(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 583 789 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.04.2013 Bulletin 2013/17

(51) Int Cl.:
B24B 13/01 *(2006.01)* ***B24D 3/28*** *(2006.01)*

(21) Application number: **12189234.3**

(22) Date of filing: **19.10.2012**

(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

(30) Priority: **21.10.2011 JP 2011231364**

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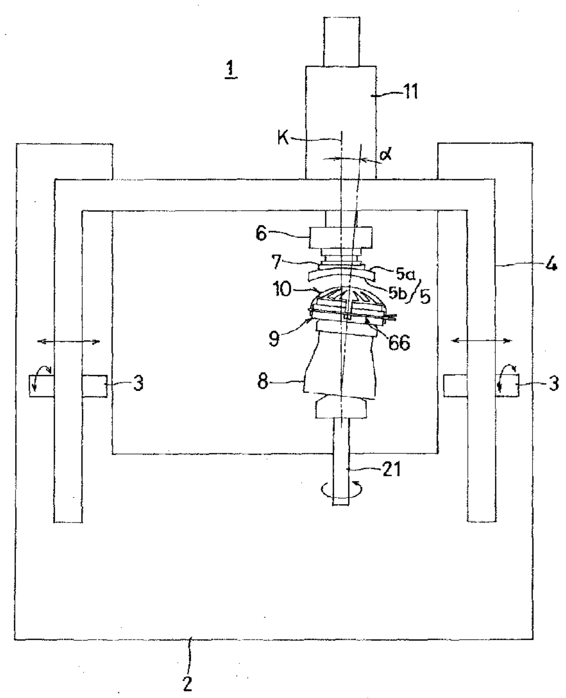
(54) Polishing tool for plastic lens, polishing method of plastic lens and method for manufacturing plastic lens

(57) To provide a polishing tool for a plastic lens, a method of polishing a plastic lens and a method of manufacturing a plastic lens, capable of suppressing a deterioration of a polishing efficiency while reducing a cost required for treating a polishing waste liquid generated during polishing applied to the plastic lens, wherein the polishing tool is used for adjusting and completing an optical surface of the plastic lens, and is composed of a single layer in which abrasive grains made of crystalline alumina are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability.

FIG. 1



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Description

BACKGROUND

Technical Field

[0001] The present invention relates to a polishing tool for a plastic lens, a method of polishing a plastic lens and a method of manufacturing a plastic lens.

Description of Related Art

[0002] In recent years, a plastic lens using a resin material is frequently used instead of a glass lens. This is because there are advantages that the plastic lens is lighter than the glass lens and is hardly cracked, and can be easily molded. Such a plastic lens is widely used in an optical field, and is used particularly as a spectacle lens, owing to having the aforementioned advantages.

[0003] Conventionally, when an edging is applied to the resin material that constitutes the plastic lens for spectacles, a curve generating edging (called CG-edging hereafter) for performing a spherical surface edging, a toric surface edging, and a free curved surface edging, is performed as a cutting/machining method. A step of performing such an edging is also called a rough cutting step.

[0004] The aforementioned CG-edging is a method of relatively disposing a diamond tool at a position where a desired form can be created over the resin material being a material to be machined, and creating a spherical surface form, a toric surface form, and a free curved surface form, while relatively moving both of the tool and the resin material.

[0005] Mechanical polishing is applied to the CG-edged resin material (called a plastic lens hereafter), using a polyurethane polishing pad, a non-woven polishing pad, and loose abrasives, and abrasive machining (for example, rough polishing and final polishing) is applied to the plastic lens, to adjust and complete an optical surface. Then, a desired optical surface is finally formed over the plastic lens, to thereby obtain a finished product of the plastic lens. Such an abrasive machining is simply called "polishing" or "polish" hereafter, and a mixture in which abrasive grains are mixed into a polishing liquid (slurry) is called "loose abrasives" hereafter.

[0006] As a polishing method called here, a method using an elastic polishing tool is proposed. As a method using the elastic polishing tool, a polishing method using a balloon-type polishing tool is known, as shown in patent document 1 for example.

[0007] In the aforementioned method, a pressurized gas is sent to an inside of the balloon-type polishing tool, with a polishing pad installed on an uppermost surface, so that the balloon-type polishing tool is inflated by an inner pressure, and a curvature is changed by changing the inner pressure, to thereby obtain the curvature in accord with a curved form of a polished surface, and polishing is applied to this surface. Therefore, this method can cope with a plurality of polished surfaces using one kind of balloon-type polishing tool, because it is possible to comply with the curvature of a concave surface.

[0008] Incidentally, when polishing is performed using the aforementioned balloon-type polishing tool, the abrasive grains are usually used. In patent document 1 mentioned above, a liquid polishing agent (abrasive material) in which abrasive grains such as aluminum oxide and diamond powder are dispersed in a polishing liquid, is used for the plastic lens.

[0009] Patent document 2 describes a technique of arranging a plurality of abrasive composite materials in which abrasive grains such as aluminum oxide are fixed to a binder, when polishing is applied to the plastic lens. Hereafter, the abrasive grains used in patent document 2 are called "fixed abrasive grains", and the abrasive grains fixed to a foam in an embodiment as will be described later are also called the "fixed abrasive grains".

Patent documents

[0010]

Patent document 1: Japanese Patent No.4681024
Patent document 2: Japanese Patent Laid Open Publication No.1995-186030

[0011] First, as the abrasive grains used for polishing (such as rough polishing and final polishing) after CG-edging, there is the following advantage in using the fixed abrasive grains as described in the technique of patent document 2, rather than using the loose abrasives as described in patent document 1.

[0012] Namely, the slurry containing the loose abrasives can be eliminated in the polishing step, and therefore generation of a large quantity of a polishing waste liquid containing the loose abrasives can be prevented after the polishing step. Further, the polishing waste liquid contains various compounds as a matter of course, thus having an adverse influence on an environment if such a polishing waste liquid is disposed as it is. Therefore, a prescribed treatment needs to be applied to a polishing waste liquid. However, by using the fixed abrasive grains, the time required for treating the waste liquid, and an equipment cost and a running cost can be reduced.

[0013] Further, when the loose abrasives are used, clogging is caused in a polishing cloth when polishing treatment is applied to the polishing cloth. Therefore, there is a high risk of reducing its performance. However, by using the fixed abrasive grains, such a risk can be suppressed. As a result, there is no necessity for frequently exchanging the polishing tool, and a reduction of an efficiency of a polishing treatment work can be suppressed.

[0014] Meanwhile, in the technique described in patent document 2 as well, a plurality of abrasive composite materials in which the abrasive grains are fixed to the binder, needs to be arranged on a base material, with a certain degree of interval provided from other abrasive composite materials (paragraphs 0076 and FIG.2 of patent document 2), and in order to form the abrasive composite materials separately from each other, at least edges of a plane and a boundary, which form the abrasive composite materials, need to be separated from each other in an upper part of a shape of the abrasive composite material (paragraph 0076 and FIG.3 of patent document 2). According to this structure in which the abrasive composite materials are soft and separated from each other, it can be considered that a polishing effect is increased (paragraph 0077 of patent document 2).

[0015] However, in a case of a polishing member described in patent document 2, there is a necessity for forming a part where the abrasive grains don't exist (for example, between trapezoidal sectional composite materials shown in FIG. 3 of patent document 2). Therefore, the abrasive grains are separated from the binder, to thereby hardly causing an autogenous blade action. Therefore, there is a problem that a polishing effect is reduced. There is also a problem that polishing is performed non-uniformly because only an upper edge part of each abrasive composite material is brought into contact with the plastic lens, or the abrasive grains are buried between the abrasive composite materials. In this case, a quality and a yield rate of the plastic lens are reduced after all.

[0016] At present, improvement of the polishing efficiency for the plastic lens is strongly requested. Such an improvement of the polishing efficiency also leads to a reduction of a manufacturing cost of the plastic lens and an improvement of the quality and yield rate of the plastic lens.

[0017] An object of the present invention is to provide the polishing tool for a plastic lens, the method of polishing a plastic lens and a method of manufacturing a plastic lens, capable of suppressing a reduction of the polishing efficiency, while reducing a cost required for a treatment applied to a polishing waste liquid generated during polishing performed to the plastic lens.

SUMMARY OF THE INVENTION

[0018] Inventors of the present invention reexamine a polishing method performed to a conventional plastic lens (particularly a technique described in patent document 2), to suppress a reduction of a polishing efficiency while reducing a cost required for treating a polishing waste liquid generated when polishing is applied to a plastic lens. Further, the inventors of the present invention examine whether an object of the present invention can be achieved, by employing a structure excluded in a description of the patent document 2 (namely, a single layer structure in which abrasive grains are uniformly dispersed and fixed).

[0019] From a description of patent document 2, it is an unconceivable matter even by a skilled person to form an abrasive composite material in a single layer structure in which the abrasive grains are uniformly dispersed and fixed. This is because in a situation that improvement of the polishing efficiency for the plastic lens is strongly requested at present, it is an unconceivable matter even by the skilled person, to apply to the current technique a structure which is not considered to achieve the object even in the past stage when the patent document 2 is filed, and the present situation is that there is even no suggestion to solve the problem. This is because in patent document 2, separation of the polishing composite materials is indispensable although an autogenous blade action hardly occurs by forming a part where the abrasive grains don't exist, and there is such a description in patent document 2.

Nevertheless, the inventors of the present invention further examine whether the aforementioned problem can be solved by the polishing tool having a single layer structure in which the abrasive grains are uniformly dispersed and fixed.

