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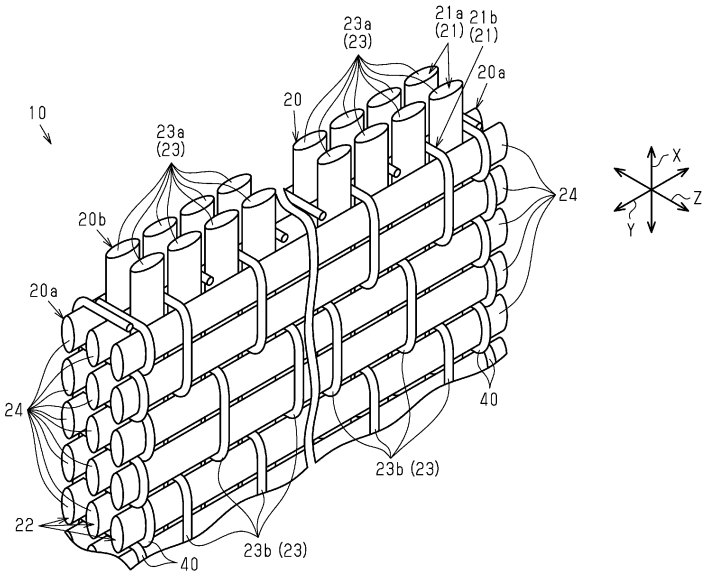
(54) FIBER STRUCTURE FOR FIBER-REINFORCED COMPOSITE MATERIAL

(57) A fiber structure includes a laminate (20) and a selvage yarn (40). The laminate (20) includes at least one warp yarn layer (21) including warp yarns (23) extending in a first direction (X) and at least two weft yarn layers (22) including weft yarns (24) extending in a second direction (Y). At each end section (20a) of the laminate (20), the selvage yarn (40) is engaged with the weft yarns (24) of the weft yarn layers (22) located at opposite ends in a laminating direction (Z). Some of the warp yarns (23) are binding yarns that bind the warp yarn layer (21) to the weft yarn layer (22). The selvage yarn (40) is a continuous yarn. The weft yarns (24) of the weft yarn layers (22) located at the opposite ends in the laminating direction (Z) are spun yarns.

Fig.1



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a fiber structure for a fiber-reinforced composite material.

BACKGROUND ART

[0002] Patent Literature 1 discloses a fiber structure used in fiber-reinforced composite materials. The fiber structure includes a warp yarn layer and a weft yarn layer. The warp yarn layer includes warp yarns that extend in a first direction. The warp yarns are arranged in a second direction that is orthogonal to the first direction. The weft yarn layer includes weft yarns that are reinforcing fiber yarns extending in the second direction. The weft yarns are arranged in the first direction.

[0003] The fiber structure of Patent Literature 1 includes a laminate in which the warp yarn layer and the weft yarn layer are laminated in a laminating direction that is orthogonal to the first and second directions. The laminate includes opposite end sections in the second direction and a general section. The opposite end sections are formed by multiple weft yarn layers arranged in the laminating direction. The general section is located between the opposite end sections in the second direction. The general section includes binding yarns that bind the warp yarn layers to the weft yarn layers by engaging with the weft yarns.

[0004] In the fiber structure disclosed in Patent Literature 1, it is known to provide selvage yarns that engage with the weft yarns at the opposite end sections in the second direction to prevent fraying of the weft yarns at the opposite end sections in the second direction.

CITATION LIST

Patent Literature

[0005] Patent Literature 1: Japanese Laid-Open Patent Publication No. 2018-178299

SUMMARY OF INVENTION

Technical Problem

[0006] When the weft yarns are continuous yarns, the surfaces of the weft yarns are smooth. As a result, the selvage yarns are prone to slipping against the weft yarns. If the selvage yarns shift toward the opposite sides of the fiber structure in the second direction, fraying occurs at the opposite end sections of the fiber structure in the second direction.

Solution to Problem

[0007] An aspect of the present disclosure provides a fiber structure for a fiber-reinforced composite material. The fiber structure includes a laminate and a selvage yarn. The laminate includes at least one warp yarn layer and at least two weft yarn layers. The warp yarn layer includes warp yarns extending in a first direction. The warp yarns are arranged in a second direction that is orthogonal to the first direction. Each of the weft yarn layers includes weft yarns that are reinforcing fiber yarns extending in the second direction. The weft yarns are arranged in the first direction. The warp yarn layers and the weft yarn layers are laminated in a laminating direction that is orthogonal to the first direction and the second direction. The laminate includes end sections that are respectively located at opposite ends in the second direction and formed by the weft yarn layers and a general section located between the end sections in the second direction. The selvage yarn engages with the weft yarns of the weft yarn layer located at at least one of opposite ends in the laminating direction. At least some of the warp yarns are binding yarns that bind the warp yarn layer to the weft yarn layer by engaging with the weft yarns in the general section. The selvage yarn is a continuous yarn. The weft yarns of the weft yarn layers located at the opposite ends in the laminating direction are spun yarns.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a perspective view schematically showing a fiber structure according to a first embodiment.

Fig. 2 is a plan view schematically showing the fiber structure of Fig. 1.

Fig. 3 is a perspective view schematically showing the fiber structure according to a second embodiment.

Fig. 4 is a cross-sectional view schematically showing the fiber structure of Fig. 3.

DESCRIPTION OF EMBODIMENTS

First Embodiment

[0009] A fiber structure for a fiber-reinforced composite material according to a first embodiment will now be described with reference to Figs. 1 and 2. The fiber structure for the fiber-reinforced composite material is a fiber structure used in a fiber-reinforced composite material. The fiber-reinforced composite material is formed by combining the fiber structure with a matrix (not shown). The fiber structure is a reinforcing base for the fiber-reinforced composite material. The matrix is, for example, a thermosetting epoxy resin. Hereinafter, the fiber structure for the fiber-reinforced composite material will be simply referred to as the fiber structure.

[0010] As shown in Fig. 1, the fiber structure 10 includes a laminate 20 and selvage yarns 40.

