



(11) **EP 4 434 676 A1**

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

(43) Date of publication:
25.09.2024 Bulletin 2024/39

(21) Application number: **22895150.5**

(22) Date of filing: **30.06.2022**

(51) International Patent Classification (IPC):
B24B 23/02 (2006.01) **B24D 3/00** (2006.01)
B24D 3/28 (2006.01) **B24D 5/02** (2006.01)
B24D 5/16 (2006.01) **B25F 5/00** (2006.01)

(52) Cooperative Patent Classification (CPC):
B24B 23/02; B24D 3/00; B24D 3/28; B24D 5/02;
B24D 5/06; B24D 5/16; B25F 5/00

(86) International application number:
PCT/JP2022/026223

(87) International publication number:
WO 2023/089861 (25.05.2023 Gazette 2023/21)

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

(30) Priority: **17.11.2021 JP 2021187008**

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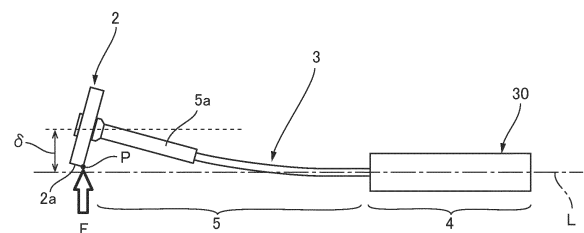
(54) **GRINDSTONE WITH AXIS, AND POLISHING TOOL**

(57) A shafted grinder (1) includes a grinder (2) and a shaft (3) extending from the grinder (2). The grinder (2) includes a plurality of fiber bundles (22) of a plurality of inorganic filaments bundled together (21) bonded by a resin (23). When a stiffness of the shaft (3) is S, the shaft (3) satisfies the following conditional expression (A). When a region 30 mm from a rear end of the shaft (3) as a shank section (4) is fixed, a rear end of an outer peripheral end (2a) of the grinder (2) is pushed from a direction orthogonal to an axis (L), a push-in load is F (N), and an amount of displacement of a front end of the shaft 3 is δ (mm), the stiffness of the shaft is determined by using the following formula (B).

$$0.4 \leq S \leq 100 \quad (A)$$

$$S = F/\delta \quad (B)$$

FIG.5



Description

Field

[0001] The present invention relates to a shafted grinder chucked into a hand-held rotary tool to be used, and to a polishing tool with a shafted grinder chucked into a hand-held rotary tool.

Background

[0002] A shafted grinder chucked into a hand-held rotary tool such as a rotary pneumatic drill to be used is described in Patent Literature 1. The shafted grinder in this literature includes a grinder and a shaft coupled to the grinder. The grinder has a shape rotationally symmetrical about the axis of the shaft. The grinder is an inorganic filament-reinforced resin body and includes a plurality of grinding element bundles of a plurality of inorganic filaments bundled together and a resin that bonds the grinding element bundles. The shaft includes a support member coupled to the grinder and a rod-shaped shank coupled to the support member. The shank is a portion to be chucked into a rotary tool. The shaft is elastically deformable at the support member in a direction orthogonal to the axial direction. In a polishing process, an outer peripheral surface of the grinder of the shafted grinder is brought into contact with a section to be polished of a workpiece.

[0003] Since the shafted grinder in this literature has a flexible shaft, the grinder can be pressed against a workpiece elastically. Thus, when a polishing process is performed with a rotary tool gripped by hand, the positioning accuracy in bringing the grinder into contact with a workpiece can be low. In addition, because of the shaft being flexible, when excessive force is applied to the grinder, such force is absorbed by elastic deformation of the shaft. The grinder therefore does not excessively shave a workpiece. Furthermore, since the grinder can be pressed against the workpiece elastically, the grinder does not bounce on a surface of the workpiece. Thus, the grinding elements can be brought into contact with a surface of the workpiece evenly, resulting in satisfactory deburring and polishing.

Citation List

Patent Literature

[0004] Patent Literature 1: Japanese Patent Application Laid-open Publication No. 2006-35414

Summary

Technical Problem

[0005] Unfortunately, in a shafted grinder having a flexible shaft, the grinder may be unevenly worn during a

polishing process. The uneven wear of the grinder results in uneven contact of the grinder with a workpiece, which may lead to failure in satisfactory deburring and polishing. Further, once uneven wear of the grinder occurs, the shape of the grinder does not return to its original rotationally symmetrical shape during a polishing process, resulting in further deformation of the grinder. This causes a phenomenon in which the grinder bounces on a surface of the workpiece during a polishing process, for example. The bouncing of the grinder results in uneven contact of the grinder with the workpiece, which leads to failure in satisfactory deburring and polishing.

[0006] In view of the above problems, an object of the present invention is to provide a shafted grinder that can suppress uneven wear of the grinder during a polishing process even when the shaft is flexible. Another object is to provide a polishing tool including such a shafted grinder.

Solution to Problem

[0007] The inventors of the present invention have conducted elaborate studies and found that uneven wear of the grinder is caused by vibrations generated by resonance of the shafted grinder during a polishing process. More specifically, it has been found that when the grinder vibrates due to resonance, the grinder repeatedly collides against a surface of a workpiece, and the impact of the collision causes a portion of the grinder to drop off, resulting in uneven wear. The present invention is based on these findings by the inventors.

[0008] To solve the above problem, the present invention provides a shafted grinder including: a shaft having a shank section at a rear end; and a grinder having a rotationally symmetrical shape around an axis of the shaft and fixed to a front end of the shaft, the grinder having an outer peripheral end located on an outer peripheral side with respect to the shaft, the shank section being chucked into a hand-held rotary tool to polish a workpiece with the outer peripheral end of the grinder, wherein the grinder includes a plurality of grinding element bundles of a plurality of inorganic filaments bundled together and includes a resin bonding the grinding element bundles, a natural frequency has a value that does not cause resonance during a polishing process when the following conditional expression is satisfied:

$$0.4 \leq S \leq 100$$

where S is a stiffness of the shaft, and when a region 30 mm from the rear end of the shaft as the shank section is fixed to a jig and a rear end of the outer peripheral end of the grinder is pushed from a direction orthogonal to the axis, the stiffness of the shaft is determined by using the following formula:

$$S = F/\delta$$

where F (N) is a push-in load, and δ (mm) is an amount of displacement of the front end of the shaft.

[0009] In the shafted grinder of the present invention, the stiffness of the shaft is set to a value within a predetermined range defined by the conditional expression. With this configuration, the natural frequency of the shafted grinder has a value that does not cause resonance during a polishing process. Thus, uneven wear of the grinder resulting from vibrations of the grinder due to resonance of the shafted grinder can be suppressed. Further, setting the stiffness of the shaft to a value within a predetermined range defined by the conditional expression can prevent or suppress bouncing of the grinder on a surface of a workpiece in a polishing process. With this configuration, the contact of the grinder with a workpiece becomes even, thereby preventing or suppressing failure in satisfactory deburring and polishing.

[0010] In other words, when the value of the stiffness of the shaft is below the lower limit of the conditional expression, the stiffness of the shaft is lower, and the natural frequency of the shafted grinder becomes lower. Accordingly, resonance is more likely to occur during a polishing process, and uneven wear of the grinder is more likely to occur due to vibrations caused by resonance. On the other hand, when the value of the stiffness of the shaft exceeds the upper limit of the conditional expression, the stiffness of the shaft is too high. In other words, if the stiffness of the shaft is high, the natural frequency of the shafted grinder is high, thus preventing occurrence of resonance in the shafted grinder during a polishing process. However, if the stiffness of the shaft is too high, the shaft is unable to sufficiently absorb the vibrations transmitted from the workpiece side to the shafted grinder during a polishing process, and the grinder easily bounces on a surface of the workpiece during a polishing process. Thus, the stiffness of the shaft is set to a value equal to or smaller than the upper limit of the conditional expression to suppress the bouncing of the grinder during a polishing process. This configuration facilitates favorable deburring and polishing of a section to be polished.

[0011] Further, the grinder includes a plurality of grinding element bundles of a plurality of inorganic filaments and a resin bonding these grinding element bundles. Compared to a grinder with abrasive grains bonded with a resin, when the grinder composed of such an inorganic filament-reinforced resin body is impacted, a part of the grinder is less likely to collapse. In other words, in a grinder with abrasive grains solidified with a resin, each individual abrasive grain collapses when impacted, and uneven wear is more likely to occur, whereas in the grinder with a plurality of grinding element bundles solidified with the resin, such collapse of each individual abrasive grain does not occur. Uneven wear of the grinder is therefore easily suppressed.

[0012] Here, when a polishing process is performed

with a shafted grinder having a flexible shaft attached to a hand-held rotary tool, vibrations generated during deburring removal or the like are absorbed by the shaft and sometimes do not reach the operator who grips the rotary tool. In such a case, the operator is unable to have a feeling of whether the polishing process is being performed satisfactorily. Thus, when a shafted grinder having a flexible shaft is used to process a section to be polished that is difficult to see, for example, to polish an inner wall surface of a deep hole in a workpiece, the operator is unable to perform the polishing process efficiently, resulting in reduced workability. In this respect, the inventors of the present invention have verified that if the value of stiffness of the shaft satisfies the conditional expression, the stiffness of the shaft does not become too low, and the vibrations generated during deburring removal of the like reach the operator through the shaft and the rotary tool. The operator therefore can determine by a feeling whether a polishing process is being performed as desired, even when processing a section to be polished that is difficult to see. Thus, reduction in workability of the polishing process can be suppressed.

