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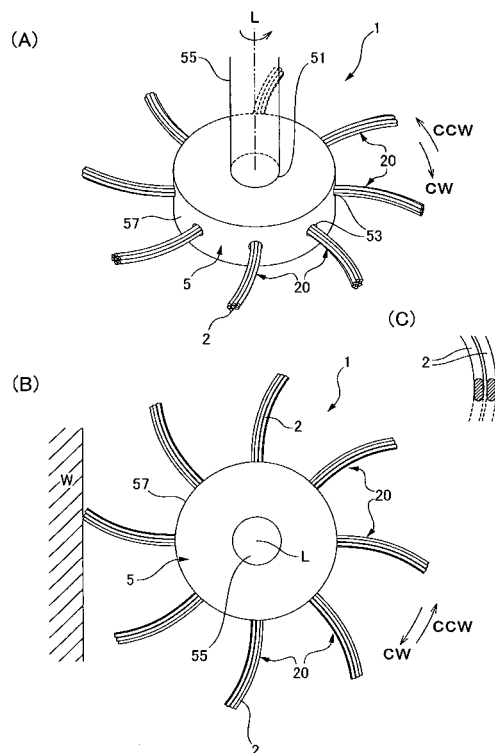
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(54) **BRUSH-LIKE GRINDSTONE**

(57) A brush-like grindstone (1) has threadlike grinding elements (2) each being a thread that is a collection of long inorganic fibers and is impregnated with resin and solidified. To grind work (W), the grindstone (1) is moved relative to the work (W) with the forward ends of the threadlike grinding elements (2) pressed against the work (W). In order to prevent the grinding elements (2) from breaking, each threadlike grinding element (2) is curved from its base end to its forward end with high hardness of the grinding elements (2) maintained. Also, the grinding elements (2) are formed in an elliptic or oblong cross-sectional shape whose minor axis is aligned with the direction of the curve. Therefore, the grinding elements (2) have extremely high rigidity in the direction perpendicular to the direction of the curve but they easily deform in the direction of the curve. Consequently, the grinding elements (2) softly engages the work (W) at their forward ends and, when excessive force acts on the elements (2), the brush-like grindstone (1) does not break because the elements (2) deform to absorb the force.

Fig. 1



Description

Technical Field

[0001] The present invention relates to a brush-like grindstone that is used for burr removal and grinding processes.

Background Art

[0002] Precision parts that are used for automobile and aircraft components are manufactured with high precision and accuracy by automated equipment such as NC benches, NC cutters, machining centers, robots and specialized processing equipment that employ tools such as end mills, drills, dies and taps. In addition, the frames and other parts of electronics equipment are produced from die-cast parts formed from magnesium and aluminum. Grinding processes are carried out on these workpieces using gritted nylon brushes, brass brushes, wire brushes, and the like in order to remove processing marks, tool marks, burrs and the like. However, gritted nylon brushes, brass brushes, and wire brushes have low grit content and low hardness, and thus have inferior grinding capacity due to their inferior stiffness, and there have thus been problems with inefficient grinding.

[0003] Thus, the applicant of the present invention provides a brush-like grindstone in which a holder holds a plurality of filamentous bodies formed by impregnating bundled fibers formed from alumina fiber, silicon carbide fiber, carbon fiber, silicon nitride fiber, or glass fiber with binder resin, which is then caused to harden. This type of brush-like grindstone that employs long inorganic fibers has high hardness and stiffness, which provides high grinding capacity and long life (see Patent Document 1, for example).

Patent Document 1: JP A 2000-94344

Disclosure of Invention

Technical Problem

[0004] However, even with the brush-like grindstone disclosed in Patent Document 1, when irregularities are present on the surface, it is not possible to grind or remove burrs in the corners of the depressions simply by moving the brush-like grindstone along the surface of the work. In addition, there is the problem that the long inorganic fibers used in the brush-like grindstone break in many locations due to their high hardness when the brush-like grindstone is moved while impinging on the workpiece with high force.

[0005] In view of the above problems, an object of the present invention is to provide a brush-like grindstone whereby it is possible to prevent breakage of the linear grinding materials while also maintaining high hardness in the linear grinding materials that are produced by im-

pregnating bundles of long inorganic fibers with a resin, which is then caused to harden.

Solution to Problem

[0006] In order to resolve the above problems, according to the present invention, there is provided a brush-like grindstone wherein a plurality of linear grinding materials are held in a holder, the linear grinding materials being obtained by impregnating an assemblage of long inorganic fiber filaments with a resin, which is caused to harden; wherein the plurality of linear grinding materials are curved in at least one location from the proximal end to the distal end.

[0007] According to the present invention, each of the plurality of linear grinding materials is preferably curved over the entire length thereof from the proximal ends to the distal ends.

[0008] According to the brush-like grindstone of the present invention, a workpiece is ground by moving the grindstone relative to the workpiece in a state in which the distal ends of the linear grinding materials are pressed against the work. Because the linear grinding materials are produced by impregnating long inorganic fiber bundles with a resin, which is then caused to harden, the long inorganic fibers that substantially function as the grinding materials have high density, high hardness, and high rigidity. Consequently, the brush-like grindstone of the present invention has high grinding capacity. In addition, according to the present invention, the linear grinding materials are in a curved state, even when the brush-like grindstone is at rest, and thus readily deform in the direction of curvature. As a result, with the brush-like grindstone according to the present invention, the linear grinding materials impinge softly on the workpiece with their distal ends relative to brush-like grindstones in which the linear grinding materials extend perpendicularly. In addition, the linear grinding materials do not break because they deform to absorb excessive force when excessive force is applied.

[0009] In the present invention, a configuration may be utilized in which each of the plurality of linear grinding materials extends radially from an outer circumferential side surface of the holder, and curves circumferentially in the same direction.

[0010] In the present invention, a configuration may also be utilized in which each of the plurality of linear grinding materials extends radially from the outer circumferential side surface of the holder, and curves in one direction in the axial direction of the holder.

[0011] In the present invention, a configuration may be utilized in which a plurality of holders are disposed in the axial direction of the holders, and each of the plurality of linear grinding materials is held on each of the plurality of holders.

[0012] In the present invention, a configuration may be utilized in which two holders are disposed as a pair in the axial direction of the holders, each of the plurality of linear

grinding materials extends radially from the circumferential surface of the two holders and curves in a direction whereby the distal ends of the plurality of linear grinding materials held in the two holders are close to one another.

[0013] In the present invention, a configuration may be utilized in which each of the plurality of linear grinding materials extends in an axial direction from the end surface of one side of the holder in the axial direction, and curves outwards from the inside of the end surface of the one side.

[0014] In the present invention, a configuration may be adopted in which each of the plurality of linear grinding materials extends in the axial direction from the end surface of one side of the holder in the axial direction, and curves inwards from the outside of the end surface of the one side.

[0015] In the present invention, it is preferable for the plurality of linear grinding materials to be held in the holder as a plurality of bundles. By adopting such a configuration, the advantage is presented that chips generated in the grinding process are efficiently discharged and heat dissipation efficiency is increased. In addition, a configuration is used in which the plurality of linear grinding materials are fixed in the holder in small groups; therefore, it is possible to prevent the linear grinding materials from being pulled out. As a result, the advantage is presented that the brush-like grindstone of the present invention is very safe.

[0016] In the present invention, a configuration may be adopted in which the plurality of linear grinding materials are held along the entirety of the circumferential direction in a circumferential groove formed on an outer circumferential side surface or on an end surface of one side of the holder.

[0017] In the present invention, it is preferable to provide the plurality of linear grinding materials with elliptical or oval cross sections in which the minor axis faces the direction of curvature. By utilizing this configuration, the materials deform when excessive force is applied to the linear grinding materials, and the excessive force is absorbed, thus preventing breakage.

[0018] In the present invention, it is preferable for a rotating drive shaft to extend from the holder in the axial direction. By utilizing this type of configuration, it is possible to drive the brush-like grindstone by simple linkage of the drive shaft to a drive device.

[0019] In the present invention, alumina fibers, silicon carbide fibers, carbon fibers, silicon nitride fibers, glass fibers, and the like may be used as the long inorganic fibers.

Brief Description of Drawings

[0020]

FIGS. 1(A), 1(B) and 1(C) are a perspective view, plan view, and descriptive view of the brush-like grindstone of a first embodiment of the present in-

vention, where the perspective view schematically portrays a cross-section of the linear grinding material used in the brush-like grindstone.

FIGS. 2(A) and 2(B) are a perspective view and side view of the brush-like grindstone of a second embodiment of the present invention.

FIG 3(A) and 3(B) are a perspective view and side view of the brush-like grindstone of a third embodiment of the present invention.

FIG 4(A) and 4(B) are a perspective view and side view of the brush-like grindstone of a fourth embodiment of the present invention.

FIG 5(A) and 5(B) are a perspective view and a side view of the brush-like grindstone of a fifth embodiment of the present invention.

FIG 6 is a side view of the brush-like grindstone of a sixth embodiment of the present invention.

FIG 7 is a descriptive view showing a usage example of the brush-like grindstone of a sixth embodiment of the present invention.

FIG 8 is a descriptive view showing the brush-like grindstone of the sixth embodiment of the present invention and a usage example thereof

FIG 9(A) and 9(B) are a plan view and a side view of the brush-like grindstone of a seventh embodiment of the present invention.

FIG 10 is a descriptive diagram showing a usage example of the brush-like grindstone of the seventh embodiment of the present invention.

FIG 11 (A) and 11(B) are a plan view and side view of the brush-like grindstone of an eighth embodiment of the present invention.

FIG 12 is a descriptive diagram showing a usage example of the brush-like grindstone of the eighth embodiment of the present invention.

FIG 13 is a descriptive diagram showing a case in which the linear grinding materials are bent at one location from the proximal end towards the distal end in the brush-like grindstone according to the present invention.

FIG 14 is a descriptive diagram showing another example in which the linear grinding materials are bent at one location from the proximal end towards the distal end in the brush-like grindstone according to the present invention.

(Symbols)

[0021]

- 1 Brush-like grindstone
- 2 Linear grinding material
- 5 Holder
- 20 Grinding material bundle
- 51 Holder shaft hole
- 53 Embedding hole
- 55 Rotational drive shaft
- 57 Outer peripheral surface of the holder

59 End surface on one side of the holder
W Workpiece

Best Mode for Carrying Out the Invention

[0022] Embodiments of the present invention are described in reference to the drawings. In the drawings referenced in the descriptions that follow, a reduced number of grinding material bundles or linear grinding materials are represented in order to facilitate understanding of the structure of each member.

(Embodiment 1)

[0023] FIG 1(A), 1(B) and 1(C) are a perspective view, plan view, and descriptive view of the brush-like grindstone of Embodiment 1 of the present invention, where the descriptive view schematically portrays a cross-section of the linear grinding materials used in the brush-like grindstone. The brush-like grindstone 1 presented in FIGS. 1(A) and (B) has a structure in which a metal holder 5 holds a plurality of linear grinding materials 2 produced by impregnating long inorganic fiber bundles with a resin, which is then caused to harden. The holder 5 has a cylindrical shape in which a shaft hole 51 is formed in the center and passes through in the axial direction. A rotational drive shaft 55 that is inserted into this shaft hole 51 is linked to the holder 5 by a screw (not shown) that is tightened from the side.

[0024] In this embodiment, the linear grinding materials 2 are produced by impregnating bundled filaments of long alumina fibers used as the long inorganic fibers with a thermosetting binder resin such as silicone resin, phenol resin, epoxy resin, polyimide resin, polymaleimide resin, unsaturated polyester resin, or urethane resin, which is caused to harden. Nylon or another thermoplastic resin may also be used as the binder resin. The bundled filaments may be a bundled material of 250 to 3000 strands of long alumina fibers with fiber diameters of 8 to 50 μm , and the diameter of the bundled filament is 0.1 to 2 mm. A material that is not twisted can be used as the bundled filament.

[0025] A plurality of embedding holes 53 are formed at equivalent angular intervals in the outer peripheral side surface 57 of the holder 5 in the brush-like grindstone 1 of the present invention. A plurality of linear grinding materials 2 are then fixed at their proximal ends with an adhesive such as silicon resin-based or epoxy resin-based adhesive in each of the plurality of embedding holes 53 in a state in which they are bundled as round grinding material bundles 20 (groups of linear grinding materials 2). For this reason, the plurality of linear grinding materials 2 extend radially from the outer peripheral side surface 57 of the holder 5 in the form of grinding material bundles 20. The plurality of linear grinding materials 2 are each in an isolated state when formed as the grinding material bundles 20.