Laminate

[0011] The laminate 20 includes warp yarn layers 21 and weft yarn layers 22. The fiber structure 10 of the present embodiment includes three warp yarn layers 21 and three weft yarn layers 22. The laminate 20 is formed by laminating the warp yarn layers 21 and the weft yarn layers 22. The direction in which the warp yarn layers 21 and the weft yarn layers 22 are laminated is referred to as the laminating direction Z. The laminating direction Z is orthogonal to a first direction X and a second direction Y, both of which will be described later.

[0012] Each warp yarn layer 21 includes warp yarns 23. The warp yarns 23 extend in the first direction X. The warp yarns 23 are arranged in the second direction Y, which is orthogonal to the first direction X. That is, each warp yarn layer 21 is formed by arranging, in the second direction Y, the warp yarns 23 extending in the first direction X.

[0013] In the present embodiment, of the three warp yarn layers 21, two warp yarn layers 21 are first warp yarn layers 21a, and one warp yarn layer 21 is a second warp yarn layer 21b. Each first warp yarn layer 21a is formed by arranging first warp yarns 23a, which are the warp yarns 23 extending in the first direction X, in the second direction Y. The second warp yarn layer 21b is formed by arranging second warp yarns 23b, which are the warp yarns 23 extending in the first direction X, in the second direction Y. The first warp yarns 23a and the second warp yarns 23b are alternately arranged in the second direction Y. The warp yarns 23 located at the opposite ends in the second direction Y are the first warp yarns 23a.

[0014] Each first warp yarn 23a is a reinforcing fiber yarn. The reinforcing fiber in the present embodiment is carbon fiber. Each second warp yarn 23b is made of phenoxy resin. The first warp yarn 23a and the second warp yarn 23b are continuous yarns formed by bundling continuous fibers. The second warp yarn 23b is thinner than the first warp yarn 23a. The first warp yarn 23a extends straight in the first direction X. The second warp yarn 23b extends in the first direction X while meandering in the laminating direction Z. The structure of the second warp yarn 23b will be described in detail later.

[0015] Each weft yarn layer 22 includes weft yarns 24. The weft yarns 24 extend straight in the second direction Y. The weft yarns 24 are arranged in the first direction X. That is, each weft yarn layer 22 is formed by arranging, in the first direction X, the weft yarns 24 extending in the second direction Y. The opposite end sections of the weft yarn layer 22 in the second direction Y protrude outward from the warp yarns 23 located at the opposite ends in the second direction Y, respectively. Each weft yarn 24 is a reinforcing fiber yarn. The reinforcing fiber in the present embodiment is carbon fiber.

[0016] The laminate 20 includes two end sections 20a and a general section 20b.

[0017] The end sections 20a are located at the opposite ends of the laminate 20 in the second direction Y, respectively. Specifically, the two end sections 20a are located outward from the warp yarns 23 located at the opposite ends in the second direction Y, respectively. Each end section 20a includes multiple weft yarn layers 22 arranged in the laminating direction Z. Specifically, the two end sections 20a are formed by laminating, in the laminating direction Z, the opposite end sections of the weft yarn layers 22 in the second direction Y.

[0018] The weft yarns 24 of the weft yarn layers 22 located at the opposite ends in the laminating direction Z are spun yarns formed by bundling discontinuous fibers. The weft yarns 24 of the weft yarn layer 22, other than those located at the opposite ends in the laminating direction Z, are continuous yarns. In the present embodiment, the weft yarn layer 22, other than those located at the opposite ends in the laminating direction Z, refer to one weft yarn layer 22 positioned between the weft yarn layers 22 located at the opposite ends in the laminating direction Z.

[0019] The general section 20b is located between the two end sections 20a in the second direction Y. The general section 20b includes multiple warp yarn layers 21 and multiple weft yarn layers 22, which are arranged in the laminating direction Z. In the general section 20b, the first warp yarn layers 21a and the weft yarn layers 22 are alternately laminated in the laminating direction Z. Each first warp yarn layer 21a is located between the weft yarn layers 22 in the laminating direction Z. In the general section 20b, the second warp yarn layers 21b are laminated on the weft yarn layers 22 at the opposite ends in the laminating direction Z.

[0020] As shown in Fig. 2, each second warp yarn 23b includes first warp yarn engagement portions 31, second warp yarn engagement portions 32, and warp yarn connection portions 33.

[0021] Each first warp yarn engagement portion 31 engages with the weft yarns 24 of the weft yarn layer 22 at a first end in the laminating direction Z. The first warp yarn engagement portion 31 is formed by folding back the second warp yarn 23b such that it passes outside the weft yarns 24 of the weft yarn layer 22 located at the first end in the laminating direction Z. The first warp yarn engagement portion 31 is laminated on the weft yarns 24 of the weft yarn layer 22 located at the first end in the laminating direction Z. In the present embodiment, the first warp yarn engagement portion 31 is engaged with two weft yarns 24 of the weft yarn layer 22 located at the first end in the laminating direction Z.

[0022] Each second warp yarn engagement portion 32 engages with the weft yarns 24 of the weft yarn layer 22 located at a second end, which is opposite to the first end, in the laminating direction Z. However, the second warp yarn engagement portion 32 engages with weft yarns 24 that are adjacent, in the first direction X, to the weft yarns 24 with which the first warp yarn engagement portion 31 are engaged. The second warp yarn engagement portion 32 is formed by folding back the second warp yarns 23b such that it passes outside the weft yarns 24 of the weft

yarn layer 22 located at the second end in the laminating direction Z. The second warp yarn engagement portion 32 is laminated on the weft yarns 24 of the weft yarn layer 22 located at the second end in the laminating direction Z. In the present embodiment, the second warp yarn engagement portion 32 is engaged with two weft yarns 24 of the weft yarn layer 22 located at the second end in the laminating direction Z.

[0023] Each warp yarn connection portion 33 connects the first warp yarn engagement portion 31 to the second warp yarn engagement portion 32. The warp yarn connection portion 33 extends in the laminating direction Z between the weft yarns 24 with which the first warp yarn engagement portion 31 is engaged and the weft yarns 24 with which the second warp yarn engagement portion 32 is engaged.