[0020] In this examination, the inventors of the present invention go back to a starting point and analyze a mechanism of the polishing in a case of using the fixed abrasive grains. First, in a technique of using the fixed abrasive grains, the abrasive grains are fixed to a foam, so to be used as a polishing tool (for example, a polishing pad). Then, it is a matter of course that when polishing is performed to the plastic lens for example, the polishing is performed by the abrasive grains fixed to the polishing pad as a matter of course. However, the abrasive grains that are separated from the foam contributes to the polishing mainly.

[0021] Incidentally, there are various kinds of polishing such as rough polishing and final polishing, and polishing is respectively performed by changing a grain size of each abrasive grain. For example, relatively rough polishing can be performed by increasing the grain size, and relatively fine polishing can be performed by decreasing the grain size. However, when the fixed abrasive grains are used, a surface area of each abrasive grain becomes small when the grain size is small. In this case, when the fixed abrasive grains are exposed to outside of the foam, an area in contact with a polished object is also small, thus hardly allowing the abrasive grains to be separated from the foam. As described above, the abrasive grains separated from the foam mainly contribute to the polishing. Therefore, when the grain size is small, the abrasive grains are hardly separated from the foam during polishing. Accordingly, reduction of the polishing efficiency cannot be avoided. To make matters worse, time is required for performing fine polishing, compared with a case of performing rough polishing, and in addition, the abrasive grains are hardly separated from the foam, due to a small size of the grain. As a result, the inventors of the present invention obtain a knowledge that when such a fine polishing is performed using the fixed abrasive grains, the polishing efficiency is considerably reduced.

[0022] Based on the aforementioned knowledge, and

as a result of strenuous efforts by the inventors of the present invention, it is found that the above-described problem can be solved by employing a substance mainly composed of polyurethane resin as the foam, and employing crystalline alumina as the fixed abrasive grains, even in a case of a single layer structure in which the abrasive grains are uniformly dispersed and fixed.
This is because:

1. The crystalline alumina has a structure not having a simple spherical form but having a plurality of unevenness and gaps, and therefore is composed of a plurality of grains having a large surface area. By having such a large surface area, it becomes easy to make the abrasive grains separated from the foam even in a case of a small grain size.
2. A chemical bond such as a hydrogen bond hardly occurs between the crystalline alumina and the polyurethane resin, and therefore it becomes easy to make the abrasive grains separated from the foam.
3. Hardness of the crystalline alumina is extremely high, and therefore a disadvantage that the abrasive grains are hardly separated from the foam in a case of a small grain size, can be compensated with the hardness of the abrasive grain itself, and the reduction of the polishing efficiency can be suppressed.

[0023] Based on the aforementioned knowledge, the inventors of the present invention employ a combination of a plurality of foams and abrasive grains, for the polishing of a fixed abrasive grain system using the polishing tool having a single layer structure. By such a combination, the inventors of the present invention obtain a knowledge that a quantity of the fixed abrasive grains and a quantity of the separated abrasive grains are well balanced, thus reducing the reduction of the polishing efficiency, and of course a large quantity of waste liquid is not generated like the loose abrasive system in which polishing is performed by mixing the abrasive grains into a polishing liquid.

SUMMARY OF THE INVENTION

[0024] Following is an aspect of the present invention respectively, achieved based on the above-described knowledge. According to a first aspect of the present invention, there is provided a polishing tool for a plastic lens, which is used for adjusting and completing an optical surface of a plastic lens, including a single layer in which abrasive grains made of crystalline alumina are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability. According to a second aspect of the present invention, there is provided the polishing tool of the first aspect, wherein the abrasive grains are composed of a grain having a mean grain size of exceeding 0.5μm and less than 8μm. According to a third aspect of the present invention, there is provided a method of manufacturing a plastic lens, including polishing a main surface of a plastic lens using a polishing tool composed of a single layer in which abrasive grains made of crystalline alumina are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability. According to a fourth aspect of the present invention, there is provided the method of the third aspect, wherein the main surface is polished while supplying a polishing liquid which does not substantially cause a chemical reaction on the main surface of the plastic lens. According to a fifth aspect of the present invention, there is provided a method of polishing a plastic lens, including:

polishing a main surface of a plastic lens using a polishing tool composed of a single layer in which abrasive grains made of crystalline alumina are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability; and
adjusting and completing an optical surface of the plastic lens.

[0025] According to the present invention, the reduction of the polishing efficiency can be suppressed, while reducing a cost required for a treatment applied to a polishing waste liquid generated during polishing performed to the plastic lens.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

FIG. 1 is a schematic block diagram of a polisher for performing a polishing method according to this embodiment.
FIG. 2 is a plane view of a polishing jig according to this embodiment.
FIG. 3 is a plane view of the polishing jig to which a polishing pad of this embodiment is attached.
FIG. 4 is a bottom view of the polishing jig according to this embodiment.
FIG. 5 is a cross-sectional view taken along the line VII-VII of FIG. 3.
FIG. 6 is a plane view of the polishing pad according to this embodiment.
FIG. 7 is a perspective view of a fastening member of the polishing pad according to this embodiment.
FIG. 8 is a conceptual view showing a track-less polishing locus of the polisher according to this embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0027] Detailed embodiments of the invention will be described hereafter. A polisher using a method of polishing a plastic lens according this embodiment will be described first. Such a polisher is based on an apparatus described in patent document 1 (Patent No.4681024). In this specification, a portion of a polishing pad is mainly focused, and the other potion is omitted, and thereafter contents of the method of polishing a plastic lens, which is a characteristic portion of this embodiment, will be described in detail. Then, based on such contents, a method of manufacturing a plastic lens including a polishing method will be described. Then, an effect of this embodiment will be described, and a modified example will be described finally.

[0028] Specifically, the embodiments will be described in the following order.

1. A polisher of a plastic lens
   - A) An overall structure of the polisher
   - B) A polishing pad
   - C) A polishing jig
   - D) Others
2. A method of polishing a plastic lens
   - A) Selection of a plastic lens
   - B) Selection of the polishing pad
     - a) Foam (sponge portion)
     - b) Fixed abrasive grains
     - c) Other compound and a method of manufacturing a polishing pad
   - C) Execution of polishing
3. A method of manufacturing a plastic lens
   - A) Selection of a semi-finish lens
   - B) CG-edging
   - C) Polishing
     - a) Rough polishing
     - b) Final polishing
   - D) Others (color dyeing, inspection, ultrasonic cleaning, hard coating, multi-coating, etc.)
4. Effect of this embodiment
5. Modified examples

<1. A polisher of a plastic lens>

A) An overall structure of a polisher

[0029] Explanation will be given for a case that a polisher is used for a spectacle lens described in patent document 1, when performing a method of polishing a plastic lens according to this embodiment. Of course, this embodiment can be applied to the "plastic lens" specified in this embodiment, even in a case of an optical lens other than the spectacle lens. However, a method of polishing the spectacle lens will be described in this embodiment.

[0030] In FIG. 1, the polisher of a spectacle lens whose whole body is indicated by mark "1", includes: a body 2 installed on a bottom surface; an arm 4 disposed in this body 2 so as to be movable in a right and left direction on a paper surface and rotatable in a direction perpendicular to the paper surface, with a horizontal axis 3 as a center; a driver not shown for reciprocally moving the arm 4 in the right and left direction and rotating the arm 4 in a direction perpendicular to the paper surface; a lens mounting part 6 provided on the arm 4, on which a convex surface 5a of a plastic lens 5 is mounted through a lens holder 7; and an oscillator 8 disposed in the body 2 so as to be positioned in a lower part of the lens mounting part 6, which carries out oscillating and turning motion (does not rotate on its own axis) by the driver not shown, with a vertical axial line K as a center.

[0031] The polisher 1 in this embodiment further includes a polishing jig 9 provided attachably and detachably to/from an upper surface of the oscillator 8; a polishing pad 10 attachably and detachably attached to/from the polishing jig 9; and an elevator 11 for elevating and descending the lens mounting part 6, and so forth. Note that the oscillator 8 is attached to a vertical rotation axis 21 in such a manner as being tilted by an oscillation angle α (for example, 5°) to carry out an oscillating and turning motion around the vertical rotation axis 21.

[0032] A member directly used for polishing the plastic lens 5, being a portion for polishing a lens, is called a "polishing tool" hereafter, which is a member corresponding to the polishing pad 10 in this embodiment.

B) A polishing pad

[0033] The polishing pad 10 in this embodiment is used for adjusting and completing an optical surface of the plastic lens. As shown in FIG. 6, the polishing pad 10 used for polishing a concave surface 5b of the plastic lens 5 is composed of a polishing part 60 (a "contact part" specified in this embodiment) formed into an elliptical form having approximately the same size as a front view form of a dome part 25A of a balloon member 25; and a plurality of fixed pieces 61 extending to outside from a peripheral edge of the polishing part 60.

[0034] The polishing part 60 is composed of eight petal pieces 63 which are formed radially by a plurality of grooves 62 which are formed from an outer periphery to a center. Each petal piece 63 is formed into a trapezoid form so that a width of a center side is narrower and a width of an outer peripheral side is wider. The fixed pieces 61 are respectively extended in a diameter direction on an outer edge of four petal pieces 63 in total positioned in a long axial direction and a short axial direction, out of the eight petal pieces 63. The width of each fixed piece 61 is set to be narrower than the width of the outer edge of each petal piece 63, for facilitating a deformation of the balloon member 25 during polishing and facilitating a deflection of the petal pieces 61 when the fixed pieces 61 are pulled-out from the fastening member 66 as will be described later.

