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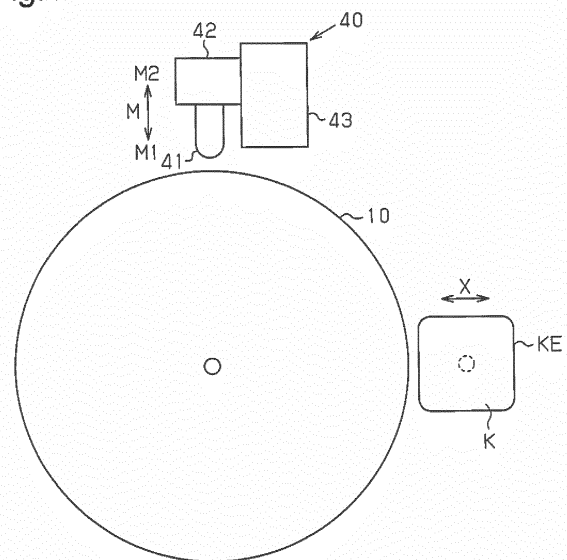
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(54) **POLISHING DEVICE, PROCESSING METHOD OF POLISHING MEMBER, MODIFICATION METHOD OF POLISHING MEMBER, SHAPE PROCESSING CUTTING TOOL, AND SURFACE MODIFICATION TOOL**

(57) It is an objective of the present invention to provide a polishing device that allows shape processing and shape modification to be easily performed on a polishing surface having a non-planar shape. The polishing device includes a polishing member (10), a tool (41), and a contact mechanism (40). The polishing member (10) includes a polishing surface that is shaped in conformance with the shape of an end (KE) of a workpiece (K). The tool (41) functions as a shape-processing cutting tool or a surface modifying tool that has the same shape as the shape of the end (KE). The shape-processing cutting tool processes the polishing surface of the polishing member (10) to be shaped in conformance with the shape of the end (KE). The surface modifying tool modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished. The contact mechanism (40) brings the tool (41) into contact with the polishing surface of the polishing member (10).

Fig.1



Description

TECHNICAL FIELD

[0001] The present invention relates to a polishing device, a method for processing a polishing member, a method for modifying the polishing member, a shape-processing cutting tool, and a surface modifying tool.

BACKGROUND ART

[0002] Patent document 1 describes that when a portion to be polished of a workpiece (object to be polished) is polished with a polishing member, the shape of a polishing surface of the polishing member gradually changes. Generally, dressing is performed to modify the polishing surface and return it to its original shape.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0003] Patent Document 1: Japanese Laid-Open Patent Publication No. 11-188590

SUMMARY OF THE INVENTION

PROBLEMS THAT ARE TO BE SOLVED BY THE INVENTION

[0004] In the prior art, dressing is often performed to modify a planar polishing surface. Little consideration is made to the dressing of polishing surfaces having various shapes in conformance with the shapes of portions to be polished of workpieces.

[0005] The present invention is made in view of such circumstances, and its objective is to provide a polishing device, a method for processing a polishing member, and a method for modifying the polishing member that allow shape processing and shape modification to be easily performed on a polishing surface having a non-planar shape. Also, it is an object of the present invention to provide a shape-processing cutting tool used in the polishing device or the processing method to process the shape of the polishing surface or a surface modifying tool used in the polishing device or the modification method to modify the polishing surface to be shaped in conformance with the shape of a portion to be polished.

MEANS FOR SOLVING THE PROBLEM

[0006] To solve the above problem, a polishing device includes a polishing member, a shape-processing cutting tool or a surface modifying tool, and a contact mechanism. The polishing member includes a polishing surface that is shaped in conformance with the shape of a portion to be polished of a workpiece. The shape-processing tool has the same shape as the portion to be polished and

processes the polishing surface to be shaped in conformance with the shape of the portion to be polished. The surface modifying tool has the same shape as the portion to be polished and modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished. The contact mechanism brings the shape-processing cutting tool or the surface modifying tool into contact with the polishing surface.

[0007] In this configuration, the polishing member includes a polishing surface that is shaped in conformance with the shape of a portion to be polished of a workpiece. Thus, the portion to be polished of the workpiece can be polished even when having a non-planar shape, for example, a curved surface or a triangular shape.

[0008] In this configuration, the contact mechanism brings a shape-processing cutting tool or a surface modifying tool into contact with the polishing surface. The shape-processing cutting tool has the same shape as the portion to be polished and processes the polishing surface to be shaped in conformance with the shape of the portion to be polished. The surface modifying tool has the same shape as the portion to be polished and modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished. Thus, the polishing surface, which is in contact with the shape-processing cutting tool or the surface modifying tool, copies the shape of the shape-processing cutting tool or the surface modifying tool that has the same shape as the portion to be polished of the workpiece. This processes or modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished of the workpiece. Although the polishing surface of the polishing member is shaped in conformance with the shape of the portion to be polished of the workpiece, the shape of the polishing surface and the shape of each of the shape-processing cutting tool and the surface modifying tool have the relationship in which one is concave and the other is convex. This allows the shape of the polishing surface having a non-planar shape to be easily processed or modified.

[0009] The portion to be polished of the workpiece and the shape-processing cutting tool or the surface modifying tool do not need to have exactly the same shape as each other and may have slightly different shapes from each other as long as no practical problem occurs.

[0010] The shape-processing cutting tool is configured to process the polishing surface of the polishing member and is not particularly limited as long as it includes a processing portion having higher hardness than the polishing surface of the polishing member. Specific examples include a processing tool including fixed abrasive grains, such as pellets or an electrode position whetstone, and a cutting tool, such as an end mill or a bit.

[0011] The surface modifying tool is configured to adjust the surface of the polishing member and to remove grime or deposition from the surface of the polishing member. Specific examples include a processing tool including fixed abrasive grains and a hard brush.

[0012] In the polishing device, the contact mechanism brings the shape-processing cutting tool or the surface modifying tool into contact with the polishing surface preferably in predetermined cycles. In this configuration, the polishing surface is processed or modified in each predetermined cycle. This appropriately maintains the accuracy for polishing the workpiece.

[0013] In the polishing device, it is preferable that through a process of bringing a surface of the polishing member that differs in shape from the portion to be polished into contact with the shape-processing cutting tool or the surface modifying tool, the polishing surface of the polishing member be formed to be shaped in conformance with the shape of the portion to be polished.

[0014] In this configuration, forming the polishing surface to be shaped in conformance with the shape of the portion to be polished of the workpiece is performed in the polishing device. Thus, the shape of the polishing surface may be formed with high accuracy compared to when the polishing member including the polishing surface that is formed in advance in conformance with the shape of the portion to be polished of the workpiece is coupled to the polishing device.

[0015] The polishing device preferably includes a motor that rotates the polishing member from below. The polishing device preferably includes a base including an upper surface. When the polishing member is located on the upper surface, the base is rotated integrally with the polishing member. These configurations obtain stable rotation of the polishing member with a small axial run-out and allows for polishing to be performed with higher accuracy.

[0016] When the polishing device includes a shape-processing cutting tool that has the same shape as the portion to be polished and processes the polishing surface to be shaped in conformance with the shape of the portion to be polished or a surface modifying tool that has the same shape as the portion to be polished and modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished, the shape of the polishing surface having a non-planar shape can be easily processed or modified.

[0017] To solve the above problem, a method for processing or modifying a polishing member includes bringing a shape-processing cutting tool or a surface modifying tool into contact with a polishing surface of the polishing member. The polishing surface is shaped in conformance with the shape of a portion to be polished of a workpiece. The shape-processing cutting tool has the same shape as the portion to be polished and processes the polishing surface to be shaped in conformance with the shape of the portion to be polished. The surface modifying tool has the same shape as the portion to be polished and modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished.

[0018] In this method, the polishing member is prepared that includes a polishing surface shaped in con-

formance with the shape of a portion to be polished of a workpiece. Thus, the portion to be polished of the workpiece can be polished even when having a non-planar shape, for example, a curved surface or a triangular shape.

[0019] In this method, the shape-processing cutting tool, which has the same shape as the portion to be polished and processes the polishing surface to be shaped in conformance with the shape of the portion to be polished, or the surface modifying tool, which has the same shape as the portion to be polished and modifies the polishing surface to be shaped in conformance with the portion to be polished, is brought into contact with the polishing surface. Thus, the polishing surface, which is in contact with the shape-processing cutting tool or the surface modifying tool, copies the shape of the shape-processing cutting tool or the surface modifying tool that has the same shape as the portion to be polished of the workpiece. This modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished of the workpiece. Although the polishing surface of the polishing member is shaped in conformance with the shape of the portion to be polished of the workpiece, the shape of the polishing surface and the shape of each of the shape-processing cutting tool and the surface modifying tool have the relationship in which one is concave and the other is convex. This allows the shape of the polishing surface having a non-planar shape to be easily modified.

EFFECT OF THE INVENTION

[0020] The present invention succeeds in facilitating shape processing or shape modification of a polishing surface having a non-planar shape.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

Fig. 1 is a schematic plan view showing the structure of a polishing device according to one embodiment.

Fig. 2 is a schematic side view showing the structure of the polishing device of the embodiment.

Fig. 3 is a partial side view showing the polishing device of the embodiment when a shape-processing cutting tool or a surface modifying tool is in contact with a polishing member.

