is circumscribed on both of the two metallic element wires 32 that, of the plurality of metallic element wires 32 that configure the one side strand 30, are positioned closest to the single wire 40.

[0022] Here, the first virtual circumscribed line B1 is a virtual line that, of the two virtual straight lines that make contact so as to straddle both of the two metallic element wires 32 that are positioned closest to the single wire 40, is positioned on the single wire 40 side. Condition 1A indicates that, compared to Condition 1 described above, one single wire 40 enters to greater extent with respect to one side strand 30. In the wire rope 10, as a result of satisfying Condition 1A, because the gap that exists between the two side strands 30 that are adjacent to other is further filled, the filling rate of the wire rope 10 can be further increased, which enables the elongation resistance of the wire rope 10 to be more effectively improved.

[0023] In the wire rope 10 of the present embodiment, it is preferable that Condition 1B below is further satisfied with respect to one single wire 40 and one side strand 30.

<Condition 1B>

[0024] In at least one transverse cross-section of the wire rope 10, at least one single wire 40 makes contact with at least one of two metallic element wires 32 that, of the plurality of metallic element wires 32 that configure one side strand 30, are positioned closest to the single wire 40.

[0025] In the wire rope 10, as a result of satisfying Condition 1B, because the gap that exists between the two side strands 30 that are adjacent to other is further filled, the filling rate of the wire rope 10 can be further increased, which enables the elongation resistance of the wire rope 10 to be more effectively improved. Furthermore, as a result of the contact between the single wire 40 and the side strand 30, the entry of liquid into the wire rope 10

from the gap between the single wire 40 and the side strand 30 is suppressed, which enables the water immersion resistance of the wire rope 10 to be improved. Moreover, as a result of the contact between the single wire 40 and the side strand 30, it is possible to suppress displacement between the single wire 40 and the side strand 30 in the axial direction of the wire rope 10 due to a change in shape of the wire rope 10.

[0026] It is preferable that one single wire 40 makes contact with both of the two metallic element wires 32 that are positioned closest to the single wire 40. As a result, it is possible to improve the elongation resistance of the wire rope 10 described above, improve the water immersion resistance of the wire rope 10, and suppress the displacement between the single wire 40 and the side strand 30 more effectively. Furthermore, the single wire 40 may be in a point contact with the metallic element wires 32, but preferably makes surface contact with each of the metallic element wires 32. Herein, surface contact refers to a case where, in the transverse cross-section of the wire rope 10, a substantially straight section of the single wire 40 and a substantially straight section of the element wires (such as the metallic element wires 32) are in a partial or total line contact. As a result of the single wire 40 and the side strand 30 (metallic element wires 32) making surface contact, the gap that exists between two side strands 30 that are adjacent to each other is filled even further, which enables the improvement in the elongation resistance of the wire rope 10 described above to be more effectively obtained, and further, because the surface contact between the single wire 40 and the side strand 30 (metallic element wires 32) is large, it is possible improve the water immersion resistance of the wire rope 10, and suppress the displacement between the single wire 40 and the side strands 30 more effectively.

[0027] In the example shown in FIG. 2, a portion of each of the six single wires 40 (40A to 40F) is positioned inside the first virtual circumscribed circles M1 of each of the two side strands 30 that are adjacent to each other, which satisfies Condition 1. Specifically, a portion of each of the six single wires 40 (40A to 40F) is positioned inside the first virtual circumscribed circle M1 of one of the two side strands 30 that are adjacent to each other, and another portion of the single wires 40 is positioned inside the first virtual circumscribed circle M1 of the other of the two side strands 30 that are adjacent to each other, which satisfies Condition 1. Furthermore, at least the single wires 40B to 40F satisfy Condition 1A and Condition 1B described above. For example, at least a portion of the single wire 40F is positioned further on the central axis Q2 side of the side strand 30 than the first virtual circumscribed line B 1 that is circumscribed on both of the two metallic element wires 32 (metallic element wires 32E and 32F in FIG. 2) of one side strand 30 that are positioned closest to the single wire 40F (see also FIG. 3 described below). The two metallic element wires 32 positioned closest to the single wire 40F (metallic element

wires 32E and 32F in FIG. 2) are the two metallic element wires 32 (metallic element wires 32E and 32F in FIG. 2) disposed next to the single wire 40F without interposing other element wires. Of the plurality of single wires 40 included in the wire rope 10, it is preferable that 50% or more of the total number of single wires 40 satisfy Condition 1 (and also Condition 1A and Condition 1B), and it is preferable that 80% or more of the total number of single wires 40 satisfy Condition 1 (and also Condition 1A and Condition 1B).

(Relationship between one single wire 40 and two side strands 30)

[0028] In the wire rope 10 of the present embodiment, it is preferable that Condition 2 below is satisfied with respect to one single wire 40 and two side strands 30.

<Condition 2>

[0029] In at least one transverse cross-section of the wire rope 10, a metallic element wire 32 (hereinafter referred to as "first metallic element wire 32X") constituting one side strand 30, and a metallic element wire 32 (hereinafter referred to as "second metallic element wire 32Y") constituting another side strand 30 are adjacently disposed with respect to one single wire 40 in a radially inward direction of the wire rope 10 (radial direction of a circle centered on the central axis Q1 of the wire rope 10). Furthermore, at least a portion of the single wire 40 is positioned between the first metallic element wire 32X and the second metallic element wire 32Y in the peripheral direction of the wire rope 10.

[0030] Here, a portion of the single wire 40 being positioned between the first metallic element wire 32X and the second metallic element wire 32Y means that a portion of the single wire 40 is positioned inside a second virtual circumscribed circle M2, which is centered on the central axis Q1 of the wire rope 10, encloses both the first metallic element wire 32X and the second metallic element wire 32Y, and is circumscribed on at least one of the first metallic element wire 32X and the second metallic element wire 32Y (see also FIG. 3 below). In the wire rope 10, by satisfying Condition 2, the gap that exists between two side strands 30 is filled as a result of the single wire 40 entering so as to be positioned between the first metallic element wire 32X and the second metallic element wire 32Y. Therefore, according to the present embodiment, compared to a configuration in which the single wire 40 is not positioned between the first metallic element wire 32X and the second metallic element wire 32Y, the filling rate of the wire rope 10 can be increased, which enables the elongation resistance of the wire rope 10 to be more effectively improved.