[0024] In the second warp yarn 23b, the first warp yarn engagement portion 31 and the second warp yarn engagement portion 32 are alternately and repeatedly provided via the warp yarn connection portion 33. The second warp yarn 23b is alternately engaged with the weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and the weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z. In the present embodiment, the second warp yarn 23b is alternately engaged with two weft yarns 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and two weft yarns 24 of the weft yarn layer 22 located at the second end in the laminating direction Z.

[0025] Two second warp yarns 23b adjacent to each other, with one first warp yarn 23a in between, in the second direction Y are each passed through a different route and engaged with the weft yarns 24 of the weft yarn layers 22 located at the opposite ends in the laminating direction Z. Specifically, the first warp yarn engagement portion 31 of one of the second warp yarns 23b and the second warp yarn engagement portion 32 of the other second warp yarn 23b are arranged side by side in the second direction Y. Further, the second warp yarn engagement portion 32 of one of the second warp yarns 23b and the first warp yarn engagement portion 31 of the other second warp yarn 23b are arranged side by side in the second direction Y. The first warp yarn engagement portion 31 of one second warp yarn 23b and the first warp yarn engagement portion 31 of the other second warp yarn 23b are shifted from each other in the first direction X. The second warp yarn engagement portion 32 of one second warp yarn 23b and the second warp yarn engagement portion 32 of the other second warp yarn 23b are shifted from each other in the first direction X.

[0026] The second warp yarns 23b are binding yarns that bind the warp yarn layers 21 to the weft yarn layers 22 by engaging with the weft yarns 24 of the weft yarn layers 22 located at the opposite ends in the laminating direction Z. Thus, in the present embodiment, some of the warp yarns 23 are binding yarns that bind the warp yarn layer 21 to the weft yarn layer 22 by engaging with the weft yarns 24 in the general section 20b. The weft yarns 24 with which the second warp yarn 23b engages in the general section 20b are the weft yarns 24 of the weft yarn layer 22 located at the opposite ends in the laminating direction Z. Thus, the weft yarn 24 with which the second warp yarn 23b engages is a spun yarn. Further, as mentioned above, the second warp yarn 23b is a continuous yarn. Therefore, the binding yarn that engages with the weft yarn 24, which is a spun yarn, is a continuous yarn.

Selvage Yarn

[0027] Two selvage yarns 40 are provided at each end section 20a of the laminate 20. Each selvage yarn 40 is located outward from the general section 20b in the second direction Y. The selvage yarn 40 extends in the first direction X while meandering in the laminating direction Z. The selvage yarn 40 is made of phenoxy resin. The selvage yarn 40 is a continuous yarn. The selvage yarn 40 is thinner than the first warp yarn 23a.

[0028] The selvage yarn 40 includes first selvage yarn engagement portions 41, second selvage yarn engagement portions 42, and selvage yarn connection portions 43.

[0029] Each first selvage yarn engagement portion 41 engages with the weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z. The first selvage yarn engagement portion 41 is formed by folding back the selvage yarn 40 such that it passes outside the weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z. In the present embodiment, the first selvage yarn engagement portion 41 is engaged with one weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z.

[0030] Each second selvage yarn engagement portion 42 engages with the weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z. However, the second selvage yarn engagement portion 42 engages with a weft yarn 24 that is adjacent, in the first direction X, to the weft yarn 24 with which the first selvage yarn engagement portion 41 is engaged. The second selvage yarn engagement portion 42 is formed by folding back the selvage yarn 40 such that it passes outside the weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z. In the present embodiment, the second selvage yarn engagement portion 42 is engaged with one weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z.

[0031] The selvage yarn connection portion 43 connects the first selvage yarn engagement portion 41 to the second selvage yarn engagement portion 42. The selvage yarn connection portion 43 extends in the laminating direction Z between the weft yarn 24 with which the first selvage yarn engagement portion 41 is engaged and the weft yarn 24 with which the second selvage yarn engagement portion 42 is engaged.

[0032] In the selvage yarn 40, the first selvage yarn

engagement portion 41 and the second selvage yarn engagement portion 42 are alternately and repeatedly provided via the selvage yarn connection portion 43. The selvage yarn 40 is alternately engaged with the weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and the weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z. In the present embodiment, the selvage yarn 40 is alternately engaged with each weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and each weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z.

[0033] The two selvage yarns 40, which are located at each end section 20a, are each passed through a different route and engaged with the weft yarns 24 of the weft yarn layers 22 at the opposite ends in the laminating direction Z. In detail, the first selvage yarn engagement portion 41 of one selvage yarn 40 and the second selvage yarn engagement portion 42 of the other selvage yarn 40 are arranged side by side in the second direction Y. Further, the second selvage yarn engagement portion 42 of one selvage yarn 40 and the first selvage yarn engagement portion 41 of the other selvage yarn 40 are arranged side by side in the second direction Y. The first selvage yarn engagement portion 41 of one selvage yarn 40 and the first selvage yarn engagement portion 41 of the other selvage yarn 40 are shifted from each other in the first direction X. The second selvage yarn engagement portion 42 of one selvage yarn 40 and the second selvage yarn engagement portion 42 of the other selvage yarn 40 are shifted from each other in the first direction X.

[0034] Operation and Advantage of Present Embodiment

[0035] The operation and advantages of the present embodiment will now be described.

(1) At the end sections 20a of the laminate 20, the selvage yarns 40 are engaged with the weft yarns 24 of the weft yarn layers 22 located at the opposite ends in the laminating direction Z. The selvage yarns 40 are continuous yarns. The weft yarns 24 of the weft yarn layers 22 at the opposite ends in the laminating direction Z are spun yarns. The surface coefficient of friction of a spun yarn is greater than that of a continuous yarn. As a result, the selvage yarn 40 is less prone to slipping against the weft yarns 24 of the weft yarn layers 22 located at the opposite ends in the laminating direction Z. This limits the shifting of the selvage yarns 40 in the second direction Y. Consequently, fraying is less likely to occur at the opposite end sections of the fiber structure 10 in the second direction Y.