[0013] Conventionally, there has been a demand for increasing the length of the shaft in order to allow the grinder to reach a section to be polished deep in a hole when an inner wall surface of a hole in a workpiece is polished. In general, however, as the length of the shaft having elasticity increases, the stiffness of the shaft decreases accordingly. Increasing the length of the shaft therefore causes resonance in a polishing process, so that the grinder is more likely to be unevenly worn. Further, when the length of the shaft is increased, the operator may be unable to determine by a feeling whether a polishing process is being performed as desired. Thus, it has not been easy to increase the length of the shaft while suppressing reduction in workability of a polishing process. In contrast, according to the present invention, when the value of stiffness of the shaft satisfies the conditional expression, uneven wear of the grinder can be suppressed regardless of the length of the shaft, and the operator can determine by a feeling whether a polishing process is being performed as desired. According to the present invention, therefore, the length of the shaft can be increased while reduction in workability of a polishing process is suppressed.

[0014] Here, conventionally, commercially available shafted grinders having flexible shafts typically have a length dimension shorter than 50 mm from the rear end of the shaft to the grinder. In contrast, in the present invention, the length dimension from the rear end of the shaft to the grinder may be 50 mm or more.

[0015] In the present invention, the outer diameter dimension of the shaft may be less than 6 mm. This setting can prevent or suppress the shaft from becoming too thick and the value of stiffness of the shaft from exceeding the upper limit of the conditional expression. If the outer diameter dimension of the shaft is less than 6 mm, shading on a section to be polished by the shaft and obstruct-

ing visibility can be easily avoided when the operator gripping the rotary tool observes the section to be polished.

[0016] In the present invention, the grinder may weigh 0.8 g or less. In this way, the bouncing of the grinder on a surface of a workpiece is easily suppressed, for example, when force is applied to the shafted grinder from the workpiece side during a polishing process.

[0017] In the present invention, the shafted grinder may further include a fixing mechanism configured to removably fix the grinder to the front end of the shaft. With such a fixing mechanism, the grinder can be replaced with a new grinder when it is worn.

[0018] In the present invention, the grinder may be square or circular when viewed from a direction orthogonal to the axis.

[0019] In the present invention, the grinder may have an outer diameter dimension of 3 mm or more, and an outer diameter dimension of the shank section and a thickness in a direction of the axis of the grinder may be smaller than the outer diameter dimension of the grinder. In this way, the grinder has a shape longer in the radial direction than in the axial direction, and the outer peripheral end of the grinder is located on the outer peripheral side with respect to the shaft. With this configuration, it is easier to bring the outer peripheral end of the grinder into contact with a section having burrs in a workpiece.

[0020] In the present invention, the grinder may have a shape that tapers toward an outer peripheral side when viewed from a direction orthogonal to the axis. In this case, the shape of the grinder viewed from a direction orthogonal to the axis is an isosceles triangle, a rhombus, an oval, or the like.

[0021] In the present invention, the grinder may be rectangular when viewed from a direction orthogonal to the axis. When the shape of the grinder viewed from a direction orthogonal to the axis is a rectangle, the radially outer peripheral end which is a polishing surface of the grinder has a constant width in the axial direction.

[0022] In the present invention, a length dimension from the rear end of the shaft to the grinder may exceed 150 mm. In this way, it is easier to allow the grinder to reach a section to be polished deep in a hole in a workpiece.

[0023] A polishing tool of the present invention includes the shafted grinder described above and a rotary tool into which the shank section of the shafted grinder is chucked.

Advantageous Effects of Invention

[0024] In the shafted grinder of the present invention, uneven wear of the grinder can be suppressed during a polishing process even when the shaft has elasticity.

Brief Description of Drawings

[0025]

FIG. 1 is a perspective view of a shafted grinder.

FIG. 2 is an exploded perspective view of the shafted grinder.

FIG. 3 is an illustration of a polishing tool including the shafted grinder and a rotary tool.

FIG. 4 is an illustration of a grinder.

FIG. 5 is an illustration of a measurement method for measuring stiffness of a shaft of the shafted grinder.

FIG. 6 is a table that lists stiffness of a shank, total length, and rotation speed in a polishing process of the shafted grinder in examples and comparative examples.

FIG. 7 is an illustration of a workpiece for use in an evaluation test.

FIG. 8 is an illustration of the evaluation test.

FIG. 9 is a table listing evaluation results of Evaluation Test 1.

FIG. 10 is a table listing evaluation results of Evaluation Test 2.

FIG. 11 is a table listing evaluation results of Evaluation Test 3.

FIG. 12 is an illustration of modifications of the shafted grinder.

25 Description of Embodiments

[0026] A shafted grinder and a polishing tool according to embodiments of the present invention will be described below with reference to the drawings.

[0027] FIG. 1 is a side view of a shafted grinder. FIG. 2 is an exploded perspective view of the shafted grinder. FIG. 3 is an illustration of a polishing tool including the shafted grinder and a rotary tool. FIG. 3 depicts a state in which an operator is gripping the polishing tool. FIG. 4 is an illustration of a grinder. FIG. 5 is an illustration of a measurement method for measuring stiffness of a shaft of the shafted grinder. In the following description, the direction along the axis L of a shaft 3 of a shafted grinder 1 is defined as the axial direction X. In the axial direction X, the side where the grinder 2 is located is defined as front side X1 of the shafted grinder 1, and the opposite side is defined as back side X2 of the shafted grinder 1.

[0028] The shafted grinder 1 includes the grinder 2 and the shaft 3 extending from the grinder 2 to the back side X2. The shaft 3 has a shank section 4 at its rear end. As illustrated in FIG. 3, the shank section 4 is a portion of the shaft 3 that is chucked into a rotary tool 10. The grinder 2 has a rotationally symmetrical shape around the axis L of the shaft 3. In this example, the grinder 2 is disk-shaped. With the grinder 2 fixed to a tip end of the shaft 3, an outer peripheral end 2a of the grinder 2 is located on the outer peripheral side with respect to the shaft 3.

[0029] The grinder 2 is fixed to the shaft 3 through a fixing mechanism 6. The fixing mechanism 6 removably fixes the grinder 2 to the shaft 3. As illustrated in FIG. 2, the fixing mechanism 6 includes a head screw 7 with a head section 7a and a threaded section 7b protruding from the head section 7a. The fixing mechanism 6 also

includes a fixing hole 8 that passes through the center of the grinder 2 in the axial direction X and a threaded hole 9 on a front end face of the shaft 3. The head screw 7 has the threaded section 7b screwed into the threaded hole 9 through the fixing hole 8 and has the head section 7a abutting on the grinder 2. The grinder 2 may be directly fixed to the shaft 3. In this case, the grinder 2 has a fixing hole at its center in which the tip end of the shaft 3 can be fitted. The fixing hole opens to the back side X2. With the tip end of the shaft 3 inserted into the fixing hole, the grinder 2 is fixed to the shaft 3 by adhesive applied to the tip end of the shaft 3 or an inner peripheral surface of the fixing hole.

[0030] As illustrated in FIG. 3, the shafted grinder 1 is chucked into the rotary tool 10 and used as a polishing tool 15. In this example, the rotary tool 10 is a hand-held electric grinding machine or a hand-held rotary pneumatic drill. In other words, in the polishing tool 15 in this example, the rotary tool 10 has a grip section 11 that is gripped by an operator. In the shafted grinder 1, the shank section 4 is held in a chuck mechanism 12 of the rotary tool 10. In a polishing process, the operator holds the rotary tool 10 in hand and brings the grinder 2 into contact with a section to be polished of a workpiece.

(Grinder)

[0031] The grinder 2 is a rotating body. As illustrated in FIG. 1, the grinder 2 has an outer diameter dimension D of 3 mm or more. The outer diameter dimension D of the grinder 2 is larger than the outer diameter dimension O of the shaft 3. The outer peripheral end 2a of the grinder 2 is therefore located on the outer peripheral side with respect to the shaft 3. Further, the outer diameter dimension D of the grinder 2 is larger than the thickness E in the axial direction X of the grinder 2. The grinder 2 is therefore longer in the radial direction than in the axial direction X. The grinder 2 has a weight of 0.8 g or less.

[0032] In this example, the shape of the grinder 2 viewed from a direction orthogonal to the axis L is a rectangle that is longer in the radial direction than in the axial direction X. The radially outer peripheral end 2a which is a processing surface of the grinder 2 therefore has a constant width in the axial direction X. In this example, the outer diameter dimension D of the grinder 2 is 15 mm and the thickness of the grinder 2 is 2 mm. The weight of the grinder 2 is 0.8 g.

[0033] The grinder 2 is what is called an inorganic filament-reinforced resin body. As illustrated in FIG. 4, the grinder 2 includes a plurality of fiber bundles 22 of a plurality of inorganic filaments 21. The grinder 2 also includes a resin 23 that bonds these fiber bundles 22. The resin 23 is a binder that solidifies the fiber bundles 22. In this example, the resin 23 is a thermosetting resin and impregnates each of the fiber bundles 22 to be cured. The tip ends of the inorganic filaments 21 reach the outer peripheral end 2a which is the processing surface of the grinder 2.