[0026] All of the linear grinding materials 2 are curved

along their entire lengths from their proximal ends to their distal ends towards one side in the circumferential direction, for example, the clockwise direction CW. All of the grinding material bundles 20 are also curved in the clockwise direction CW in accordance therewith. In addition, as shown in FIG 1(C), the linear grinding materials 2 have an elliptical or oval cross-section with the minor axis faces the direction of curvature.

[0027] When the brush-like grindstone 1 of this embodiment is used in order to grind or remove burrs from the surface of a workpiece W, as shown in FIG 1(A) and 1(B), rotation is carried out in the direction opposite the direction of curvature of the linear grinding material 2 (counterclockwise direction CCW) about the axis L with the drive shaft 55 linked to the drive device of the grinder, and the distal ends of the linear grinding materials 2 are brought into contact with the surface of the workpiece W that is situated at the outer periphery of the brush-like grindstone 1. As a result, the long inorganic fibers that are exposed at the tips of the linear grinding materials 2 in the brush-like grindstone 1 cut away and grind off the irregularities and burrs of the workpiece W, acting substantially as grinding materials. When this grinding operation is carried out, in addition to rotational movement, there are also cases in which movement occurs along the surface of the workpiece W in the form of reciprocating movement, oscillation, vibration, or combinations of these movements. In addition, combinations of movements may also be carried out in which the brush-like grindstone 1 is moved towards and away from the workpiece W.

[0028] In producing this type of brush-like grindstone 1, when the curved linear grinding materials 2 are formed, first, 1000 individual long alumina fibers with diameters of, for example, 10 to 15 μm are first bundled together in a flat, untwisted state, and a bobbin of the bundled filament (strand) that has been continuously wound is placed in a creel. Next, the bundled filament is taken from the bobbin and dipped in binder resin such as epoxy resin, thereby being impregnated with binder resin, whereupon the excess binder resin is removed with a squeeze roll. As this occurs, the material is wound upon itself around the circumference of a cylindrical or cylinder-shaped winding roll. In accordance with tension applied to the bundled filament, the location of each of the long alumina fibers that constitutes a bundled filament is shifted, and the bundled filament is deformed to produce a state in which it has an elliptical or oval cross-section. When the binder resin is subsequently caused to harden, a linear grinding material 2 is formed which is curved along the circumference of the winding roll. The cross-section the linear grinding materials 2 is elliptical or oval, with the minor axis facing the direction of curvature of the linear grinding material 2. Next, the linear grinding material 2 that has been wound on the circumference of the winding roll is cut in the axial direction of the winding roll, thereby separating the linear grinding materials 2 from the winding roll. The linear grinding materials 2 are

then cut and aligned at the desired length. Next, the prescribed number of linear grinding materials 2 are bundled with the directions of curvature matching, and the ends are inserted into the embedding holes 53 of the holder 5 and secured in the holder 5 using an adhesive such as an epoxy resin-based or silicone resin-based adhesive.

[0029] According to this production method, curved linear grinding materials 2 can be efficiently formed, and by changing the external diameter dimension of the winding roll, the linear grinding materials 2 can be formed while being curved at a prescribed radius of curvature. In addition, because the external form of the wound roll can be made ovular or elliptical, curved linear grinding materials 2 can be formed with linear regions or radii of curvature that vary depending on the location.

[0030] As described above, with the brush-like grindstone 1 of this embodiment, the grindstone is moved relative to the workpiece W in a state in which the tips of the linear grinding material 2 are in contact with the workpiece W, whereby the workpiece W is ground. Because the linear grinding materials 2 are produced, in this case, by impregnating long inorganic fiber bundles with resin, which is then caused to harden, the long inorganic fibers that substantially function as the grinding materials have high density, high hardness, and high rigidity. Consequently, the brush-like grindstone 1 of this embodiment has high grinding capacity.

[0031] In addition, with the brush-like grindstone 1 of this embodiment, all of the plurality of linear grinding materials 2 are in a state in which they curve from their proximal ends to their distal ends, while also having elliptical or oval cross-sections in which the minor axis faces the direction of curvature. For this reason, the linear grinding materials 2 can readily deform in the direction of curvature, while having extremely high rigidity in the direction that is perpendicular to the direction of curvature. Consequently, with the brush-like grindstone 1 of this embodiment, the linear grinding materials 2 softly impinge on the workpiece W at their distal ends in comparison to brush-like grindstones in which the linear grinding materials 2 extend straight and perpendicularly. In addition, the linear grinding materials 2 do not break because they deform to absorb the excessive force when excessive force has been supplied.

[0032] In addition, because the linear grinding materials 2 are fixed in the holder 5 in a state in which they are in small groups as grinding material bundles 20, the advantage is presented that chips during the grinding process are efficiently discharged, and heat dissipation effects are enhanced. For this reason, the brush-like grindstone 1 of this embodiment has superior grinding properties. Consequently, the material can be used with high precision and good efficiency in carrying out deburring and grinding processes on precision processed parts. In addition, the linear grinding material 2 allows the cost of the brush-like grindstone 1 to be decreased because a small number can be used with high grinding performance. Moreover, because a configuration is utilized in

which a large number of linear grinding materials 2 are fixed to the holder 5 in small groups, the linear grinding materials 2 can be kept from being pulled out. For this reason, the advantage is presented that the brush-like grindstone 1 of this embodiment has high safety.

[Modification of Embodiment 1]

[0033] Embodiment 1 described above has a configuration in which the plurality of linear grinding materials 2 are held in a holder 5 as a plurality of grinding material bundles 20, but a configuration may also be utilized in which a circumferential groove is formed in a outer peripheral side surface 57 of the holder 5, and the plurality of linear grinding materials 2 are held across the entire circumferential length of this circumferential groove.

[Embodiment 2]

[0034] FIG 2(A) and (B) are a perspective view and a side view of the brush-like grindstone of embodiment 2 of the present invention. With this embodiment and embodiments 3 to 8 below, the basic configuration is the same as in embodiment 1, and the descriptions thus employ the same symbols for parts having the same function. The brush-like grindstone 1 shown in FIG 2(A) and 2(B) also has a configuration that is similar to that of embodiment 1, in which bundles of long alumina fibers (long inorganic fibers) are impregnated with a resin, which is caused to harden to produce linear grinding materials 2, a plurality of which are held by a metal holder 5. The holder 5 is a hollow cylinder in which a shaft hole 51 that passes through it in the axial direction L is formed at the center, with a rotational drive shaft 55 linked therewith.

[0035] In the brush-like grindstone of this embodiment, a plurality of embedding holes 53 are formed with equivalent angular spacing on the outer circumferential surface 57 of the holder 5. The plurality of linear grinding materials 2 are then fixed at their proximal ends using adhesive such as silicon resin-based or epoxy resin-based adhesive in the plurality of embedding holes 53 in a state in which round bundles are produced as grinding material bundles 20 (groups of linear grinding materials 2). Consequently, the plurality of linear grinding materials 2 extend radially from the circumferential surface 57 of the holder 5 as grinding material bundles 20. The plurality of linear grinding materials 2 are separated from each other in the form of grinding material bundles 20.

[0036] All of the linear grinding materials 2 curve to one side in the direction of the axis line L from their bases to their tips, and accordingly all of the grinding material bundles 20 curve to one side in the direction of the axis line L. In addition, the linear grinding materials 2 are provided with elliptical or oval cross sections in which the minor axis faces the direction of curvature, as has been described in reference to FIG 1(C).

[0037] When the brush-like grindstone 1 of this embodiment is used in order to grind or remove burrs from

the surface of a workpiece W, rotation is performed, for example, in the counterclockwise direction CCW as shown in FIG 2(A) and 2(B) with the drive shaft 55 linked to the drive device of the grinder, and the tips of the linear grinding materials 2 are brought into contact with the surface of the workpiece W that is disposed at the outer periphery of the brush-like grindstone 1. As a result, the long inorganic fibers that are exposed at the tips of the linear grinding materials 2 of the brush-like grindstone 1 grind the material by cutting away the irregularities and burrs in the workpiece W.

[0038] With the brush-like grindstone 1 having this configuration, the linear grinding materials 2 are produced in the same manner as in Embodiment 1 by impregnating long inorganic fiber bundles with resin, which is then caused to harden, thus producing high hardness and high grinding capacity. In addition, all of the plurality of linear grinding materials 2 curve from their bases to their tips, and have elliptical or oval cross sections in which the minor axis faces in the direction of curvature. For this reason, the linear grinding materials 2 readily deform in the direction of curvature. As a result, the linear grinding materials 2 softly impinge upon the workpiece W at their distal ends and deform to absorb excessive force when excessive force is supplied in making them impinge upon the irregularities or the like of the surface of the workpiece W, so that breakage does not occur. In addition, because the linear grinding materials 2 are fixed in the holder 5 in a state in which they are in small groups as grinding material bundles 20, the advantage is presented that chips generated in the grinding process are efficiently discharged, and heat dissipation effects are enhanced.

[Modification of Embodiment 2]

[0039] Embodiment 2 described above has a configuration in which the plurality of linear grinding materials 2 are held in a holder 5 as a plurality of grinding material bundles 20, but a configuration may also be employed in which a circumferential groove is formed in the outer peripheral side surface 57 of the holder 5, and a plurality of linear grinding materials 2 are held across the entire circumferential length of this circumferential groove.

[Embodiment 3]

[0040] FIGS. 3(A) and 3(B) are perspective and side views of the brush-like grindstone of Embodiment 3 of the present invention. The brush-like grindstone 1 in FIGS. 3(A) and 3(B), as with Embodiments 1 and 2, has a configuration in which fiber bundles of long aluminum fibers (long inorganic fibers) are impregnated with a resin, which is then caused to harden to produce linear grinding materials 2, a plurality of which are held in a metal holder 5. The holder 5 is a cylinder with a shaft hole 51 that passes through in the direction of the axis line L at its center. A rotational drive shaft 55 is linked therewith.

[0041] With the brush-like grindstone 1 of this embod-

iment, a plurality of embedding holes 53 are formed with equivalent angular spacing on the outer peripheral side surface 57 of the holder 5. The plurality of linear grinding materials 2 are fixed in the plurality of embedding holes 53 using an adhesive such as a silicone resin-based or epoxy resin-based adhesive at their proximal ends in a state in which the grinding materials are bundled as round grinding material bundles 20 (assemblages of linear grinding materials 2). Consequently, the plurality of linear grinding materials 2 extend radially from the outer peripheral side surface 57 of the holder 5 as grinding material bundles 20. Each of the plurality of linear grinding materials 2 is in an isolated state as grinding material bundles 20.

[0042] All of the linear grinding materials 2 curve to one side in the direction of the axis line L from their bases to their tips, and accordingly all of the grinding material bundles 20 curve to one side in the direction of the axis line L. In addition, the linear grinding materials 2 are provided with elliptical or oval cross sections in which the minor axis faces the direction of curvature, as has been described in reference to FIG 1(C).

[0043] With the brush-like grindstone 1 of this embodiment, the linear grinding material 2 is longer than in the brush-like grindstone 1 of Embodiment 2, and the distal ends of the linear grinding materials 2 extend approximately parallel to the axis line L. Consequently, when the brush-like grindstone 1 of this embodiment is used in order to grind or remove burrs from the surface of a workpiece W, rotation is made to occur, for example, in the counterclockwise direction CCW about the axis line L as shown in FIGS. 3(A) and 3(B) with the drive shaft 55 linked to the drive device of the grinder. The workpiece W is thus ground by the distal ends of the linear grinding materials 2 with the surface (surface to be ground) facing the axis line L.

[0044] With the brush-like grindstone 1 having this configuration, as with Embodiment 1, the linear grinding materials 2 are produced by impregnating long inorganic fiber bundles with a resin, which is then caused to harden, and thus have high hardness and high grinding capacity. In addition, all of the plurality of linear grinding materials 2 are in a state in which they are curved from their proximal ends to their distal ends, and have an elliptical or oval cross section in which the minor axis faces the direction of curvature. For this reason, the linear grinding materials 2 readily deform in the direction of curvature. Consequently, the linear grinding materials 2 softly impinge upon the workpiece W at their distal ends and deform to absorb excessive force when excessive force is supplied in making them impinge upon the irregularities or the like in the surface of the workpiece W, so that breakage does not occur. In addition, because the linear grinding materials 2 are secured in the holder 5 in a state in which they are in small groups as grinding material bundles 20, the advantage is presented that chips generated in the grinding process are efficiently discharged, and heat dissipation effects are enhanced.