(2) Among the warp yarns 23, the second warp yarns 23b are binding yarns that engage with the weft yarns 24, which are spun yarns. The second warp yarns 23b are continuous yarns. Thus, compared to when the second warp yarns 23b are spun yarns, the strength of the fiber-reinforced composite material is improved.

[0036] For example, there may be a case in which the selvage yarns 40 are spun yarns and the weft yarns 24 of the weft yarn layers 22 at the opposite ends in the laminating direction Z are continuous yarns. In this case, although the selvage yarns 40 are less prone to slipping against the weft yarns 24, the second warp yarns 23b, which are continuous yarns, are more prone to slipping against the weft yarns 24. In the present embodiment, the selvage yarns 40 are continuous yarns, and the weft yarns 24 of the weft yarn layers 22 at the opposite ends in the laminating direction Z are spun yarns. As a result, not only are the selvage yarns 40 less prone to slipping against the weft yarns 24, but the second warp yarns 23b are also less prone to slipping. Accordingly, not only is the shifting of the selvage yarns 40 in the second direction Y limited, but the shifting of the second warp yarns 23b in the second direction Y is also limited.

[0037] (3) Among multiple weft yarn layers 22, the weft yarns 24 of the weft yarn layers 22 at the opposite ends in the laminating direction Z are spun yarns, and the weft yarns 24 of the other weft yarn layer 22 are continuous yarns. That is, among multiple weft yarn layers 22, the weft yarns 24 of the weft yarn layer 22 other than those at the opposite ends in the laminating direction Z are continuous yarns. Thus, compared to when the weft yarns 24 of the weft yarn layer 22 other than those at the opposite ends in the laminating direction Z are also spun yarns, the strength of the fiber-reinforced composite material is improved.

[0038] (4) The selvage yarn 40 is alternately engaged with each weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and each weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z. Thus, as compared to when the selvage yarn 40 is alternately engaged with multiple weft yarns 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and multiple weft yarns 24 of the weft yarn layer 22 located at the second end in the laminating direction Z, the selvage yarn 40 is less likely to be shifted.

Second Embodiment

[0039] The fiber structure for the fiber-reinforced composite material according to a second embodiment will now be described with reference to Figs. 3 and 4. In the second embodiment, the structure of the warp yarn layer 21 mainly differs from that in the first embodiment. The components that are the same as those in the first embodiment will not be described.

[0040] As shown in Figs 3 and 4, the laminate 20 of the present embodiment is formed by laminating four warp yarn layers 21 and six weft yarn layers 22 in the laminating direction Z.

[0041] Each warp yarn layer 21 of the present embodi-

ment includes first binding warp yarns 23c, which are warp yarns 23, and second binding warp yarns 23d, which are also warp yarns 23. The first binding warp yarns 23c and the second binding warp yarns 23d extend in the first direction X. The first binding warp yarns 23c and the second binding warp yarns 23d are alternately arranged in the second direction Y. That is, the warp yarn layer 21 is formed by alternately arranging, in the second direction Y, the first binding warp yarns 23c and the second binding warp yarns 23d, which extend in the first direction X. In the present embodiment, the warp yarns 23 at the opposite ends in the second direction Y are the first binding warp yarns 23c.

[0042] The first binding warp yarns 23c and the second binding warp yarns 23d are fiber-reinforced yarns. The reinforcing fiber in the present embodiment is carbon fiber. Additionally, the first binding warp yarns 23c and the second binding warp yarns 23d are continuous yarns.

[0043] The first binding warp yarns 23c are engaged with the weft yarns 24 of one weft yarn layer 22. In detail, the first binding warp yarns 23c are engaged with the weft yarns 24, which are arranged in the first direction X to form one weft yarn layer 22, by alternately passing through one side and the other side of the weft yarns 24 in the laminating direction Z relative to the weft yarns 24. The first binding warp yarns 23 are binding yarns that bind the warp yarn layer 21 to the weft yarn layer 22 by engaging with the weft yarns 24 in the general section 20b.

[0044] The second binding warp yarns 23d are engaged with the weft yarns 24 of two weft yarn layers 22 on the opposite sides in the laminating direction Z of the weft yarn layers 22 with which the first binding warp yarns 23c are engaged. Specifically, the second binding warp yarns 23d are engaged with the weft yarns 24 by alternately passing through the outer side of the weft yarns 24 of the weft yarn layer 22 on one side in the laminating direction Z relative to the weft yarn layer 22 with which the first binding warp yarns 23c are engaged and through the outer side of the weft yarns 24 of the weft yarn layer 22 on the other side in the laminating direction relative to the weft yarn layer 22 with which the first binding warp yarns 23c are engaged. The second binding warp yarns 23d are binding yarns that bind the warp yarn layer 21 to the weft yarn layer 22 by engaging with the weft yarns 24 in the general section 20b. Thus, in the present embodiment, all the warp yarns 23 are binding yarns that bind the warp yarn layer 21 to the weft yarn layer 22.

[0045] Some of the weft yarns 24 with which the warp yarns 23 engage in the general section 20b are the weft yarns 24 of the weft yarn layer 22 located at the opposite ends in the laminating direction Z. Thus, some of the weft yarns 24 with which the second warp yarns 23b engage are spun yarns. As described above, the warp yarns 23 are continuous yarns. Therefore, the binding yarn that engages with the weft yarn 24, which is a spun yarn, is a continuous yarn.

[0046] As described in the first embodiment, each weft yarn layer 22 is formed by arranging, in the first direction X, multiple weft yarns 24 extending the second direction Y. In the present embodiment, the number of weft yarns 24 in the weft yarn layer 22 at the opposite ends in the laminating direction Z is smaller than that of weft yarns 24 in the four weft yarn layers 22 located between the weft yarn layers 22 at the opposite ends in the laminating direction Z. The weft yarns 24 of the weft yarn layers 22 at the opposite ends in the laminating direction Z are arranged such that, in the first direction X, each of them overlaps in the laminating direction Z with every other weft yarn 24 of the weft yarn layer 22 located between the weft yarn layers 22 located at the opposite ends in the laminating direction Z.