[0035] If the width of the fixed piece 61 is excessively wide, the fixed piece 61 is lack in flexibility and is hardly deflexed. Meanwhile, if the width of the fixed piece 61 is excessively narrow, the fixed piece 61 is weak in strength and is easily broken during polishing. Accordingly, the width of the fixed piece 61 is determined in consideration of strength and flexibility. For example, when a felt having a thickness of 1mm is used, the width is preferably set to about 5 to 15mm. Durability is reduced when the width is set to 5mm or less, and the flexibility is reduced when the width is set to 15mm or more, thus making it difficult to follow the deformation of the balloon member 25. Preferably, two or more fixed pieces 61 are disposed at constant intervals. Note that if excessively large numbers of the fixed pieces 61 are disposed, a contact area between the fixed pieces 61 and the fastening member 66 as will be described later becomes large, thus dispersing a pressure of the fastening member 66 added on the fixed pieces 61, and making it easy to detach the polishing pad 10 from the polishing jig 9. Reversely, if excessively small numbers of the fixed pieces 61 are disposed, the polishing pad 10 cannot be stably fixed to the polishing jig 9. Accordingly, about three to five fixed pieces 61 are more preferably disposed.

C) A polishing jig

[0036] Such a polishing pad 10 is detachably attached to the polishing jig 9 by the fastening member 66. The polishing jig 9 will be described hereafter.

[0037] In FIG. 2 to FIG. 5, the polishing jig 9 is composed of the balloon member 25 with its back face side opened, which is formed in a cup shape by natural rubber, synthetic rubber, or rubber-like resin; a fixture 26 for closing the back face side opening part and air-tightly maintaining an inside of the balloon member 25; and a valve 27 for supplying a compressed air into the balloon member 25.

[0038] The balloon member 25 is composed of a dome part 25A, with its front view form formed into approximately an elliptical form, and a front surface formed as a flat or gentle convex curved surface; approximately an elliptical columnar part 25B integrally extended toward a lower part from an outer periphery of the dome part 25A; and an annular inner flange 25C integrally extended to a rear end of the columnar part 25B. Further, an annular locking part 28 protruded upward is integrally provided on an inner end of the inner flange 25C.

[0039] The locking part 28 is engaged with an inside fixture 29 as will be described later, to thereby temporarily fix the balloon member 25 and the inside fixture 29, so that assembly of the polishing jig 9 is facilitated, and the balloon member 25 is prevented from being detached from the fixture 26 when an outside fixture 30 is attached, and air-tight closure of inside is secured.

[0040] As a material of the balloon member 25, the synthetic rubber (for example, IIR) which is close to the natural rubber having a hardness of 20 to 50 degrees, or the natural rubber is used for example. Thickness T of the balloon member 25 is uniform over the whole body, and is about 0.5 to 2mm (usually about 1mm). A plurality of balloon members 25 are preferably prepared in accordance with a size of the polished plastic lens 5 and a polished surface requested to be polished.

[0041] The fixture 26 is formed by two members of the inside fixture 29 and the outside fixture 30, and by these members, the inner flange 25C of the balloon member 25 and the locking part 28 are sandwiched from inside and outside, to thereby air-tightly close the back face side opening part of the balloon member 25. The inside fixture 29 is formed by an elliptic plate having approximately the same size as an inside form of the columnar part 25B of the balloon member 25, wherein a front side outer peripheral edge is chamfered, and an annular groove 31 is formed on a rear side outer peripheral part so that the inner flange 25C is engaged with this annular groove 31. Further, an annular groove 31a is formed over the whole periphery of the inner periphery of the annular groove 31, so that the locking part 28 is engaged with this annular groove 31a. Depth W of the annular groove 31 is set to be slightly smaller than the thickness (T) of the inner flange 25C. Further, a height of the inside fixture 29 is set to be lower than a height of the columnar part 25B, so that an air-tightly closed space 32 is formed inside of the balloon member 25.

[0042] When the air is supplied to the air-tightly closed space 32 through the valve 27 to expand the dome 25A upward, a curvature radius of a sectional face including a central axis of the dome part 25A becomes minimum in the short axial direction of an ellipse, thus forming a form close to a toric surface which becomes maximum in the long axial direction. In this case, the curvature radius of the dome part 25A is varied in accordance with a central height (top height) of the dome part 25A, and therefore by measuring and adjusting the central height of the dome by a suitable device, the curvature radius of the dome part 25A can be set to a desired curvature radius. Note that in order to form the dome part 25A so as to be close to the concave surface 5b of the plastic lens 5, a plurality of kinds of polishing jigs are prepared, which have various dimensions in the long axis and the short axis and various ratio of the long axis to the short axis, and the polishing jig close to the concave surface form of the plastic lens 5 is preferably selected and used. If the curvature radius of the dome part 25A is set to be smaller than the curvature radius of the concave surface 5b of the plastic lens 5, a gap is hardly generated between the central part of the concave surface 5b and the central part of the dome part 25A when the concave surface of the lens is pressed against the dome part 25A, and this is preferable.

[0043] The polishing tool 9 is suitably selected based on a lens diameter and the curvature of a polished surface. However, in a case of a lens having the same diameter, it is preferable to use the polishing jig in which the long axis becomes shorter as the curvature becomes larger.

D) Others

[0044] In FIG. 5, the outside fixture 30 is formed into a cup shape opened upward, including a disc-like bottom plate 30A and a cylindrical part 30B protruded integrally with an upper surface outer periphery of the bottom plate 30A, and a recessed part 36 is formed inside of the cylindrical part 30B, so that the inside fixture 29 is inserted into this recessed part 36 together with the columnar part 25B of the balloon member 25. The inside fixture 29 is inserted into the recessed part 36 together with the columnar part 25B of the balloon member 25, and is fixed to the inside of the recessed part 36 by a plurality of screws 37 from a lower surface side of the outside fixture 30, and by pressing the inner flange 25C of the balloon member 25 against a bottom surface of the recessed part 36, the back face side opening part of the balloon member 25 is air-tightly closed together with the outside fixture 30.

[0045] As shown in FIG. 4 and FIG. 5, such an outside fixture 30 is positioned and fixed by an engagement of an engagement recess 38 or an engagement groove 38' provided on the bottom surface, and an engagement part not shown provided on the upper surface of the oscillator 8. The recessed part 36 of the outside fixture 30 is formed into an elliptic recess having approximately the same size as an outer shape of the columnar part 25B of the balloon member 25, and having a depth of about 10mm which is lower than the height of the columnar part 25B. Accordingly, the columnar part 25B is more protruded upward than the outside fixture 30, in a state that the fixture 26 is attached to the balloon member 25. Thus, by setting the height of the outside fixture 30 to be lower than the height of the dome part 25A, interference between the lens 5 and the outside fixture 30 can be prevented even if the polishing jig 9 is oscillated and turned during polishing the lens 5. The outer shape of the outside fixture 30 is formed into a circular form. This is because power is uniformly added during fastening, in a case that the fastening member 66 as will be described later is formed into approximately a circular ring-shape.

[0046] As shown in FIG. 7, the fastening member 66 used for attaching the polishing pad 10 to the polishing jig 9, is formed in such a manner that a wire spring 67 having a suitable thickness is bent in a circular form with end portions crossed each other, and has a smaller diameter than an outer diameter of the outside fixture 30 in a natural state, wherein both end portions 67a, 67b are bent to outside respectively at a substantially right angle. The ring-shape of the fastening member 66 is suitably set according to the outer shape of the outside fixture 30 so that the power is uniformly added on each fixed piece 61 during fastening. Note that when the outer shape of the outside fixture 30 is the circular shape, and the ring-shape of the fastening member 66 is the circular shape during fastening, there is no necessity for adjusting directions, and this is preferable.

[0047] In order to attach the polishing pad 10 to the polishing jig 9, first, the dome part 25A of the balloon member 25 is expanded in a prescribed dome shape by supplying the compressed air, and thereafter the polishing part 60 of the polishing pad 10 is placed thereon. Next, by sandwiching both end portions 67a, 67b of the fastening member 66 by fingertips, thereby narrowing an interval between the both end portions 67a, 67b, the diameter of the fastening member 66 is increased, and in this state, the fastening member 66 is pressed against the fixed pieces 61 of the polishing pad 10 from above so that the fixed pieces 61 are bent downward and are brought into contact with the outer periphery of the outside fixture 30. Then, by separating the fingertips from the both end portions 67a, 67b, the fastening member 66 is returned to an original shape and the fixed pieces 61 are fastened and fixed to the outer periphery of the outside fixture 30, to thereby end attachment of the polishing pad 10. Accordingly, an adhesive agent is not required, and the attachment/detachment work can be simple.

<2. A method of polishing a plastic lens>

A) Selection of a plastic lens

[0048] A method of polishing the plastic lens 5 will be described hereafter.

First, the plastic lens 5 to which this embodiment can be applied, may be formed of a resin material, and may be formed of a publicly-known material. Although the kind of the resin material is not particularly limited, each kind of resin usually used for the plastic lens, such as urethane resin, epithio resin, polycarbonate resin, and diethylene glycol bis (allyl carbonate (CR39)) resin, can be given. In this embodiment, explanation is given for a case that resin containing polyether polyol is selected as the resin material in the plastic lens 5.