Fig. 4 is a partial side view showing the polishing device of the embodiment when the shape-processing cutting tool or the surface modifying tool is separated from the polishing member.

Fig. 5 is a schematic plan view showing the structure of a polishing device according to a modified example of the embodiment.

Fig. 6 is a side view showing the structure of a shape-processing cutting tool according to another modified example of the embodiment.

Fig. 7(A) is a side view showing the structure of a shape-processing cutting tool according to another modified example of the embodiment.

Fig. 7(B) is a cross-sectional view taken along line C-C.

Fig. 8 is a side view showing the structure of a surface modifying tool according to another modified example of the embodiment.

Fig. 9 is a side view showing the operation of a contact mechanism according to another modified example of the embodiment.

Fig. 10 is a side view showing the operation of the contact mechanism according to the modified example shown in Fig. 9.

Fig. 11 is a side view showing the operation of the contact mechanism according to the modified example shown in Fig. 9.

Fig. 12 is a perspective view showing a rod according to another modified example of the embodiment.

Fig. 13 is a plan view showing a polishing member according to the modified example shown in Fig. 12.

Fig. 14 is a side view showing a polishing member according to another modified example of the embodiment.

Fig. 15 is a plan view showing the polishing member according to the modified example shown in Fig. 14.

Fig. 16 is a side cross-sectional view showing the polishing member according to the modified example shown in Fig. 14.

Fig. 17 is a partial side view showing a workpiece and a polishing member according to another modified example of the embodiment.

Fig. 18 is a partial side view showing a workpiece and a polishing member according to another modified example of the embodiment.

Fig. 19 is a partial side view showing a workpiece and a polishing member according to another modified example of the embodiment.

Fig. 20 is a partial side view showing a workpiece and a polishing member according to another modified example of the embodiment.

Fig. 21 is a partial side view showing a workpiece and a polishing member according to another modified example of the embodiment.

Fig. 22 is a partial side view showing a polishing member according to another modified example of the embodiment.

Fig. 23 is a partial side view showing the polishing member according to the modified example shown in Fig. 22.

MODES FOR CARRYING OUT THE INVENTION

[0022] A polishing device, a method for modifying a polishing member, a shape-processing cutting tool, and a surface modifying tool according to one embodiment of the present invention will now be described with reference to Figs. 1 to 4.

[0023] As shown in Fig. 1, the polishing device includes a discoid polishing member 10. The polishing member 10 includes a radially outer circumferential surface that is used to polish an end KE of a workpiece K, which is a portion to be polished. The end KE is machined in advance to have a curved surface. The workpiece K may have any shape, for example, in accordance with its application.

[0024] Any optimal material for polishing the end KE may be used for the polishing member 10. For example, when a resin is used as the material of the polishing member 10, any synthetic resin may be used. Examples of such a synthetic resin include a thermosetting resin (phenol resin, epoxy resin, urethane resin, polyimide, etc.) and a thermoplastic resin (polyethylene, polypropylene, acrylic resin, polyamide, polycarbonate, etc.). Alternatively, a cloth, a non-woven fabric, a resin processed non-woven fabric, synthetic leather, or a composite thereof may be used. The polishing surface of the polishing member 10 preferably has a Shore A hardness of 5 or greater. When a polishing member 10 having a shore A hardness of 5 or greater, which is subject to hardness measurement, is left for 60 minutes or longer in a dry condition where the humidity is 20% to 60% under room temperature, the hardness of the polishing surface of the polishing member is then measured with a durometer (type A) that is compliance with JIS K6253, and the measured value is 5 or greater. When the Shore A hardness is 5 or greater, the surface of the workpiece K can be polished in a preferred manner. Further, deformation of the polishing surface of the polishing member 10 can be reduced that would be caused by polishing performed within a short period of time.

[0025] The Shore A hardness of the polishing surface of the polishing member 10 is preferably 40 or greater, more preferably 70 to 95, and particularly preferably 70 to 85.

[0026] When a metal is used as the material of the polishing member 10, magnesium, aluminum, titanium, iron, nickel, cobalt copper, zinc, manganese, or an alloy of which the main component is any of these metals may be used.

[0027] When a resin or a metal is used as the material of the polishing member 10, the polishing member 10 may include abrasive grains. The kind of the used abrasive grains is not particularly limited and may be metal oxide particles of silicon oxide, aluminum oxide, zirconium oxide, cerium oxide, magnesium oxide, calcium oxide, titanium oxide, manganese oxide, iron oxide, or chromium oxide; a carbide, such as silicon carbide; a nitride; a boride; or a diamond.

[0028] When a ceramic is used as the material of the polishing member 10, any of ceramics and glass; any of an oxide, nitride, boride, and carbide of silicon, aluminum, zirconium, calcium, and barium; or any of aluminum oxide, zirconium oxide, silicon oxide, silicon carbide, silicon nitride, and boron nitride may be used.

[0029] Further, any material may be used for the work-

piece K. For example, when a resin is used as the material of the workpiece K, any synthetic resin may be used. Examples of such a synthetic resin include a thermosetting resin (phenol resin, epoxy resin, urethane resin, polyimide, etc.) and a thermoplastic resin (polyethylene, polypropylene, acrylic resin, polyamide, polycarbonate, etc.).

[0030] When a ceramic is used as the material of the workpiece K, any of ceramics, glass, and fine ceramics; any of an oxide, carbide, nitride, and boride of silicon, aluminum, zirconium, calcium, and barium may be used.

[0031] When a metal is used as the material of the workpiece K, magnesium, aluminum, titanium, iron, nickel, cobalt, copper, zinc, manganese, or an alloy of which the main component is any of these metals may be used.

[0032] The workpiece K may be used for any purpose. For example, the workpiece K may be used as a wheel, a shaft, a container, a casing (for example, case and housing), a frame, a ball, a wire, an ornament, or the like.

[0033] As shown in Fig. 2, the polishing member 10 is fixed to the upper surface of a discoid base 20 in a removable manner. The lower surface of the base 20 includes a center portion that is fixed to a rotation shaft of a first motor 21. When the first motor 21 is driven to be rotated, the base 20 and the polishing member 10 rotate. The first motor 21 is located below the polishing member 10 and the base 20. The polishing member 10, which is located on the upper surface of the base 20, is rotated together with the base 20 from below. This obtains stable rotation of the polishing member 10 with a small axial run-out and allows for polishing to be performed with higher accuracy.

[0034] The radially outer circumferential surface of the polishing member 10 includes a polishing surface 11, which is a curved grooved surface that circumferentially extends. The curvature of the polishing surface 11 is shaped in conformance with the shape of the end KE of the workpiece K (shape of portion to be polished). More specifically, the polishing surface 11 and the end KE have the same curvature.

[0035] The workpiece K is held by a fixing seat 32 in a removable manner. The fixing seat 32 is fixed to a rotation shaft 31 of a second motor 30. The second motor 30 is coupled to a motor moving mechanism 33 that reciprocates the second motor 30 in directions orthogonal to a rotation axis of the polishing member 10 (directions of arrows X shown in Figs. 1 and 2). When the motor moving mechanism 33 moves the second motor 30, the second motor 30, the rotation shaft 31, the fixing seat 32, and the workpiece K are integrally move in the directions orthogonal to the rotation axis of the polishing member 10. Such movement of the second motor 30 caused by the motor moving mechanism 33 presses the end KE of the workpiece K against the polishing surface 11. Then, a contact portion of the end KE and the polishing surface 11 is appropriately supplied with, for example, a processing liquid, and each of the first motor 21 and the second motor 30 is driven at a predetermined rotation speed. This polishes the end KE having the curved surface.

When pressing the end KE of the workpiece K against the polishing surface 11, the pressing force is adjusted so that predetermined pressure is applied.

[0036] The processing liquid may be directly supplied to the contact portion of the end KE and the polishing surface 11 from the outer side. Alternatively, a processing liquid supply mechanism such as a rotary joint may be arranged in a portion that connects the polishing member 10 and the first motor 21. When the processing liquid supply mechanism supplies the processing liquid into the polishing member 10, the processing liquid may be supplied from the polishing member 10 to the contact portion through a supply passage formed in the polishing member 10. When supplied from the inside of the polishing member 10 toward the contact portion, the processing liquid may be further efficiently supplied. Additionally, to efficiently use the processing liquid, it is further preferable that a cover be arranged around the polishing member 10 and that a collection device be provided to increase the efficiency for collecting the processing liquid.

[0037] A suitable kind of the processing liquid may be used in accordance with the material of the workpiece K to be polished and the polishing member 10. Specifically, a cutting liquid, grinding liquid, a lapping material, a polishing agent, or a chemical mechanical polishing liquid may be used. The processing liquid may include abrasive grains. The kind of the used abrasive grains is not particularly limited and may be metal oxide particles of silicon oxide, aluminum oxide, zirconium oxide, cerium oxide, magnesium oxide, calcium oxide, titanium oxide, manganese oxide, iron oxide, or chromium oxide; a carbide, such as silicon carbide; a nitride; a boride; or a diamond.

[0038] For example, the amount of the abrasive grains contained in the processing liquid is preferably 1 mass percent or greater, and more preferably 2 mass percent or greater. The amount of the abrasive grains contained in the processing liquid is also preferably 50 mass percent or less, and more preferably 40 mass percent or less.