[0047] The second embodiment achieves the same advantages as the advantages (1) to (4) of the first embodiment.

Modifications

[0048] Each of the above-described embodiments may be modified as follows. The above-described embodiments and the following modifications can be combined as long as the combined modifications remain technically consistent with each other.

[0049] Reinforcing fibers are not limited to carbon fibers. Examples of the reinforcing fibers may include glass fibers, silicon carbide-based ceramic fibers, aramid fibers, and ultra-high molecular weight polyethylene fibers.

[0050] In the first embodiment, the number of the weft yarn layers 22 is not limited to three. The number of weft yarn layers 22 may be changed as long as there are two or more layers. The number of the first warp yarn layers 21a is not limited to two. The number of first warp yarn layers 21a may be changed. However, the first warp yarn layer 21a needs to be located between the weft yarn layers 22 in the laminating direction Z. Two or more first warp yarn layers 21a may be arranged between adjacent ones of the weft yarn layers 22 in the laminating direction Z.

[0051] In the first embodiment, the first warp yarn 23a is not limited to a reinforcing fiber yarn. The first warp yarn 23a may be, for example, a yarn made of phenoxy resin or nylon. The second warp yarn 23b does not have to be made of phenoxy. The second warp yarn 23b may be, for example, a yarn made of nylon or a reinforcing fiber yarn. When the first warp yarn 23a and the second warp yarn 23b are not reinforcing fiber yarns, the fiber structure 10 is a unidirectional fiber structure for a fiber-reinforced composite material that is reinforced only in the second direction Y by the weft yarns 24, which are reinforcing fibers.

[0052] In the first embodiment, the first warp yarn 23a may be a spun yarn.

[0053] In the first embodiment, the second warp yarn 23b may be a spun yarn.

[0054] In the first embodiment, the second warp yarn

23b may be alternately engaged with each weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and each weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z. The second warp yarn 23b may be alternately engaged with three weft yarns 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and three weft yarns 24 of the weft yarn layer 22 located at the second end in the laminating direction Z.

[0055] In the first embodiment, two second warp yarns 23b that engage with the weft yarns 24 by each passing through a different route may be arranged between adjacent ones of the first warp yarns 23a in the second direction Y.

[0056] In the second embodiment, the number of weft yarn layers 22 is not limited to six. The number of weft yarn layers 22 may be changed as long as there are two or more layers. The number of warp yarn layers 21 is not limited to four. The number of warp yarn layers 21 may be changed within the range where the warp yarns 23 can bind the warp yarn layers 21 to the weft yarn layers 22.

[0057] In the second embodiment, the warp yarn 23 is not limited to a reinforcing fiber yarn. The warp yarn 23 may be, for example, a yarn made of phenoxy resin or nylon. In this case, the fiber structure 10 is a unidirectional fiber structure for a fiber-reinforced composite material that is reinforced only in the second direction Y by the weft yarns 24, which are reinforcing fiber yarns.

[0058] In the second embodiment, the warp yarn 23 may be a spun yarn.

[0059] In the second embodiment, the warp yarns 23 at the opposite ends in the second direction Y may be the second binding warp yarns 23d. The warp yarns 23 at one end in the second direction Y may be the first binding warp yarns 23c, and the warp yarns 23 at the other end in the second direction Y may be the second binding warp yarns 23d.

[0060] In each embodiment, the weft yarns 24 of the weft yarn layers 22, except for the weft yarn layers 22 at the opposite ends in the laminating direction Z, may also be spun yarns.

[0061] In each embodiment, the selvage yarn 40 may be made of material other than phenoxy. The selvage yarn 40 may be, for example, a nylon yarn or a reinforcing fiber yarn.

[0062] In each embodiment, the selvage yarn 40 may be engaged only with the weft yarns 24 of the weft yarn layer 22 at the first end in the laminating direction Z. In this case, the selvage yarn 40 is not engaged with the weft yarns 24 of the weft yarn layer 22 at the second end in the laminating direction Z, as it is folded back at an intermediate point in the laminating direction Z. As another example, the selvage yarn 40 may be engaged only with the weft yarns 24 of the weft yarn layer 22 at the second end in the laminating direction Z. In this case, the selvage yarn 40 is not engaged with the weft yarns 24 of the weft yarn layer 22 at the first end in the laminating direction Z, as it is folded back at an intermediate point in the laminating direction Z. In other words, it is sufficient for the selvage yarn 40 to be engaged with the weft yarn 24 of the weft yarn layer 22 located at at least one end in the laminating direction Z. The phrase "at least one end in the laminating direction" refers to either only one end, only the other end, or the opposite ends in the laminating direction.

[0063] In each embodiment, the selvage yarn 40 does not have to be alternately engaged with each weft yarn 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and each weft yarn 24 of the weft yarn layer 22 located at the second end in the laminating direction Z. Instead, the selvage yarn 40 may be alternately engaged with multiple weft yarns 24 of the weft yarn layer 22 located at the first end in the laminating direction Z and multiple weft yarns 24 of the weft yarn layer 22 located at the second end in the laminating direction Z.

[0064] The matrix is not limited to epoxy resin. The matrix may be another thermosetting resin such as vinyl ester resin, unsaturated polyester resin, or phenolic resin. Alternatively, the matrix may be a thermoplastic resin such as polyamide, polybutylene terephthalate, polycarbonate, polyethylene, polypropylene, polyimide resin, or ABS resin.

Claims

1. A fiber structure for a fiber-reinforced composite material, the fiber structure comprising:

a laminate including at least one warp yarn layer and at least two weft yarn layers, wherein the warp yarn layer includes warp yarns extending in a first direction, the warp yarns are arranged in a second direction that is orthogonal to the first direction, each of the weft yarn layers includes weft yarns that are reinforcing fiber yarns extending in the second direction, the weft yarns are arranged in the first direction, the warp yarn layer and the weft yarn layers are laminated in a laminating direction that is orthogonal to the first direction and the second direction, the laminate includes end sections that are respectively located at opposite ends in the second direction and formed by the weft yarn layers and a general section located between the end sections in the second direction; and

a selvage yarn that engages with the weft yarns of the weft yarn layer located at at least one of opposite ends in the laminating direction, wherein

at least some of the warp yarns are binding yarns that bind the warp yarn layer to the weft yarn layer by engaging with the weft yarns in the general section,

the selvage yarn is a continuous yarn, and

the weft yarns of the weft yarn layers located at the opposite ends in the laminating direction are spun yarns.