[Modification of Embodiment 3]

[0045] Embodiment 3 described above has a configuration in which the plurality of linear grinding materials 2 are held in a holder 5 as a plurality of grinding material bundles 20, but a configuration may also be employed in which a circumferential groove is formed in the outer peripheral side surface 57 of the holder 5, and a plurality of linear grinding materials 2 are held across the entire circumferential length of this circumferential groove.

[Embodiment 4]

[0046] FIG 4(A) and 4(B) are a perspective view and plan view of a brush-like grindstone of Embodiment 4 of the present invention. The brush-like grindstone 1 shown in FIGS. 4(A) and 4(B), as in Embodiment 1, has a configuration in which bundles of long alumina fibers (long inorganic fibers) are impregnated with a resin, which is caused to harden to produce linear grinding materials 2, a plurality of which are held in a metal holder 5. The holder 5 is cylindrical with a shaft hole 51 that is formed at its center and passes through in the direction of the axis line L. A rotational drive shaft 55 that inserts into the shaft hole 51 is linked to the holder 5 with a screw that is tightened from the side (not shown).

[0047] A plurality of holders 5, e.g., three holders, are disposed along the axis line L. In addition, a plurality of embedding holes 53 are formed at equivalent angular spacing on the outer peripheral side surface 57 of the three holders 5. The plurality of linear grinding materials 2 are fixed in the plurality of embedding holes 53 using an adhesive such as a silicone resin-based or epoxy resin-based adhesive at their proximal ends in a state in which the linear grinding materials are bundled as round grinding material bundles 20 (assemblages of linear grinding materials 2). Consequently, the plurality of linear grinding materials 2 extend radially from the outer peripheral side surface 57 of the holder 5 as grinding material bundles 20. In this embodiment, the holding positions of the linear grinding materials 2 are shifted circumferentially between adjacent holders 5. Each of the plurality of linear grinding materials 2 is in an isolated state as grinding material bundles 20.

[0048] With all of the three holders 5, the linear grinding materials 2 curve to one side in the circumferential direction, e.g., in the clockwise CW direction, from their proximal ends to their distal ends, and accordingly all of the grinding material bundles 20 curve in the clockwise direction CW. In addition, the linear grinding materials 2, as described in reference to FIG 1(C), have an elliptical or oval cross section in which the minor axis faces the direction of curvature.

[0049] When the brush-like grindstone 1 of this embodiment is used in order to grind or remove burrs from the surface of a workpiece W, in the same manner as in Embodiment 1, the brush-like grindstone 1 is rotated in the counter-clockwise direction CCW as shown in FIG 4

(A) and 4(B) with the drive shaft 55 linked to the drive device of the grinder, and the surface of the workpiece W is disposed at the outer periphery of the brush-like grindstone 1 and is ground by the distal ends of the linear grinding materials 2.

[0050] Although a configuration is used in this embodiment in which three holders 5 are stacked in three levels, a plurality of sets of embedding holes 53 formed at equivalent angular spacing in the circumferential direction may be formed with shifted positions along the axis line L in a single holder 5. In addition, the number of holders 5 may be 2 or 4 or greater.

[Modification of Embodiment 4]

[0051] Embodiment 4 described above has a configuration in which the plurality of linear grinding materials 2 are held in a plurality of holders 5 as a plurality of grinding material bundles 20, but a configuration may also be employed in which a circumferential groove is formed in the outer peripheral side surface 57 of each of the plurality of holders 5, and a plurality of linear grinding materials 2 are held across the entire circumferential length of this circumferential groove.

[Embodiment 5]

[0052] FIGS. 5(A) and 5(B) are a perspective view and side view of a brush-like grindstone of Embodiment of the present invention. The brush-like grindstone 1 shown in FIG 5(A and 5(B), as in Embodiment 1, has a configuration in which assemblages of long alumina fibers (long inorganic fibers) are impregnated with a resin, which is caused to harden to produce linear grinding materials 2, a plurality of which are held in a metal holder 5. The holder 5 is cylindrical with a shaft hole 51 that is formed at its center and passes through in the direction of the axis line L. A rotational drive shaft 55 that inserts into the shaft hole 51 is linked to the holder 5 with a screw that is tightened from the side (not shown).

[0053] Three holders 5 are disposed along the axis line L. A plurality of embedding holes 53 are formed at equivalent angular spacing on the outer peripheral side surface 57 of each of the three holders 5. The plurality of linear grinding materials 2 are cured in the plurality of embedding holes 53 using an adhesive such as a silicone resin-based or epoxy resin-based adhesive at their proximal ends in a state in which the grinding materials are bundled as round grinding material bundles 20 (assemblages of linear grinding materials 2). Consequently, the plurality of linear grinding materials 2 extend radially from the outer peripheral side surface 57 of the holder 5 as grinding material bundles 20. In this embodiment, of the three holders 5, the holding positions of the linear grinding materials 2 are shifted circumferentially between adjacent holders 5. Each of the plurality of linear grinding materials 2 are in an isolated state as grinding material bundles 20.

[0054] With all of the three holders 5, the linear grinding

materials 2 curve to one side in the direction of the axis line L from their proximal ends to their distal ends, and accordingly all of the grinding material bundles 20 curve to one side in the direction of the axis line L. In addition, the linear grinding materials 2, as described in reference to FIG 1(C), have elliptical or oval cross sections in which the minor axis faces the direction of curvature.

[0055] When the brush-like grindstone 1 of this embodiment is used in order to grind or remove burrs from the surface of a workpiece W, in the same manner as in the second embodiment, the brush-like grindstone 1 is rotated in the counterclockwise direction CCW as shown in FIG 5(A) and 5(B) with the drive shaft 55 linked to the drive device of the grinder, and the surface of the workpiece W is disposed at the outer periphery of the brush-like grindstone 1 and is ground by the distal ends of the linear grinding materials 2.

[0056] Although a configuration is used in this embodiment in which three holders 5 are stacked in three levels, a plurality of sets of embedding holes 53 formed at equivalent angular spacing in the circumferential direction may be formed with shifted positions along the axis line L in a single holder 5. In addition, the number of holders 5 may be 2 or 4 or greater.

[Modification of Embodiment 5]

[0057] Embodiment 5 described above has a configuration in which the plurality of linear grinding materials 2 are held in a plurality of holders 5 as a plurality of grinding material bundles 20, but a configuration may also be employed in which a circumferential groove is formed in the outer peripheral side surface 57 of each of the plurality of holders 5, and a plurality of linear grinding materials 2 are held across the entire circumferential length of this circumferential groove.

[Embodiment 6]

[0058] FIG 6 is a side view of a brush-like grindstone of Embodiment 6 of the present invention. FIG 7 is a descriptive diagram showing a usage example of the brush-like grindstone of this embodiment. The brush-like grindstone 1 shown in FIG. 6, as with Embodiment 1, has a configuration in which bundles of long alumina fibers (long inorganic fibers) are impregnated with a resin, which is caused to harden to produce linear grinding materials 2, a plurality of which are held in a metal holder 5. The holder 5 is cylindrical with a shaft hole 51 that is formed at its center and passes through in the direction of the axis line L. A rotational drive shaft 55 that inserts into the shaft hole 51 is linked to the holder 5 with a screw (not shown) that is tightened from the side.

[0059] Two holders 5 are disposed along the axis line L. In addition, a plurality of embedding holes 53 are formed at equivalent angular spacing on the circumferential side surfaces 57 of the two holders 5. The plurality of linear grinding materials 2 are fixed in the plurality of

embedding holes 53 using an adhesive such as a silicone resin-based or epoxy resin-based adhesive at their proximal ends in a state in which the plurality of linear grinding materials 2 are bundled as round grinding material bundles 20 (assemblages of linear grinding materials 2). Consequently, the plurality of linear grinding materials 2 extend radially from the outer peripheral side surface 57 of the holder 5 as grinding material bundles 20. In this embodiment, the holding positions of the linear grinding materials 2 are shifted circumferentially between adjacent holders 5. Each of the plurality of linear grinding materials 2 is in an isolated state as grinding material bundles 20.

[0060] With one of the pair of two holders 5, the linear grinding materials 2 curve to one side in the direction of the axis line L from their proximal ends to their distal ends, and accordingly all of the grinding material bundles 20 curve in the direction of the axis line L. With the other of the pair of two holders 5, on the other hand, the linear grinding materials curve towards the other side in the direction of the axis line L from their proximal ends to their distal ends, and accordingly all of the grinding material bundles 20 curve towards the other side in the direction of the axis line L. Consequently, the plurality of linear grinding materials 2 held in the two holders 5 curve in directions whereby each of their distal ends approaches the other. In addition, as shown in FIG. 1(C), the linear grinding materials 2 have an elliptical or oval cross section in which the minor axis faces the direction of curvature.

[0061] When the brush-like grindstone 1 of this embodiment is used in order to grind or remove burrs from the surface of a workpiece W, the brush-like grindstone 1 is rotated about the axis line L as shown in FIG (6) with the drive shaft 55 linked to the drive device of the grinder, and the surface of the workpiece W is disposed at the outer periphery of the brush-like grindstone 1 and is ground by the distal ends of the linear grinding materials 2.

[0062] In addition, as shown in FIG 7, when a male thread W12 is formed on a shaft body W11 and the brush-like grindstone 1 of this embodiment is used in order to finish the male threads W12, the thread peaks and valleys can be efficiently finished.

[0063] The two holders 5 are fixed to the rotational drive shaft 55 with screws in this embodiment; therefore, when the linear grinding materials 2 are abraded and shortened, the two holders 5 can be moved closer in order to adjust the positional relationship of the distal ends of the linear grinding materials 2.

[0064] Although a configuration is used in this embodiment in which two holders 5 are disposed at two levels and the positional relationship can be adjusted, two sets of embedding holes 53 formed at equivalent angular spacing in the circumferential direction may be formed with shifted positions along the axis line L in a single holder 5. The plurality of linear grinding materials 2 may also be held in the respective sets of embedding holes

53 in an orientation whereby the distal ends curve in a direction whereby they are close to one another.

[Modification 1 of Embodiment 6]

[0065] Although a configuration is used in Embodiment 6 in which a plurality of linear grinding materials 2 are held in a plurality of holders 5 as a plurality of grinding material bundles 20, a configuration may be utilized in which a circumferential groove is formed in the outer peripheral side surface 57 in each of the plurality of holders 5, and a plurality of linear grinding materials 2 are held over the entire circumferential length of this circumferential groove.

[Modification 2 of Embodiment 6]

[0066] Embodiment 6 described above has a configuration in which the distal ends of the plurality of linear grinding materials 2 held in the two holders 5 face each other. As shown in FIG 8, however, a configuration may be utilized in which the two holders 5 are closer than in the state shown in FIG 6, and the plurality of linear grinding materials 2 held in the two holders 5 intersect each other. In this case, the inner side surfaces of the protrusions W2 that oppose each other at a prescribed spacing in a workpiece W21 can be finished simultaneously.

[Embodiment 7]

[0067] FIGS. 9(A) and 9(B) are a plan view and side view of a brush-like grindstone of Embodiment of the present invention. FIG 10 is a descriptive diagram showing a usage example of the brush-like grindstone of this embodiment. The brush-like grindstone 1 shown in FIGS. 9 (A) and 9(B), as in Embodiment 1, has a configuration in which bundles of long alumina fibers (long inorganic fibers) are impregnated with a resin, which is caused to harden to produce linear grinding materials 2, a plurality of which are held in a metal holder 5. The holder 5 is cylindrical with a shaft hole 51 that is formed at its center and passes through in the direction of the axis line L. A rotational drive shaft 55 that inserts into the shaft hole 51 is linked to the holder 5 with a screw that is tightened from the side (not shown).

[0068] In the brush-like grindstone 1 of this embodiment, a plurality of embedding holes 53 are formed at equivalent angular spacing on the end surface 59 of one side of the holder 5 in the direction of the axis line L. The plurality of linear grinding materials 2 are fixed in the plurality of embedding holes 53 using an adhesive such as a silicone resin-based or epoxy resin-based adhesive at their proximal ends in a state in which the grinding materials are bundled as round grinding material bundles 20 (assemblages of linear grinding materials 2). In this state, the linear grinding materials 2 extend in the direction of the axis line L. Each of the plurality of linear grinding materials 2 are in an isolated state as grinding mate-

rial bundles 20.

[0069] All of the linear grinding materials 2 curve outwards from the end surface 59 of one side of the holder 5 from their proximal ends to their distal ends, and accordingly all of the grinding material bundles 20 curve outwards. In addition, the linear grinding materials 2, as described in reference to FIG 1(C), have an elliptical or oval cross section in which the minor axis faces the direction of curvature.