[0031] In the wire rope 10 of the present embodiment, it is preferable that Condition 2A below is further satisfied with respect to one single wire 40 and two side strands 30.

<Condition 2A>

[0032] In at least one transverse cross-section of the wire rope 10, at least a portion of one single wire 40 is positioned further on the central axis Q1 side of the wire rope 10 than a second virtual circumscribed line B2 that is circumscribed on both the first metallic element wire 32X and the second metallic element wire 32Y.

[0033] Here, the second virtual circumscribed line B2 is a virtual straight line that, of the two virtual straight lines that make contact so as to straddle both the first metallic element wire 32X and the second metallic element wire 32, are positioned on the single wire 40 side. Condition 2A indicates that, compared to Condition 2 described above, one single wire 40 enters to a greater extent between the first metallic element wire 32X and the second metallic element wire 32Y. In the wire rope 10, as a result of satisfying Condition 2A, because the gap that exists between the two side strands 30 that are adjacent to other is further filled, the filling rate of the wire rope 10 can be further increased, which enables the elongation resistance of the wire rope 10 to be more effectively improved.

[0034] In the wire rope 10 of the present embodiment, it is preferable that Condition 2B below is further satisfied with respect to one single wire 40 and two side strands 30.

<Condition 2B>

[0035] In at least one transverse cross-section of the wire rope 10, at least one single wire 40 makes contact with at least one of the first metallic element wire 32X and the second metallic element wire 32Y.

[0036] In the wire rope 10, as a result of satisfying Condition 2B, because the gap that exists between the two side strands 30 that are adjacent to other is further filled, the filling rate of the wire rope 10 can be further increased, which enables the elongation resistance of the wire rope 10 to be more effectively improved. Furthermore, as a result of the contact between the single wire 40 and the side strands 30 (metallic element wires 32X and 32Y), the entry of liquid into the wire rope 10 from the gap between the single wire 40 and the side strand 30 is suppressed, which enables the water immersion resistance of the wire rope 10 to be improved. Moreover, as a result of the contact between the single wire 40 and the side strands 30, it is possible to suppress displacement between the single wire 40 and the side strands 30 in the axial direction of the wire rope 10 due to a change in shape of the wire rope 10.

[0037] It is preferable that one single wire 40 makes contact with both the first metallic element wire 32X and the second metallic element wire 32Y. As a result, it is possible to improve the elongation resistance of the wire rope 10 described above, improve the water immersion resistance of the wire rope 10, and suppress the displacement between the single wire 40 and the side strands 30 more effectively. Furthermore, the single wire 40 may be in a point contact with the first metallic element wire 32X

and the second metallic element wire 32Y, but preferably makes surface contact with the first metallic element wire 32X and the second metallic element wire 32Y. As a result of the single wire 40 and the metallic element wires 32X and 32Y making surface contact, the gap that exists between the two side strands 30 that are adjacent to each other is filled even further, which enables the elongation resistance of the wire rope 10 described above to be more effectively improved, and further, because the surface contact between the single wire 40 and the side strands 30 (metallic element wires 32X and 32Y) is large, it is possible to improve the water immersion resistance of the wire rope 10, and suppress the displacement between the single wire 40 and the side strands 30 more effectively.

[0038] In the wire rope 10 of the present embodiment, it is preferable that Condition 2C below is further satisfied with respect to one single wire 40 and two side strands 30.

<Condition 2C>

[0039] In at least one transverse cross-section of the wire rope 10, a distance L1 between a pair of metallic element wires 32 positioned so as to sandwich a first single wire 40 in the peripheral direction with a first group of side strands 30 is larger than a distance L2 between a pair of metallic element wires 32 positioned so as to sandwich the second single wire 40 in the peripheral direction with a second group of side strands 30. Furthermore, the number of metallic element wires 32 of the first group of side strands 30 making contact with the first single wire 40 is larger than the number of metallic element wires 32 of the second group of side strands 30 making contact with the second single wire 40. In the wire rope 10, by satisfying Condition 2C, the larger the distance between the pair of metallic element wires 32 sandwiching the single wire 40, the larger the number of metallic element wires 32 that make contact with the single wire 40. As a result, as the gap that exists between the two side strands 30 that are adjacent to each other becomes larger, the gap that exists between the two side strands 30 is filled such that the single wire 40 makes contact with a large number of metallic element wires 32. Therefore, according to the present embodiment, compared to a configuration in which the number of metallic element wires 32 making contact with the single wire 40 is the same regardless of the size of the gap that exists between the two side strands 30, the filling rate of the wire rope 10 can be increased, which enables the elongation resistance of the wire rope 10 to be improved.

[0040] In the wire rope 10 of the present embodiment, it is preferable that Condition 2D below is further satisfied with respect to one single wire 40 and two side strands 30.

<Condition 2D>

[0041] The distance in a first transverse cross-section of the wire rope between a pair of metallic element wires

32, which are in one group of side strands 30 that are adjacent to each other, that are positioned so as to sandwich the single wire 40 in the peripheral direction is larger than the distance in a second transverse cross-section of the wire rope 10 (a transverse cross-section taken in a different position to the first cross-section in the axial direction of the wire rope 10) between a pair of metallic element wires 32, which are in the one group of side strands 30, that are positioned so as to sandwich the single wire 40 in the peripheral direction. Furthermore, the number of metallic element wires 32 in one group of side strands 30 making contact with the single wire 40 in the first transverse cross-section is larger than the number of metallic element wires 32 in the one group of side strands 30 making contact with the single wire 40 in the second transverse cross-section. In the wire rope 10, by satisfying Condition 2D, of the shared one group of side strands 30, because the distance between the pair of metallic element wires 32 that are positioned so as to sandwich the single wire 40 in the peripheral direction is different in the first transverse cross-section (which corresponds to an example of the "transverse cross-section" in claim 9) and the second transverse cross-section (which corresponds to an example of "another transverse cross-section different from the transverse cross-section" in claim 9) of the wire rope 10, and the number of metallic element wires 32 making contact with the single wire 40 increases as the distance between the pair of metallic element wires 32 that sandwich the single wire 40 becomes larger. As a result, with respect to the common two side strands 30 and the single wire 40, as the gap that exists between the two side strands 30 becomes larger in the transverse cross-section, the gap that exists between the two side strands 30 is filled such that the single wire 40 makes contact with a larger number of metallic element wires 32. Therefore, according to the present embodiment, compared to a configuration in which the number of metallic element wires 32 making contact with the single wire 40 is the same despite the gap that exists between the two side strands 30 being different depending on the axial direction position of the wire rope 10, the filling rate of the wire rope 10 can be increased, which enables the elongation resistance of the wire rope 10 to be improved.