[0039] The abrasive grains in the processing liquid have an average secondary particle diameter of preferably 0.1 μm or greater, and more preferably 0.3 μm or greater. As the average secondary particle diameter of the abrasive grains increases, the processing liquid improves the processing speed.

[0040] Additionally, the average secondary particle diameter of the abrasive grains in the processing liquid is preferably 20 μm or less, and more preferably 5 μm or less. As the average secondary particle diameter of the abrasive grains decreases in the processing liquid, the surface of the workpiece K can be further evenly polished. The average secondary particle diameter of the abrasive grains is a volume average particle diameter that is measured with a laser diffraction/scattering particle size distribution measurement instrument, such as "LA-950" manufactured by HORIBA, Ltd.

[0041] When necessary, the processing liquid may include another component such as a pH adjuster, an etching agent, an oxidant, a water-soluble polymer, a copol-

mer and a salt and derivative thereof, an anticorrosive, a chelating agent, a dispersant aid, an antiseptic, or a fungicide

[0042] For example, a known acid, base, or a salt of them may be used as the pH adjuster. Examples of such an acid that can be used as the pH adjuster include an inorganic acid, such as hydrochloric acid, sulfuric acid, nitric acid, hydrofluoric acid, boric acid, carbonic acid, hypophosphorous acid, phosphorous acid, or phosphoric acid; and an organic acid, such as formic acid, acetic acid, propionic acid, butyric acid, valeric acid, 2-methylbutyric acid, n-hexanoic acid, 3,3-dimethylbutyric acid, 2-ethylbutyric acid, 4-methylpentanoic acid, n-heptanoic acid, 2-methylhexanoic acid, n-octanoic acid, 2-ethylhexanoic acid, benzoic acid, glycolic acid, salicylic acid, glyceric acid, oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, maleic acid, phthalic acid, malic acid, tartaric acid, citric acid, lactic acid, diglycolic acid, 2-furancarboxylic acid, 2,5-furandicarboxylic acid, 3-furancarboxylic acid, 2-tetrahydrofurancarboxylic acid, methoxyacetic acid, methoxyphenylacetic acid, or phenoxycetic acid.

[0043] Examples of such a base that can be used as the pH adjuster include an amine, such as aliphatic amine or aromatic amine; an organic base, such as quaternary ammonium hydroxide; an alkali metal hydroxide, such as potassium hydroxide; an alkaline earth metal hydroxide; and ammonia.

[0044] Instead of the above acid or in combination with the above acid, a salt of the above acid, such as an ammonium salt or an alkali metal salt, may be used as the pH adjuster. Such a pH adjuster is used to adjust the pH value of the processing liquid to the optimal value, which differs in accordance with the kind of the workpiece K to be polished.

[0045] Examples of the etching agent include an inorganic acid, such as nitric acid, sulfuric acid, or phosphoric acid; an organic acid, such as acetic acid, citric acid, tartaric acid, or methanesulfonic acid; an inorganic alkali, such as potassium hydroxide or sodium hydroxide; and an organic alkali, such as ammonia, amine, or quaternary ammonium hydroxide.

[0046] Examples of the oxidant include hydrogen peroxide, peracetic acid, a percarbonate, urea peroxide, a perchlorate, a persulfate, an oxoacid, such as sulfuric acid, nitric acid, or phosphoric acid, and a salt of the oxoacid.

[0047] Examples of the water-soluble polymer, the copolymer and the salt and derivative thereof include a polycarboxylic acid, such as a polyacrylate; a polysulfonic acid, such as polyphosphonic acid or polystyrenesulfonic acid; a polysaccharide, such as xanthan gum or sodium alginate; a cellulose derivative, such as hydroxyethyl cellulose or carboxymethyl cellulose; polyethylene glycol; polyvinyl alcohol; polyvinylpyrrolidone; sorbitan monooleate; an oxyalkylene-based polymer having one or more kinds of oxyalkylene unit; a non-ionic surfactant; and an anionic surfactant. Examples of the non-ionic sur-

factant include polyoxyethylene alkylether, polyoxyethylene alkylphenylether, sorbitan monooleate, and an oxyalkylene-based polymer having one or more kinds of oxyalkylene unit. Examples of the anionic surfactant include an alkylsulfonic acid-based compound, an alkylbenzenesulfonic acid-based compound, an alkyl-naphthalenesulfonic acid-based compound, a methyltaurine acid-based compound, an alkyl-diphenyletherdisulfonic acid-based compound, an α -olefinsulfonic acid-based compound, a naphthalenesulfonic acid condensate, and a sulfosuccinic acid diester-based compound.

[0048] Examples of the anticorrosive include a monocyclic compound, a polycyclic compound having a condensed ring, and heterocyclic compound, such as an amine, a pyridine, a tetraphenylphosphonium salt, a benzotriazole, a triazole, a tetrazole, or benzoic acid.

[0049] Examples of the chelating agent include a carboxylic acid-based chelating agent, such as gluconic acid; an amine-based chelating agent, such as ethylenediamine, diethylenetriamine, or trimethyltetraamine; polyaminopolycarbon-based chelating agent, such as ethylenediaminetetraacetic acid, nitrilotriacetic acid, hydroxyethylethylenediaminetriacetic acid, triethylenetetraminehexaacetic acid, or diethylenetriaminepentaacetic acid; an organic phosphonic acid-based chelating agent, such as 2-aminoethylphosphonic acid, 1-hydroxyethylidene-1,1-diphosphonic acid, aminotri(methylenephosphonic acid), ethylenediaminetetrakis(methylenephosphonic acid), diethylenetriaminepenta(methylenephosphonic acid), ethane-1,1,1-diphosphonic acid, ethane-1,1,2-triphosphonic acid, methanediolhydroxyphosphonic acid, or 1-phosphonobutan-2,3,4-tricarboxylic acid; a phenol derivative; and 1,3-diketone.

[0050] Examples of the dispersant aid include a condensed phosphate, such as pyrophosphate or hexametaphosphate.

[0051] Examples of the antiseptic include sodium hypochlorite.

[0052] Examples of the fungicide include an oxazoline, such as oxazolidine-2,5-dione.

[0053] When the diameter of the polishing member 10 is maximized within a range in which the polishing accuracy is appropriately maintained, ends KE of workpieces K may be simultaneously polished with the circumferential surface of the polishing member 10. This improves the productivity. Additionally, the maximum diameter of the polishing member 10 increases the linear velocity of the polishing member 10 at the outer circumference even when the rotation speed of the polishing member 10 is the same. This obtains the sufficient linear velocity for the polishing even when the rotation speed of the polishing member 10 is relatively decreased. Thus, for example, dispersion of the processing liquid may be reduced.

[0054] As shown in Fig. 1, a contact mechanism 40 is located at a position that is proximate to the radially outer circumferential surface of the polishing member 10 and opposed to the polishing surface 11.

[0055] The contact mechanism 40 includes a tool 41. The tool 41 is rod-shaped and includes a distal processing portion. The processing portion is shaped in conformance with the shape of the end KE and, more specifically, has the same curvature as the end KE. The tool 41 functions as a shape-processing cutting tool that processes the polishing surface 11 to be shaped in conformance with the shape of the end KE or a surface modifying tool that modifies the polishing surface 11 to be shaped in conformance with the shape of the end KE. An optimal material for processing or modifying the polishing surface 11 is selected for the tool 41. The end KE of the workpiece K to be polished and the tool 41 do not need to have exactly the same shape as each other and may have slightly different shapes from each other as long as no practical problem occurs.

[0056] The contact mechanism 40 also includes a holder 42, to which the tool 41 is fixed in a removable manner, and a moving mechanism 43 that reciprocates the holder 42 in directions (directions of arrows M shown in Fig. 1) orthogonal to the rotation axis of the polishing member 10. The drive source of the moving mechanism 43 may be electric power or hydraulic pressure. The moving mechanism 43 may be automatically driven by a controller including, for example, a CPU, a RAM, and a ROM or may be driven, for example, when the operator of the polishing device operates a switch.

[0057] Figs. 3 and 4 show the operation of the contact mechanism 40.

[0058] As shown in Fig. 3, when the contact mechanism 40 moves the holder 42 toward the rotation center of the polishing member 10 (in direction of arrow M1), the tool 41 contacts the polishing surface 11. More specifically, the tool 41 is pressed against the polishing surface 11.

[0059] When pressing the tool 41 against the polishing surface 11, a constant pressure processing can be performed. However, a constant dimension processing (constant dimension cutting) is more preferable. In the constant pressure processing, which is mainly used to improve surface roughness, the tool 41 is pressed against the polishing surface 11 at a constant pressing force when polishing. In the constant dimension processing, which is mainly used to finish the shape, the tool 41 is cut into the polishing surface 11 by a constant dimension. The constant dimension processing, which is suitable for the shape finishing, is suitable when modifying or processing the shape of the polishing surface 11 with the tool 41. Thus, the shape may be further accurately modified or processed compared to the constant pressure processing.

[0060] The constant pressure processing may be performed when modifying or processing the shape of the polishing surface 11 with the tool 41. In this case, the processing may be performed, for example, to improve the accuracy of the surface roughness of the workpiece K, and is suitable mainly when the tool 41 is the surface modifying tool and modifies the polishing surface 11.

[0061] As shown in Fig. 4, when the contact mechanism 40 moves the holder 42 in a direction (direction of arrow M2) separated away from the rotation center of the polishing member 10, the tool 41 is separated away from the polishing surface 11.