[0070] Consequently, when the brush-like grindstone 1 of this embodiment is used in order to grind or remove burrs from the surface of a workpiece W, rotation is made to occur in the counter-clockwise direction CCW, for example, as shown in FIGS. 9(A) and 9(B), with the drive shaft 55 linked to the drive device of the grinder. The workpiece W is ground by the distal ends of the linear grinding materials 2 with its surface (surface to be ground) facing in the direction of the axis line L.

[0071] With the brush-like grindstone 1 configured in this manner, because the linear grinding materials 2 are formed by impregnating long inorganic fiber bundled filaments with a resin that is then caused to harden, high hardness and high grinding capacity are produced in the same manner as in the first embodiment. In addition, all of the plurality of linear grinding materials 2 curve from their bases to their tips, and have elliptical or oval cross sections in which the minor axis faces in the direction of curvature. For this reason, the linear grinding materials 2 readily deform in the direction of curvature. As a result, the linear grinding materials 2 softly impinge upon the workpiece W at their distal ends and deform to absorb excessive force when excessive force is supplied in making them impinge upon the irregularities or the like of the surface of the workpiece W, so that breakage does not occur. In addition, because the linear grinding materials 2 are fixed in the holder 5 in a state in which they are in small groups as grinding material bundles 20, the advantage is presented that chips generated in the grinding process are efficiently discharged, and heat dissipation effects are enhanced.

[0072] In addition, the brush-like grindstone 1 of this embodiment is suitable for finishing female threading W32 formed on a workpiece W31 as shown in FIG 10 (A), for finishing the inner circumferential surface of a hole W34 formed in a workpiece as shown in FIG. 10(B), or for deburring intersecting parts of intersecting holes W36 and W37 formed in a workpiece 5, as shown in FIG 10(C).

[Modification of Embodiment 7]

[0073] Embodiment described above has a configuration in which the plurality of linear grinding materials 2 are held in a holder 5 as a plurality of grinding material bundles 20, but a configuration may also be employed in which a circumferential groove is formed in the end surface 59 on one side of the holder 5, and a plurality of linear grinding materials 2 are held across the entire cir-

cumferential length of this circumferential groove.

[Embodiment 8]

[0074] FIGS. 11(A) and 11(B) are a plan view and side view of a brush-like grindstone of Embodiment 8 of the present invention. FIG 12 is a descriptive diagram showing a usage example of the brush-like grindstone of this embodiment. The brush-like grindstone 1 shown in FIG 11(A) and 11(B), as in Embodiment 1, has a configuration in which bundles of long alumina fibers (long inorganic fibers) are impregnated with a resin, which is caused to harden to produce linear grinding materials 2, a plurality of which are held in a metal holder 5. The holder 5 is cylindrical with a shaft hole 51 that is formed at its center and passes through in the direction of the axis line L. A rotational drive shaft 55 that inserts into the shaft hole 51 is linked to the holder 5 with a screw (not shown) that is tightened from the side.

[0075] In the brush-like grindstone 1 of this embodiment, a plurality of embedding holes 53 are formed at equivalent angular spacing on the end surface 59 of one side of the holder 5 in the direction of the axis line L. The plurality of linear grinding materials 2 are fixed in the plurality of embedding holes 53 using an adhesive such as a silicone resin-based or epoxy resin-based adhesive at their proximal ends in a state in which the grinding materials are bundled as round grinding material bundles 20 (assemblages of linear grinding materials 2). In this state, the linear grinding materials 2 extend in the direction of the axis line L. Each of the plurality of linear grinding materials 2 are in an isolated state as grinding material bundles 20.

[0076] All of the linear grinding materials 2 curve outwards from the end surface 59 of one side of the holder 5 from their proximal ends to their distal ends, and accordingly all of the grinding material bundles 20 curve outwards. In addition, the linear grinding materials 2, as described in reference to FIG 1(C), have an elliptical or oval cross section in which the minor axis faces the direction of curvature.

[0077] When the brush-like grindstone 1 of this embodiment is used in order to grind or remove burrs from the surface of a workpiece W, rotation is made to occur about the axis L; for example, in the counter-clockwise direction CCW, as shown in FIGS. 11(A) and 11(B), with the drive shaft 55 linked to the drive device of the grinder. The workpiece W is ground by the distal ends of the linear grinding materials 2 with its surface (surface to be ground) facing in the direction of the axis line L.

[0078] The brush-like grindstone 1 of this embodiment is suitable for finishing male threading W42 formed in a workpiece W41 as shown in FIG 12(A), and for finishing the outer circumferential surface of a shaft-shaped workpiece W43.

[0079] With the brush-like grindstone 1 configured in this manner, because the linear grinding materials 2 are formed by impregnating long inorganic fiber bundled fil-

aments with a resin that is then caused to harden, high hardness and high grinding capacity are produced in the same manner as in the first embodiment. In addition, all of the plurality of linear grinding materials 2 curve from their bases to their tips, and have elliptical or oval cross sections in which the minor axis faces in the direction of curvature. For this reason, the linear grinding materials 2 readily deform in the direction of curvature. As a result, the linear grinding materials 2 softly impinge upon the workpiece W at their distal ends and deform to absorb excessive force when excessive force is supplied in making them impinge upon the irregularities or the like of the surface of the workpiece W, so that breakage does not occur. In addition, because the linear grinding materials 2 are fixed in the holder 5 in a state in which they are in small groups as grinding material bundles 20, the advantage is presented that chips generated in the grinding process are efficiently discharged, and heat dissipation effects are enhanced.

[Modification of Embodiment 8]

[0080] Embodiment 8 described above has a configuration in which the plurality of linear grinding materials 2 are held in a holder 5 as a plurality of grinding material bundles 20, but a configuration may also be employed in which a circumferential groove is formed in the end surface 59 on one side of the holder 5, and a plurality of linear grinding materials 2 are held across the entire circumferential length of this circumferential groove.

[Another Embodiments]

[0081] In all of the above embodiments, all of the linear grinding materials 2 are configured so that the entire material curves from the proximal end to the distal end. However, as shown in FIGS. 13(A) and 13(B) and in FIG 14, a configuration may also be utilized in which the linear grinding materials 2 curve at one location from the proximal end to the distal end. In producing this type of brush-like grindstone 1, first, 1000 long alumina fibers (individual long alumina fibers) are bundled together in a flat and untwisted state, and the continuously wound bundled filament (strand) is dipped in a binder resin such as epoxy resin, allowing the bundled filament to be impregnated with the binder resin. Next, for example, the material is wound upon itself on the circumferential surface of a square roller in which the square part becomes R. The binder resin is then allowed to harden, and the linear grinding materials 2 are cut off.

[0082] In all of the above embodiments, examples were described in which a plurality of linear grinding materials 2 are held in a metal holder 5, where the grinding materials are produced by impregnating long alumina fiber (long inorganic fiber) bundles with a resin, which was then caused to harden. However, the present invention may also be utilized for producing a brush-like grindstone 1 in which the long inorganic fibers are silicon carbide

fibers, carbon fibers, silicon nitride fibers, or glass fibers.

[0083] In all of the above embodiments, a configuration is used in which the linear grinding materials 2 are fixed in the holder 5 in a state in which they are in small groups as grinding material bundles 20, or the linear grinding materials 2 are fixed in a circumferential groove without being in small groups of grinding material bundles 20. However, the present invention may also be utilized in order to produce a brush-like grindstone 1 in which the linear grinding materials 2 are held in a holder 5 as a single bundle.

[0084] In all of the above embodiments, untwisted materials are used for the bundled filaments used in the linear grinding materials 2, but the linear grinding materials 2 may be configured using twisted bundled filaments. In addition, some linear grinding materials that do not curve but extend linearly can be included in the curved linear grinding materials 2.

Industrial Applicability

[0085] As described above, the linear grinding material of the brush-like grindstone of the present invention is produced by impregnating long inorganic fiber bundles with a resin, which is then caused to harden. As a result, the long inorganic fibers that substantially function as grinding materials have high rigidity, density and hardness, thus providing high grinding capacity. In addition, the linear grinding materials are in a curved state, and thus readily deform in the direction of curvature. Consequently, with the brush-like grindstone of the present invention, the linear grinding material softly impinges upon the workpiece at its distal ends relative to brush-like grindstones in which the linear grinding materials extend linearly. The materials thus deform and absorb excessive force when excessive force is applied, thereby preventing breakage.

Claims

1. A brush-like grindstone wherein a plurality of linear grinding materials are held in a holder, the linear grinding materials being obtained by impregnating an assemblage of long inorganic fiber filaments with a resin, which is caused to harden; wherein:

each of the plurality of linear grinding materials is curved in at least one location from its proximal end to its distal end.

2. The brush-like grindstone according to claim 1, wherein each of the plurality of linear grinding materials is curved over the entire length thereof from the proximal end to the distal end.
3. The brush-like grindstone according to claim 1, wherein each of the plurality of linear grinding mate-

rials extends radially from an outer circumferential side surface of the holder, and curves circumferentially in the same direction.

4. The brush-like grindstone according to claim 3, wherein:

a plurality of the holders are disposed in an axial direction of the holders, and
each of the plurality of linear grinding materials is held on each of the plurality of holders.

5. The brush-like grindstone according to claim 1, wherein the plurality of linear grinding materials extend radially from an outer circumferential side surface of the holder, and curve toward one side in an axial direction of the holder.

6. The brush-like grindstone according to claim 5, wherein
a plurality of holders are disposed in the axial direction of the holders; and
the plurality of linear grinding materials are held in each of the plurality of holders.

7. The brush-like grindstone according to claim 1, wherein
two holders are disposed as a pair in an axial direction of the holders; and
the plurality of linear grinding materials extend radially from a circumferential surface of the two holders, and curve in a direction whereby the distal ends of the plurality of linear grinding materials held in the two holders are close to one another.

8. The brush-like grindstone according to claim 1, wherein each of the plurality of linear grinding materials extends in an axial direction from an end surface of one side of the holder in the axial direction, and curves outwards from an inside of the end surface of the one side.

9. The brush-like grindstone according to claim 1, wherein each of the plurality of linear grinding materials extends in an axial direction from an end surface of one side of the holder in the axial direction, and curves inwards from an outside of the end surface of the one side.

10. The brush-like grindstone according to claim 1, wherein the plurality of linear grinding materials are held in the holder as a plurality of bundles.

11. The brush-like grindstone according to claim 1, wherein the plurality of linear grinding materials are held along the entirety of the circumferential direction in a circumferential groove formed on an outer circumferential side surface or on an end surface of

one side of the holder.

12. The brush-like grindstone according to claim 1, wherein the plurality of linear grinding materials have an elliptical or oval cross section in which a minor axis faces a direction of curvature. 5
13. The brush-like grindstone according to claim 1, wherein a drive shaft extends from the holder in an axial direction. 10
14. The brush-like grindstone according to any of claims 1 to 13, wherein the long inorganic fibers are selected from alumina fibers, silicon carbide fibers, carbon fibers, silicon nitride fibers, and glass fibers. 15

Amended claims under Art. 19.1 PCT

1. (Amended) A brush-like grindstone wherein a plurality of linear grinding materials are held in a holder, the linear grinding materials is obtained by impregnating an assemblage of long inorganic fiber filaments with a resin and hardening the resin, and an circumferential outer side surface of the holder is a circular circumferential surface, **characterized in that:** 20 25

the long inorganic fibers are selected from alumina fibers, silicon carbide fibers, carbon fibers, silicon nitride fibers, and glass fibers, and each of the plurality of linear grinding materials is curved in at least one location from its proximal end to its distal end. 30 35

2. The brush-like grindstone according to claim 1, wherein each of the plurality of linear grinding materials is curved over the entire length thereof from the proximal end to the distal end. 40

3. The brush-like grindstone according to claim 1, wherein each of the plurality of linear grinding materials extends radially from an outer circumferential side surface of the holder, and curves circumferentially in the same direction. 45

4. The brush-like grindstone according to claim 3, wherein:

a plurality of the holders are disposed in an axial direction of the holders, and each of the plurality of linear grinding materials is held on each of the plurality of holders. 50

5. The brush-like grindstone according to claim 1, wherein the plurality of linear grinding materials extend radially from an outer circumferential side surface of the holder, and curve toward one side in an 55

axial direction of the holder.

6. The brush-like grindstone according to claim 5, wherein a plurality of holders are disposed in the axial direction of the holders; and the plurality of linear grinding materials are held in each of the plurality of holders.