2. The fiber structure for the fiber-reinforced composite material according to claim 1, wherein
the binding yarns that engage with the weft yarns are continuous yarns, the weft yarns being spun yarns.

3. The fiber structure for the fiber-reinforced composite material according to claim 1 or 2, wherein
the weft yarns of the weft yarn layer, other than the weft yarn layers located at the opposite ends, in the laminating direction, are continuous yarns.

4. The fiber structure for the fiber-reinforced composite material according to claim 3, wherein
the selvage yarn is alternately engaged with each of the weft yarns of the weft yarn layer located at one of the opposite ends in the laminating direction and each of the weft yarns of the weft yarn layer located at the other one of the opposite ends in the laminating direction.

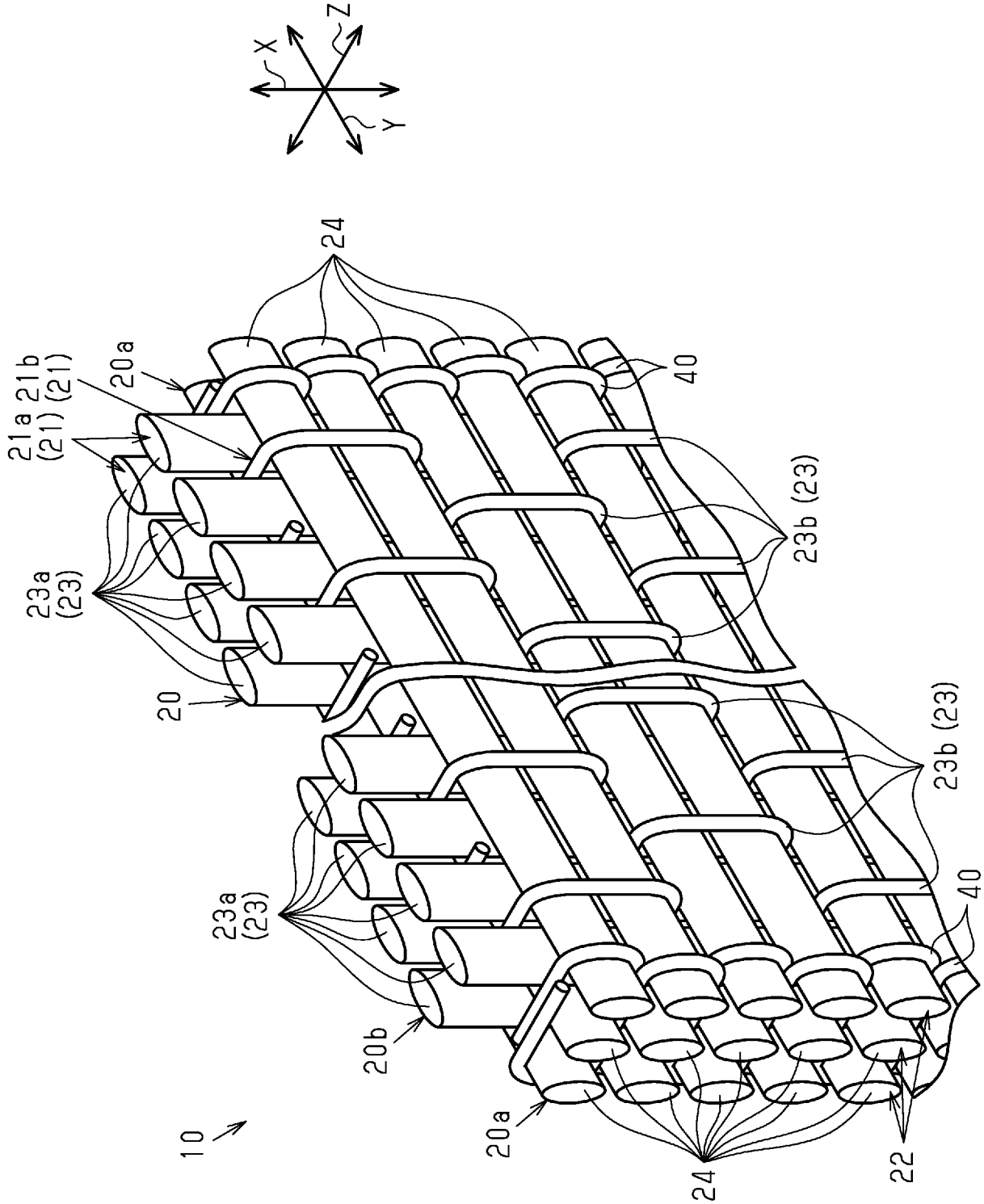
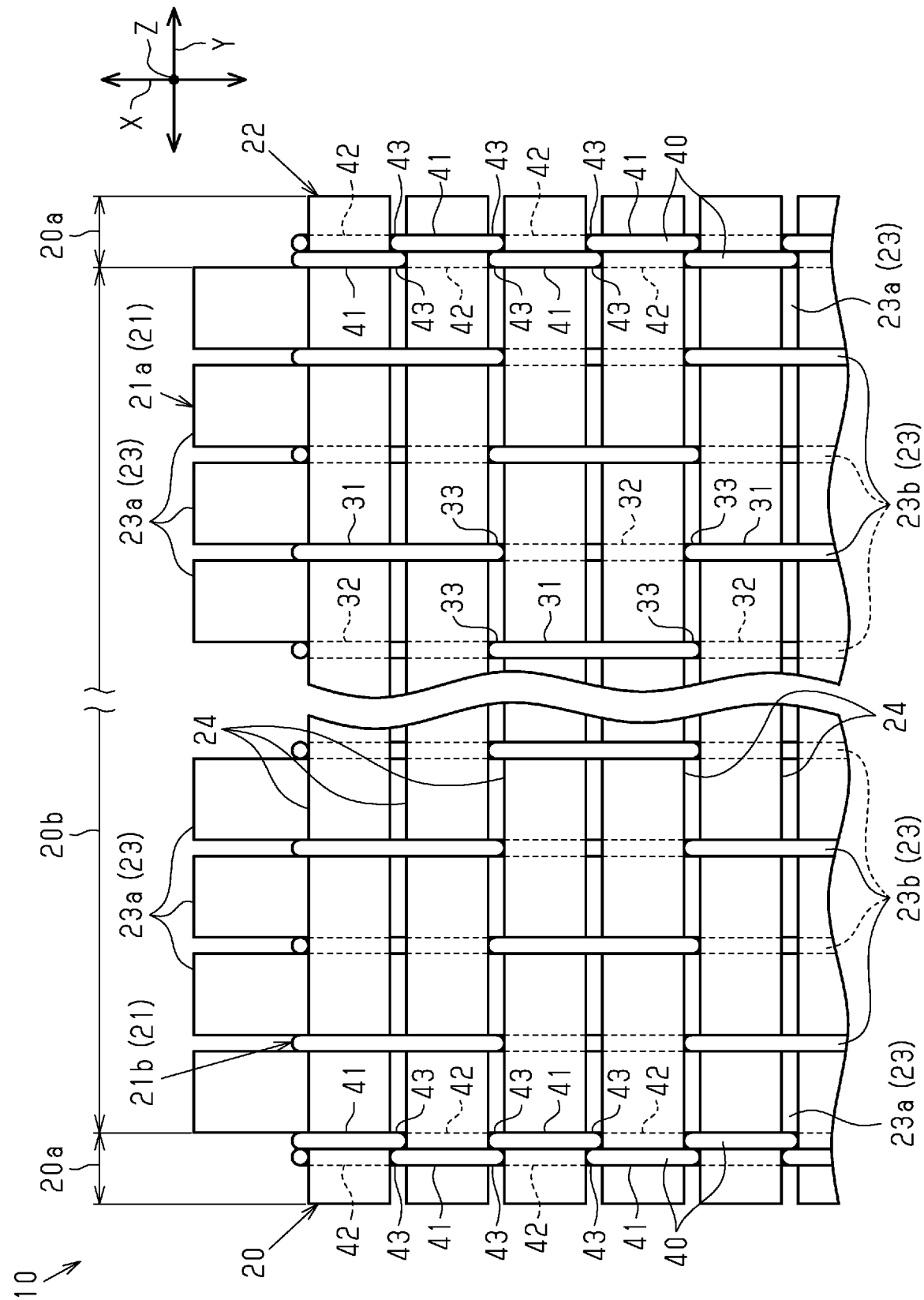