B) Selection of a polishing pad

[0049] The polishing tool (namely, the polishing pad 10) used for executing this embodiment will be described next. More specifically, explanation will be given for a portion constituting the foam (polyurethane resin having foamability) in the polishing tool (the polishing pad 10) and the abrasive grains (fixed abrasive grains) fixed thereby. Note that the "polishing tool (polishing pad)" in this embodiment is composed of a single layer in which the abrasive grains are uniformly dispersed over the foam (sponge portion). Of course, other member may be added to this polishing pad 10. For example, a base material may be stuck to a surface opposed to a polished surface of the polishing pad 10, or an adhesive layer and a release liner may also be provided.

a)A foam (sponge portion)

[0050] In this embodiment, a substance mainly composed of the polyurethane resin having foamability, is used as the foam. Further, a compound used for synthesizing the polyurethane resin in this embodiment (in other words, the compound contained in the polishing pad 10) is isocyanate, a chain extender, and a foaming agent, etc., in addition to the aforementioned polyether polyol. Of course, additives may be suitably added, in addition to the aforementioned substances. Note that the aforementioned "mainly composed of..." means a maximum quantity in the foam, and a quantity in the foam that can be used for polishing the plastic lens 5.

[0051] The polyurethane resin is selected for the reason that the polyurethane resin also has toughness in addition to the required hardness. The polyurethane resin is a material excellent in a wear and abrasion resistance, and durability, and is extremely suitable as the material of the polishing pad 10. Further, it is a large characteristic of the polyurethane resin, that the resin having a desired physical property can be obtained by variously changing a raw material composition, which is also suitable as the material of forming the polishing pad 10.

[0052] Further, both of the polyether polyol and isocyanate as will be described later, being raw materials of the polyurethane resin, are also in a liquid state having a relatively low viscosity, and can be easily mixed with each kind of abrasive grains. Therefore, they can be molded into various forms.

[0053] In addition, the foam made of the polyurethane resin, has uniform microbubbles. Therefore, the bubbles for holding the polishing liquid can be secured, wherein the polishing liquid is supplied when the foam is used as the polishing pad 10. With this microfoam structure, the polishing liquid can be retained in the holes of the microfoam portion. This is extremely effective for stabilizing a polish rate because a wet-type mechanical polish action occurs cooperatively with the abrasive grains dispersed and fixed to the surface. Therefore, the polish rate becomes sufficiently large, and the polish work can be stabilized.

[0054] Note that when manufacturing the foam made of the polyurethane resin, it is advantageous that water being the foaming agent, and the abrasive grains as will be described later, are previously mixed into the polyurethane source, and a silicon-based foam stabilizer is previously mixed into the polyurethane raw material, for stably preparing the microbubbles. This is because the polyurethane foam having uniform bubbles can be stably obtained without damaging physical properties of polyurethane.

[0055] Note that publicly-known polyether polyol can be used as the polyether polyol used for the polyurethane resin. For example, polytetramethylene glycol (PTMG), polypropylene glycol (PPG), polyethylene glycol (PEG), etc., can be given for example as the polyether polyol. In addition, polyoxypropylene glycol and polyoxypropylene glycerin obtained by adding propylene oxide and ethylene oxide, and tetrahydrofuran-neopentyl glycol copolymer, and polytetra methylene ether glycol, etc., can be used.

[0056] Publicly-known isocyanate can be used. For example, tolylene diisocyanate (TDI), 4,4-diphenyl methane isocyanate (MDI), polymeric MDI, xylene diisocyanate (XDI), naphthylene diisocyanate (NDI), paraphenylene diisocyanate (PPDI), hexamethylene diisocyanate (HDI), dicyclohexyl methane diisocyanate (HMDI), inphoron diisocyanate (IPDI), lysine diisocyanate (LDI), tolidinc diisocyanate (TODI), etc., can be used.

[0057] Further, a mixing ratio of polyether polyol and isocyanate, being a functional group ratio, is preferably set in a range of polyether polyol (namely an active hydrogen-containing compound): isocyanate = 1:1 to 1:1.2. When active hydrogen and isocyanate in the polyether polyol are reacted with each other, for example, a metal compound catalyst such as an organic tin compound and an amine catalyst such as triethylene diamine can be used.

[0058] Further, a publicly-known foaming agent can be used. For example, water or carboxylic acid can be used.

b) Fixed abrasive grains

[0059] In this embodiment, crystalline alumina is used as the fixed abrasive grains. The abrasive grains composed of crystalline alumina, are uniformly dispersed and fixed to the foam of the polyurethane resin. As a result, the fixed abrasive grains are provided on the polishing pad 10. The polishing pad 10 has a single layer structure.

[0060] Here, explanation will be given for a reason for selecting the crystalline alumina in this embodiment. First, the crystalline alumina is composed of grains, each having a large surface area, because the crystalline alumina itself is not formed into a simple spherical form but has a structure having a plurality of unevenness and gaps. Therefore, each grain constituting the abrasive grains composed of crystalline alumina, has a large surface area. With this structure, when the foam is scraped and the fixed abrasive grains are exposed to a polished surface, a contact area and a contact opportunity of the plastic lens 5 and the abrasive grains during polishing can be increased, compared with other compound having substantially spherical grains. In this case, even if a grain size is small, the abrasive grains can be easily separated from the foam.

[0061] Further, a chemical bond such as a hydrogen bond hardly occurs between the crystalline alumina and the polyurethane resin having foamability, and therefore the abrasive grains can be easily separated from the foam.
If hydrated alumina is fixed to the polyurethane resin, there is a possibility that both of them are firmly bonded to each other by the hydrogen bond. In this case, the number of the abrasive grains mainly separated by polishing becomes smaller than estimated, thus involving a

problem that the polishing efficiency is deteriorated.
Meanwhile, when the crystalline alumina is fixed to the polyurethane resin, the abrasive grains are simply fixed to the foam of the polyurethane resin physically, because the crystalline alumina itself is an extremely stable substance. Therefore, even if the grain size of each abrasive grain is small, a sufficient amount of abrasive grains can be separated from the foam during polishing, thus improving the polishing efficiency.

[0062] Further, when the hardness of the crystalline alumina is extremely large and the grain size is extremely small, a disadvantage that the abrasive grains are hardly separated from the foam, can be compensated with the hardness of the abrasive grain itself, and a sufficient polishing efficiency can be secured.

[0063] Note that the "crystalline alumina" in this specification indicates aluminum oxide. As such an aluminum oxide, each crystal form of γ, η, δ, ρ, χ, θ, κ, α that can be detected by X-ray diffraction, can be given. One kind or two kinds or more of them can be used as dispersoids. Further, aluminum oxide is preferably a non-hydrate. The reason is as follows. If the aluminum oxide is a hydrate, the hydrogen bond is formed between the polyurethane resin and the aluminum oxide, thus posing a problem that a sufficient amount of abrasive grains cannot be separated from the foam.

[0064] In addition, "the abrasive grains are uniformly dispersed in the foam" indicates a state excluding a state as shown in patent document 2 in which the fixed abrasive grains are intentionally non-uniformly arranged, and indicates a state that raw materials of the foam and the fixed abrasive grains are uniformly mixed and cured, and also indicates a state that the fixed abrasive grains are uniformly exposed on the polished surface of the polishing pad 10 after being cured, to thereby uniformly fix the abrasive grains to each of the polished surface and the foam.

[0065] Further, regarding the surface area of the abrasive grain composed of crystalline alumina, as described above, when the fixed abrasive grains are used, there is a tendency that the surface area of the abrasive grain becomes small when the grain size is small, and the abrasive grains are hardly separated from the polished surface and the foam during polishing. In order to increase the contact area and the contact opportunity of the plastic lens 5 and the abrasive grains during polishing in consideration of the above tendency, it is preferable that the fixed abrasive grain of this embodiment has a larger surface area than a case of a spherical form. It is preferable that at least most of the grains constituting the abrasive grains have such a large surface area.
If there are relatively a larger number of approximately spherical grains, pulverization may be performed separately, to thereby obtain a structure having a plurality of unevenness and gaps or obtain an irregular form, so that grains having a large surface area can be formed.

[0066] Further, non-uniform shape of each grain (namely irregular form) is preferable. When the grain constituting the abrasive grains has an irregular form in a combination of the aforementioned "polyurethane resin as a foam", "crystalline alumina as fixed abrasive grains", and "a single layer structure in which fixed abrasive grains are uniformly dispersed in the foam", there is of course an effect that the grain having a large surface area can exist during polishing applied to the plastic lens 5. In addition, when the abrasive grains are easily separated due to an excessively large surface area, anchor effects can be exhibited to the foam, by the grain having the irregular surface, as a function of a regulating valve. Further, owing to its irregular form, all grains can be prevented from having the anchor effects, and as a result, the quantity of the fixed abrasive grains and the quantity of the separated abrasive grains can be further well balanced.

[0067] Further, owing to the irregular form of the abrasive grains composed of crystalline alumina, an extremely useful effect can be exhibited from a point of the "single layer structure in which the fixed abrasive grains are uniformly dispersed in the foam". Namely, when polishing is performed while "uniformly" dispersing into the foam the abrasive grains composed of crystalline alumina, it is possible to "non-uniformly (at random)" generating the abrasive grains fixed to the foam and the abrasive grains separated from the foam. More specifically, there are some abrasive grains firmly fixed to the foam by the anchor effects because the abrasive grains have a sharp unevenness, and there are also some abrasive grains relatively easily separated from the foam because the abrasive grains have a relatively gentle unevenness, and there are also some abrasive grains hardly separated from the foam and easily fixed to the foam because the abrasive grains have a complete spherical form. As a result, a sufficient polishing efficiency can be secured even in a case of using the "polyurethane resin as the foam" and the "crystalline alumina as the fixed abrasive grains" for the "plastic lens". However, when the crystalline alumina has an irregular form in particular, the quantity of the fixed abrasive grains and the quantity of the separated abrasive grains can be further easily well balanced. In addition, such a non-uniform separation can be realized by an extremely simple step of forming a single layer by uniformly dispersing and fixing the raw materials of the foam and the abrasive grains. Note that the "irregular form" is a form in which there is almost no deviation in the number of the grains having a specific shape, and is a form generated by pulverizing the raw materials of the abrasive grains into a grain shape at random.