7. The brush-like grindstone according to claim 1, wherein two holders are disposed as a pair in an axial direction of the holders; and the plurality of linear grinding materials extend radially from a circumferential surface of the two holders, and curve in a direction whereby the distal ends of the plurality of linear grinding materials held in the two holders are close to one another.

8. The brush-like grindstone according to claim 1, wherein each of the plurality of linear grinding materials extends in an axial direction from an end surface of one side of the holder in the axial direction, and curves outwards from an inside of the end surface of the one side.

9. The brush-like grindstone according to claim 1, wherein each of the plurality of linear grinding materials extends in an axial direction from an end surface of one side of the holder in the axial direction, and curves inwards from an outside of the end surface of the one side.

10. The brush-like grindstone according to claim 1, wherein the plurality of linear grinding materials are held in the holder as a plurality of bundles.

11. The brush-like grindstone according to claim 1, wherein the plurality of linear grinding materials are held along the entirety of the circumferential direction in a circumferential groove formed on an outer circumferential side surface or on an end surface of one side of the holder.

12. The brush-like grindstone according to claim 1, wherein the plurality of linear grinding materials have an elliptical or oval cross section in which a minor axis faces a direction of curvature.

13. The brush-like grindstone according to claim 1, wherein a drive shaft extends from the holder in an axial direction.

14. (Cancelled)

Fig.1

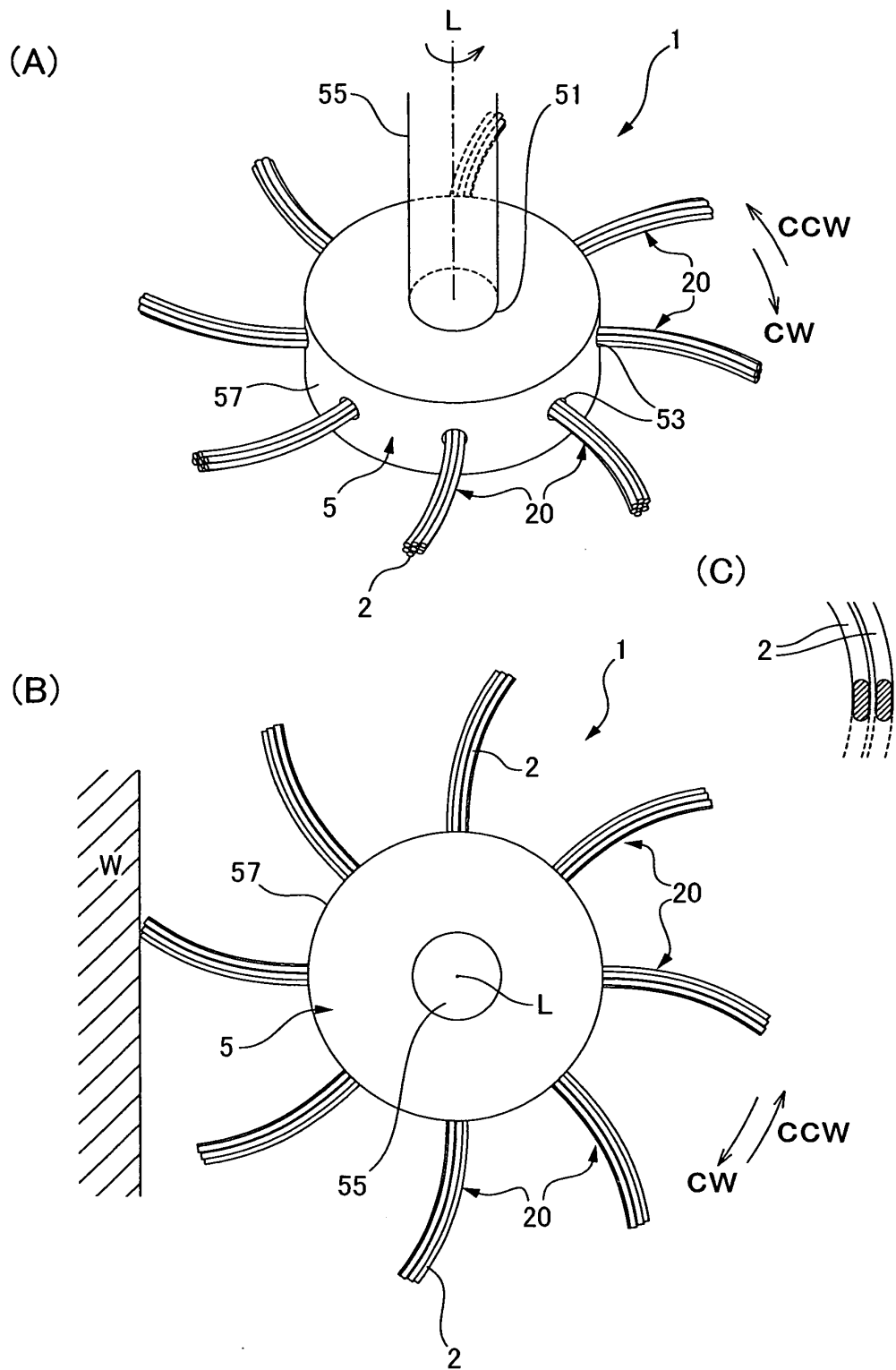


Fig.2

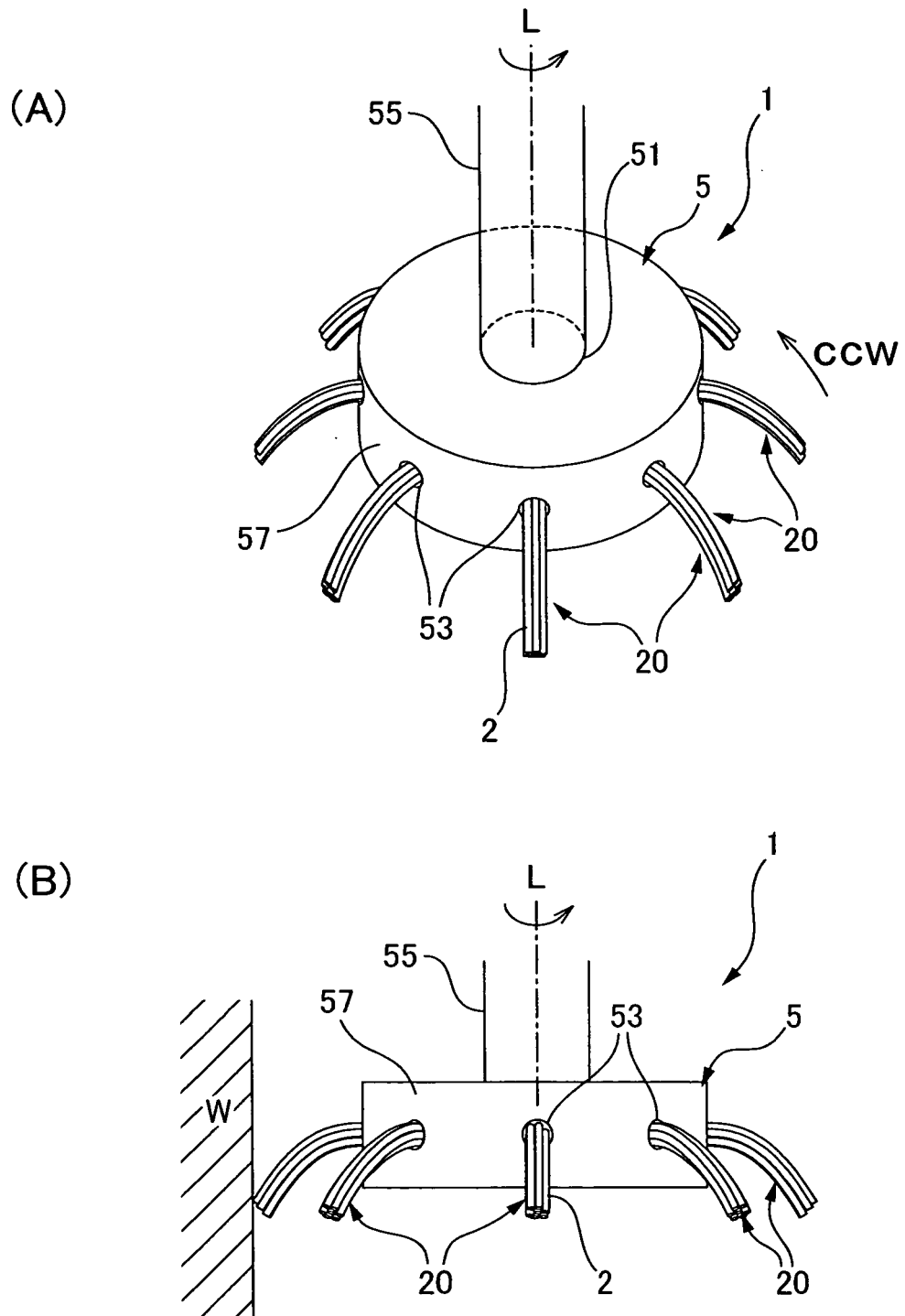


Fig.3

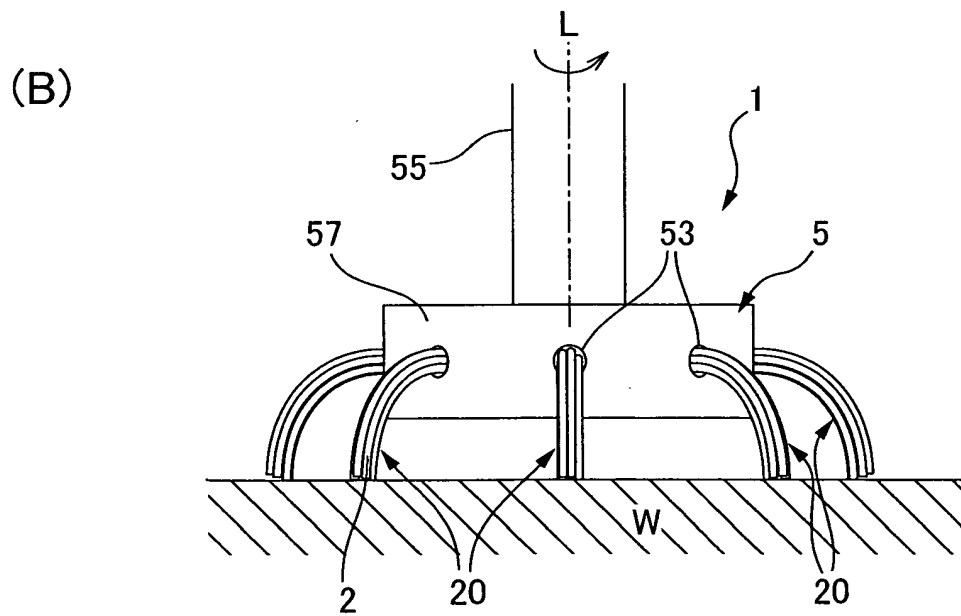
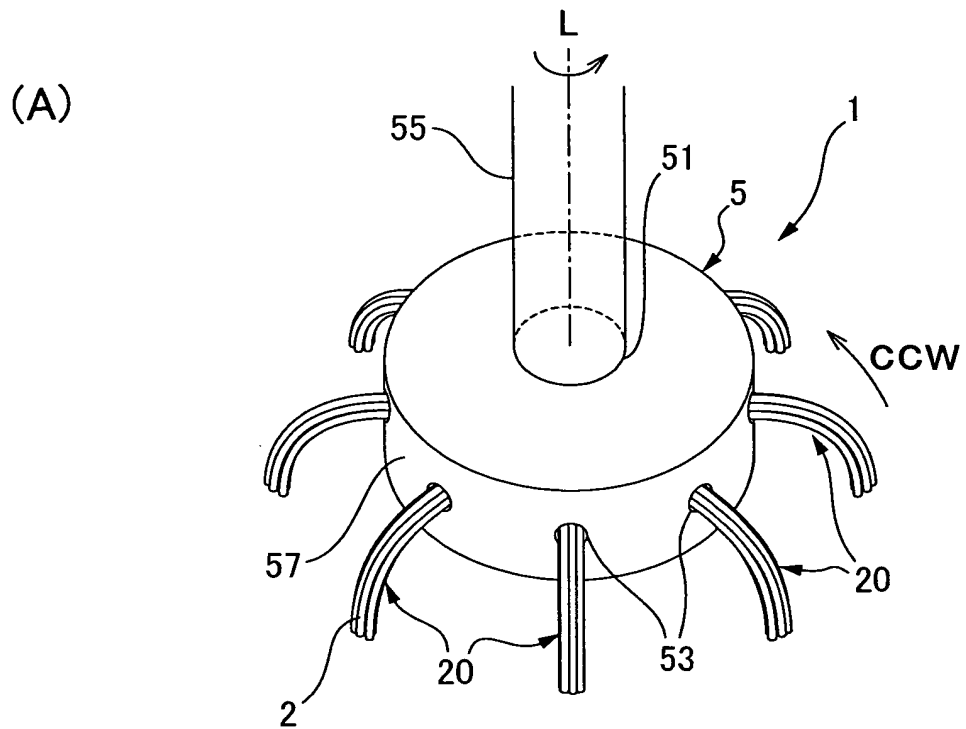