X
Z
Y
24
21a 21b
(21) (21)
20a
40
23b (23)
23a
(23)
20
23b (23)
23a
(23)
40
20b
10
20a
24
22

Fig.1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Y
X
22
42
43
41
40
20a
21a (21)
23a (23)
23b (23)
31
32
33
24
20b
21b (21)
20
10

Fig.2

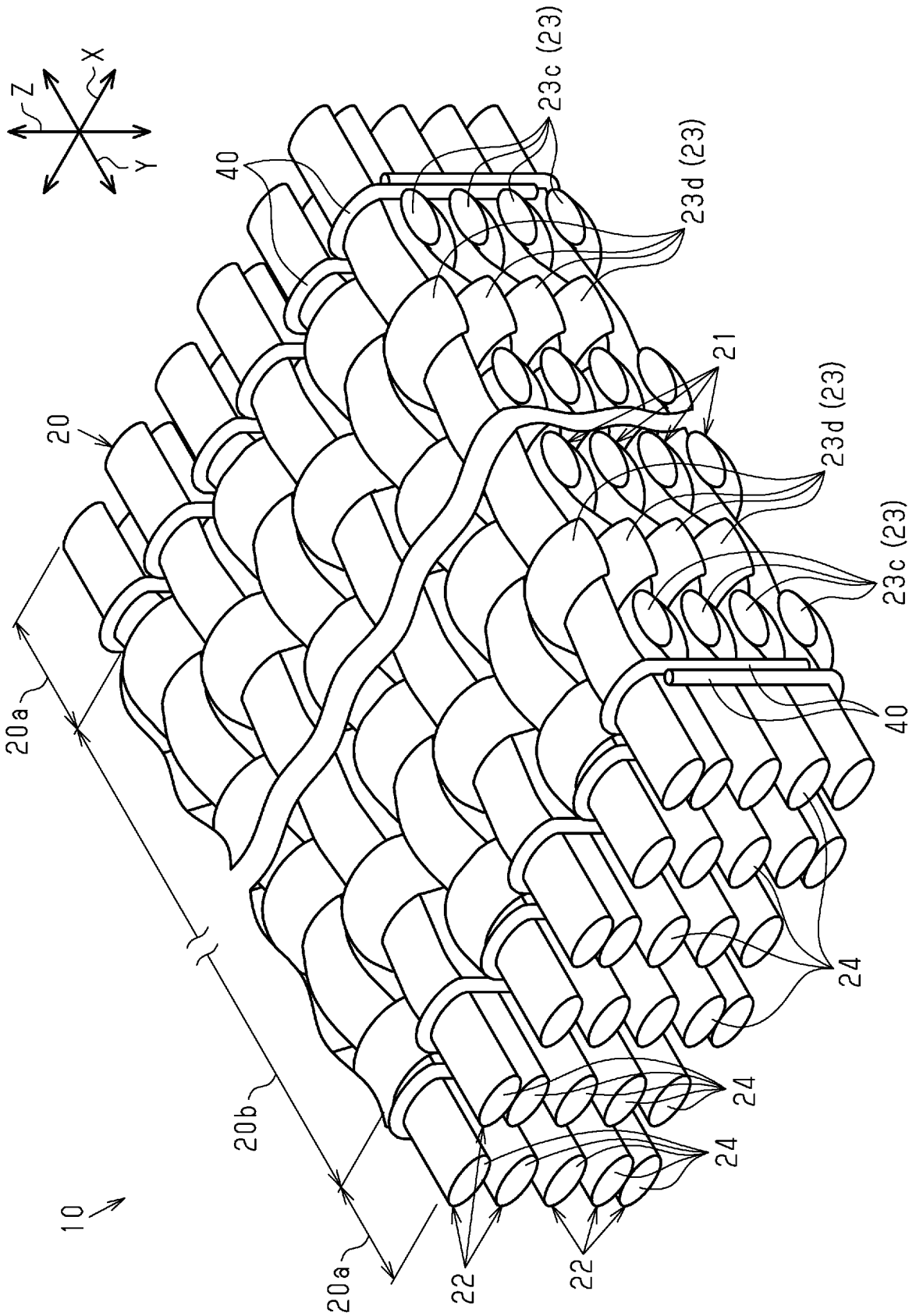
Z
X
Y
23c (23)
40
23d (23)
21
20
23d (23)
23c (23)
20a
40
24
20b
24
24
10
20a
22
22