[0068] The fixed abrasive grains composed of crystalline alumina are preferably composed of grains having a mean grain size of exceeding 0.5μm and less than 8μm. Regarding the mean grain size, as shown in examples described later, if the mean grain size exceeds 0.5μm, the polishing efficiency that does not hinder an actual polishing, can be secured. Further, if the mean grain size is less than 8μm, even a generation of a slight abrasion scratch can be prevented while suppressing the reduction of the polishing efficiency. Further, the fixed abrasive grains are more preferably composed of the grains having the mean grain size of 1μm or more and 5μm or less. Note that the "mean grain size" in this specification means a grain size in a case of an integrated value of 50% in a grain size distribution obtained by laser diffraction/scattering method.

[0069] Further, the volume ratio of the abrasive grains in the polishing pad 10 is preferably beyond 2.7% and less than 54% as shown in examples described later. When the volume ratio exceeds 2.7%, the polishing efficiency that does not hinder an actual polishing, can be secured. Further, when a volume ratio is less than 50%, excessive hardening of the polishing pad 10 can be suppressed, and the edging can follow the curved surface of the plastic lens 5, and generation of an unpolished part and scratches can be suppressed. 5.4% or more and 46% or less of the volume ratio is further preferable. Also, in this specification, the "volume ratio of the abrasive grains in the polishing pad" means the ratio of the volume of the abrasive grains based on the volume in a raw material stage when fabricating the polishing pad.

c) Other compound, and a method of manufacturing a polishing pad

[0070] When manufacturing the foam made of polyurethane resin of this embodiment, the foam may be molded by containing a crosslinking agent, a chain extender, a resinification catalyst, a foaming catalyst, an antioxidant, an age resister, a filler, a plasticizer, a coloring agent, an anti-mold agent, an antibacterial agent, a flame retardant, and an ultraviolet absorber, other than the polyether polyol, isocyanate, foam stabilizer, and foaming agent.

[0071] Further, although the method of manufacturing the foam is not particularly limited, the foam can be manufactured by a method such as an injection molding and a reaction molding, etc. Particularly preferably, a high-pressure injection unit is used for making the raw materials collapse with each other in a mixing head so that the raw materials are instantaneously mixed, and a low-pressure injection unit is used for mechanically mixing each raw material supplied to the mixing head by a stirring wing, etc., to thereby perform mold shaping and a slab shaping.

Thus, according to this embodiment, the fixed abrasive grains are stirred and mixed into a liquid polyether polyol and also a liquid isocyanate, and are provided as the fixed abrasive grains fixed to the foam made of polyurethane resin by a slab method or a mold method.

[0072] When the polishing pad 10 is manufactured, in this embodiment, the polishing pad 10 is fabricated so that the abrasive grains are uniformly dispersed and fixed to the foam, and further the polishing pad 10 is formed as a single layer structure. Thus, there is no necessity for providing a region where the abrasive grains don't exist, in the polishing pad 10. Therefore, the abrasive grains of a quantity capable of sufficiently exhibiting a self-planted edge can be contained in the polishing pad 10. Further, even in a case of employing the single layer structure, owing to the aforementioned combination of the "polyurethane resin as a foam" and "crystalline alumina as fixed abrasive grains", a sufficient polishing efficiency can be secured for the "plastic lens" as shown in examples described later. Note that when the "plastic lens" is used as the object to be polished, why polishing is successful has been studied at present. The combination of hard and soft, such as "crystalline alumina", "polyurethane resin", and "plastic lens" may be successful.

C) Execution of polishing

[0073] As described above, the plastic lens 5 being the object to be polished, and the polishing pad 10 are prepared in advance, and thereafter polishing is performed to the plastic lens 5 by the polisher. Note that in this embodiment, explanation is given for a case that the aforementioned technique is applied to the polishing of at least either the rough polishing or the final polishing.

[0074] The polishing in this embodiment is performed in the following procedure.

First, the plastic lens 5 is mounted on the lens mounting part 6 of the arm 4 through the lens holder 7. The plastic lens 5 is a lens edged (namely, already CG-edged) by a curve generator.

[0075] Next, the polishing jig 9, with the polishing pad 10 attached thereto, is installed on the upper surface of the oscillator 8, and the lens 5 is descended by the elevator 11, to thereby press the concave surface 5b against the surface of the polishing pad 10. In this state, the polishing liquid is supplied to the surface of the polishing pad 10, and the oscillator 8 is made to carry out oscillating and turning motion, while reciprocally moving the arm 4 in the right-left direction and in the fore-back direction. By these movements, the concave surface 5b of the lens 5 is polished by the polishing pad 10 following a trackless polishing locus in which a polished locus is slightly deviated every one round as shown in FIG. 8A or FIG. 8B, to thereby finish the surface into a desired toric surface. A polishing margin is set to about 5 to 9μm.

[0076] Regarding the polishing liquid supplied for polishing in this embodiment, the polishing liquid is not particularly limited, provided that it does not generate a trouble in the polisher 1, and a publicly-known polishing liquid may be used. However, in order to achieve the object of the present invention, there is a necessity for using a polishing liquid not containing the abrasive grains. For example, in a case of water or a solution not containing loose abrasives (for example, having pH of 2 to 12), and in a case of an alkaline solution, the polishing liquid is generated by mixing potassium hydroxide, sodium hydroxide, potassium carbonate, sodium carbonate, potassium hydrogen carbonate, ammonia aqueous solution, and amines such as ethylenediamine., at a prescribed ratio. Further, in a case of an acid solution, the polishing liquid is prepared by mixing hydrochloric acid, salt of the hydrochloric acid, sulfuric acid, nitric acid, salt of the nitric acid, carboxylic acid, and sulfonic acid, etc.

[0077] Further, the polishing liquid that does not cause a chemical reaction substantially with a main surface of the plastic lens 5, is preferably selected as the polishing liquid in this embodiment. Usually, it is probably preferable that the chemical reaction of the object to be polished is caused by the polishing liquid, from a viewpoint of performing a chemical mechanical polishing. However, even in a case of the polishing using the fixed abrasive grains, there is still a problem when treating the polishing waste liquid. Therefore, the polishing liquid with a small load added on the water or an environment is preferable. The polishing pad 10 of this embodiment is capable of sufficiently finely performing the polishing even in a case of a mechanical polishing not using the chemical reaction, by combining the structures of the "plastic lens", "polyurethane resin as a foam", "crystalline alumina as fixed abrasive grains", and "a single layer structure in which fixed abrasive grains are uniformly dispersed in the foam". Namely, the polishing liquid is not required, which causes the chemical reaction on the main surface of the plastic lens 5.

As a result, it is preferable to use the polishing liquid not causing the chemical reaction substantially on the main surface of the plastic lens 5.

Note that "not causing the chemical reaction substantially" indicates a state that the chemical reaction that can be estimated in the publicly-known chemical polishing, does not occur, or even if it occurs, there is almost no influence on the polishing efficiency, and there is almost no influence of the chemical polishing.

[0078] Such a polishing liquid is supplied on the polishing pad 10 from a polishing liquid supply nozzle, and thereafter enters between the polished surface of the plastic lens 5 and the surface of the polishing pad 10. Then, the CG-edged optical surface of the plastic lens 5 is polished.

[0079] In an actual polishing, a level difference caused by edging for backlash by NC control is included in edging traces. Therefore, such a level difference is removed in the polishing thereafter (namely rough polishing and final polishing).

[0080] Incidentally, when such a level difference is removed by polishing, a suitable polishing power can be obtained by using a hard pad and the abrasive grains having a certain degree of size. However, under an influence of the grain size during polishing, there is a limit in a surface roughness by polishing only by using such a pad and abrasive grains. Accordingly, in order to further minutely finish the surface into a mirror surface and remove the edging traces, polishing may be performed twice by varying polishing conditions (by varying a mean grain size of the abrasive grains, and the polishing time, etc.).

<3. A method of manufacturing a plastic lens>

[0081] A method of manufacturing a plastic lens 5 according to this embodiment will be described hereafter.

A) Selection of a semi-finish lens

[0082] Any kind of object to be polished may be selected, if satisfying the aforementioned conditions of the plastic lens 5. This embodiment shows an example of applying the present invention to the polisher for polishing a concave surface formed as a toric surface made of a resin material for correcting astigmatism, being the resin material with only the convex surface finished, which is the object to be polished, while satisfying the aforementioned conditions.

B) CG-edging

[0083] After the resin material being the semi-finish lens, is selected, first, the lens holder 7 is attached to the convex surface 5a of the resin material, and the resin material is attached to a curve generator through the lens holder 7, and an edging step of edging the convex surface 5b of the resin material into a prescribed shape, is performed.

[0084] In order to attach the resin material to the lens holder 7, a protective film 12 for preventing scratches is air-tightly adhered to the convex surface 5a of the resin material in advance, and the lens holder 7 is attached thereon by an apparatus called a layout blocker which is produced by LOH Corporation for example.