[0034] More specifically, the grinder 2 has a plurality of first fiber bundles 22A oriented in a first direction at predetermined intervals and a plurality of second fiber bundles 22B oriented in a second direction intersecting the first fiber bundles 22A at predetermined intervals. The first fiber bundle 22A and the second fiber bundle 22B are in a state in which one of the fiber bundles 22A and 22B partially overlaps the other of the fiber bundles 22A and 22B. The fiber bundles 22A and 22B are impregnated with the resin 23 and cured. The resin 23 bonds the fiber bundles 22 together. Epoxy resin, unsaturated polyester resin, vinyl ester resin, bismaleimide resin, phenolic resin, or the like is used as the resin 23.

[0035] Glass filaments, alumina filaments, boron filaments, or silicon carbide filaments are used as the inorganic filaments 21. In this example, alumina filaments are used as the inorganic filaments 21. As the inorganic filaments 21, those with an average fiber diameter of monofilament of 3 μm to 40 μm are used. As the fiber bundles 22, those with 500 to 3000 Tex are used. In this example, a base material of the grinder 2 is formed by impregnating thin fiber bundles 22 of about 500 Tex with the resin 23, aligning a plurality of grinding element bundles into an arrangement illustrated in FIGS. 4(a) and 4(b), and then impregnating and curing them with the resin 23 again.

(Shaft)

[0036] The shaft 3 is rod-shaped and has elasticity to flex in a direction orthogonal to the axis L. The shaft 3 is a rotating body with a rotationally symmetrical shape around the axis L. As illustrated in FIG. 1, the shaft 3 includes the shank section 4 and a neck section 5 in this order from the back side X2 toward the front side X1. The shank section 4 is a region 30 mm from the rear end of the shaft 3. The neck section 5 is a region located between the shank section 4 and the grinder 2 in the axial direction X. The neck section 5 has a large-diameter portion 5a at its front end side that has a larger outer diameter dimension than that of the rear side therefrom of the shaft 3. The threaded hole 9 for fixing the grinder 2 to the shaft 3 is formed on a front end face of the large-diameter portion 5a. In this example, the shaft 3 is made of stainless steel.

[0037] The shaft 3 satisfies the following conditional expression (A) when its stiffness is S.

$$0.4 \leq S \leq 100 \quad (A)$$

[0038] When the stiffness of the shaft 3 is measured, a region 30 mm from the rear end of the shaft 3 is fixed as the shank section 4 to a jig 30, as illustrated in FIG. 5. Then, a predetermined push-in load is applied to a load application position P at the rear end of the outer peripheral end 2a of the grinder 2, from a direction orthogonal to the axis L. The stiffness of the shaft 3 is de-

terminated by the following formula (B):

$$S = F/\delta \quad (B)$$

where F (N) is the push-in load, and δ (mm) is the amount of displacement of the front end of the shaft 3.

[0039] Here, the shaft 3 may be of any material, total length M, and outer diameter dimension O, as long as its stiffness satisfies the conditional expression (A). However, the total length M of the shaft 3 is preferably 50 mm or more. The total length M of the shaft 3 is the length dimension from the rear end of the shaft 3 to the grinder 2. Thus, in the shafted grinder 1 in which the grinder 2 is fixed to the shaft 3 with the tip end of the shaft 3 inserted into the fixing hole of the grinder 2, the total length M of the shaft 3 is a length dimension from the rear end of the shaft 3 to the opening edge of the fixing hole of the grinder 2.

[0040] Further, the outer diameter dimension O of the shaft 3 is preferably less than 6 mm. This setting can prevent or suppress the shaft 3 from becoming too thick and the value of stiffness of the shaft 3 from exceeding the upper limit of the conditional expression (A). Here, the outer diameter dimension O of the shaft 3 is the outer diameter dimension of the thickest portion of the shaft 3. In this example, therefore, the outer diameter dimension O of the shaft 3 is the outer diameter dimension of the large-diameter portion 5a.

(Examples and Comparative Examples)

[0041] Hereinafter, seven shafted grinders 1(1) to 1(7) with the same grinder 2 and fixing mechanism 6 but with varying stiffness and total length M of the shaft 3 will be described. FIG. 6 is a table that lists shaft stiffness, shaft total length, and rotation speed in a polishing process for the shafted grinders in examples and comparative examples. Among the shafted grinders 1(1) to 1(7), the shafted grinders 1(2) to 1(5) are examples of the present invention, and the stiffness of the shaft 3 is within the range of the conditional expression (A). The shafted grinders 1(1), (6), and (7) are comparative examples, and the stiffness of the shaft 3 is outside the range of the conditional expression (A).

[0042] In the shafted grinders 1(1) to 1(7), the grinder 2 is made of an inorganic filament-reinforced resin body. The outer diameter dimension D of the grinder 2 is 15 mm. The thickness E in the axial direction X of the grinder 2 is 2 mm. The material of the shaft 3 is stainless steel (SUS303). On the other hand, the shafted grinders 1(1) to 1(7) differ from each other in the stiffness of the shaft 3 and the total length M of the shaft 3. The shafted grinders 1(1) to 1(7) also differ from each other in the rotation speed at which the rotary tool 10 rotates each shafted grinder 1 when performing a polishing process.

[0043] In the shafted grinder 1(1), the stiffness of the shaft 3 is 0.2 N/mm. The stiffness of the shaft 3 is below

the lower limit of the conditional expression (A). The total length M of the shaft 3 is 261 mm. The length dimension N of the neck section 5 excluding the shank section 4 to be chucked into the rotary tool 10 is 231 mm. The rotation speed in a polishing process is 2000 revolutions/min.

[0044] In the shafted grinder 1(2), the stiffness of the shaft 3 is 0.4 N/mm. The stiffness of the shaft 3 satisfies the conditional expression (A). The total length M of the shaft 3 is 213 mm. The length dimension N of the neck section 5 is 183 mm. The rotation speed in a polishing process is 3000 revolutions/min. In the shafted grinder 1(3), the stiffness of the shaft 3 is 5 N/mm. The stiffness of the shaft 3 satisfies the conditional expression (A). The total length M of the shaft 3 is 109 mm. The length dimension N of the neck section 5 is 79 mm. The rotation speed in a polishing process is 5000 revolutions/min. In the shafted grinder 1(4), the stiffness of the shaft 3 is 10 N/mm. The stiffness of the shaft 3 satisfies the conditional expression (A). The total length M of the shaft 3 is 93 mm. The length dimension N of the neck section 5 is 63 mm. The rotation speed in a polishing process is 8000 revolutions/min. In the shafted grinder 1(5), the stiffness of the shaft 3 is 100 N/mm. The stiffness of the shaft 3 satisfies the conditional expression (A). The total length M of the shaft 3 is 59 mm. The length dimension N of the neck section 5 is 29 mm. The rotation speed in a polishing process is 10000 revolutions/min.

[0045] In the shafted grinder 1(6), the stiffness of the shaft 3 is 110 N/mm. The stiffness of the shaft 3 exceeds the upper limit of the conditional expression (A). The total length M of the shaft 3 is 58 mm. The length dimension N of the neck section 5 is 28 mm. The rotation speed in a polishing process is 10000 revolutions/min. In the shafted grinder 1(7), the stiffness of the shaft 3 is 120 N/mm. The stiffness of the shaft 3 exceeds the upper limit of the conditional expression (A). The total length M of the shaft 3 is 57 mm. The length dimension N of the neck section 5 is 27 mm. The rotation speed in a polishing process is 10000 revolutions/min.

(Evaluation Test)

[0046] Evaluation Tests 1 to 3 were conducted on the shafted grinders 1(1) to 1(7). In Evaluation Tests 1 to 3, each of the shafted grinders 1(1) to 1(7) is chucked into the rotary tool 10 and rotated at the aforementioned rotation speed to remove burrs on a section to be polished of a workpiece 50. Evaluation Test 1 evaluated whether a feeling that the grinder 2 was polishing the workpiece was transferred to the operator through the grinder 2, the shaft 3, and the rotary tool 10 during a polishing process. In Evaluation Test 2, the bouncing of the grinder 2 during a polishing process was evaluated. In Evaluation Test 3, the uneven wear of the grinder 2 during a polishing process was evaluated. FIG. 7 is a perspective view of the workpiece used in Evaluation Tests 1 to 3. FIG. 8 is an illustration of Evaluation Tests 1 to 3. In FIG. 8, the workpiece is depicted in cross section. In FIG. 8, the workpiece

and the shafted grinder 1 are depicted without the rotary tool 10.

[0047] The workpiece 50 is made of carbon steel for machine structural use. As illustrated in FIG. 7, the workpiece 50 is cylindrical. The workpiece 50 has an outer diameter dimension R of 30 mm and an inner diameter dimension T of 20 mm. As illustrated in FIG. 8, an annular groove 51 is provided on an inner peripheral surface 50a of the workpiece 50 at a distance Q of 20 mm from an end of the workpiece 50. The annular groove 51 has a width dimension U of 5 mm and a depth dimension V of 2.5 mm. The workpiece 50 also has a bore hole 52 with a diameter W of 3 mm at a position overlapping with the annular groove 51 when viewed from the radial direction. The bore hole 52 is provided by allowing a drill to penetrate the workpiece 50 from the radially outside to the inside. The opening edge of the bore hole 52 in an annular bottom surface 51a of the annular groove 51 is a section to be polished. The section to be polished has burrs. It can be said that such a section to be polished is located deep in a deep hole in the workpiece 50.