[0062] The tool 41 is normally located in a position separated from the polishing surface 11 as shown in Fig. 4. While the polishing member 10 is driven to be rotated, the tool 41 is moved to the position shown in Fig. 3, where the tool 41 contacts the polishing surface 11, in each predetermined cycle, for example, when an accumulated value of polishing time exceeds a predetermined value or when the operator operates a switch.

[0063] When the tool 41 is in contact with the polishing surface 11, it is preferred that water or the processing liquid be supplied to the contact portion of the tool 41 and the polishing surface 11. This helps the processing or modification of the polishing surface 11 performed by the tool 41 and cools the contact portion.

[0064] Any appropriate kind of the used processing liquid may be selected in accordance with the kind of the shape-processing cutting tool or the surface modifying tool or the material of the polishing member. For example, when a cutting tool is used, a processing liquid for cutting may be applied. When a processing tool including fixed abrasive grains is used, a processing liquid for grinding may be applied. When a hard brush is used, for example, a cleaning liquid may be applied.

[0065] The present embodiment has the advantages described below.

(1) The polishing device includes a polishing member 10 having a polishing surface 11 shaped in conformance with the shape of an end KE of a workpiece K to be polished. Thus, even when the end KE of the workpiece K has a non-planar surface, or a curved surface, the end KE can be polished.

(2) The polishing device includes a tool 41 and a contact mechanism 40. The tool 41, which has the same shape as the end KE, modifies or processes the polishing surface 11 to be shaped in conformance with the shape of the end KE. The contact mechanism 40 brings the tool 41 into contact with the polishing surface 11. Thus, as shown in Fig. 3, when in contact with the tool 41, the polishing surface 11 copies the shape of the tool 41, which has the same curvature as the shape of the end KE of the workpiece K. This modifies or processes the polishing surface 11 to be shaped in conformance with the shape of the end KE of the workpiece K.

[0066] The polishing surface 11 of the polishing member 10 is shaped in conformance with the shape of the end KE of the workpiece K. However, the shape of the polishing surface 11 and the shape of the tool 41 have the relationship in which one is concave and the other is convex. This allows the shape processing or shape mod-

ification to be easily performed on the polishing surface 11 that is non-planar, or curved.

(3) The contact mechanism 40 brings the tool 41 into contact with the polishing surface 11 in each predetermined cycle. Thus, the polishing surface 11 is modified in each predetermined cycle. This maintains the accuracy for polishing the end KE of the workpiece K for a long time.

[0067] The above embodiment may be modified as follows.

- The tool 41 may modify the polishing surface 11 during an interval between the polishing of the workpiece K. Alternatively, the tool 41 may modify the polishing surface 11 at the same time as when polishing the workpiece K for the entire time or a partial time of polishing.
- The shape-processing cutting tool is configured to process the polishing surface of the polishing member and is not particularly limited as long as it includes a processing portion having higher hardness than the polishing surface of the polishing member. Specific examples include a processing tool including fixed abrasive grains, such as pellets or an electrodeposition whetstones, and a cutting tool, such as an end mill or a bit.

[0068] When the electrodeposition whetstone is used, the abrasive grains may fall off when grinding the polishing surface 11 of the polishing member 10. This may damage the surface of the workpiece K. One needs to pay attention to such damages particularly when grinding the polishing surface 11 with the electrodeposition whetstone during the polishing of the workpiece K with the polishing member 10. In this regard, the surface of the electrodeposition whetstone may be coated with a hard layer, for example, diamond-like carbon (DLC). This limits fall-off of the abrasive grains and damages such as that describe above.

- The surface modifying tool is configured to adjust the surface of the polishing member and to remove grime or deposition from the surface of the polishing member. Specific examples include a processing tool including fixed abrasive grains and a hard brush.
- As shown in Fig. 5, a rotary cutter may be used as the tool 41, which functions as the shape-processing cutting tool or the surface modifying tool. The rotary cutter includes an outer circumferential blade that has the same shape as the end KE of the workpiece K to be polished and modifies the polishing surface 11 to be shaped in conformance with the shape of the end KE.

[0069] Fig. 5 shows the schematic structure of this modified example of the polishing device. As shown in Fig. 5, a contact mechanism 60 is located at a position that is proximate to the radially outer circumference surface of the polishing member 10 and opposed to the polishing surface 11. The contact mechanism 60 includes a cutter 50 such as that described above and a moving mechanism that reciprocates a rotation axis of the cutter 50 in directions (directions of arrows M shown in Fig. 5) orthogonal to the rotation axis of the polishing member 10. When the contact mechanism 60 moves the cutter 50 toward the rotation center of the polishing member 10 (in direction of arrow M1), the blade of the cutter 50 contacts the polishing surface 11 as indicated by the double-dashed line shown in Fig. 5. When the contact mechanism 60 moves the cutter 50 in a direction separated away from the rotation center of the polishing member 10 (in direction of arrow M2), the blade of the cutter 50 is separated from the polishing surface 11. In this modified example, the shape of the polishing surface 11 and the shape of the blade of the cutter 50 also have the relationship in which one is concave and the other is convex. This allows for the easy shape modification of the polishing surface 11 that is non-planar, or curved.

- A tool other than the tool 41 may be used as the tool functioning as the shape-processing cutting tool or the surface modifying tool. Such modified examples will now be described below.

[0070] Fig. 6 shows a tubular shape-processing cutting tool 200 including a plurality of cutting blades 210 that axially extend and are circumferentially arranged at intervals. The shape-processing cutting tool 200 includes a distal portion 210a in which the external shape of the cutting blades 210 has the same curvature as the end KE. When the shape-processing cutting tool 200 is used instead of the tool 41, the distal portion 210a comes in contact with the polishing surface 11 as the shape-processing cutting tool 200 rotates. This processes the polishing surface 11 of the polishing member 10 to be shaped in conformance with the shape of the end KE.

[0071] Figs. 7(A) and 7(B) show a flat shape-processing cutting tool 300 that includes a round cutting blade having the same curvature as the end KE defining a distal portion 310. As shown in Fig. 7(B), the shape-processing cutting tool 300 is thinned toward the distal portion 310. When the shape-processing cutting tool 300 is used instead of the tool 41, the distal portion 310 comes in contact with the polishing surface 11 as the shape-processing cutting tool 300 rotates. This processes the polishing surface 11 of the polishing member 10 to be shaped in conformance with the shape of the end KE. A plurality of flat shape-processing cutting tools 300 may be combined. The flat shape-processing cutting tools 300 may be combined so that the flat shape-processing cutting tools 300 intersect with one another at a predetermined angle, such as 60° or 90°.

[0072] Fig. 8 shows a tubular surface modifying tool 400 including a distal hard brush 410. The distal shape of the brush 410 is semispherical as a whole. The semispherical shape has substantially the same curvature as the end KE. When the surface modifying tool 400 is used instead of the tool 41, the brush 410 comes in contact with the polishing surface 11 as the surface modifying tool 400 rotates. This modifies the polishing surface 11 of the polishing member 10 to be shaped in conformance with the shape of the end KE.

- In the above embodiment, the polishing member 10 that is provided in advance with the curved polishing surface 11 is fixed to the base 20. However, the polishing surface 11 may be formed using the shape-processing cutting tool. Thus, when a polishing member that is not shaped in conformance with the shape of the shape of a portion to be polished is prepared, the shape-processing cutting tool may be used to form a polishing surface in conformance with the shape of the portion to be polished of the workpiece. For example, as shown in Figs. 9 to 11, the tool 41 may contact the circumferential surface of a polishing member 10A that differs in shape from the end KE of the workpiece K to be polished and form the polishing surface 11 in conformance with the shape of the end KE.

[0073] More specifically, as shown in Fig. 9, the polishing member 10A having a flat radially outer circumferential surface is fixed to the base 20. As shown in Fig. 10, when the contact mechanism 40 moves the holder 42 toward the rotation center of the polishing member 10A (in direction of arrow M1), the tool 41 contacts the radially outer circumferential surface of the polishing member 10A. More specifically, the tool 41 is pressed against the radially outer circumferential surface of the polishing member 10A. The pressing of the tool 41 forms the polishing surface 11 in the flat outer circumferential surface of the polishing member 10A. When forming the polishing surface 11, it is also desirable to supply the processing liquid. After the polishing surface 11 is formed, as shown in Fig. 11, the contact mechanism 40 moves the holder 42 in a direction separated away from the rotation center of the polishing member 10A (in direction of arrow M2) to separate the tool 41 away from the polishing surface 11.

[0074] In this modified example, forming the polishing surface 11 to be shaped in conformance with the shape of the end KE of the workpiece K is performed in the polishing device. Thus, the shape of the polishing surface 11 may be formed with high accuracy compared to when the polishing member 10 including the polishing surface 11 that is formed in advance in conformance with the shape of the end KE of the workpiece K is coupled to the polishing device. This eliminates the task for preparing the polishing member 10 that includes the polishing surface 11 in advance.

- As shown in Fig. 12, a straight rod 70 includes a longitudinal side surface including a polishing surface 71. The polishing surface 71 and the polishing surface 11 have similar shapes. Any material may be selected as the material of the rod 70. It is preferable to use, for example, a material that is easily bent such as a synthetic resin or brass.