[0042] In the example shown in FIG. 2, a portion of each of at least the single wires 40B, 40D, and 40F is positioned between the first metallic element wire 32X and the second metallic element wire 32Y in the peripheral direction of the wire rope 10, which satisfies Condition 2. Furthermore, at least the single wires 40B, 40D, and 40F satisfy Condition 2A and Condition 2B described above. For example, a portion of the single wire 40B is positioned further on the central axis Q1 side of the wire rope 10 than the second virtual circumscribed line B2 that is circumscribed on both the first metallic element wire 32X and the second metallic element wire 32Y (see also FIG. 3 described below).

[0043] Furthermore, the single wires 40 (40B, 40D, and

40F) that satisfy Condition 2 (Condition 2A), and the single wires 40 (40A, 40C, and 40E that do not satisfy Condition 2 (Condition 2A) are alternately arranged along the peripheral direction of the wire rope 10. As a result, it is possible to suppress the occurrence of a bias in the strength of the wire rope 10 caused by an uneven distribution of the single wires 40 that satisfy Condition 2 (Condition 2A) and the single wires 40 that do not satisfy Condition 2 (Condition 2A). Of the plurality of single wires 40 included in the wire rope 10, it is preferable that 30% or more of the total number of single wires 40 satisfy Condition 2 (and also Condition 2A and Condition 2B), and it is preferable that 50% or more of the total number of single wires 40 satisfy Condition 2 (and also Condition 2A and Condition 2B).

[0044] Moreover, in the example shown in FIG. 2, the distance L1 between a pair of metallic element wires 32 positioned so as to sandwich the first single wire 40B is larger than the distance L2 between a pair of metallic element wires 32 positioned so as to sandwich the second single wire 40C. In addition, the number of metallic element wires 32 making contact with the first single wire 40B is larger than the number of metallic element wires 32 making contact with the second single wire 40C. Note that, for example, the same relationship is established between the single wire 40F and the single wire 40A, and the single wire 40D and the single wire 40E. In this way, in the wire rope 10, the plurality of side strands 30 are unevenly arranged in the peripheral direction, and even though the size of the gaps in each group of side strands 30 is also uneven, single wires 40 having a shape corresponding to the gaps of each group of side strands 30 are positioned so as to enter and fill the uneven gaps. As a result, the filling rate of the wire rope 10 can be increased, which enables the elongation resistance of the wire rope 10 to be improved.

[0045] FIG. 3 is an explanatory view partially showing different transverse cross-sectional configurations of the wire rope 10. In FIG. 3(A), a transverse cross-sectional configuration near the single wire 40B in a first transverse cross-section (the same transverse cross-section as FIG. 2) is shown, and in FIG. 3(B), a transverse cross-sectional configuration near the single wire 40B in a second transverse cross-section (a transverse cross-section taken in a different position than the first cross-section in the axial direction of the wire rope 10) is shown. As shown in FIG. 3, the distance L1 in the first transverse cross-section between a pair of metallic element wires 32 positioned so as to sandwich the single wire 40B in the peripheral direction is larger than a distance L3 in the second transverse cross-section between a pair of metallic element wires 32 positioned so as to sandwich the single wire 40B in the peripheral direction. Furthermore, the number of metallic element wires 32 making contact with the single wire 40B in the first transverse cross-section is larger than the number of metallic element wires 32 making contact with the single wire 40B in the second transverse cross-section. As a result, compared to a con-

figuration in which the number of metallic element wire 32 making contact with the single wire 40 is the same despite the gap that exists between the two side strands 30 being different depending on the axial direction position of the wire rope 10, the filling rate of the wire rope 10 can be increased, which enables the elongation resistance of the wire rope 10 to be improved.

(Relationship between structure of single wire 40 and metallic element wires 32 constituting side strand 30)

[0046] In the wire rope 10 of the present embodiment, it is preferable that Condition 3 below is satisfied with respect to the structure of the single wire 40 and the metallic element wires 32 constituting the side strands 30.

<Condition 3>

[0047] In at least one transverse cross-section of the wire rope 10, the cross-sectional area of one single wire 40 is larger than the cross-sectional area of each of the metallic element wires 32 constituting one side strand 30.

[0048] In the wire rope 10, as a result of satisfying Condition 3, compared to a configuration in which the cross-sectional area of the single wire 40 is smaller than the cross-sectional area of the metallic element wires 32 constituting the side strand 30, the strength of the wire rope 10 can be improved by the single wire 40. Furthermore, for example, the single wire 40 can more easily enter between the metallic element wires 32 when the wire rope 10 is formed and when the wire rope 10 is bent, and therefore, the filling rate of the wire rope 10 can be increased, which enables the elongation resistance of the wire rope 10 to be more effectively improved.

[0049] In the present embodiment, the cross-sectional area of one single wire 40 is preferably less than or equal to the sum of the cross-sectional areas of two metallic element wires 32. The diameter of the virtual circumscribed circle of one single wire 40 is preferably larger than the diameter of the virtual circumscribed circle of one metallic element wire 32. However, the diameter of the circumscribed circle of one single wire 40 is preferably smaller than the diameter of the first virtual circumscribed circle M1 of one side strand 30. As a result, a decrease in the flexibility of the wire rope 10 caused by the thickness of the single wire 40 can be suppressed. Furthermore, the diameter is preferably two times or less than the diameter of the virtual circumscribed circle of one metallic element wire 32, and more preferably 1.5 times or less than the diameter of the virtual circumscribed circle of one metallic element wire 32.

[0050] In the wire rope 10 of the present embodiment, it is preferable that Condition 3A below is satisfied with respect to the structure of the single wire 40 and the metallic element wires 32 constituting the side strands 30.

<Condition 3A>

[0051] The tensile strength (N/mm²) of at least one single wire 40 is substantially equal to the tensile strength of each of the metallic element wires 32 constituting the side strands 30.