[0085] Thus, the resin material having the lens holder 7 attached thereto, is attached to the curve generator that performs three dimensional NC-control, through the lens holder 7, so that the convex surface 5b is cut and edged into a prescribed surface shape (edging precision of within $3\mu m$: 50□, surface roughness Ry: 0.3 to $0.5\mu m$). Thus, CG-edging is applied to the resin material, to thereby obtain the plastic lens before polishing.

[0086] Note that in a recent CG-edging, the CG-edging under highly precise NC (numerical value) control can be performed at a high polishing rate. Therefore, a sand-falling step may be omitted, which is the step similar to a lapping step after the edging step of edging a surface into a prescribed surface shape. Of course, after the sand-falling step is performed, the following polishing may be performed.

C) Polishing

a) Rough polishing

[0087] After the CG-edging, the plastic lens 5 is attached to the polisher of this embodiment through the lens holder 7, and rough polishing is performed by attaching the plastic lens 5 to the polisher of this embodiment through the lens holder 7, so that the edged surface is polished. By this step, the level difference, etc., such as edging traces formed on the optical surface of the plastic lens 5 can be eliminated by the CG-edging. Note that this step may be performed collectively in the same polisher, together with a final polishing as will be described later, or the aforementioned CG-edging may be performed by the polisher having a CG-edging function.

b) Final polishing

[0088] After the aforementioned rough polishing is performed, polishing (namely final polishing) is performed until the plastic lens 5 is polished into a mirror surface state. The rough polishing and the final polishing may be performed collectively in one step.
Further, in this embodiment, the rough polishing and the final polishing are collected in one step, and thereafter the aforementioned polishing is performed. However, the polishing of this embodiment may be applied to either one of the rough polishing and the final polishing, or the polishing of this embodiment may be applied to only one of the rough polishing and the final polishing, while the rough polishing and the final polishing are performed as separate steps respectively.
[0089] D) Others (color dyeing, inspection, ultrasonic cleaning, hard coating, multi-coating, etc.)
After the final polishing is ended, color dyeing, inspection, ultrasonic cleaning, hard coating, multi-coating, etc., are applied to the plastic lens 5 as needed. Thus, a final complete product of the plastic lens for spectacles is manufactured.

<Effects of this embodiment>

[0090] In this embodiment, the following effects can be exhibited.
First, the crystalline alumina itself is not formed into a simple spherical shape but has a structure including a plurality of unevenness and gaps, and therefore is composed of a plurality of grains having a large surface area. Therefore, each grain constituting the abrasive grains made of the crystalline alumina has a large surface area. With this structure, the contact area and the contact opportunity of the plastic lens 5 and the abrasive grains during polishing can be increased, compared with other compound having substantially spherical grains. In this case, even if a grain size is small, the abrasive grains can be easily separated from the foam.
[0091] Further, almost no chemical bond such as a hydrogen bond occurs between the crystalline alumina and the polyurethane resin having the foamability, and therefore the abrasive grains are easily separated from the foam.
If the hydrated alumina is fixed to the polyurethane resin, there is a possibility that both of them are firmly bonded to each other by hydrogen-bond. In this case, the number of the separated abrasive grains mainly separated by polishing is more reduced than estimated, thus involving a problem that the polishing efficiency is deteriorated.
Meanwhile, when the crystalline alumina is fixed to the polyurethane resin, the abrasive grains are simply physically fixed to the foam made of polyurethane resin, because the crystalline alumina itself is an extremely stable substance. Therefore, even if the grain size of the abrasive grain is small, a sufficient amount of abrasive grains can be separated from the foam, thus improving the polishing efficiency.
[0092] Further, the hardness of the crystalline alumina is extremely high, and therefore a disadvantage that the abrasive grains are hardly separated from the foam in a case of a small grain size, can be compensated with the hardness of the abrasive grain itself, and a sufficient polishing efficiency can be secured.
[0093] As described above, by employing the combination of the structures of the "plastic lens", "polyurethane resin as a foam", "crystalline alumina as fixed abrasive grains", and "a single layer structure in which fixed abrasive grains are uniformly dispersed in the foam", the deterioration of the polishing efficiency can be suppressed by taking advantage of the fixed abrasive grains even if fine polishing is performed, while reducing the cost required for treating the polishing waste liquid generated during polishing applied to the plastic lens.

<5. Modified examples>

[0094] Modified examples except for the aforementioned embodiments will be described hereafter.

(Raw materials of the foam)

[0095] Polyether polyol is used as the raw material of the foam in this embodiment. However, of course a compound excluding the polyether polyol can be used, and polyester polyol can also be used for example. Polyester polyol is a reaction product of one kind or two kinds or more of the aliphatic polycarboxylic acids and one kind or two kinds or more of aliphatic diols.
As the aforementioned aliphatic polycarboxylic acids, for example, oxalic acid, malonic acid, succinic acid, glutamic acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, nonamethylene dicarboxylic acid, decamethylene dicarboxylic acid. Undecamethylene dicarboxylic acid, and dodecamethylene dicarboxylic acid, etc., can be used.
Further, as the aforementioned aliphatic diols, for example, ethylene glycol, diethylene glycol, propylene glycol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexandiol, 1,7-heptanediol, 1,8-octanediol, 1,9-nonanediol, 1,10-decanediol, neopentylglycol, etc., can be used.
Further, polycarbonate polyol may be used other than the polyether polyol and polyester polyol, or the other publicly-known plastic lens may also be used.

(A polishing tool other than the polished pad)

[0096] This embodiment shows a case that the polishing tool is the polishing pad 10. However, of course, the other polishing tool may also be used.

(The kind of an applicable polishing)

[0097] This embodiment shows a case that a technical concept of the present invention is applied to the rough polishing and the final polishing. However, this embodiment can also be applied to the polishing of adjusting and completing the optical surface of the plastic lens 5 which is the polishing other than the rough polishing and the final polishing.

(A case that the final polishing is omitted)

[0098] Further, this embodiment shows a case that the final polishing is performed after the rough polishing, and the other step (such as a hard coating step) is performed after the final polishing. However, for example when the hard coat film is formed on the optical surface of the plastic lens 5 in the hard coating, a degree of the mirror surface required for the optical surface can be small. Further, by using the method of manufacturing the plastic lens 5 according to this embodiment, generation of the edging traces showing minute wavy forms, for example, can be suppressed to minimum (or can be not allowed to be generated). Then, a sufficiently smooth optical surface can be obtained even in a stage of the rough polishing, and there is a possibility that the plastic lens 5 sufficiently satisfying a quality standard even in the stage of the rough polishing, can be manufactured.
As described above, it is suitable that the final polishing is omitted, and the other step such as hard coating, etc., is directly applied to the optical surface of the plastic lens 5.

[Examples]

[0099] The present invention will be more specifically described, with reference to examples. Of course, the present invention is not limited to the following examples.

<Example 1>

[0100] In this example, a liquid mixture is prepared by mixing 100 pts.wt. of polyether polyol (by Sanyo Chcemical Industries, Ltd. Product name: Sunnix), 80 pts.wt. of isocyanate (by Dow polyurethane, Ltd. Product name: PAPI 135), 1 pts.wt. of water, 0.5 pts.wt. of amine-based catalyst (by Tosoh Corporation, Product name: TOYOCAT-ET), 0.5 pts.wt. of silicon-based foam stabilizer (by Nippon Unicar Company Limited, Product name: L-5309), and 180 pts.wt. of fixed abrasive grains (crystalline alumina having a mean grain size of 0.1μm). Note that the crystalline alumina is mixed by a volume ratio of 22% in the polishing pad 10. Such a liquid mixture is injected into a mold, which is then left to stand for 24 hours at a room temperature of 20 to 30°C, and is foamed and cured, to thereby manufacture the polishing pad 10 according to this example.

<Examples 2 to 5>

[0101] In example 1, the mean grain size of the crystalline alumina was set to 0.1μm. However, the mean grain size was set to 0.5μm in example 2, and the mean grain size was set to 1μm in example 3, and the mean grain size was set to 5μm in example 4, and the mean grain size was set to 8μm in example 5.
Note that a condition is the same as example 1, excluding a point that the mean grain size is varied.

<Examples 6 to 10>

[0102] In examples 6 to 10, the volume ratio of the crystalline alumina was varied in the polishing pad 10, with the mean grain size of 1μm in example 1 as a reference. More specifically, the volume ratio was set to 2.7% in example 6, the volume ratio was set to 5.4% in example 7, the volume ratio was set to 22% in example 8, the volume ratio was set to 46% in example 9, and the volume ratio was set to 54% in example 10. Although conditions were the same between example 8 and example 3, an experiment was performed separately in example 8, to examine a variation of a polishing rate which was caused by varying the volume ratio.
Note that the other contents were the same as example 1.

[0103] A correction ring with diamond electrodeposited thereon was used for the polishing pad 10 of examples 1 to 20, and the surface of the polishing pad 10 was corrected, to thereby obtain the polishing pad 10 having a thickness of 5mm, in which a foaming structure was exposed to the surface.

[0104] Subsequently, the polishing pad 10 was mounted on the polisher (FIG. 1) described in this embodiment. Thereafter, the plastic lens 5 (by Mitsui Chemical, Inc. Product name: MR-6) after CG-edging, which was the object to be polished, was pressed against the polishing pad 10, to thereby edge and polish the plastic lens 5 by a relative movement of the polishing pad 10 and the plastic lens 5, while supplying the polishing liquid (water with pH = 7.0) between the polishing pad 10 and the plastic lens 5. A CCP grinder by Schneider Corporation was used as the polisher. Conditions in the abrasive machining were set as follows.