Fig.4

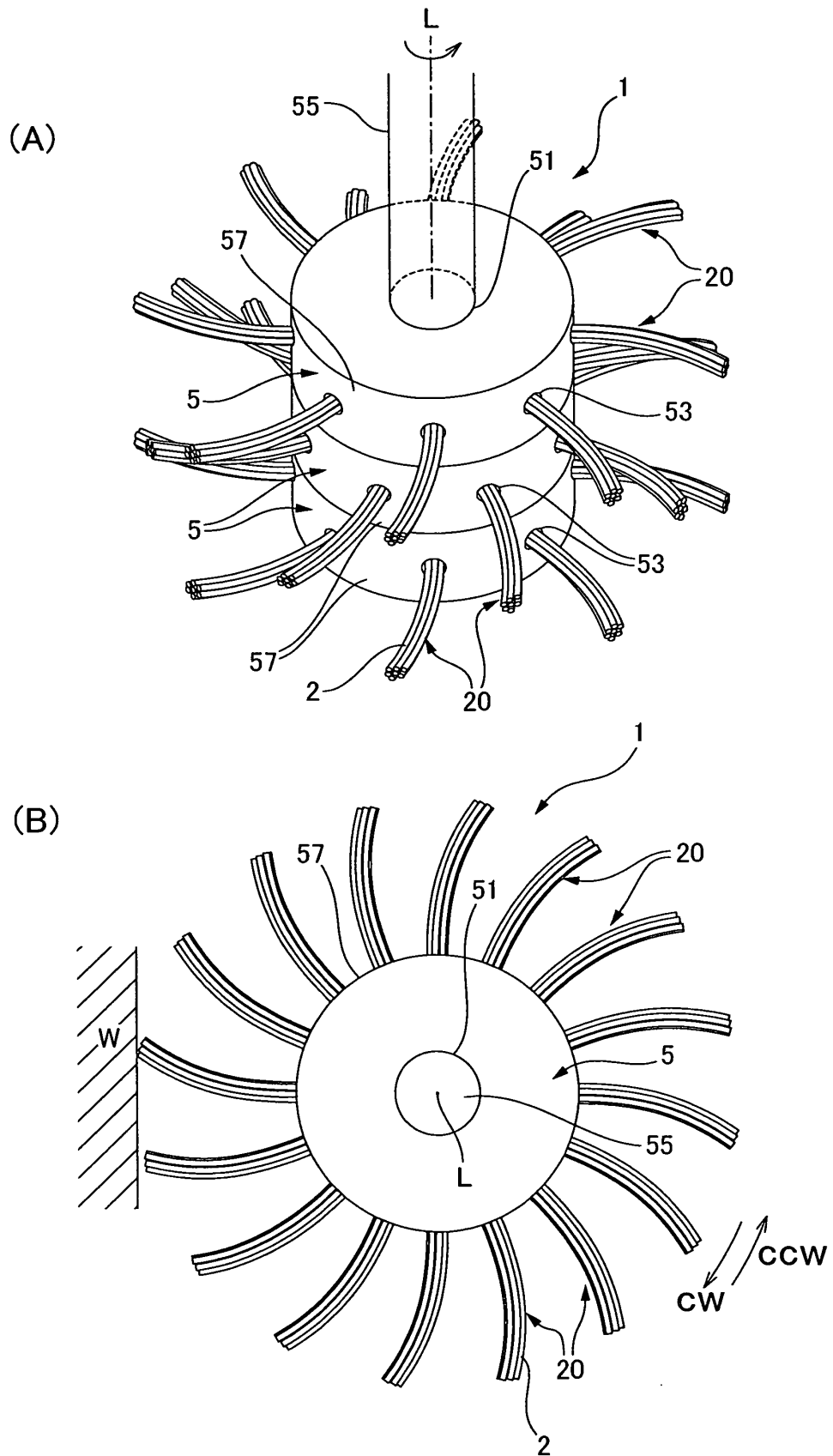


Fig.5

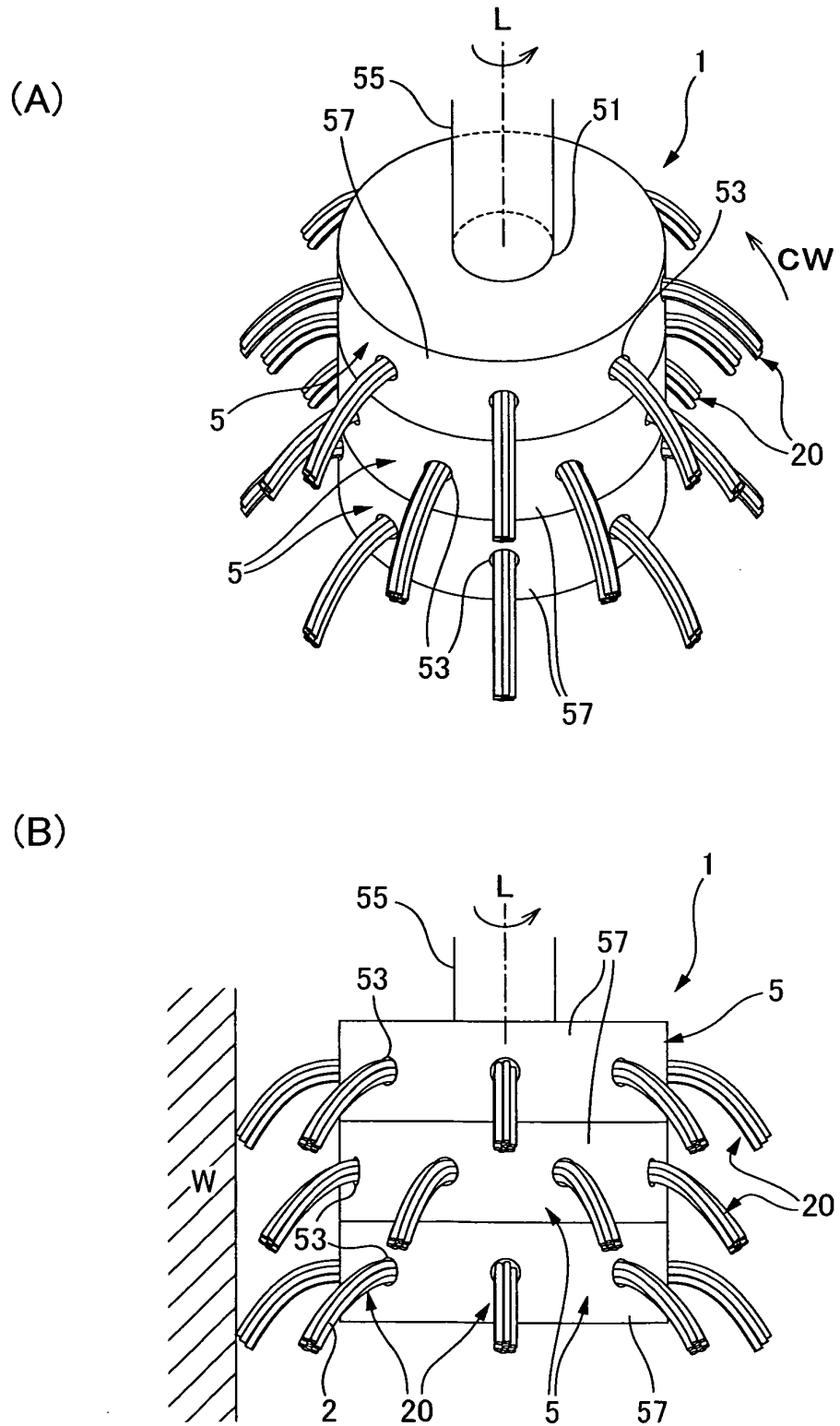


Fig.6

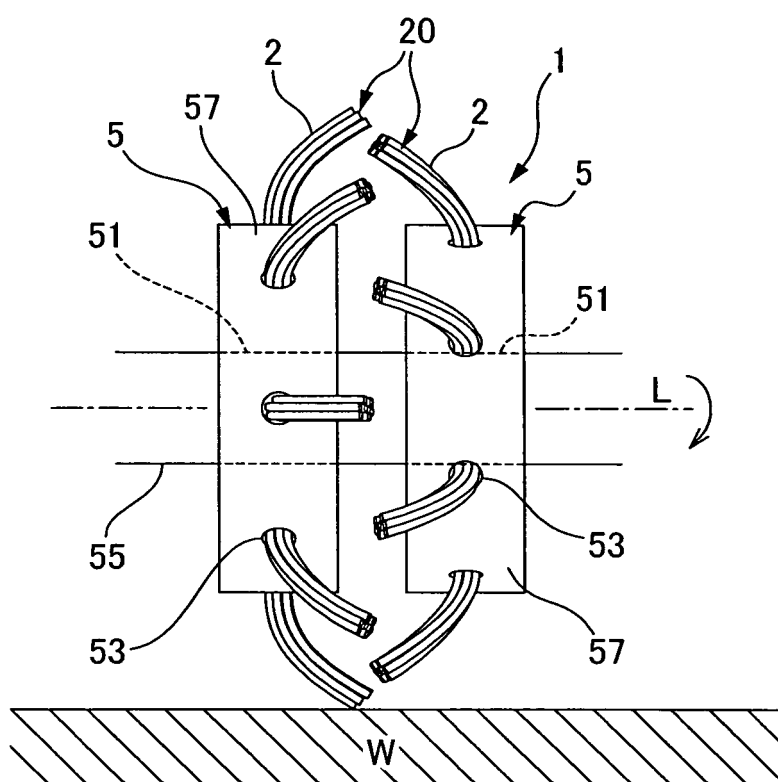


Fig.7

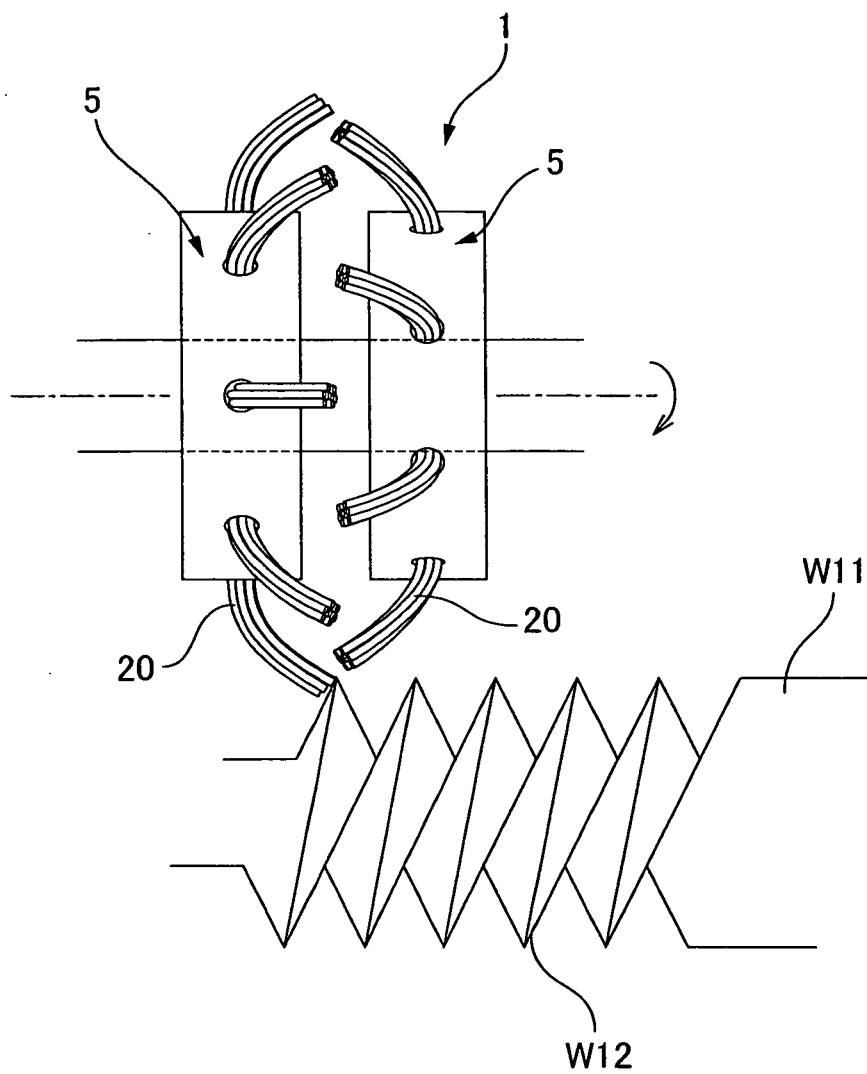


Fig.8

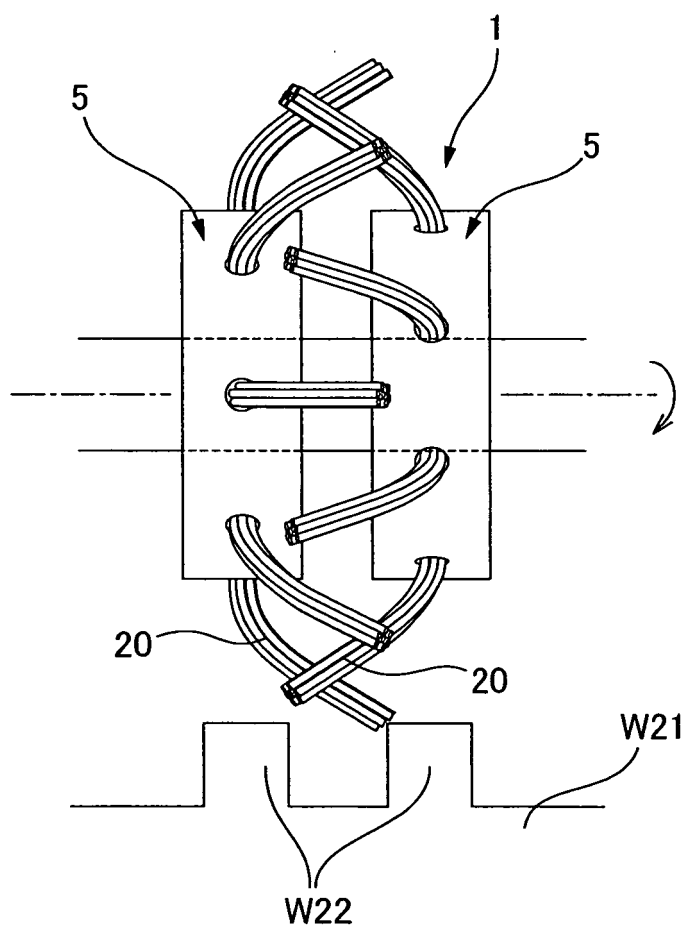