[0052] That is to say, the hardness of the single wire 40 is substantially equal to the hardness of each of the metallic element wires 32 constituting the side strands 30. Specifically, the tensile strength of each of the single wire 40 and the metallic element wires 32 is, for example, 1,500 N/mm² or more and 2,500 N/mm² or less. Here, the tensile strength of the single wire 40 and the metallic element wires 32 being substantially equal means that the difference in the tensile strength between them is less than $\pm 5\%$. The tensile strength of each of the single wire 40 and the metallic element wires 32 may be, for example, 1,500 N/mm² or more and 2,000 N/mm² or less.

[0053] In the example shown in FIG. 2, the cross-sectional area of each of the six single wires 40 (40A to 40F) is larger than the cross-sectional area of each of the metallic element wires 32 constituting one side strand 30, which satisfies Condition 3. Furthermore, the tensile strength of each of the six single wires 40 (40A to 40F) is substantially equal to the tensile strength of the side strands 30 (metallic element wires 32). As a result, it can be seen that the single wire 40 changes shape with the metallic element wires 32, and enter the gap that exists between the two side strands 30 that are adjacent to each other.

(Relationship between plurality of single wires 40)

[0054] As shown in FIG. 2, the plurality of side strands 30 each have an irregular shape (a shape different from a perfect circle, an ellipse, or an oval), and the shapes are different from each other. Therefore, the shapes of the gaps (recess sections) between two side strands 30 that are adjacent to each other are all different from each other, and each of the gaps has a single wire 40 that has changed shape into a shape that corresponds to the gap (a shape different from a perfect circle, an ellipse, or an oval), and which is disposed so as to enter between the two side strands 30. In this way, in the wire rope 10 of the present embodiment, because the plurality of side strands 30 are unevenly disposed, and the shapes of the plurality of side strands 30 are different from each other, the plurality of single wires 40 are also unevenly disposed, and the shapes are different from each other. This is described in detail below.

[0055] In the wire rope 10 of the present embodiment, it is preferable that Condition 4 below is satisfied with respect to the plurality of single wires 40.

<Condition 4>

[0056] In at least one transverse cross-section of the wire rope 10, at least two single wires 40 have a third

virtual circumscribed circle M3 of the single wire 40 having different diameters from each other.

<Condition 4A>

[0057] In at least one transverse cross-section of the wire rope 10, the distance in the peripheral direction of a pair of single wires 40 positioned so as to sandwich one side strand 30 (the shortest distance between the pair of single wires 40 in the peripheral direction of the wire rope 10) and the distance in the peripheral direction of a pair of single wires 40 positioned so as to sandwich another side strand 30 are different.

[0058] In the example shown in FIG. 2, the cross-sectional shapes of the six single wires 40 (40A to 40F) are different from each other. Furthermore, the third virtual circumscribed circles M3 of at least the single wire 40A and the 40C have different diameters. Moreover, there is a variation in the distances between the six single wires 40 (40A to 40F) in the peripheral direction. In this way, in the wire rope 10, as a result of single wires 40 having uneven shapes being disposed so as to enter between a plurality of side strands 30 having uneven shapes that are disposed in uneven positions, the filling rate of the wire rope 10 can be increased, which enables the elongation resistance of the wire rope 10 to be improved.

(Relationship between side strands 30)

[0059] In the wire rope 10 of the present embodiment, it is preferable that Condition 5 below is satisfied with respect to the side strands 30.

<Condition 5>

[0060] In the peripheral direction of the wire rope 10, the area of the first virtual circumscribed circle M1 of at least one of the two side strands 30 between which the single wire 40 is disposed is smaller than a fourth virtual circumscribed circle M4 of a virtual strand 30P in a case where all of the metallic element wires 32 constituting the side strand 30 are perfectly circular.

[0061] In the wire rope 10, by satisfying Condition 5, compared to a configuration in which the area of the first virtual circumscribed circle M1 of the side strand 30 is the same as that of the fourth virtual circumscribed circle M4 of the virtual strand 30P, the elongation resistance of the wire rope 10 can be more effectively improved by an amount corresponding to the extent in which the gap between the metallic element wires 32 of the side strand 30 is narrowed.

[0062] In the present embodiment, the plurality of side strands 30 are disposed along the peripheral direction of the wire rope 10 such that they make contact with each other, and are disposed over the entire periphery. Furthermore, all of the side strands 30 make contact with the core material 20. The contact between the side strands 30 may be a point contact, but is preferably a

surface contact. Moreover, the contact between the side strands 30 and the core material 20 may be a point contact, but is preferably a surface contact.

[0063] FIG. 4 is an explanatory view showing transverse cross-sectional configurations of the side strand 30 and the virtual strand 30P. FIG. 4(A) shows the transverse cross-sectional configuration of the virtual strand 30P, and FIG. 4(B) shows the transverse cross-sectional configuration of the side strand 30. As mentioned below, in the production process of the wire rope 10, by performing secondary processing with respect to the wire rope 10 before processing such as swaging processing for deforming the side strands 30, or wire drawing processing using a deforming die, the side strands 30 have the metallic element wires 32P in the virtual strand 30P deformed such that they are flattened. As shown in FIG. 3, the area (radius $r1$) of the first virtual circumscribed circle M1 of the side strand 30 is smaller than the area (radius $r4$) of the fourth virtual circumscribed circle M4 of the virtual strand 30P, which satisfies Condition 5.

[0064] The area of a third virtual circumscribed circles M3 of the single wires 40 shown in FIG. 2 may be configured to be larger than the area of the single wires (area of the perfect circles) when the single wires 40 are perfectly circular (perfect circles circle having the same area as the area of the single wires 40). As a result of such a configuration, it is possible to effectively fill (block) the recess sections formed on the outer peripheral side of the wire rope 10 by two side strands 30 that are adjacent to each other with the single wires 40. Consequently, the gaps between the plurality of metallic element wires 32 in the side strands (each side strand) 30 can be more effectively filled (blocked) by the plurality of metallic element wires 32. Therefore, the elongation resistance of the wire rope 10 can be more effectively improved. Furthermore, the entry of liquid into the core material 20 of the wire rope 10 from the gaps between the single wires 40 and the side strands 30 or the gaps between adjacent metallic element wires 32 in the side strands 30 is suppressed, which enables the durability of the wire rope 10 to be improved.