Polishing pressure: 1bar
The number of rotation of a plastic lens: 200rpm
The number of rotation of a polishing pad: 800rpm
Polishing time: 4 minutes

[0105] After the abrasive machining was performed, the variation of the thickness of the plastic lens 5 was measured based on a weight variation of the plastic lens 5, to thereby calculate the polishing rate (μm/min) when using the polishing pad 10 manufactured in examples 1 to 10.

<Comparative example 1>

[0106] Comparative example 1 compared with the aforementioned examples showed a case that polishing was performed not by the fixed abrasive grains but by the loose abrasive grains. Note that in this polishing, a commercially available polishing liquid (by FUJIMI INCORPORATED, Alumina slurry) is used, and the polishing pad used in this polishing is a commercially available urethane polishing pad (by Nitta Haas Inc., Product name: Polishing cloth MH).
In this comparative example 1 as well, the test for examining the polishing rate was performed.

<Conclusion>

[0107] In the polishing pad 10 in example 1, the polishing rate was 1.0μm/min. When the mean grain size of the crystalline alumina was varied, the polishing rate was 2.0μm/min in example 2, and the mean grain size was 2.1μm/min in example 3, and the mean grain size was 2.0μm/min in example 4, and the mean grain size was 1.8μm/min in example 5.
When the volume ratio of the crystalline alumina of the polishing pad 10 was varied, the volume ratio was 1.5μm/min in example 6, the volume ratio was 2.0μm/min in example 7, the volume ratio was 2.2μm/min in example 8, the volume ratio was 2.3μm/min in example 9, and the volume ratio was 2.0μm/min in example 10.
[0108] Only a small quantity of the crystalline alumina was contained in the polishing waste liquid in any one of the examples, and therefore clogging in the polishing pad 10 could be avoided. Then, polishing could be performed without leaving non-edged portion after CG-edging, to thereby obtain an adjusted and completed optical surface of the plastic lens 5. Further, the cost and time required for treating the polishing waste liquid could be reduced.
[0109] Further, when the mean grain size of the crystalline alumina was set to beyond 0.5μm and less than 8μm (examples 2 to 4), the polishing rate could be maintained, and even a slight abrasion scratch was not allowed to occur. Further, when the volume ratio of the abrasive grains were set to beyond 2.7% and less than 54% (examples 6 to 9), the polishing rate could be similarly maintained, and even a slight abrasion scratch was not allowed to occur.
[0110] Meanwhile, in the polishing pad of comparative example 1, although the polishing rate was 2.0μm/min, a large quantity of alumina slurry was contained in the polishing waste liquid as a matter of course, thus generating the clogging in the polishing pad. Further a large quantity of polishing waste liquid was generated, and the cost and the time required for treating the polishing waste liquid could not be reduced.
[0111] The other preferable embodiments of the present invention will be supplementarily described hereafter.

[Supplementary description 1]

[0112] There is provided a method of polishing a plastic lens, wherein abrasive grains are stirred and mixed with a liquid polyether polyol and also a liquid isocyanate, and are provided as fixed abrasive grains fixed to a foam made of polyurethane resin by a srab or mold method.

[Supplementary description 2]

[0113] There is provided a method of polishing a plastic lens, wherein a plastic lens is used for spectacles, and has a curved surface.

[Supplementary description 3]

[0114] There is provided a method of polishing a plastic lens, wherein an optical surface of the plastic lens is adjusted and completed by polishing a main surface while supplying a polishing liquid not substantially causing a chemical reaction on the main surface of the plastic lens, using a polishing tool composed of a single layer in which abrasive grains composed of crystalline alumina are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability.

[Supplementary description 4]

[0115] There is provided a polishing tool for a plastic lens, which is the polishing tool for fixing abrasive grains to a substance mainly composed of polyurethane resin having foamability, and polishing an object to be polished by the abrasive grains, wherein the abrasive grains are composed of crystalline alumina non-hydrate.

[Supplementary description 5]

[0116] There is provided a polishing tool for a plastic lens, which is the polishing tool used for adjusting and completing an optical surface of the plastic lens, and is composed of a single layer in which abrasive grains are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability, wherein a polishing liquid that causes a chemical reaction on the main surface of the plastic lens is not required.

[Supplementary description 6]

[0117] There is provided a polishing tool for a plastic lens, wherein a polishing liquid that causes a chemical reaction on the main surface of the plastic lens is not required.

[Supplementary description 7]

[0118] There is provided a polishing tool for a plastic lens, wherein a volume ratio of the abrasive grains in the polishing tool is beyond 2.7% and less than 54%.

[Supplementary description 8]

[0119] There is provided a polishing tool for a plastic lens, wherein each abrasive grain has an irregular form.

Claims

1. A polishing tool for a plastic lens, which is used for adjusting and completing an optical surface of a plastic lens, comprising
a single layer in which abrasive grains made of crystalline alumina are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability.

2. The polishing tool according to claim 1, wherein the abrasive grains are composed of a grain having a mean grain size of exceeding 0.5μm and less than 8μm.

3. A method of manufacturing a plastic lens, comprising polishing a main surface of a plastic lens using a polishing tool composed of a single layer in which abrasive grains made of crystalline alumina are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability.

4. The method of manufacturing a plastic lens according to claim 3, wherein the main surface is polished while supplying a polishing liquid which does not substantially cause a chemical reaction on the main surface of the plastic lens.

5. A method of polishing a plastic lens, comprising:

> polishing a main surface of a plastic lens using a polishing tool composed of a single layer in which abrasive grains made of crystalline alumina are uniformly dispersed and fixed to a substance mainly composed of polyurethane resin having foamability; and
> adjusting and completing an optical surface of the plastic lens.