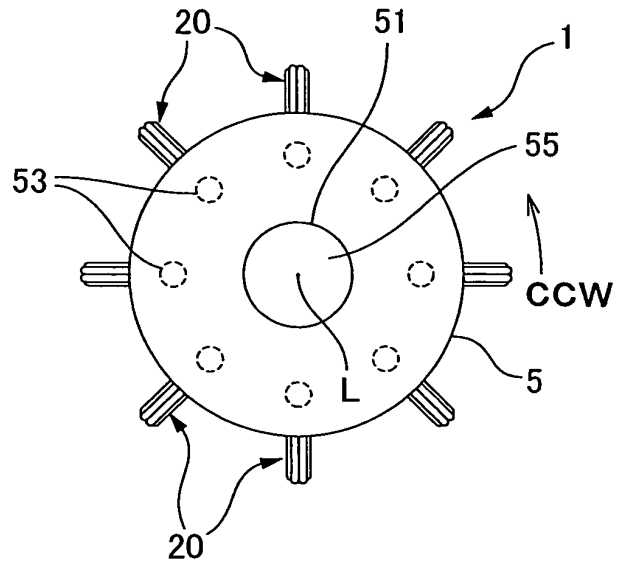


Fig.9

(A)



(B)

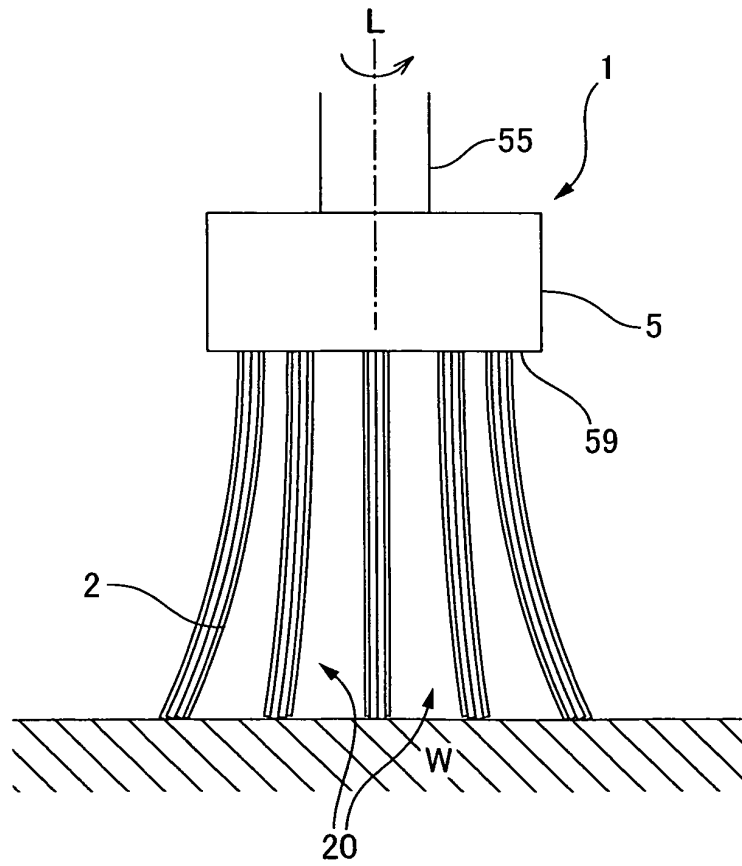


Fig.10

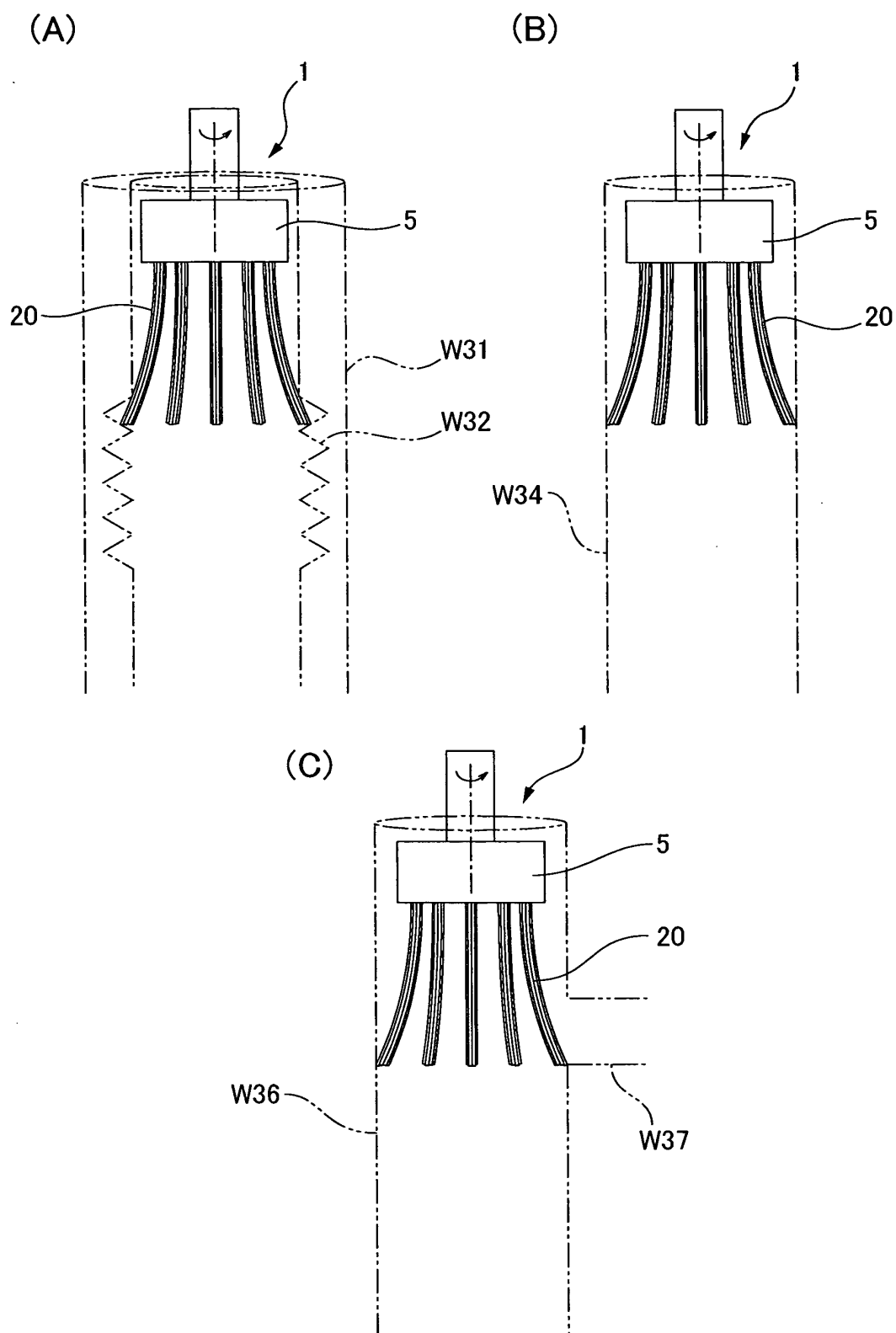


Fig. 11

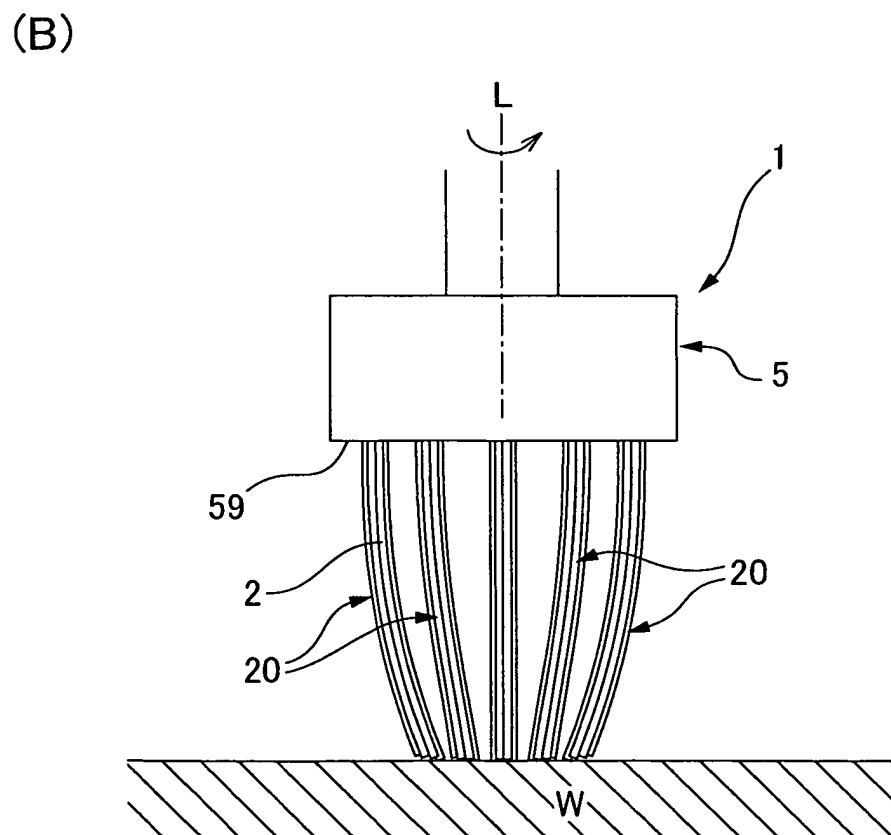
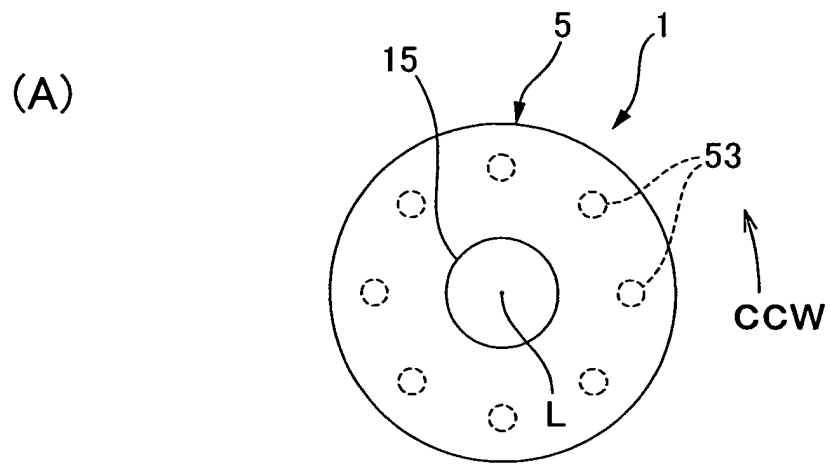