[0075] As shown in Fig. 13, the rod 70 is wound around a disk 80 so that the polishing surface 71 is opposed outward, and the wound rod 70 is fixed to the disk 80 in an appropriate manner. This forms a polishing member including the rod 70 and the disk 80. A polishing member that is similar to the polishing member 10 is also formed through such a manner. Any material may be selected for the disk 80. For example, a metal or ceramic may be used. However, the material is preferred to be as light as possible.

[0076] In the modified example shown in Figs. 12 and 13, after the polishing surface 71 is formed in the rod 70, the rod 70 is wound around the disk 80. Instead, for example, after the straight rod 70 is wound around the disk 80, the polishing surface 71 may be formed in the rod 70.

[0077] In these modified examples, for example, when the polishing surface 71 has worn, only the rod 70 including the polishing surface 71 may be replaced. This reduces the replacement cost compared to the polishing member 10. When polishing workpieces K each having a different shape of a portion to be polished, the different shapes of the portions to be polished may be easily coped with by replacing the rod 70.

- As shown in Fig. 14, a discoid polishing member 90 includes a radially outer circumferential surface including a curved surface 91 that circumferentially extends and is similar to the polishing surface 11. The curved surface 91 may be applied or coated with a different member to form a polishing surface. As shown in Figs. 15 and 16, for example, a tape-like non-woven fabric 100, which will serve as a polishing surface, may be applied to the curved surface 91 formed in the radially outer circumferential surface of the polishing member 90. In this case, the polishing surface may be renewed by replacing the non-woven fabric 100. Thus, it is preferred that a material having relatively high durability, for example, a metal such as stainless steel be used as the material of the polishing member 90. However, any material may be selected for the polishing member 90. For example, when the polishing member 90 is formed from a metal, the curved surface 91 may undergo resin-coating to serve as a polishing surface.

- The polishing member 10 is located on the upper surface of the base 20. However, the base 20 may be omitted, and the rotation shaft of the first motor 21 may be directly fixed to the center of the polishing member 10.

- When the motor moving mechanism 33 is driven, the end KE is pressed against the polishing surface 11. Instead, another mechanism for pressing the end KE against the polishing surface 11 may be included.
- Instead of rotating the polishing member 10, the polishing member 10 may be linearly reciprocated.
- The end KE of the workpiece K is polished. However, the portion to be polished is not limited to such an end and may be a different portion.
- The end KE of the workpiece K to be polished may have a non-planar shape other than a curved surface. For example, as shown in Fig. 17, the shape may be a triangle. Alternatively, as shown in Fig. 18, the shape may be a triangle with a round peak. Additionally, the end KE of the workpiece K to be polished may have the form of steps as shown in Fig. 19 or the form of steps with round corners as shown in Fig. 20. Additionally, as shown in Fig. 21, the end KE may be recessed inward in the workpiece K. Further, a curve surface may have a plurality of curvatures or partially have a straight portion. In such modified examples, when the polishing surface 11 of the polishing member 10 is shaped in conformance with the shape of the end KE of the workpiece K (shape of portion to be polished), the end KE may be polished.
- As shown in Fig. 2, in the embodiment, when the workpiece K is pressed against the polishing surface 11 in the direction orthogonal to the rotation axis of the polishing member 10 (direction of arrow X shown in Fig. 2), the end KE of the workpiece K is polished. In this case, the pressed end KE is polished. However, the upper and lower surfaces of the workpiece K, that is, two surfaces of the workpiece K that are parallel to the planar orthogonal to the rotation axis of the polishing member 10, do not receive much pressure when being polished and may fail to be sufficiently polished.

[0078] In this regard, the polishing member 10 is formed from a material such as a resin that has elasticity to a certain extent and elastically deforms. Then, as shown in Fig. 22, the width H1 of the polishing surface 11 in a direction parallel to the rotation axis of the polishing member 10 (direction of arrow Y in Fig. 22) is set less than the thickness T1 of the workpiece K prior to the processing (i.e., length between upper surface KU and lower surface KD of workpiece K) by a predetermined amount α . Such an example, in which the polishing member 10 is formed by an elastic body and the polishing surface 11 is smaller in shape than the workpiece K to be polished, has the advantages described below.

[0079] As shown in Fig. 23, in this modified example, when the workpiece K is polished as being pressed

against the polishing member 10, pressing force F is applied to the upper surface KU and the lower surface KD of the workpiece K from the polishing member 10 that is elastically deformed by the predetermined amount α .

5 This obtains an advantage such that when polishing the workpiece K, not only the end KE but also the upper surface KU and the lower surface KD are polished at the same time. As the predetermined amount α becomes larger, the elastic deformation amount of the polishing member 10 increases when polishing the workpiece K. Thus, the optimization of the predetermined amount α optimizes the pressing force F applied to the upper surface KU and the lower surface KD of the workpiece K to be polished.

10 **[0080]** When force pressing the end KE of the workpiece K against the polishing surface 11 and the pressing force F applied to the upper surface KU and the lower surface KD of the workpiece K are adjusted as necessary, the workpiece K may be appropriately processed.

DESCRIPTION OF REFERENCE CHARACTERS

[0081] 10, 10A, 90: polishing member; 11: polishing surface; 20: base; 21: first motor; 30: second motor; 31: rotation shaft; 32: fixing seat; 33: motor moving mechanism; 40: contact mechanism; 41: tool; 42: holder; 43: moving mechanism; 50: cutter; 60: contact mechanism; 70: rod; 71: polishing surface; 80: disk; 91: curved surface; 100: non-woven fabric; 200: shape-processing cutting tool; 210: cutting blade; 210a: distal portion; 300: shape-processing cutting tool; 310: distal portion; 400: surface modifying tool; 410: brush; K: workpiece to be polished; KE: end (of workpiece); KU: upper surface (of workpiece); KD: lower surface (of workpiece).

Claims

1. A polishing device comprising:

a polishing member including a polishing surface that is shaped in conformance with the shape of a portion to be polished of a workpiece; a shape-processing cutting tool or a surface modifying tool having the same shape as the portion to be polished, wherein the shape-processing tool processes the polishing surface to be shaped in conformance with the shape of the portion to be polished, and the surface modifying tool modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished; and a contact mechanism that brings the shape-processing cutting tool or the surface modifying tool into contact with the polishing surface.

2. The polishing device according to claim 1, wherein the contact mechanism brings the shape-processing

cutting tool or the surface modifying tool into contact with the polishing surface in predetermined cycles.

3. The polishing device according to claim 1 or 2, wherein through a process of bringing a surface of the polishing member that differs in shape from the portion to be polished into contact with the shape-processing cutting tool or the surface modifying tool, the polishing surface of the polishing member is formed to be shaped in conformance with the shape of the portion to be polished. 5
4. The polishing device according to any one of claims 1 to 3, further comprising: 10
 - a motor that rotates the polishing member from below. 15
5. The polishing device according to any one of claims 1 to 4, further comprising: 20
 - a base including an upper surface, wherein when the polishing member is located on the upper surface, the base is rotated integrally with the polishing member. 25
6. A shape-processing cutting tool that is a member used in the polishing device according to any one of claims 1 to 5, wherein the shape-processing cutting tool has the same shape as the portion to be polished, and the shape-processing cutting tool processes the polishing surface to be shaped in conformance with the shape of the portion to be polished. 30
7. A surface modifying tool that is a member used in the polishing device according to any one of claims 1 to 5, wherein the surface modifying tool has the same shape as the portion to be polished, and the surface modifying tool modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished. 35
8. A method for processing a polishing member, the method comprising: 40
 - bringing a shape-processing cutting tool into contact with a polishing surface of the polishing member, wherein 50
 - the polishing surface is shaped in conformance with the shape of a portion to be polished of a workpiece, and
 - the shape-processing cutting tool has the same shape as the portion to be polished and processes the polishing surface to be shaped in conformance with the shape of the portion to be polished. 55

9. A method for modifying a polishing member, the method comprising:

bringing a surface modifying tool into contact with a polishing surface of the polishing member, wherein the polishing surface is shaped in conformance with the shape of a portion to be polished of a workpiece, and the surface modifying tool has the same shape as the portion to be polished and modifies the polishing surface to be shaped in conformance with the shape of the portion to be polished.