Fig.3

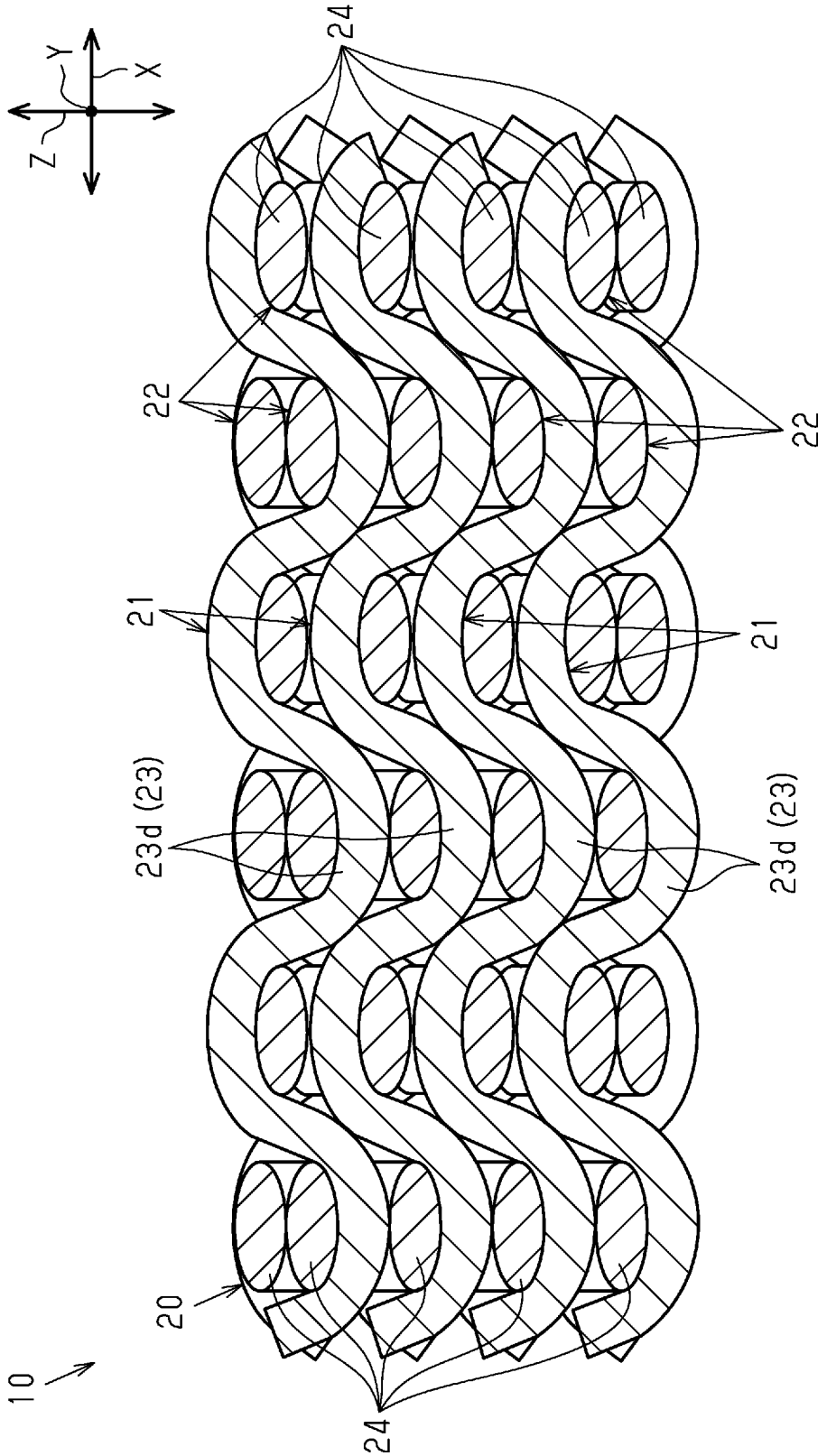

Fig.4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/020778

A. CLASSIFICATION OF SUBJECT MATTER

D03D 1/00(2006.01)i; ***D03D 5/00***(2006.01)i; ***D03D 11/00***(2006.01)i
FI: D03D1/00 A; D03D5/00 Z; D03D11/00 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)

D03D1/00; D03D5/00; D03D11/00

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 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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 2021-17670 A (TOYOTA IND CORP) 15 February 2021 (2021-02-15) entire text, all drawings	1-4
A	JP 2006-144847 A (BANDO CHEM IND LTD) 08 June 2006 (2006-06-08) entire text	1-4
A	JP 6-815 A (NISSAN MOTOR CO LTD) 11 January 1994 (1994-01-11) entire text	1-4

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 August 2023	**15 August 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **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/JP2023/020778

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2021-17670 A	15 February 2021	US 2022/0258436 A1 entire text, all drawings WO 2021/014851 A1 EP 4000843 A1	
JP 2006-144847 A	08 June 2006	(Family: none)	
JP 6-815 A	11 January 1994	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2018178299 A **[0005]**