Fig.12

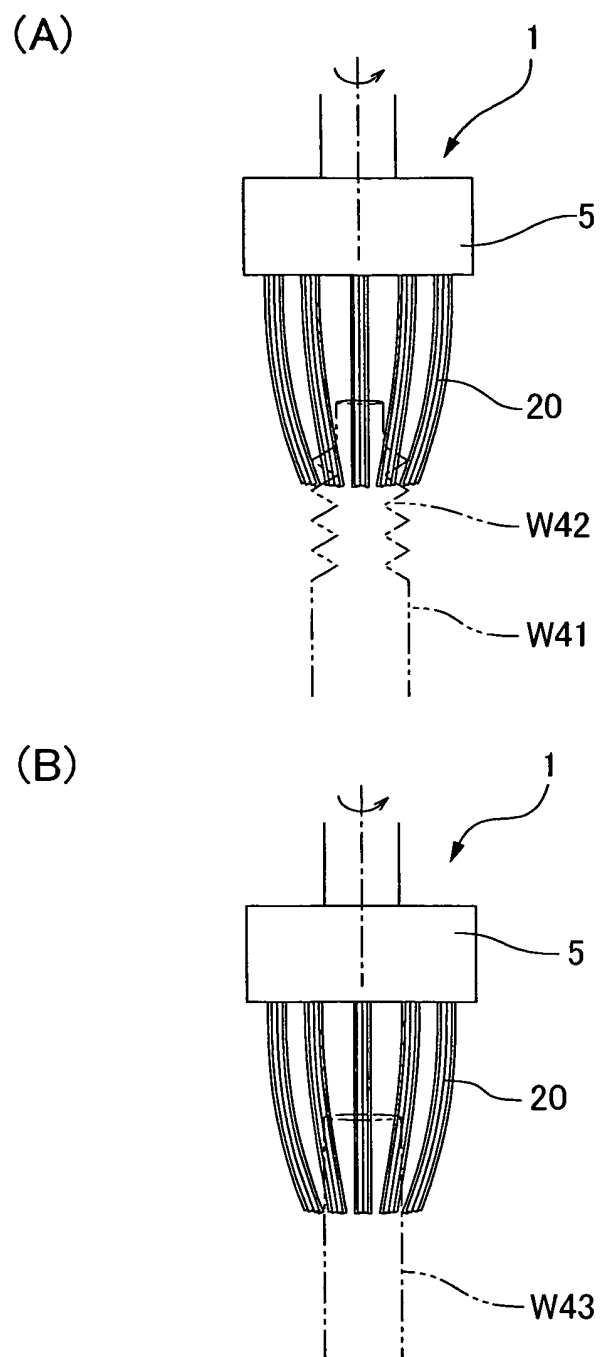
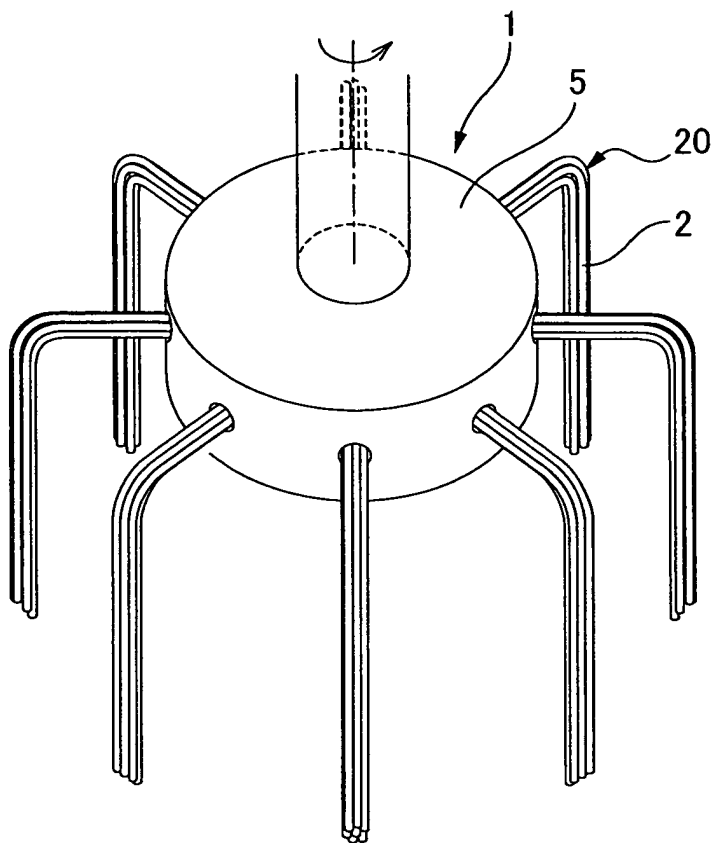


Fig.13

(A)



(B)

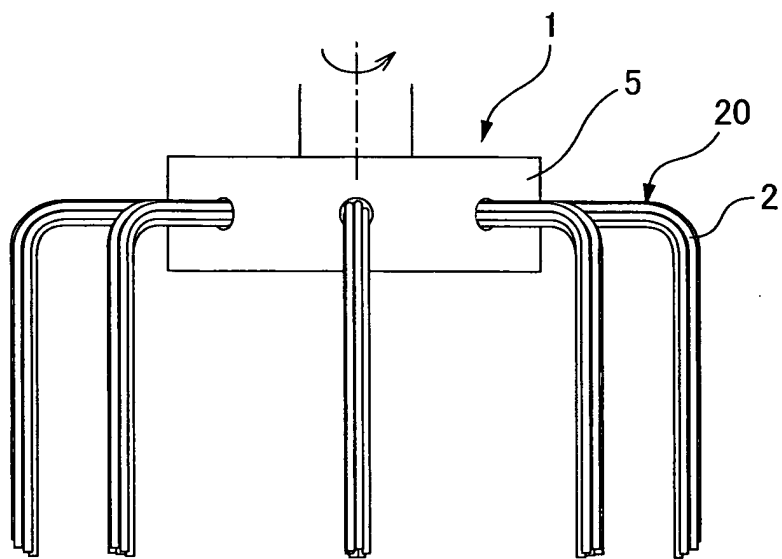
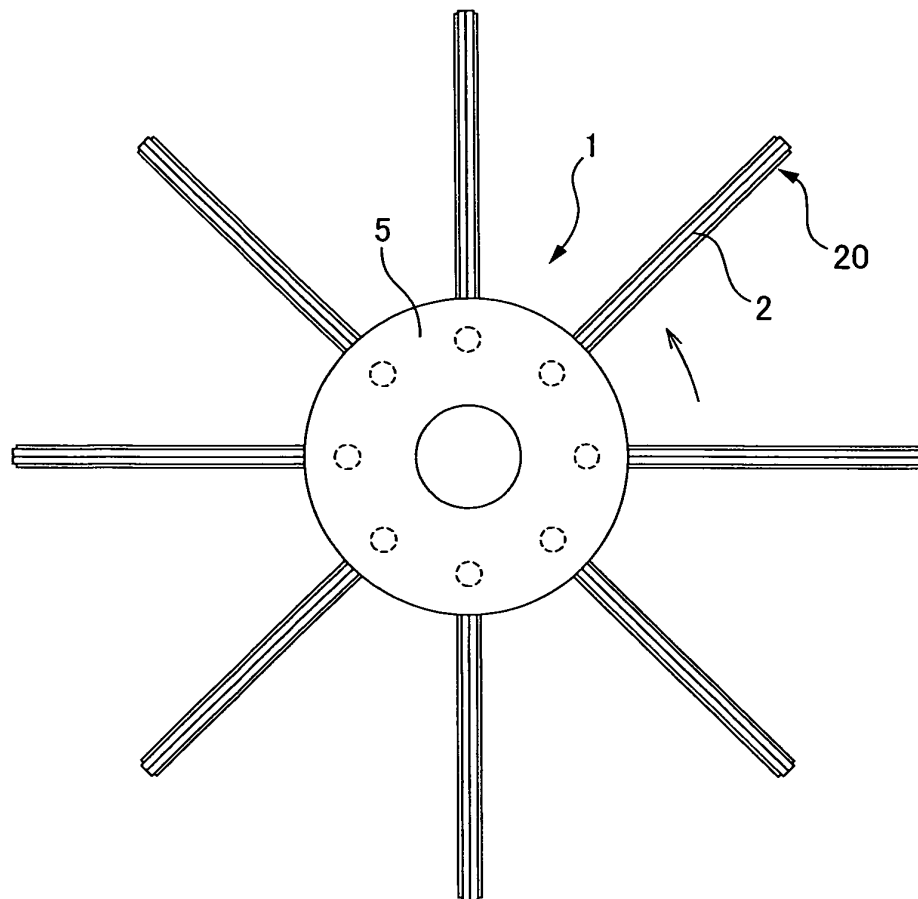
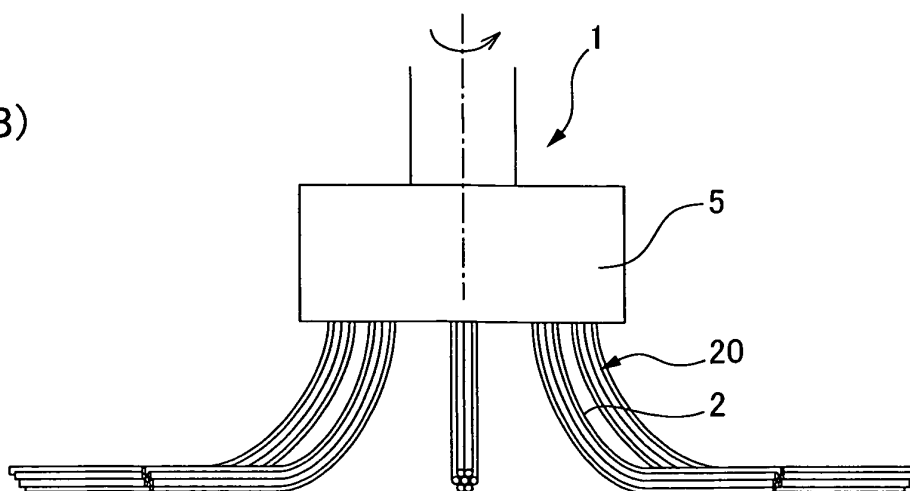


Fig.14

(A)



(B)



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/000084

A. CLASSIFICATION OF SUBJECT MATTER
B24D13/10, B24D13/14, B24D3/28

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)
B24D3/00-18/00, A46B1/00-17/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

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. |
|-----------|---|-----------------------|
| Y | JP 2002-210662 A (Xebec Technology Co., Ltd., Taimei Chemicals Co., Ltd.), 30 July, 2002 (30.07.02), Claim 1; Par. No. [0035]; Figs. 9(A), 9(B) (Family: none) | 1-14 |
| Y | JP 3-228581 A (Jason, Inc.), 09 October, 1991 (09.10.91), Claims; page 5, lower left column, line 12 to lower right column, line 18; page 8, upper left column, line 10 to lower left column, line 8; page 10, upper left column, lines 2 to 6 & US 5329730 A & GB 2236969 A & GB 2264250 A & DE 4029600 A | 1-14 |

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

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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

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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
14 March, 2007 (14.03.07)

Date of mailing of the international search report
03 April, 2007 (03.04.07)

Name and mailing address of the ISA/
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2007/000084

| C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT | | |
|---|--|-----------------------|
| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
| Y | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 120367/1983 (Laid-open No. 29464/1985) (Aida Engineering, Ltd.), 27 February, 1985 (27.02.85), Full text; Fig. 1 (Family: none) | 1-14 |
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