(Relationship between single wires 40 and core material 20)

[0065] As shown in FIG. 2, in at least one transverse cross-section of the wire rope 10, each of the single wires 40 is separated from the core material 20. Specifically, each of the single wires 40 is positioned outside a fifth virtual circumscribed circle M5 of the core material 20. Furthermore, each of the single wires 40 is positioned further outward in the radial direction of the wire rope 10 than the contact position of the two side strands 30 that are adjacent to each other. Moreover, one metallic element wire 22 constituting the core material 20 is disposed so as to face the one single wire 40 via the contact position of the two side strands 30 that are adjacent to each other. As a result of such a configuration, the entry of

liquid into the core material 20 the wire rope 10 from the gap between the single wire 40 and the side strands 30 is suppressed, which enables the water immersion resistance of the wire rope 10 to be improved.

[0066] The wire rope 10 that satisfies the each of the conditions described above can be produced as follows. A plurality of wire ropes 10 are twisted together with a plurality of side strands 30 around a wire rope 10. As a result, the plurality of side strands 30 are disposed side by side around the wire rope 10, and a twisted wire is produced in which the single wires 40 are disposed in recess sections formed on the outer peripheral side of the wire rope 10 by two side strands 30 that are adjacent to each other. The twisted wire is subjected to secondary processing such as swaging processing for deforming the side strands 30 and the single wires 40, or wire drawing processing using a deforming die. As a result, the core material 20, the side strands 30, and the single wires 40 are inwardly flattened in the radial direction of the wire rope 10, and as a result, the wire rope 10 described above is produced.

A-3. Effects of the Embodiment:

[0067] As described above, in the wire rope 10 according to the present embodiment, single wires 40 are disposed between each of the plurality of side strands 30 in the multi-twisted wire. Further, in at least one transverse cross-section of the wire rope 10, at least a portion of one single wire 40 is positioned inside the first virtual circumscribed circle M1 of at least one of the two side strands 30 that are adjacent to each other in the peripheral direction of the wire rope 10 (Condition 1 described above). This makes it possible to improve the elongation resistance of the wire rope 10 while ensuring the flexibility of shape changes in the wire rope 10.

B. Modified Examples:

[0068] The techniques disclosed herein are not limited to the above embodiment, and can be modified in various forms without departing from the gist of the embodiment. For example, the following modifications are also possible.

[0069] The configuration of the wire rope 10 in the embodiment described above is thoroughly an example, and can be modified in various ways. For example, the number of side strands 30 in the wire rope 10 of the above embodiment, and the number of element wires and number of layers constituting the side strands 30 and the core material 20 can be changed in various ways. For example, the number of side strands 30 may be three or more. Furthermore, although the wire rope 10 of the above embodiment includes the core material 20, it is also possible to use a configuration in which a plurality of side strands 30 and a plurality of single wires 40 are twisted with each other without providing the core material 20. Moreover, in the above embodiment, although

the core material 20 is a twisted wire in which a plurality of element wires are twisted together, it may also be a single wire constituted by a single element wire.

[0070] Furthermore, the wire rope 10 does not have to satisfy at least one of Conditions 1A and 1B, Condition 2, Conditions 2A to 2D, Condition 3, Condition 3A, Condition 4, Condition 4A, and Condition 5. For example, the tensile strength of the single wires 40 may be higher or lower than the tensile strength of each of the metallic element wires 32 constituting the side strands 30. If the tensile strength of the single wires 40 is lower than the tensile strength of the metallic element wires 32, compared to a configuration in which the tensile strength of the single wires 40 is greater than or equal to the tensile strength of the metallic element wires 32, the single wires 40 becomes enter between the metallic element wires 32 of the two side strands 30 more easily, which enables the elongation resistance of the wire rope 10 to be more effectively improved.

[0071] The material of each member of the wire rope 10 of the embodiment described above is thoroughly an example, and can be modified in various ways. For example, the metallic element wires 22 and 32 constituting the core material 20 and the side strands 30, and the single wire 40 may be formed of a metal other than stainless steel, and may be formed of a material other than a metal (such as a resin).

DESCRIPTION OF REFERENCE NUMERALS

[0072]

10: Wire rope
 20: Core material
 22, 32 (32E, 32 F, 32P): Metallic element wire
 30: Side strand
 30P: Virtual strand
 32X: First metallic element wire
 32Y: Second metallic element wire
 40 (40A to 40F): Single wire
 B1: First virtual circumscribed line
 B2: Second virtual circumscribed line
 M1: First virtual circumscribed circle
 M2: Second virtual circumscribed circle
 M3: Third virtual circumscribed circle
 M4: Fourth virtual circumscribed circle
 M5: Fifth virtual circumscribed circle
 Q1: Central axis
 Q2: Central axis

Claims

1. A wire rope provided with a plurality of strands that are twisted with each other, the plurality of strands each having a configuration in which a plurality of element wires are twisted with each other, the wire rope including:

a single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by two strands that are adjacent to each other along a peripheral direction of the wire rope; wherein

in a transverse cross-section of the wire rope, a portion of the single wire is positioned inside a virtual circumscribed circle of one of the two strands.

2. The wire rope according to claim 1, wherein

in the transverse cross-section, an element wire of the one of the two strands and an element wire of the other of the two strands are adjacently disposed further inward of the single wire in a radial direction of the wire rope, and a portion of the single wire is positioned between the element wire of the one strand and the element wire of the other strand in the peripheral direction.

3. The wire rope according to claim 1 or 2, wherein in the transverse cross-section, the single wire makes contact with each of the element wire of the one of the two strands and the element wire of the other strand.

4. The wire rope according to any one of claims 1 to 3, wherein in the transverse cross-section, a cross-sectional area of the single wire is larger than a cross-sectional area of each of the element wires constituting the strands.

5. The wire rope according to any one of claims 1 to 4, wherein a tensile strength of the single wire is lower than a tensile strength of each of the element wires constituting the strands.

6. The wire rope according to any one of claims 1 to 4, wherein a tensile strength of the single wire is within a range of $\pm 5\%$ of a tensile strength of each of the element wires constituting the strands.

7. The wire rope according to any one of claims 1 to 6, wherein an area of the virtual circumscribed circle is smaller than an area of a virtual circumscribed circle of a virtual strand in which all of the element wires constituting the one strand are perfectly circular.

8. The wire rope according to any one of claims 1 to 7, wherein in the transverse cross-section, an area of a virtual circumscribed circle of the single wire is larger than

an area of the single wire being perfectly circular.