[0048] In Evaluation Test 1, the grinder 2 rotated is aimed at the opening edge of the bore hole 52 in the inner peripheral surface 50a of the workpiece 50 and brought into contact with the workpiece 50 to perform deburring. In Evaluation Test 1, each of three evaluators determines whether burrs are being removed by a feeling transferred to the hand through the grinder 2, the shaft 3, and the rotary tool 10.

[0049] The test results of Evaluation Test 1 are as listed in FIG. 9. In FIG. 9, "poor" indicates that the evaluator was unable to determine whether burrs were being removed by the feeling transferred to the hand, and "good" indicates that the evaluator was able to determine whether burrs were being removed by the feeling transferred to the hand. As illustrated in FIG. 9, when a polishing process was performed with the shafted grinder 1(1) chucked into the rotary tool 10, each of the three evaluators was unable to determine whether burrs were being removed by the feeling transferred to the hand through the grinder 2, the shaft 3, and the rotary tool 10. In other words, the shaft 3 of the shafted grinder 1(1) had low stiffness and flexed easily, so vibrations and the like generated during burr removal were absorbed by the shaft 3 and did not reach the evaluator. When a polishing process was performed with the shafted grinders 1(2) to (7) chucked into the rotary tool 10, all of the three evaluators felt that burrs were being removed at the section to be polished.

[0050] Evaluation Test 1 is a test to confirm whether the shafted grinders 1(1) to 1(7) can be used for a polishing process in which a section to be polished is unable to be visually checked directly. According to the test results, the shafted grinders 1(2) to 1(7) can be used for a polishing process in which a section to be polished is unable to be visually checked directly.

[0051] In Evaluation Test 2, the grinder 2 rotated is aimed at the opening edge of the bore hole 52 in the inner

peripheral surface 50a of the workpiece 50 and brought into contact with the workpiece 50 to perform deburring. In Evaluation Test 2, each of three evaluators determines whether the grinder 2 is bouncing during a polishing process by a feeling transferred to the hand through the shaft 3 and the rotary tool 10.

[0052] The test results of Evaluation Test 2 are as listed in FIG. 10. In FIG. 10, "poor" indicates that the evaluator felt the bouncing of the grinder 2, and "good" indicates that the evaluator did not feel the bouncing of the grinder 2. As illustrated in FIG. 10, when a polishing process was performed with the shafted grinders 1(1) to 1(5) chucked into the rotary tool 10, none of the three evaluators felt the bouncing of the grinder 2 during the polishing process. When a polishing process was performed with the shafted grinder 1(6) chucked into the rotary tool 10, one of the three evaluators felt the bouncing of the grinder 2 during the polishing process. When a polishing process was performed with the shafted grinder 1(7) chucked into the rotary tool 10, all of the three evaluators felt the bouncing of the grinder 2 during the polishing process. The three evaluators had the impression that the polishing tool 15 was difficult to use when the grinder 2 bounced during a polishing process. The three evaluators also had the impression that when the grinder 2 bounced, the vibrations transmitted to the operator's hand caused fatigue accumulation in the operator.

[0053] In Evaluation Test 3, the grinder 2 rotated is aimed at the opening edge of the bore hole 52 in the inner peripheral surface 50a of the workpiece 50 and brought into contact with the workpiece 50 to start deburring. The deburring is then finished when the outermost diameter of the grinder 2 reaches 10 mm. The deburring operation is interrupted every 15 seconds from the start to the end of deburring to observe the grinder 2 and the workpiece 50. Such observation is made by three evaluators on a plurality of workpieces 50 without replacing each of the shafted grinders 1 with a new one.

[0054] If the evaluator recognizes all of three factors "the profile of the grinder is not circular", "wear of the grinder 2 has rapidly progressed, compared to the previous observation", and "bouncing of the grinder 2 is felt" until the deburring is finished, and when the evaluator observes the workpiece 50 after deburring is finished and determines that "unevenness is found in the finished edge of the opening edge of the bore hole 52 in the annular bottom surface 51a", the grinder 2 was assessed as having uneven wear.

[0055] The test results of Evaluation Test 3 are as listed in FIG. 11. In FIG. 11, "poor" indicates that uneven wear occurred in the grinder 2, and "good" indicates that uneven wear did not occur in the grinder 2. As illustrated in FIG. 11, when a polishing process was performed with the shafted grinder 1(1) chucked into the rotary tool 10, all of the three evaluators assessed the grinder 2 as having uneven wear. When a polishing process was performed with the shafted grinders 1(2) to 1(7) chucked into the rotary tool 10, all of the three evaluators assessed

the grinder 2 as not having uneven wear.

[0056] According to Evaluation Tests 1 to 3, it is clear that if the shafted grinders 1(2) to 1(5) with the stiffness of the shaft 3 that satisfies the conditional expression (A) are chucked into the rotary tool 10 to perform a polishing process, uneven wear of the grinding element during a polishing process can be prevented or suppressed, and bouncing of the grinding element during a polishing process can be prevented or suppressed. It is also found that if the shafted grinders 1(2) to 1(5) with the stiffness of the shaft 3 that satisfies the conditional expression (A) are chucked into the rotary tool 10 to perform a polishing process, the operator can determine that the polishing process is being performed by the feeling transferred to the hand, and fatigue accumulation in the operator is suppressed.

(Operation Effects)

[0057] In the shafted grinders 1(2) to 1(5) in this example, the stiffness of the shaft 3 is set to a value within a predetermined range defined by the conditional expression (A). With this configuration, the natural frequency of the shafted grinder 1 has a value that does not cause resonance during a polishing process. Thus, uneven wear of the grinder 2 resulting from vibrations of the grinder 2 due to resonance of the shafted grinder 1 can be suppressed. In the shafted grinders 1(2) to 1(5) in this example, since the stiffness of the shaft 3 is set to a value within a predetermined range defined by the conditional expression (A), bouncing of the grinder 2 on a surface of the workpiece 50 can be prevented or suppressed in a polishing process.

[0058] In other words, when the value of stiffness of the shaft 3 is below the lower limit of the conditional expression (A), as in the shafted grinder 1(1), the stiffness of the shaft 3 is lower, and the natural frequency of the shafted grinder 1 becomes lower. Accordingly, resonance is more likely to occur during a polishing process, and uneven wear of the grinder 2 is more likely to occur due to vibrations caused by resonance. Here, uneven wear of the grinder 2 results in uneven contact of the grinder 2 with the workpiece 50, which may lead to failure in satisfactory deburring and polishing. Further, once uneven wear of the grinder 2 occurs, the shape of the grinder 2 does not return to its original rotationally symmetrical shape during a polishing process, resulting in further deformation of the grinder 2. This causes a phenomenon in which the grinder 2 bounces on a surface of the workpiece 50 during a polishing process, for example. The bouncing of the grinder 2 results in uneven contact of the grinder 2 with the workpiece 50, which leads to failure in satisfactory deburring and polishing. In the shafted grinders 1(2) to 1(5) in this example, therefore, the stiffness of the shaft 3 is set to a value equal to or greater than the lower limit of the conditional expression (A) to prevent or suppress uneven wear of the grinder 2. Thus, occurrence of such inconvenience can be avoided.

[0059] On the other hand, when the value of stiffness of the shaft 3 exceeds the upper limit of the conditional expression (A), as in the shafted grinder 1(6) and the shafted grinder 1(7), the stiffness of the shaft 3 is too high. In other words, if the stiffness of the shaft 3 is high, the natural frequency of the shafted grinder 1 is high, thus preventing occurrence of resonance in the shafted grinder 1 during a polishing process. However, if the stiffness of the shaft 3 is too high, the shaft 3 is unable to sufficiently absorb the vibrations transmitted from the workpiece 50 side to the shafted grinder 1 during a polishing process, and the grinder 2 easily bounces on a surface of the workpiece 50 in a polishing process. Here, the bouncing of the grinder 2 results in uneven contact of the grinder 2 with the workpiece 50, which leads to failure in satisfactory deburring and polishing. Further, the bouncing of the grinder 2 may cause the grinder 2 to come into contact with a section different from a section to be polished of the workpiece 50 and damage the workpiece 50. Furthermore, the bouncing of the grinder 2 causes fatigue accumulation in the operator due to vibrations transmitted to the operator's hand. In the shafted grinders 1(2) to 1(5) in this example, therefore, the stiffness of the shaft 3 is set to a value equal to or smaller than the upper limit of the conditional expression (A) to suppress the bouncing of the grinder 2 during a polishing process. Thus, occurrence of such inconvenience can be avoided.

[0060] Here, when the value of stiffness of the shaft 3 is within the range of the conditional expression (A), the natural frequency of the shafted grinder 1 can be increased to the extent that resonance can be prevented, regardless of the material, the total length M, and the outer diameter dimension O of the shaft 3. The natural frequency of the shafted grinder 1 is higher than the excitation frequency, which depends on the rotation speed of the shafted grinder 1 in a polishing process. Thus, when the value of stiffness of the shaft 3 is within the range of the conditional expression (A), resonance of the shafted grinder 1 can be prevented or suppressed, regardless of the rotation speed of the shafted grinder 1 during a polishing process.