Fig.1

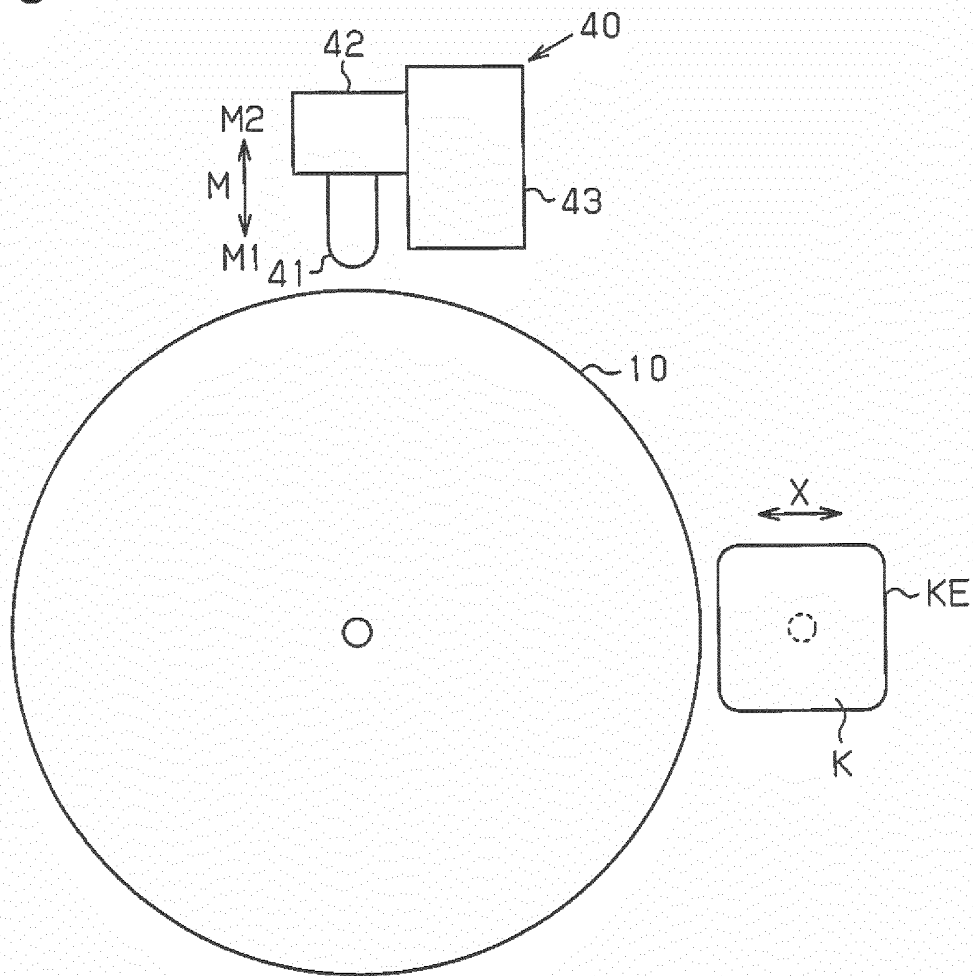


Fig.2

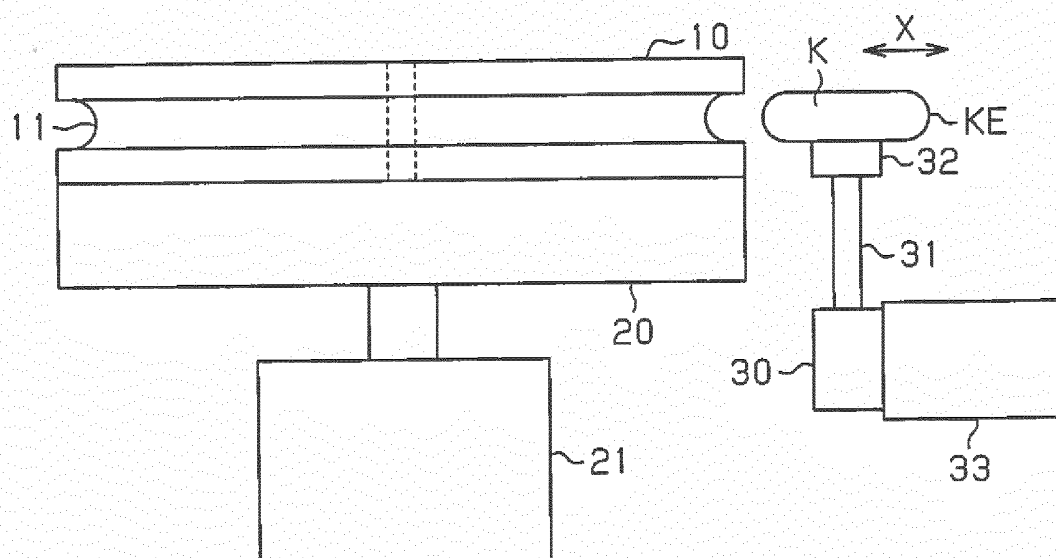


Fig.3

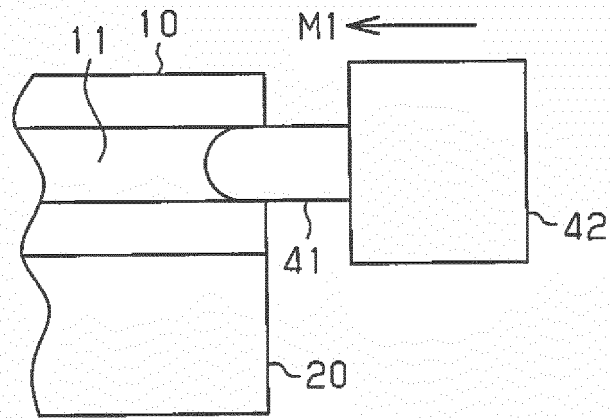


Fig.4

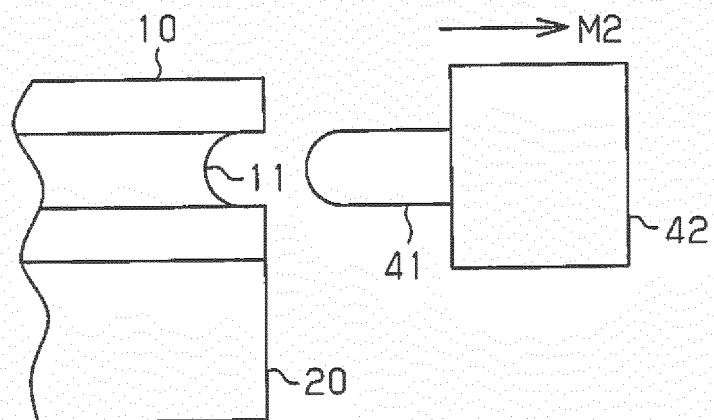


Fig.5

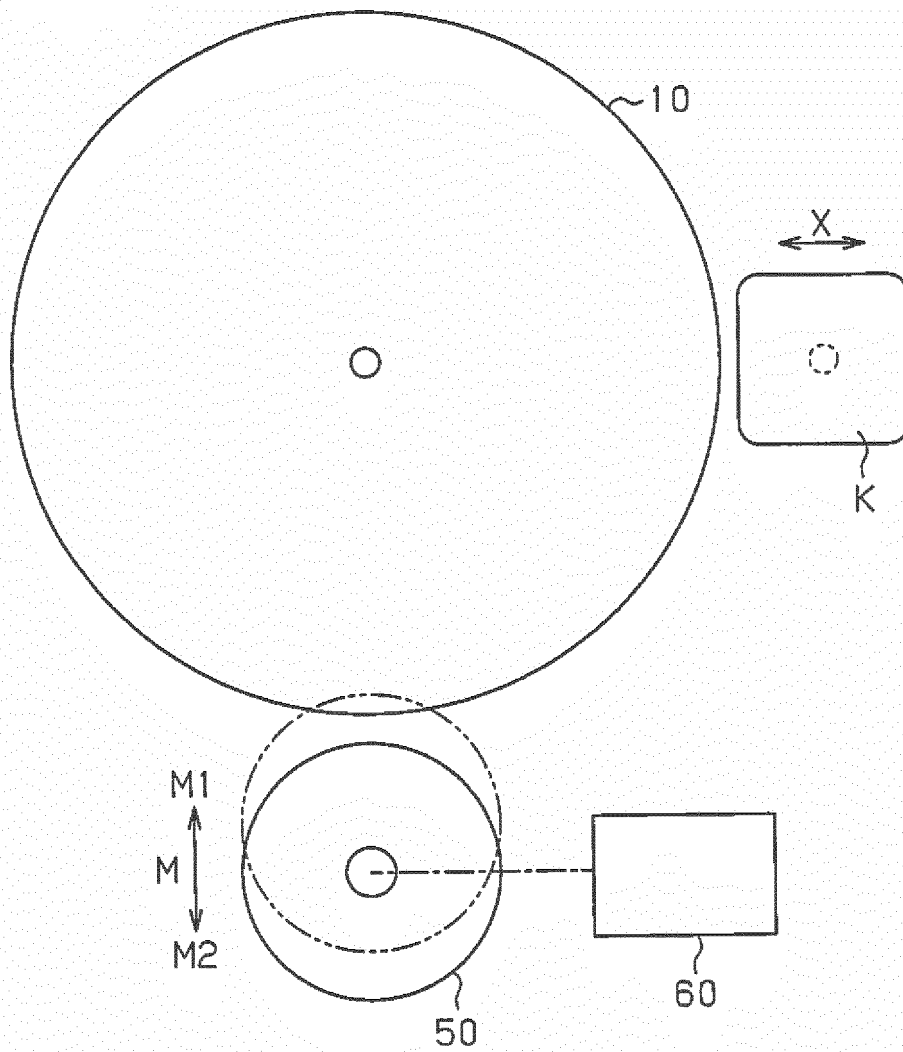


Fig.6

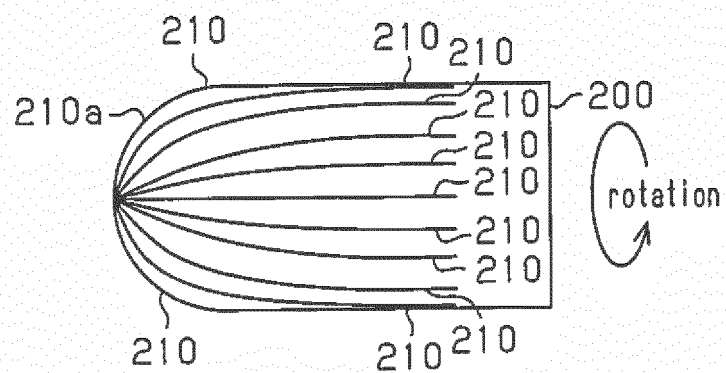


Fig.7(A)