9. The wire rope according to claim 1, wherein

the single wire includes a first single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a first group of strands that are adjacent to each other, and a second single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a second group of strands that are adjacent to each other, and in the transverse cross-section, a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction is larger than a distance between a pair of element wires positioned so as to sandwich the second single wire in the peripheral direction, and further, the number of element wires of the first group of strands making contact with the first single wire is larger than the number of element wires of the second group of strands making contact with the second single wire.

10. The wire rope according to claim 1, wherein

the single wire includes a first single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a first group of strands that are adjacent to each other, and in the transverse cross-section, a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction is larger than a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction in another transverse cross-section different from the transverse cross-section, and further, of the first group of strands, the number of element wires making contact with the first single wire in the transverse cross-section is larger than the number of element wires making contact with the first single wire in the another transverse cross-section.

11. The wire rope according to claim 1, wherein

the single wire includes a first single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a first group of strands that are adjacent to each other, and a second single wire that is disposed in a recess section formed on an outer peripheral side of the wire rope by a second group of strands that are adjacent to each other, in the transverse cross-section, a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral

direction is larger than a distance between a pair of element wires positioned so as to sandwich the second single wire in the peripheral direction, and further, the number of element wires of the first group of strands making contact with the first single wire is larger than the number of element wires of the second group of strands making contact with the second single wire, and in the transverse cross-section, a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction is larger than a distance between a pair of element wires positioned so as to sandwich the first single wire in the peripheral direction in another transverse cross-section different from the transverse cross-section, and further, of the first group of strands, the number of element wires making contact with the first single wire in the transverse cross-section is larger than the number of element wires making contact with the first single wire in the another transverse cross-section.

12. The wire rope according to any one of claims 1 to 11, wherein

a shape of the element wires in a transverse cross-section is a shape which is different from a perfect circle, an ellipse, or an oval.

13. The wire rope according to any one of claims 1 to 12, wherein

a shape of the single wire in a transverse cross-section is a shape which is different from a perfect circle, an ellipse, or an oval.