[0061] The grinder 2 of the shafted grinder 1 is an inorganic filament-reinforced resin body and includes a plurality of fiber bundles 22 composed of a plurality of inorganic filaments 21 and the resin 23 that bonds these fiber bundles 22. Compared to a grinder with abrasive grains bonded with a resin, when such a grinder 2 is impacted, a part of the grinder 2 is less likely to collapse. In other words, in a grinder with abrasive grains solidified with a resin, each individual abrasive grain collapses when impacted, and uneven wear is more likely to occur, whereas in the grinder 2 with a plurality of fiber bundles 22 solidified with the resin 23, such collapse of each individual abrasive grain does not occur. Uneven wear of the grinder 2 during a polishing process is therefore easily suppressed.

[0062] In this example, the total length M of the shaft

3 is 50 mm or more. Here, conventionally, there has been a demand for increasing the total length M of the shaft 3 in order to allow the grinder 2 to reach a section to be polished deep in a hole when an inner wall surface of a hole in a workpiece is polished. In general, however, as the total length M of the shaft 3 having elasticity increases, the stiffness of the shaft 3 decreases accordingly. Increasing the total length M of the shaft 3 therefore causes resonance in a polishing process, so that the grinder is more likely to be unevenly worn. Further, when the total length M of the shaft 3 is increased, the operator may be unable to determine by a feeling whether a polishing process is being performed as desired. Thus, it has not been easy to increase the length of the shaft 3 while suppressing reduction in workability of a polishing process. In contrast, in the shafted grinders 1(2) to 1(5) in this example, since the value of stiffness of the shaft 3 satisfies the conditional expression (A), uneven wear of the grinder 2 can be prevented regardless of the total length M of the shaft 3. Further, the operator can determine by a feeling whether a polishing process is being performed as desired. In the shafted grinders 1(2) to 1(5) in this example, therefore, the total length of the shaft 3 can be increased while reduction in workability of a polishing process is suppressed.

[0063] Here, conventionally, commercially available shafted grinders having flexible shafts typically have a length dimension shorter than 50 mm from the rear end of the shaft 3 to the grinder. In contrast, the shafted grinders 1(2) to 1(5) in this example have a length dimension of 50 mm or more from the rear end of the shaft 3 to the grinder.

[0064] Further, currently, no shafted grinder 1 with a flexible shaft 3 having a total length of the shaft 3 exceeding 150 mm has been provided. The reason for this is as follows. In a polishing process for an inner peripheral surface of a deep hole that requires the use of the shafted grinder 1 having a total length of the shaft 3 exceeding 150 mm, it is difficult for the operator to visually check a section to be polished of a workpiece during the polishing process, while it is difficult for the operator to have a feeling that desired processing is being done during the polishing process through the rotary tool 10 gripped by the operator. In this respect, in the shafted grinder 1(2) in this example with a total length of the shaft 3 exceeding 150 mm, since the value of stiffness of the shaft 3 satisfies the conditional expression (A), the operator can have a feeling that desired processing is being done during a polishing process even when the operator is unable to visually check a section to be polished of a workpiece. Further, when the stiffness of the shaft 3 is set to a value that satisfies the range of the conditional expression (A), occurrence of uneven wear in the grinder 2 can be prevented or suppressed, and bouncing of the grinder 2 during a polishing process can be prevented or suppressed. Deburring and polishing therefore can be performed satisfactorily by the shafted grinder 1(2) with a total length of the shaft 3 exceeding 150 mm.

[0065] In this example, the outer diameter dimension O of the shaft 3 is less than 6 mm. This setting easily prevents or suppresses the shaft 3 from becoming too thick and the value of stiffness of the shaft 3 from exceeding the upper limit of the conditional expression (A). If the outer diameter dimension O of the shaft 3 is less than 6 mm, shading on a section to be polished by the shaft 3 and obstructing visibility can be easily avoided when the operator gripping the rotary tool 10 observes the section to be polished.

[0066] In this example, the grinder 2 weighs 0.8 g or less. The bouncing of the grinder 2 on a surface of the workpiece 50 is therefore easily suppressed, for example, when force is applied to the shafted grinder 1 from the workpiece 50 side during a polishing process.

[0067] In this example, the shafted grinder 1 has the fixing mechanism 6 that removably fixes the grinder 2 to the front end of the shaft 3. Thus, when the grinder 2 is worn, the worn grinder 2 can be replaced with a new grinder 2.

(Modifications)

[0068] FIGS. 12(a) to (f) illustrate shafted grinders of first to sixth modifications. In all of shafted grinders 1A to 1F of the first to sixth modifications illustrated in FIGS. 12(a) to (f), the stiffness of the shaft 3 satisfies the conditional expression (A). FIG. 12 depicts a load application position P for measuring the stiffness of the shaft 3 of the shafted grinders 1A to 1F of the first to sixth modifications.

[0069] The shafted grinder 1A of the first modification illustrated in FIG. 12(a) has a square shape when the grinder 2 is viewed from a direction orthogonal to the axis L. The grinder 2 is therefore cylindrical. The shafted grinder 1B of the second modification illustrated in FIG. 12(b) has a circular shape when the grinder 2 is viewed from a direction orthogonal to the axis L. The grinder 2 is therefore spherical.

[0070] Next, the grinder 2 may have a shape that tapers toward the outer peripheral side when viewed from a direction orthogonal to the axis L. In this case, the grinder 2 can have an isosceles triangle shape when viewed from a direction orthogonal to the axis L, as in the shafted grinder 1C of the third modification illustrated in FIG. 12(c) and the shafted grinder 1D of the fourth modification illustrated in FIG. 12(d). In the shafted grinder 1C of the third modification, the grinder 2 has a conical shape with the apex pointing to the front side X1. In the shafted grinder 1D of the fourth modification, the grinder 2 as a whole has a conical shape with the apex pointing to the back side X2. In this case, the grinder 2 can have a rhombus shape when viewed from a direction orthogonal to the axis L, as in the shafted grinder 1E of the fifth modification. In this case, the grinder 2 can have an oval shape when viewed from a direction orthogonal to the axis L, as in the shafted grinder 1F of the sixth modification.

[0071] In each of the shafted grinders 1A to 1F of the first to sixth modifications, the grinder 2 has a fitting hole

25 at its center into which the tip end of the shaft 3 can be fitted. The fitting hole 25 opens to the back side X2. With the tip end of the shaft 3 inserted into the fitting hole 25, the grinder 2 is fixed to the shaft 3 by adhesive applied to the tip end of the shaft 3 and the inner peripheral surface of the fitting hole 25. In each of the shafted grinders 1A to 1F of the first to sixth modifications, uneven wear of the grinder 2 and bouncing of the grinder 2 during a polishing process can also be suppressed.

Claims

1. A shafted grinder comprising: a shaft having a shank section at a rear end; and a grinder having a rotationally symmetrical shape around an axis of the shaft and fixed to a front end of the shaft, the grinder having an outer peripheral end located on an outer peripheral side with respect to the shaft, the shank section being chucked into a hand-held rotary tool to polish a workpiece with the outer peripheral end of the grinder, wherein

the grinder includes a plurality of grinding element bundles of a plurality of inorganic filaments bundled together and includes a resin bonding the grinding element bundles, a natural frequency has a value that does not cause resonance during a polishing process when the following conditional expression is satisfied:

$$0.4 \leq S \leq 100$$

where S is a stiffness of the shaft, and when a region 30 mm from the rear end of the shaft as the shank section is fixed to a jig and a rear end of the outer peripheral end of the grinder is pushed from a direction orthogonal to the axis, the stiffness of the shaft is determined by using the following formula:

$$S = F/\delta$$

where F (N) is a push-in load, and δ (mm) is an amount of displacement of the front end of the shaft.

2. The shafted grinder according to claim 1, wherein a length dimension from the rear end of the shaft to the grinder is 50 mm or more.
3. The shafted grinder according to claim 1 or 2, wherein the shaft has an outer diameter dimension of less than 6 mm.

4. The shafted grinder according to any one of claims 1 to 3, wherein the grinder weighs 0.8 g or less.

5. The shafted grinder according to any one of claims 1 to 4, further comprising a fixing mechanism configured to removably fix the grinder to the front end of the shaft.

6. The shafted grinder according to any one of claims 1 to 5, wherein the grinder is square or circular when viewed from a direction orthogonal to the axis.

7. The shafted grinder according to any one of claims 1 to 5, wherein

the grinder has an outer diameter dimension of 3 mm or more, and an outer diameter dimension of the shank section and a thickness in a direction of the axis of the grinder are smaller than the outer diameter dimension of the grinder.

8. The shafted grinder according to claim 7, wherein the grinder has a shape that tapers toward an outer peripheral side when viewed from a direction orthogonal to the axis.

9. The shafted grinder according to claim 7, wherein the grinder is rectangular when viewed from a direction orthogonal to the axis.

10. The shafted grinder according to any one of claims 1 to 9, wherein a length dimension from the rear end of the shaft to the grinder exceeds 150 mm.

11. A polishing tool comprising:

the shafted grinder according to any one of claims 1 to 10; and a rotary tool into which the shank section of the shafted grinder is chucked.