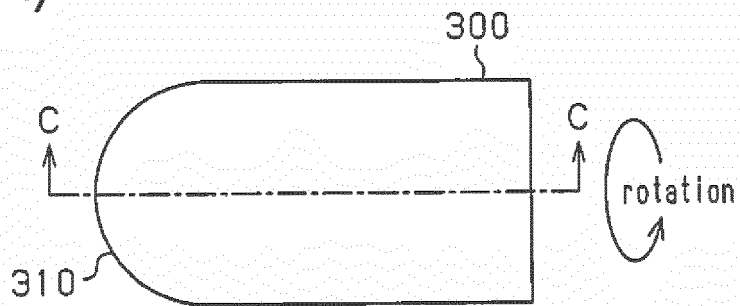


Fig.7(B)

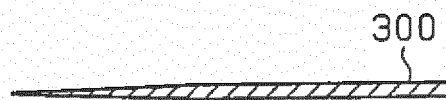


Fig.8

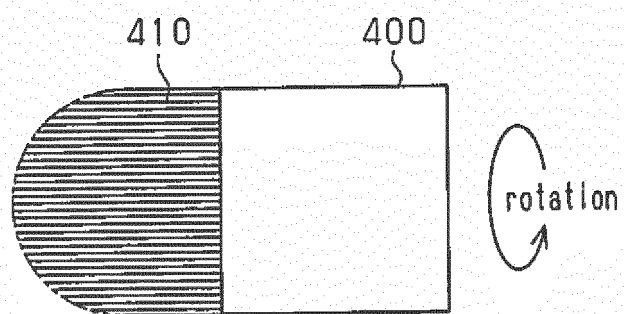


Fig.9

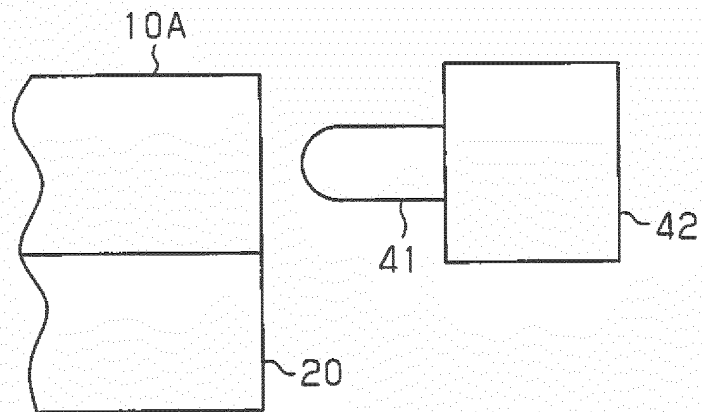


Fig.10

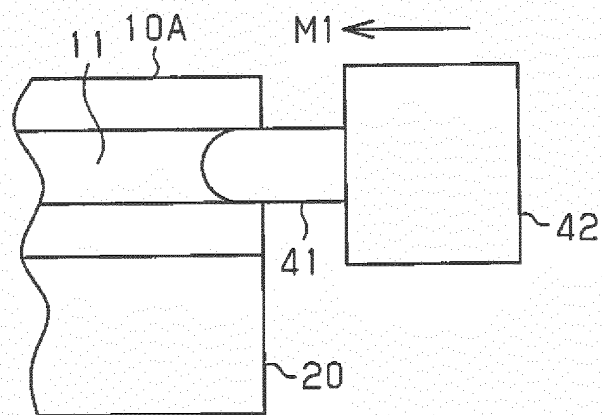


Fig.11

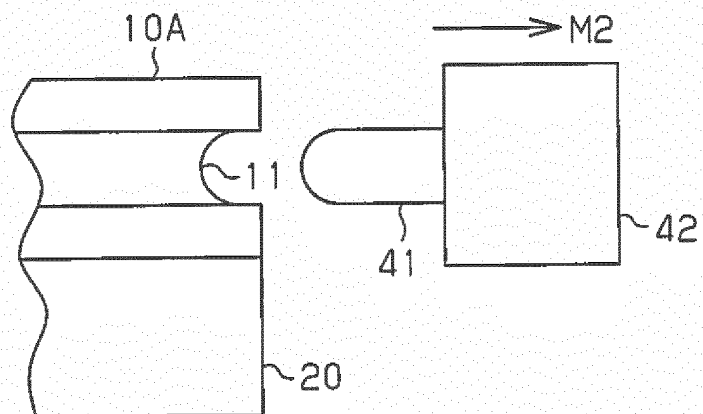


Fig.12

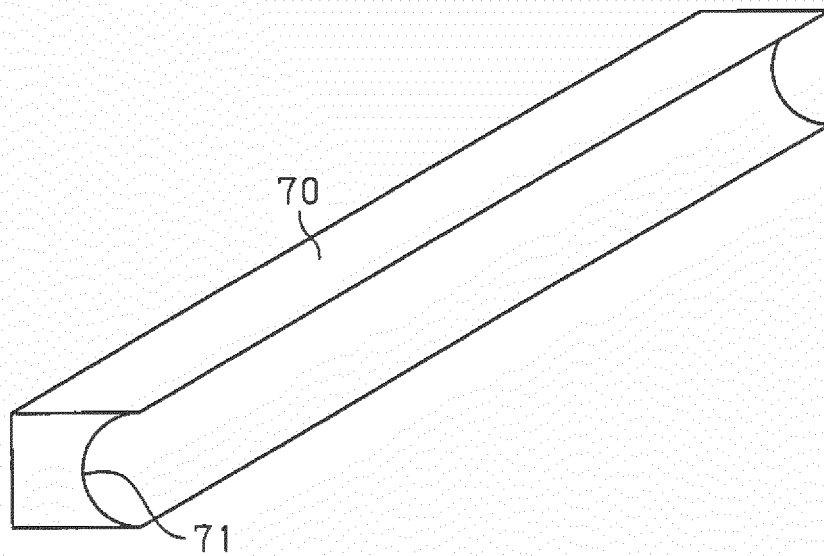


Fig.13

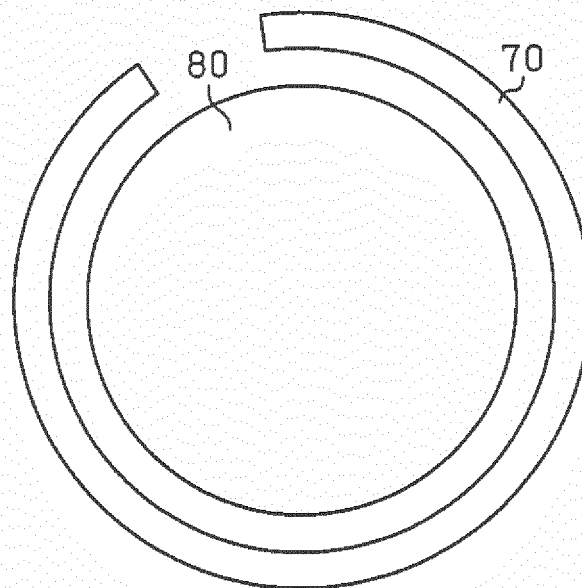


Fig.14

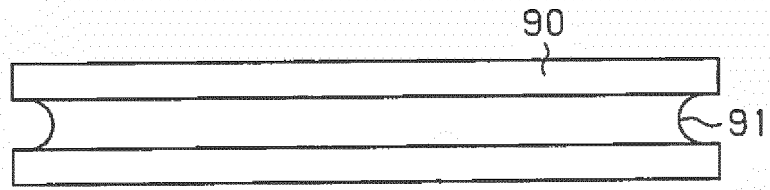


Fig.15

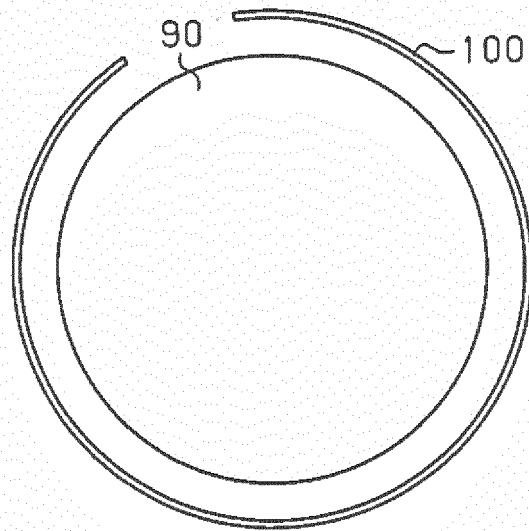


Fig.16

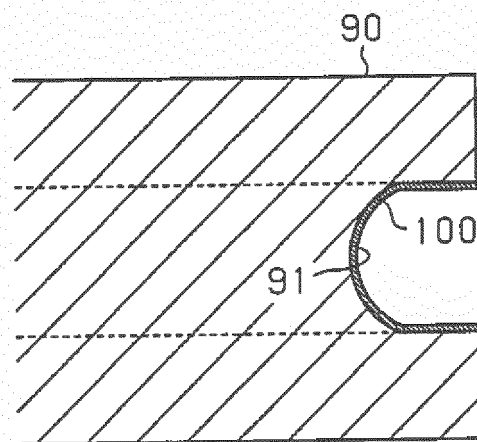


Fig.17

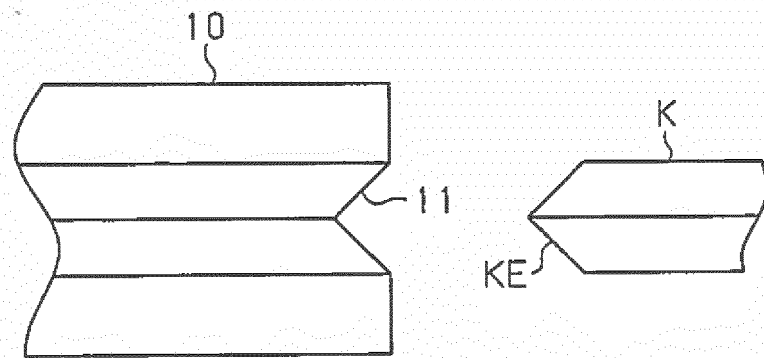


Fig.18

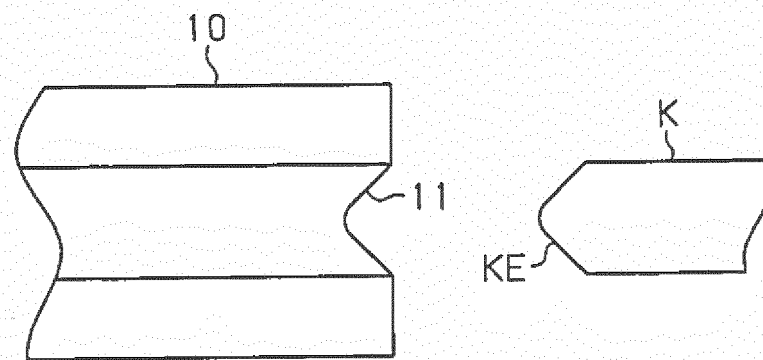


Fig.19

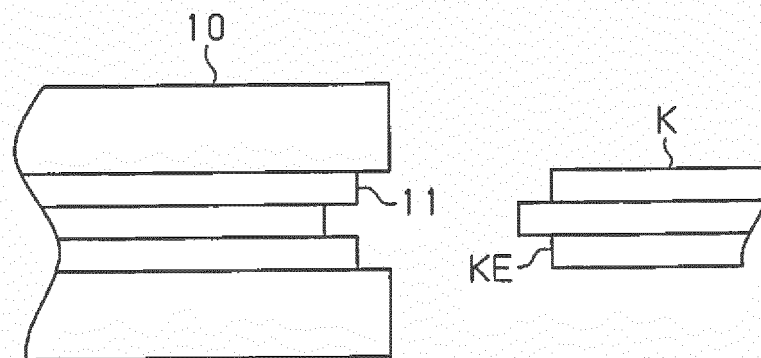


Fig.20

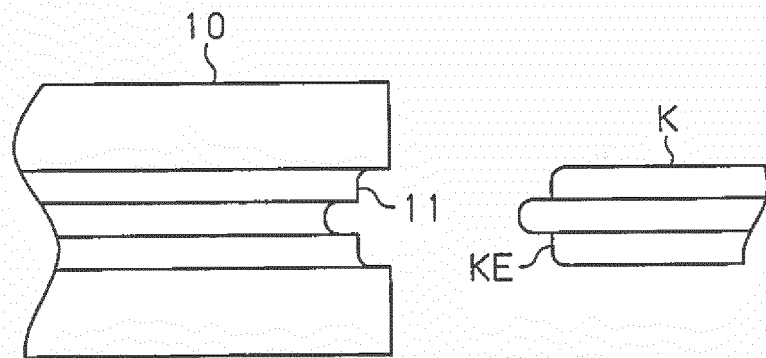


Fig.21

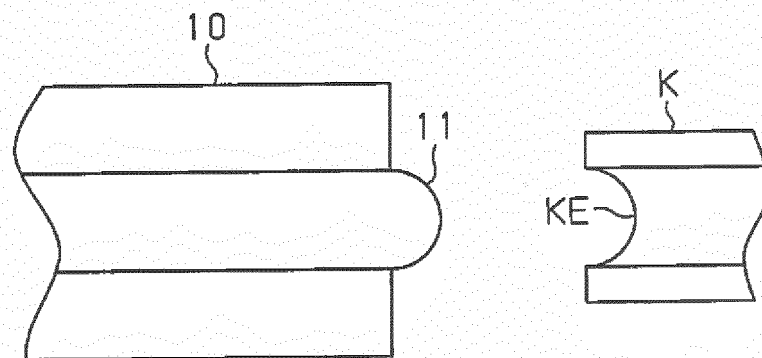


Fig.22

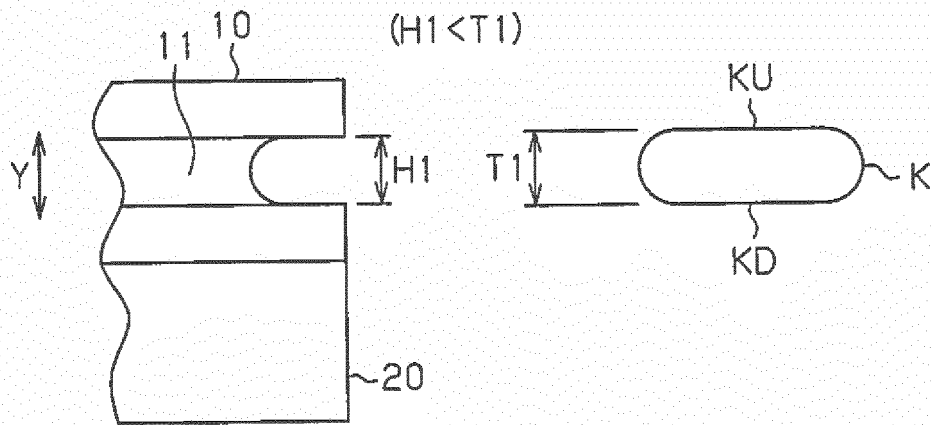
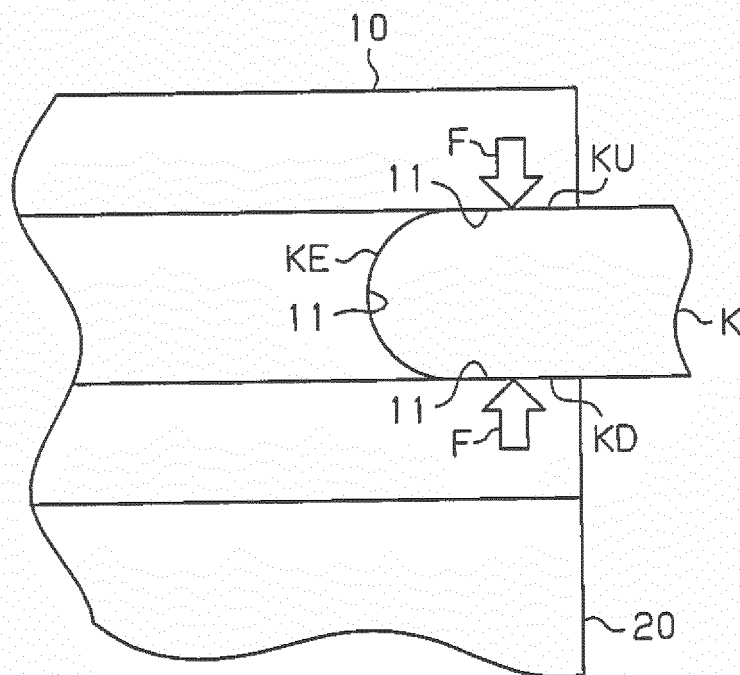


Fig.23



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/076359

A. CLASSIFICATION OF SUBJECT MATTER

B24B53/07(2006.01)i, B24B53/02(2012.01)i

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)

B24B53/07, B24B53/02

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 1996-2014

Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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.
X Y	JP 2001-121391 A (Canon Inc.), 08 May 2001 (08.05.2001), paragraphs [0002] to [0015]; fig. 1 to 3 (Family: none)	1, 3-9 2
Y	JP 2010-173016 A (Mitsubishi Materials Corp.), 12 August 2010 (12.08.2010), paragraph [0003] (Family: none)	2
Y	JP 2010-182813 A (Noritake Super Abrasive Co., Ltd.), 19 August 2010 (19.08.2010), paragraph [0004] (Family: none)	2

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

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"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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"&" document member of the same patent family

Date of the actual completion of the international search

29 October, 2014 (29.10.14)

Date of mailing of the international search report

11 November, 2014 (11.11.14)

Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2014/076359

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-165712 A (Shin-Etsu Handotai Co., Ltd.), 28 June 2007 (28.06.2007), paragraphs [0019] to [0029]; fig. 2 to 5 & US 2009/0163119 A1 & WO 2007/069629 A1 & KR 10-2008-0076934 A	1-9
A	JP 2005-340732 A (Disco Inc.), 08 December 2005 (08.12.2005), paragraphs [0013] to [0017]; fig. 1 to 3 (Family: none)	1-9

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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