FIG. 1

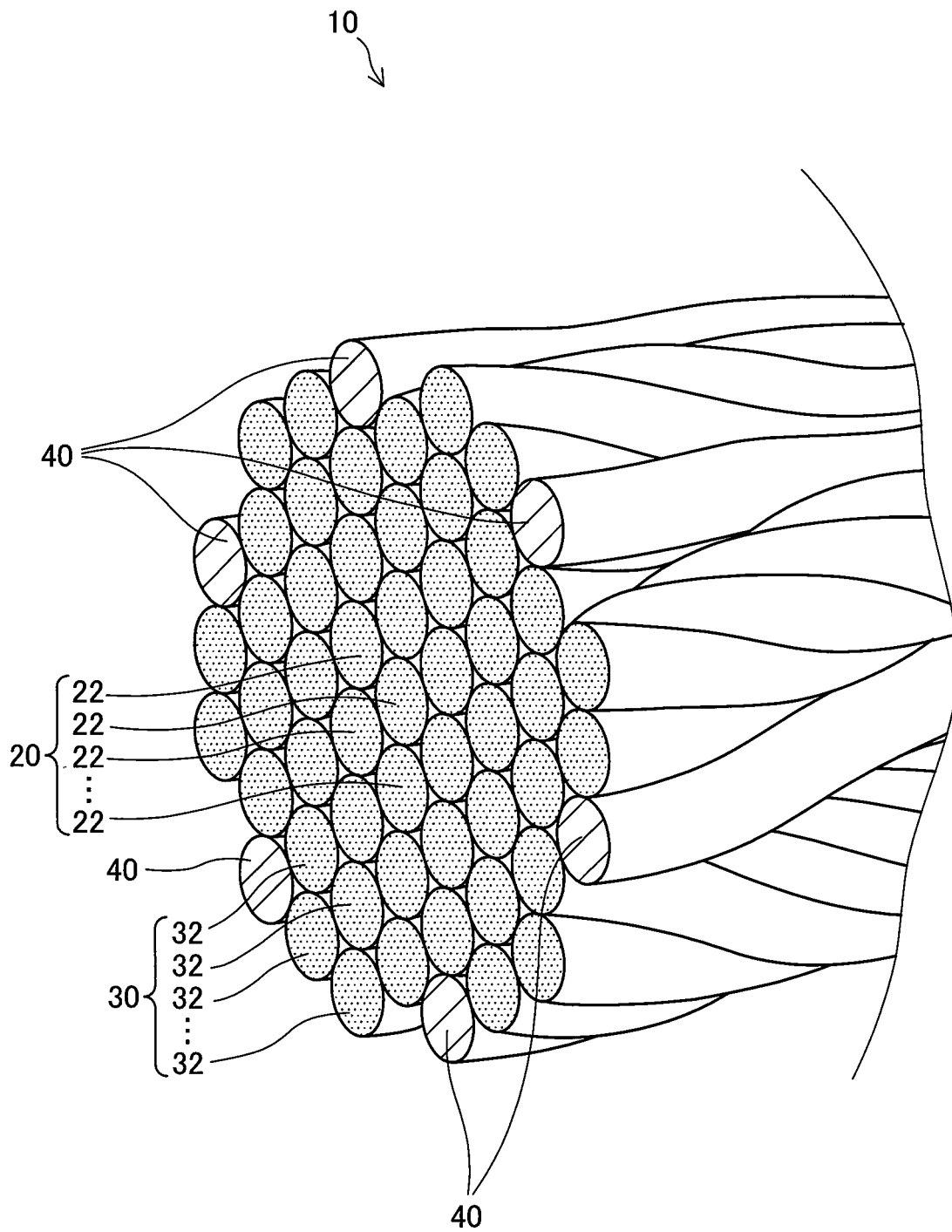


FIG. 2

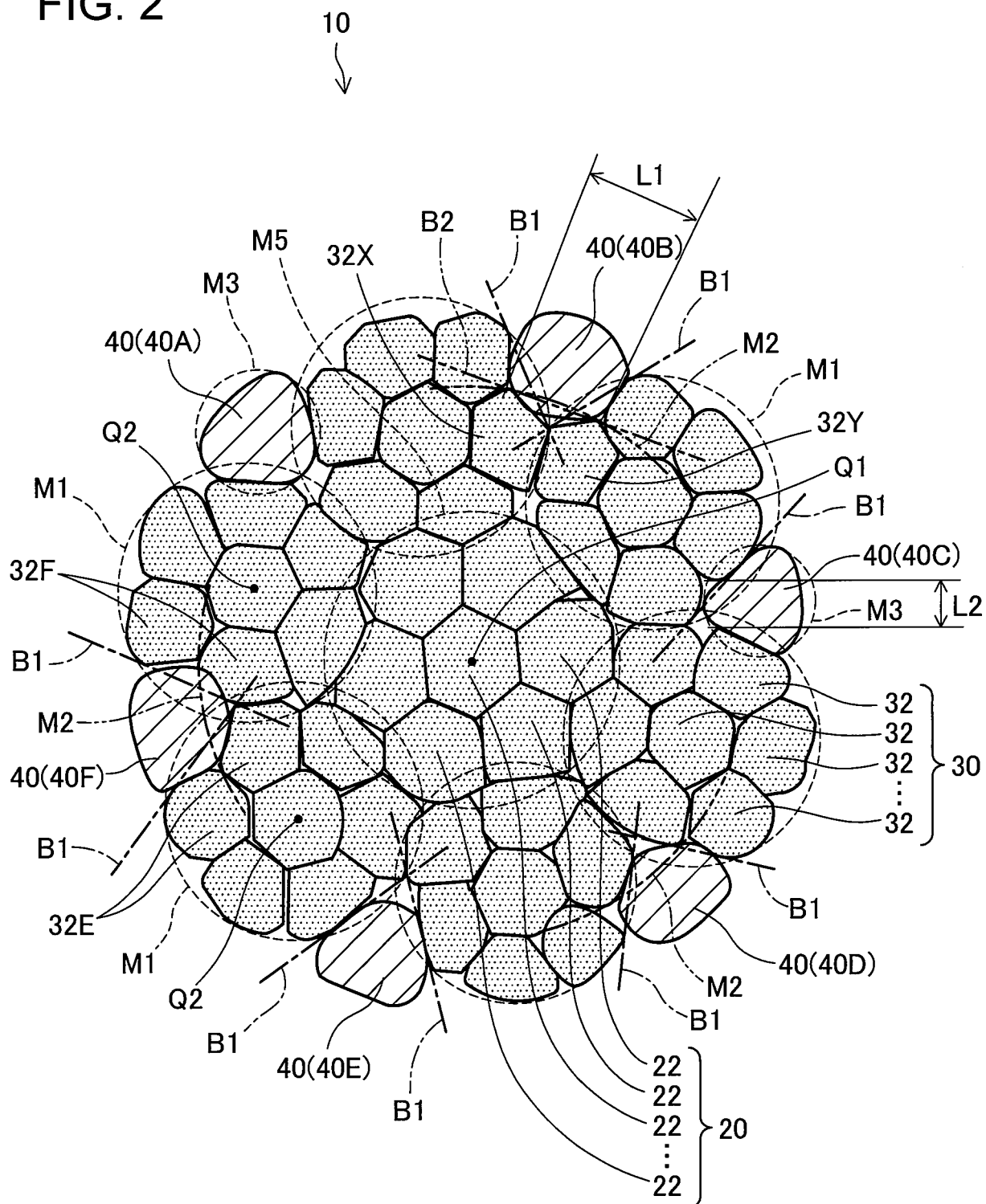


FIG. 3

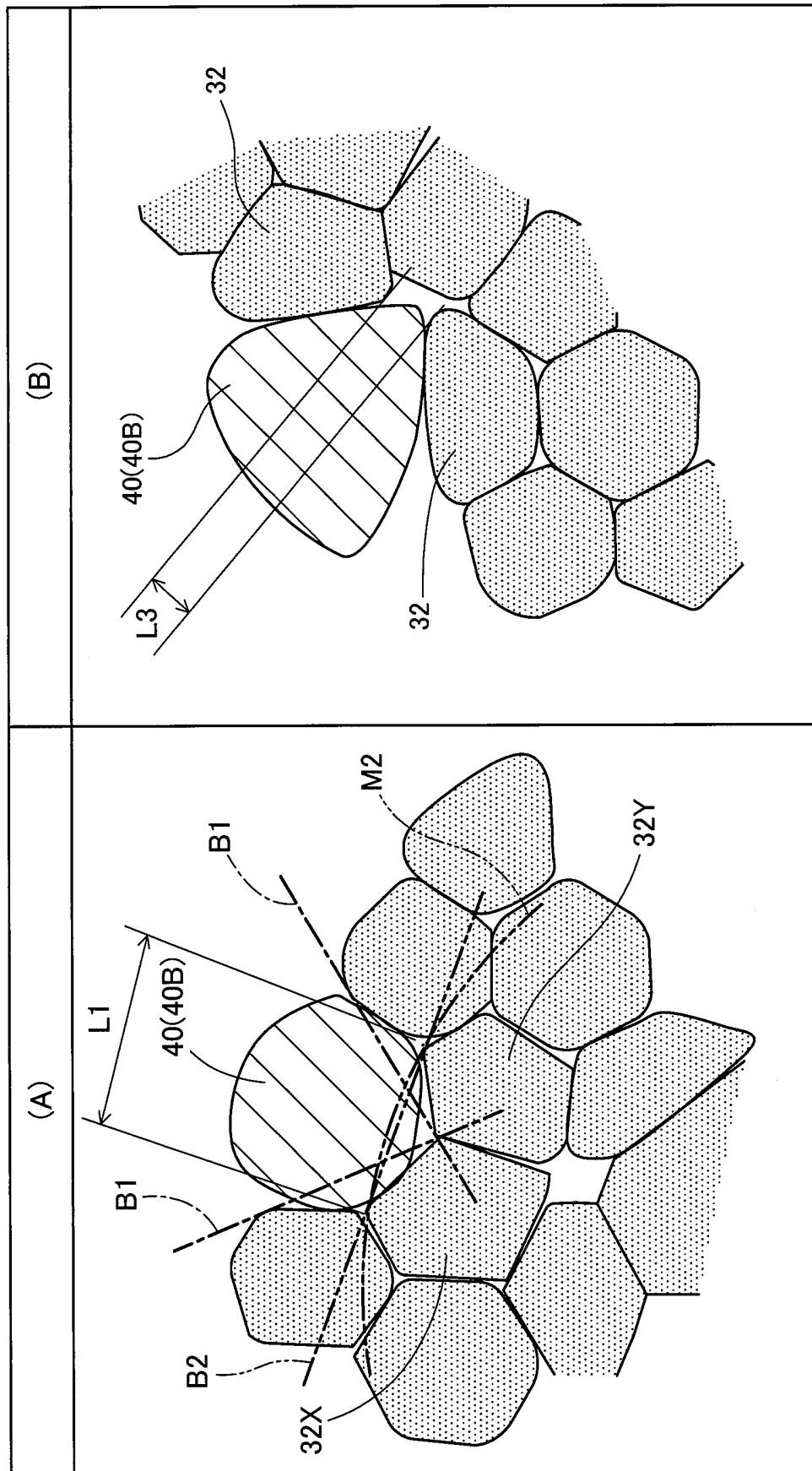
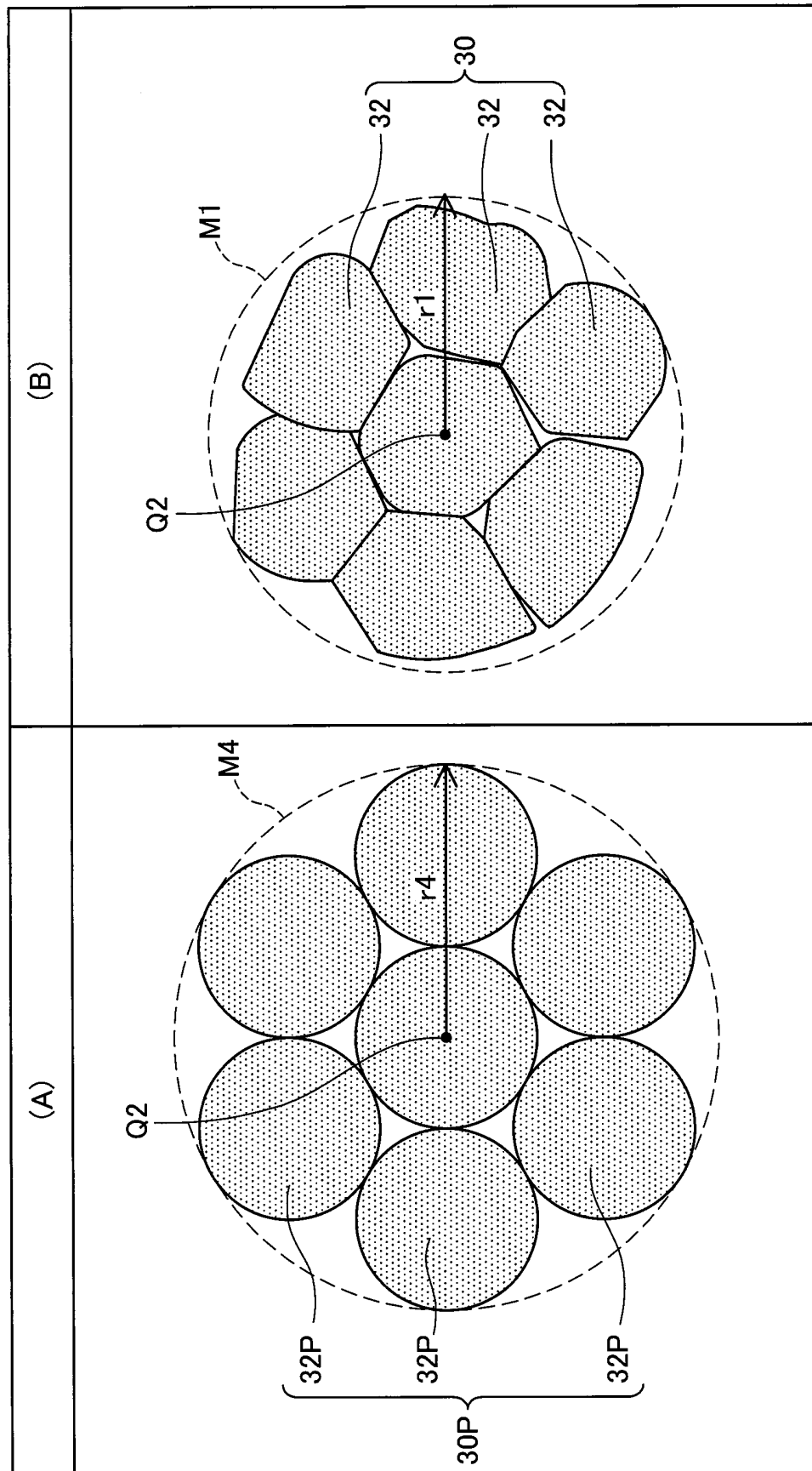


FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/028833

A. CLASSIFICATION OF SUBJECT MATTER

D07B 1/06 (2006.01) i

FI: D07B1/06 Z

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)

D07B1/06

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 1971-2020

Registered utility model specifications of Japan 1996-2020

Published registered utility model applications of Japan 1994-2020

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2003-201688 A (TOKYO ROPE MFG. CO., LTD.) 18.07.2003 (2003-07-18) claims, examples, entire text	1-13
A	JP 04-050388 A (TOKYO ROPE MFG. CO., LTD.) 19.02.1992 (1992-02-19) claims, examples, entire text	1-13
A	JP 2014-237908 A (HITACHI, LTD.) 18.12.2014 (2014-12-18) claims, examples, entire text	1-13
A	KR 10-2016-0056273 A (DIESEUGEULROBEOL CO., LTD.) 19.05.2016 (2016-05-19) claims, examples	1-13
A	JP 48-077151 A (ODESSKIY POLITEHNIЧЕСKIY INSTITUT.) 17.10.1973 (1973-10-17) claims, examples, entire text	1-13

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

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Date of the actual completion of the international search
24 September 2020 (24.09.2020)Date of mailing of the international search report
06 October 2020 (06.10.2020)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/JP2020/028833

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. 145505/1984 (Laid-open No. 177995/1985) (SHINKO WIRE COMPANY, LTD.) 26.11.1985 (1985-11-26) claims, entire text	1-13

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2020/028833

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JP 2003-201688 A	18 Jul. 2003	(Family: none)	
JP 04-050388 A	19 Feb. 1992	(Family: none)	
JP 2014-237908 A	18 Dec. 2014	CN 104229594 A	
KR 10-2016-0056273 A	19 May 2016	(Family: none)	
JP 48-077151 A	17 Oct. 1973	(Family: none)	
JP 60-177995 U1	26 Nov. 1985	(Family: none)	

REFERENCES CITED IN THE DESCRIPTION

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- JP H7138923 A [0004]
- US 6049042 A [0004]