FIG.1

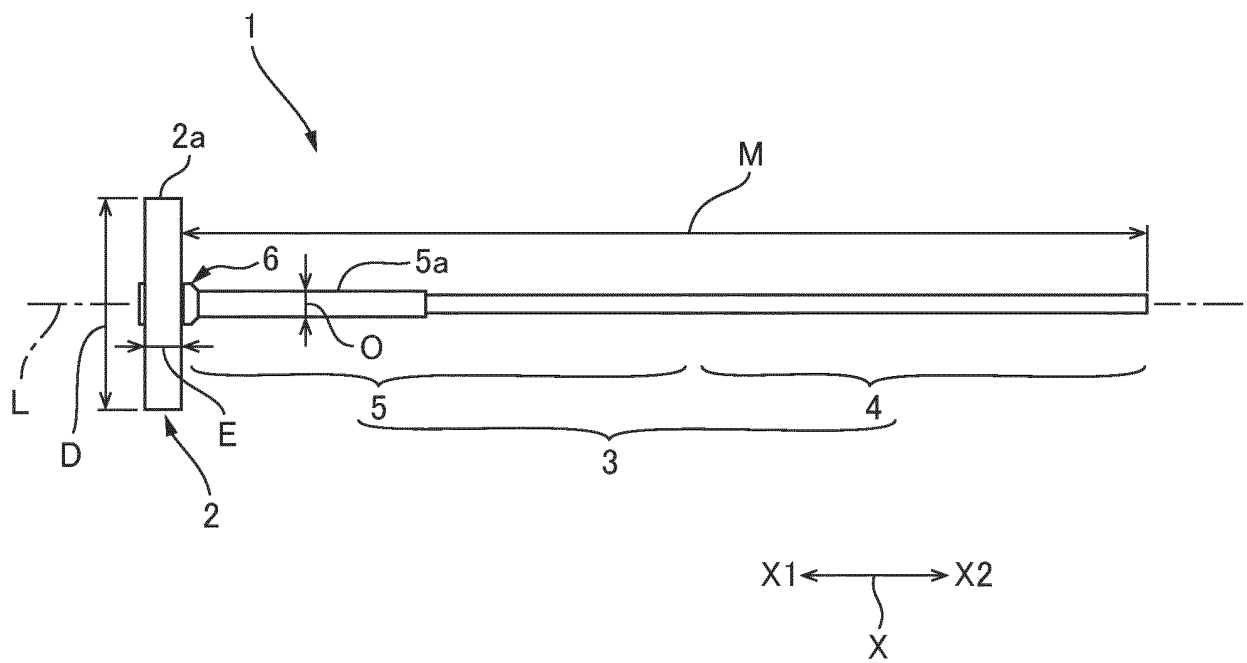


FIG.2

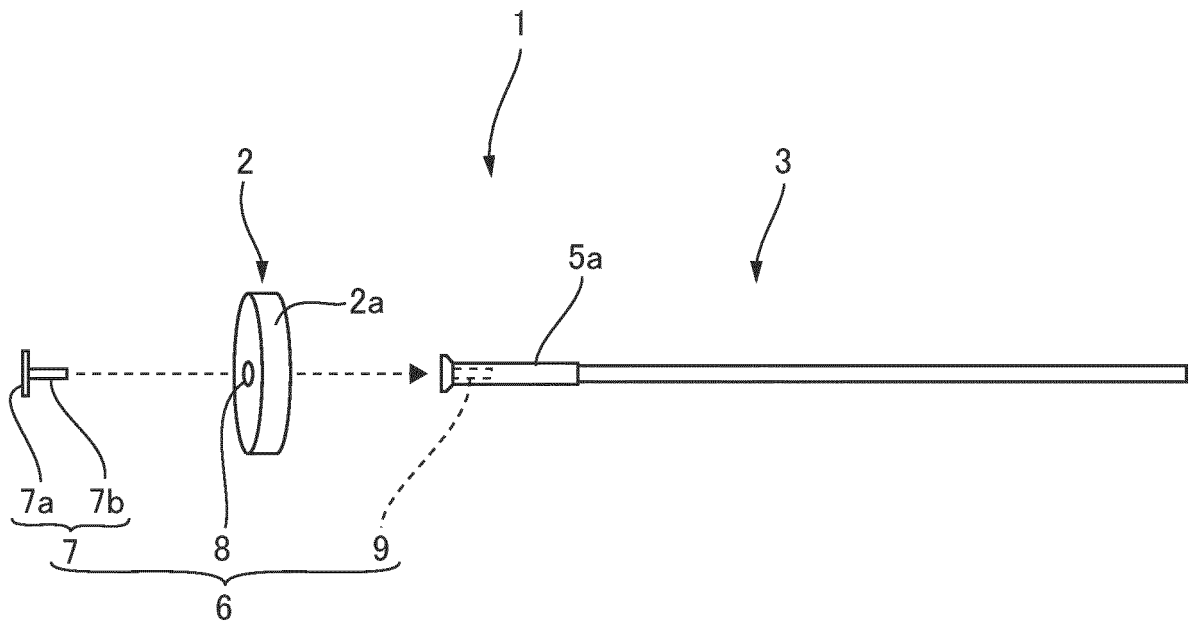


FIG.3

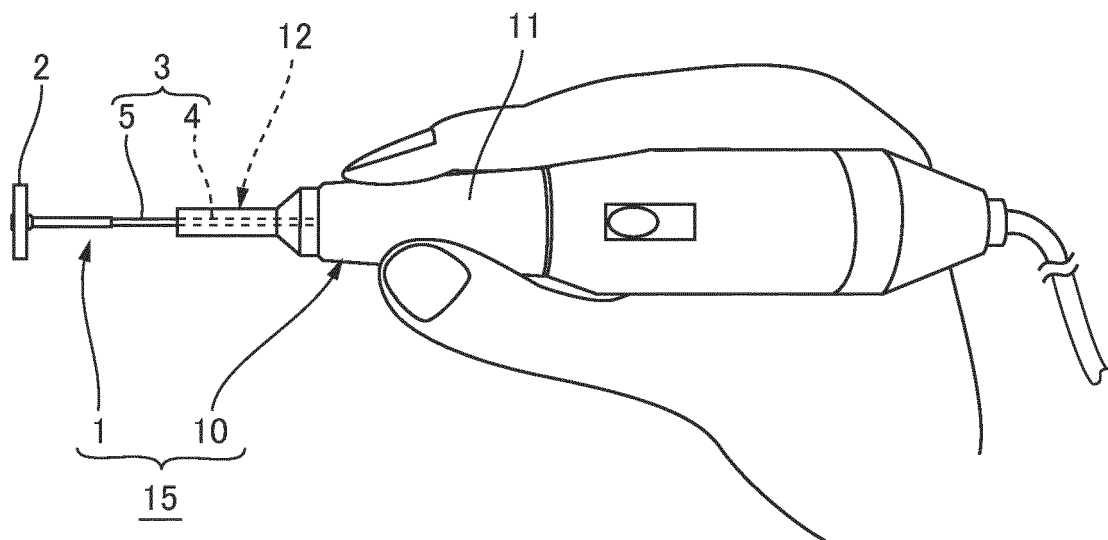


FIG.4

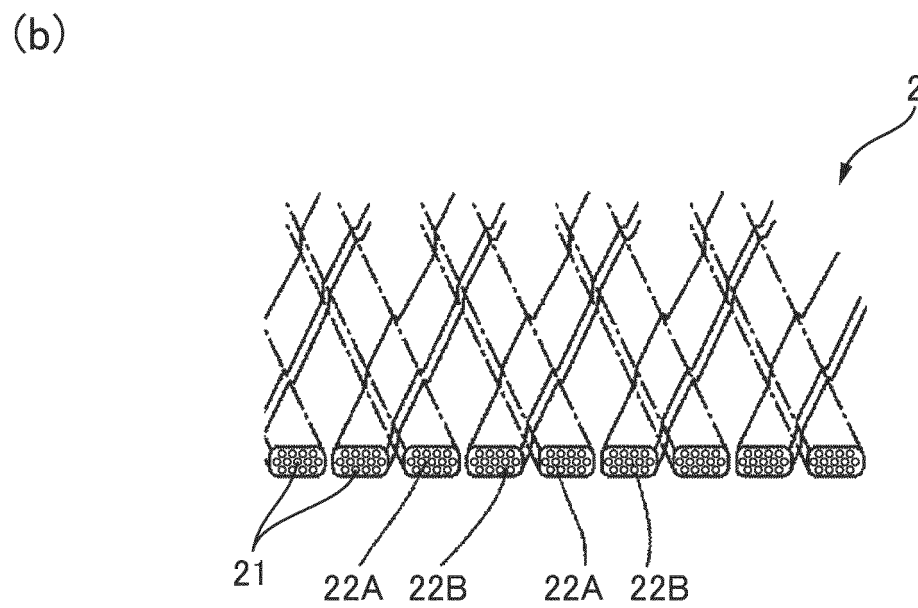
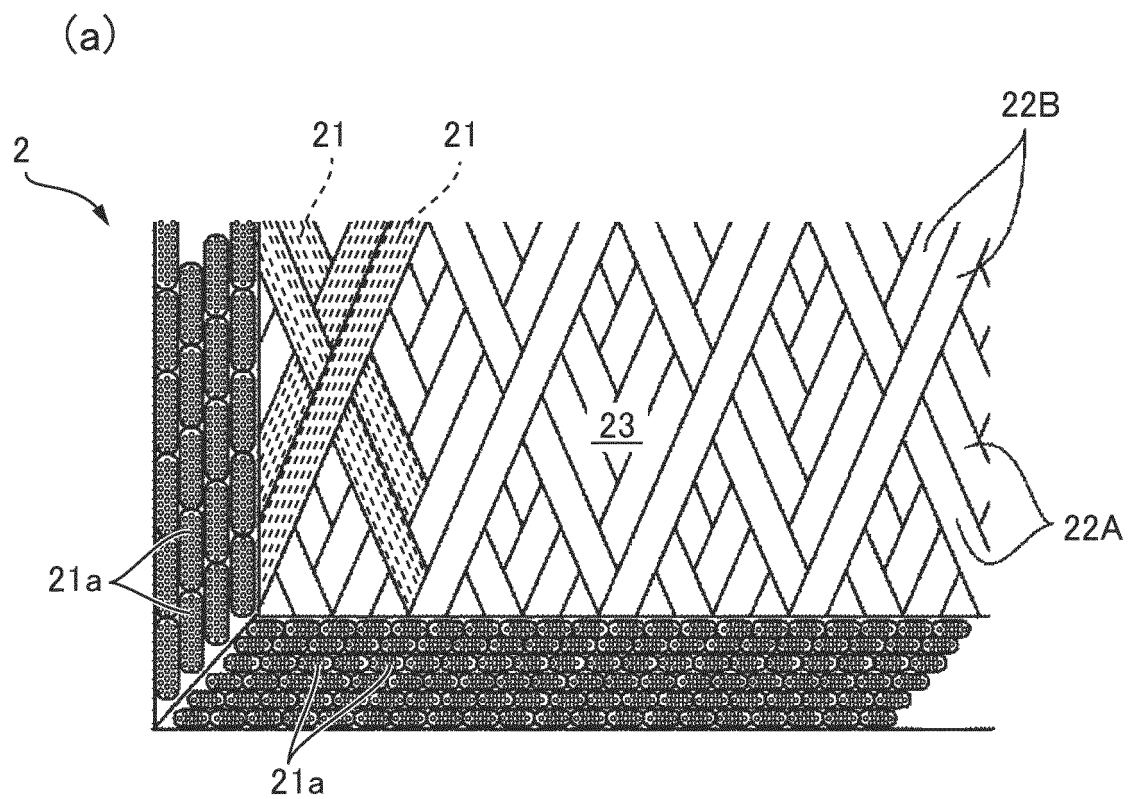


FIG.5

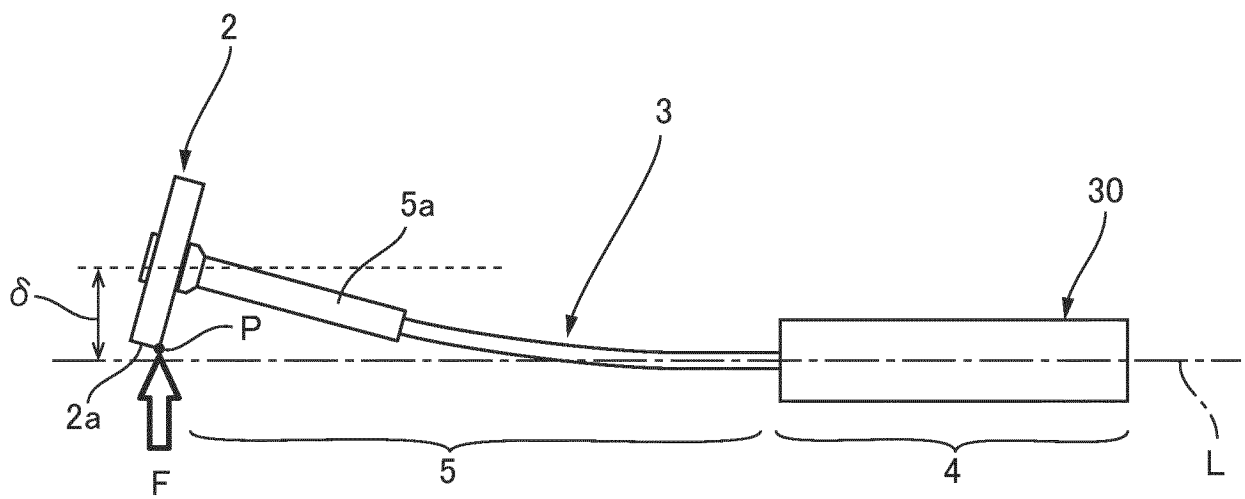


FIG.6

	Stiffness [N/mm]	Shaft total length (Rotation speed in a polishing process) [mm]	Rotation speed in a polishing process [revolutions/min]
The shafted grinder1(1)	0.2	261(231)	2,000
The shafted grinder1(2)	0.4	213(183)	3,000
The shafted grinder1(3)	5	109(79)	5,000
The shafted grinder1(4)	10	93(63)	8,000
The shafted grinder1(5)	100	59(29)	10,000
The shafted grinder1(6)	110	58(28)	10,000
The shafted grinder1(7)	120	57(27)	10,000

FIG. 7

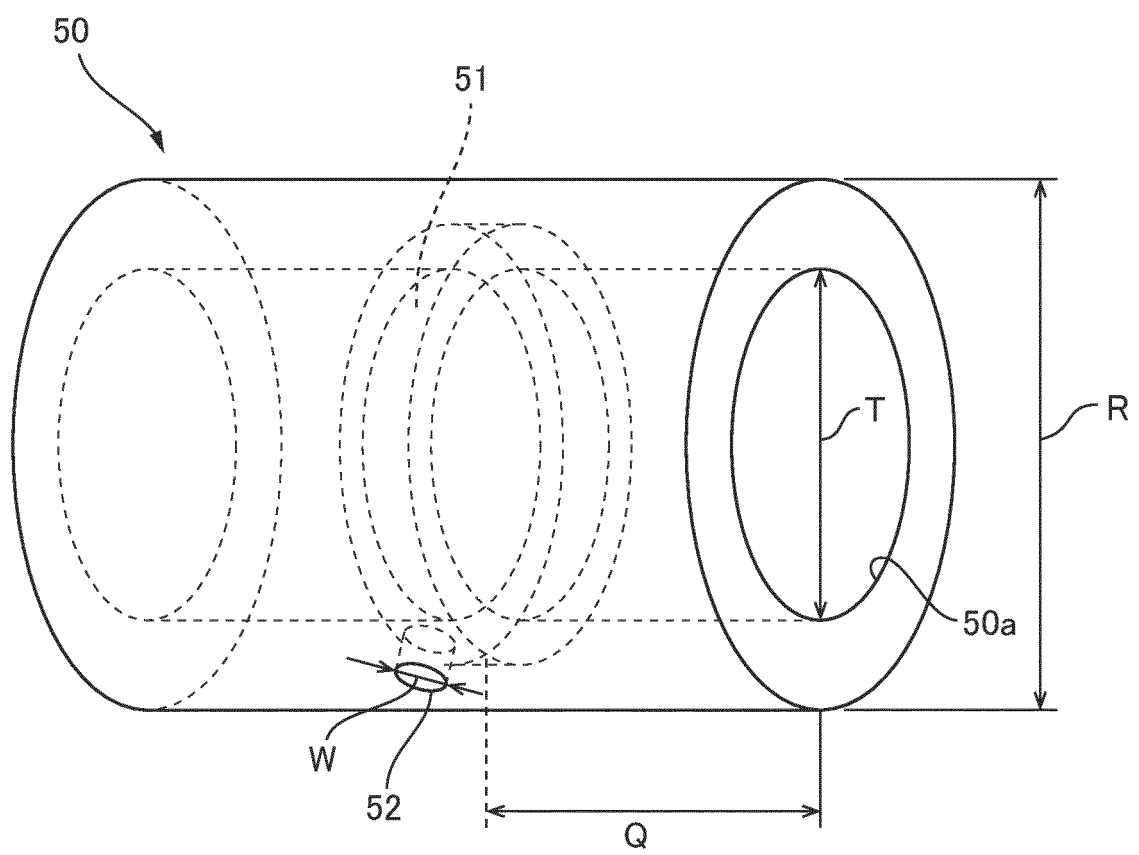


FIG.8

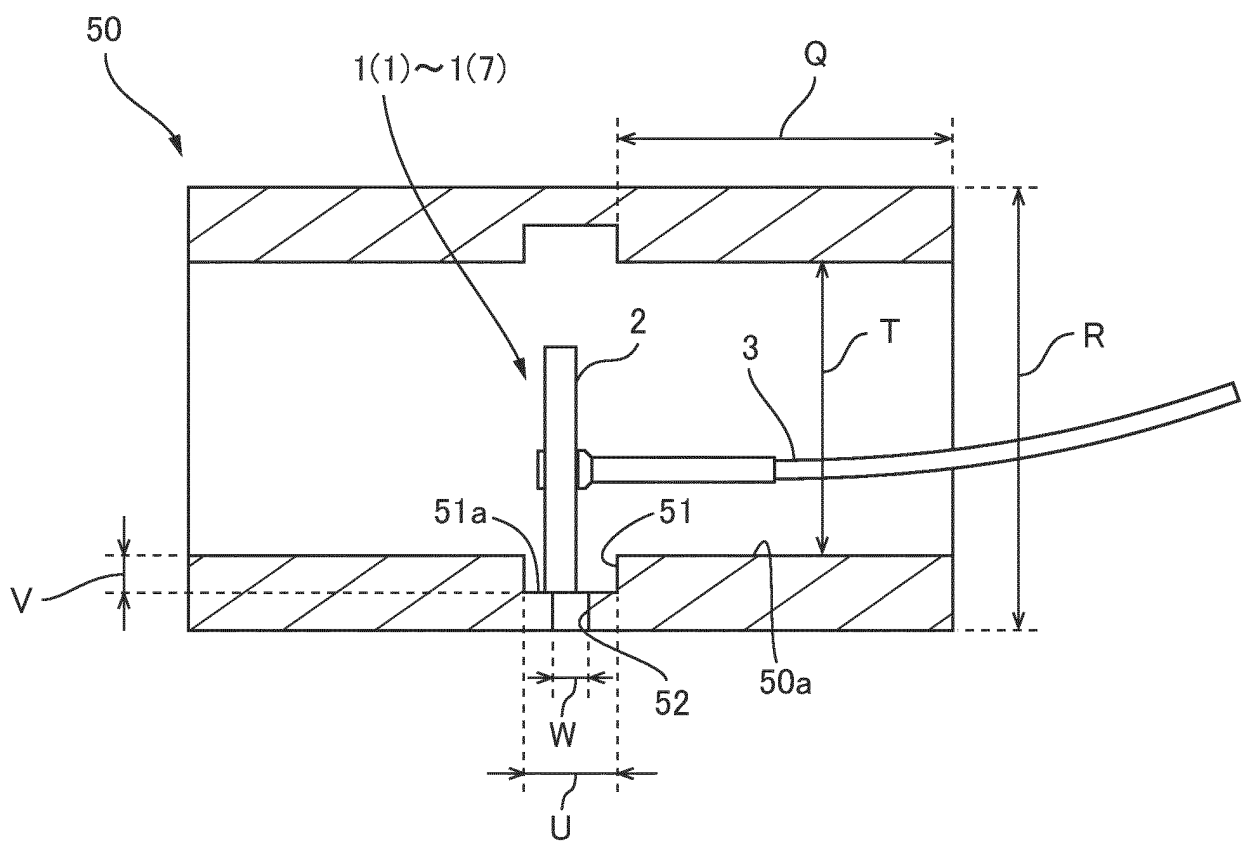


FIG.9

	Stiffness [N/mm]	The evaluator 1	The evaluator 2	The evaluator 3
The shafted grinder1(1)	0.2	×	×	×
The shafted grinder1(2)	0.4	○	○	○
The shafted grinder1(3)	5	○	○	○
The shafted grinder1(4)	10	○	○	○
The shafted grinder1(5)	100	○	○	○
The shafted grinder1(6)	110	○	○	○
The shafted grinder1(7)	120	○	○	○

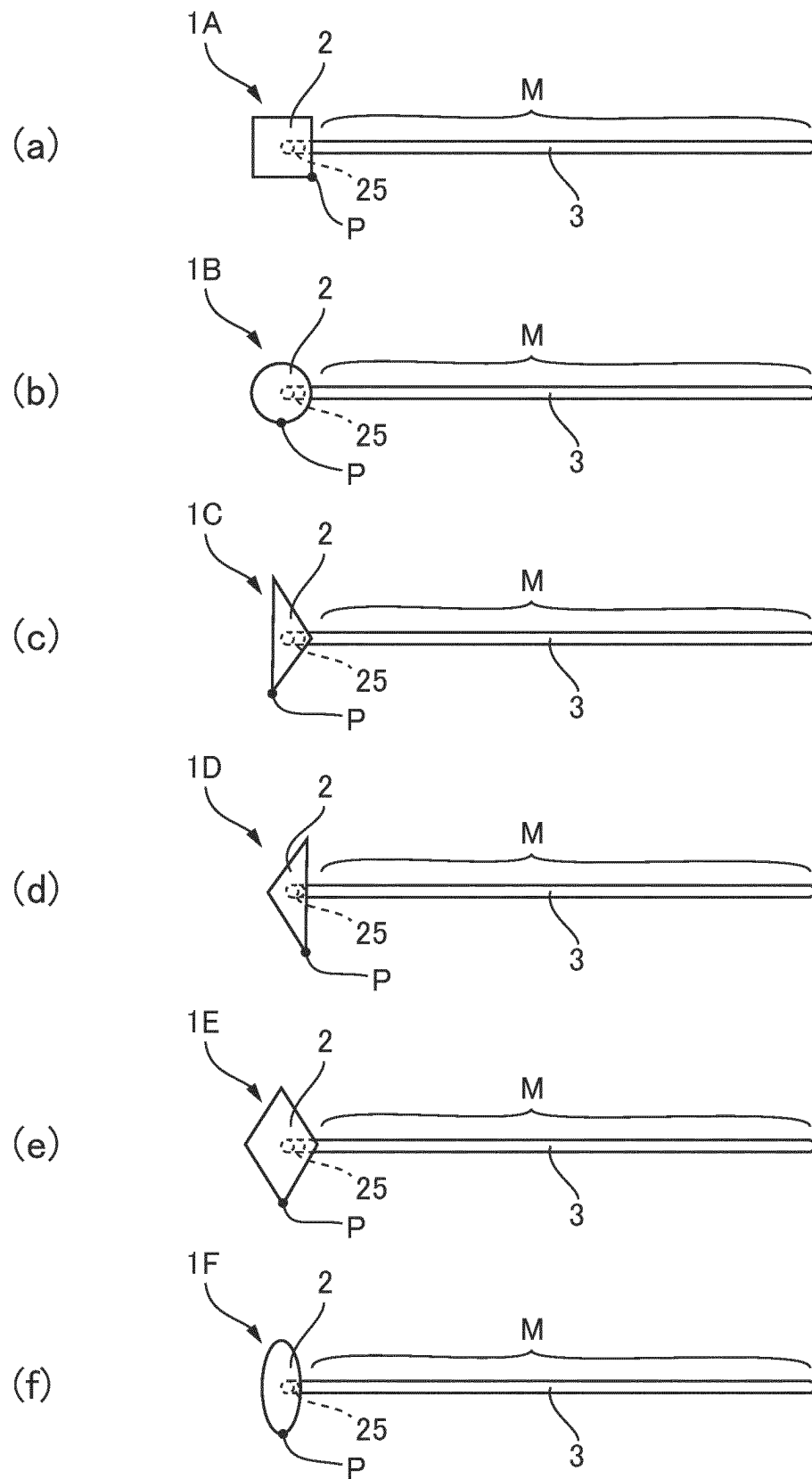
FIG.10

	Stiffness [N/mm]	The evaluator 1	The evaluator 2	The evaluator 3
The shafted grinder1(1)	0.2	○	○	○
The shafted grinder1(2)	0.4	○	○	○
The shafted grinder1(3)	5	○	○	○
The shafted grinder1(4)	10	○	○	○
The shafted grinder1(5)	100	○	○	○
The shafted grinder1(6)	110	○	×	×
The shafted grinder1(7)	120	×	×	×

FIG.11

	Stiffness [N/mm]	The evaluator 1	The evaluator 2	The evaluator 3
The shafted grinder1(1)	0.2	×	×	×
The shafted grinder1(2)	0.4	○	○	○
The shafted grinder1(3)	5	○	○	○
The shafted grinder1(4)	10	○	○	○
The shafted grinder1(5)	100	○	○	○
The shafted grinder1(6)	110	○	○	○
The shafted grinder1(7)	120	○	○	○

FIG.12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/026223

A. CLASSIFICATION OF SUBJECT MATTER

B24B 23/02(2006.01)i; **B24D 3/00**(2006.01)i; **B24D 3/28**(2006.01)i; **B24D 5/02**(2006.01)i; **B24D 5/16**(2006.01)i;
B25F 5/00(2006.01)i

FI: B24B23/02; B24D3/00 310Z; B24D3/28; B24D5/02 Z; B24D5/16; B25F5/00 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)

B24B23/02; B24D3/00; B24D3/28; B24D5/02; B24D5/16; B25F5/00

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 1971-2022
 Registered utility model specifications of Japan 1996-2022
 Published registered utility model applications of Japan 1994-2022

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 2006-035414 A (XEBEC TECHNOLOGY CO., LTD.) 09 February 2006 (2006-02-09) entire text, all drawings	1-11
A	JP 3688368 B2 (HILTI AG) 24 August 2005 (2005-08-24) entire text, all drawings	1-8
A	JP 5427613 B2 (3M INNOVATIVE PROPERTIES CO.) 26 February 2014 (2014-02-26) entire text, all drawings	1-11

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

* Special categories of cited documents:

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“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

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“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

07 September 2022

Date of mailing of the international search report

20 September 2022

Name and mailing address of the ISA/JP

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 Japan**

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2022/026223

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2006-035414 A	09 February 2006	(Family: none)	
JP 3688368 B2	24 August 2005	US 5733074 A entire text, all drawings EP 720890 A1 DE 4444853 A1	
JP 5427613 B2	26 February 2014	US 2008/0233845 A1 entire text, all drawings WO 2008/116043 A2 entire text, all drawings KR 10-2009-0121365 A CN 101641183 A KR 10-2015-0104219 A	

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2006035414 A [0004]