FIG.1

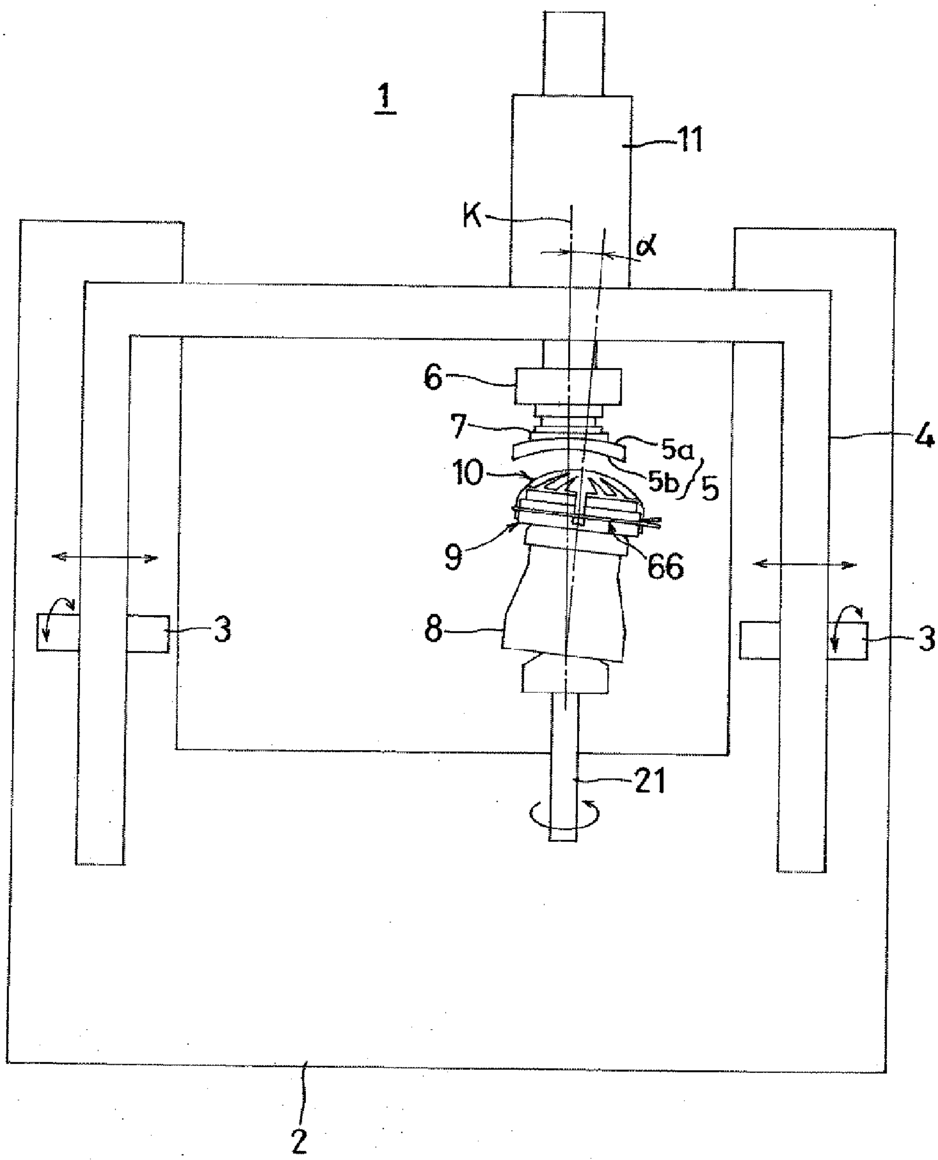

FIG.2

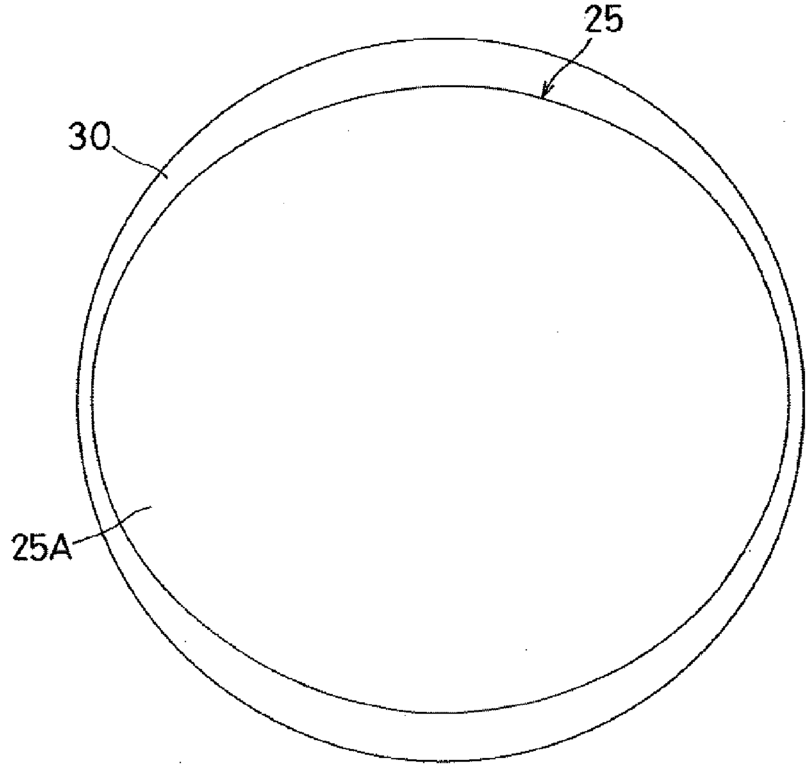

FIG.3

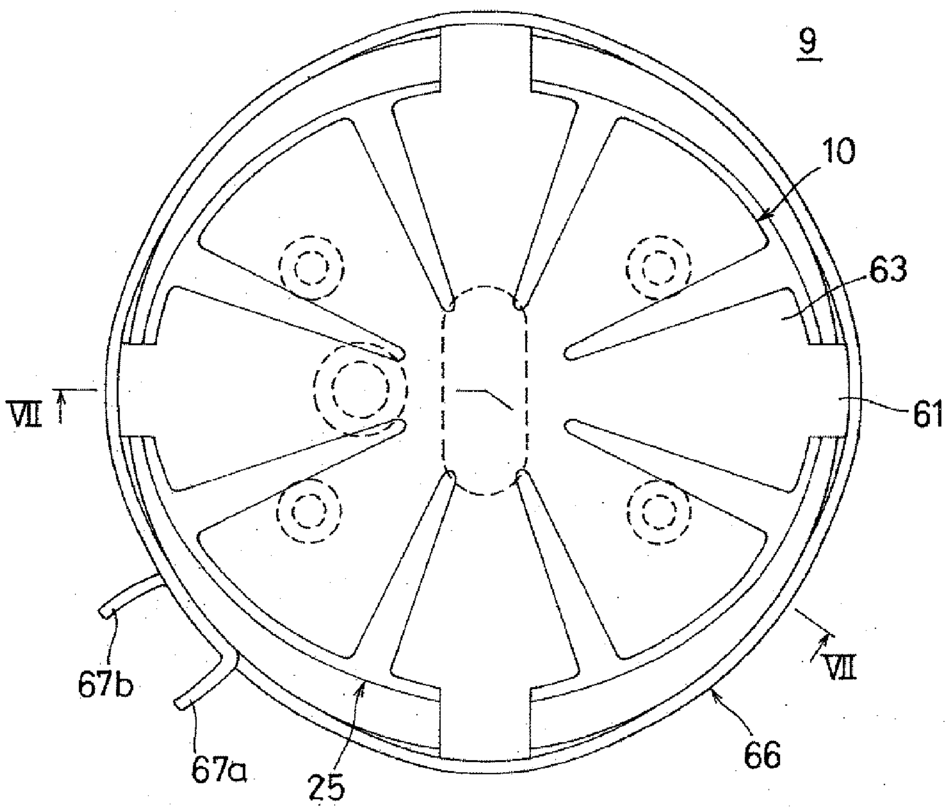

FIG.4

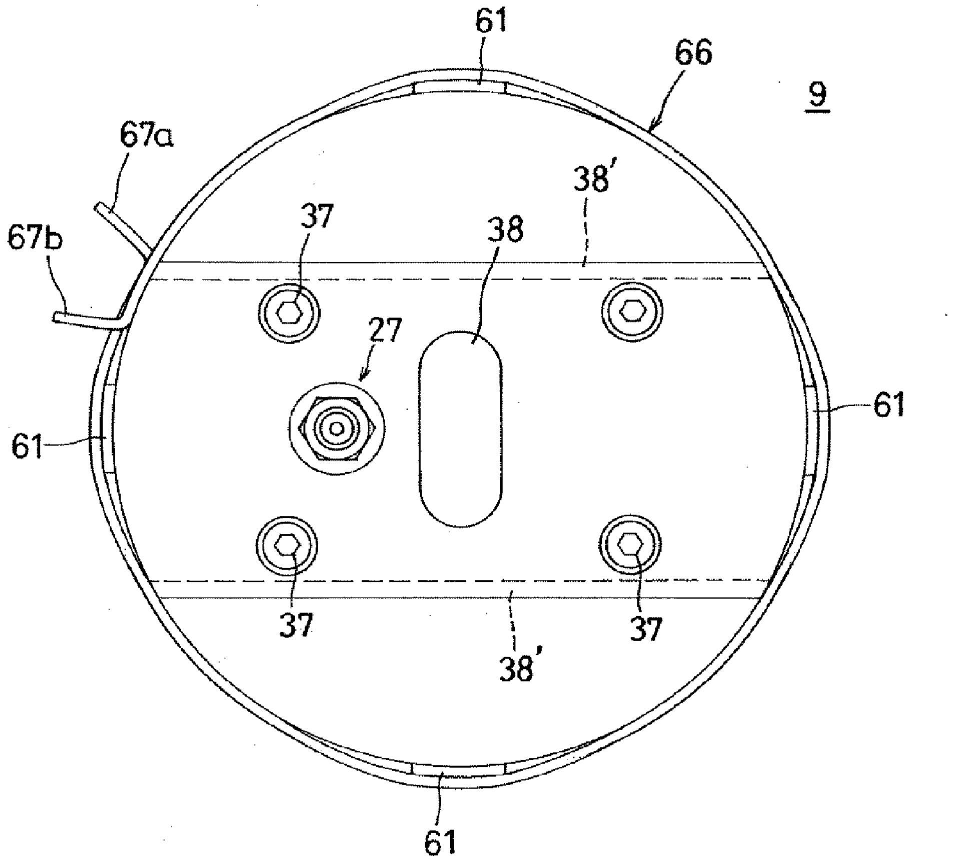
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FIG.5

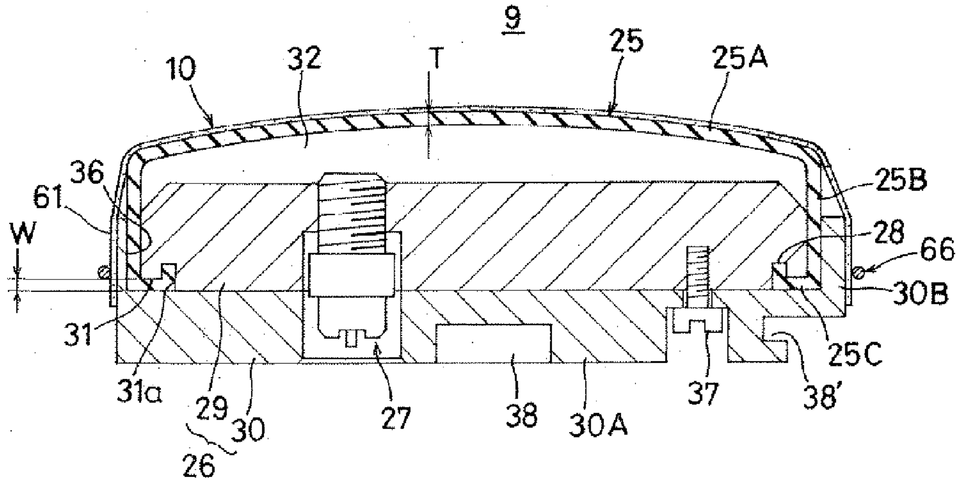
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FIG. 6

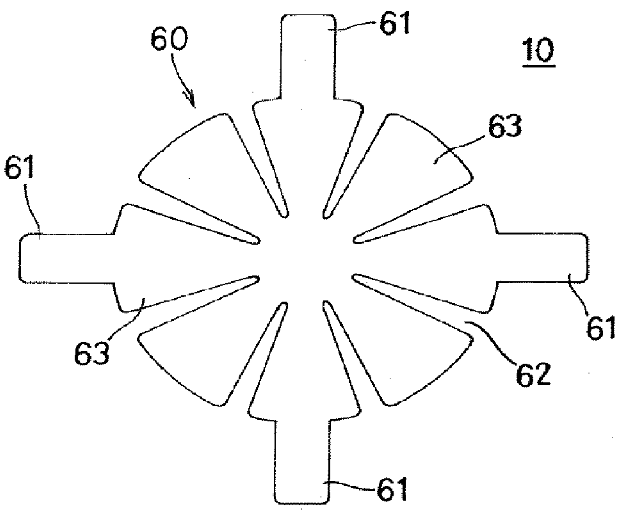


FIG. 7

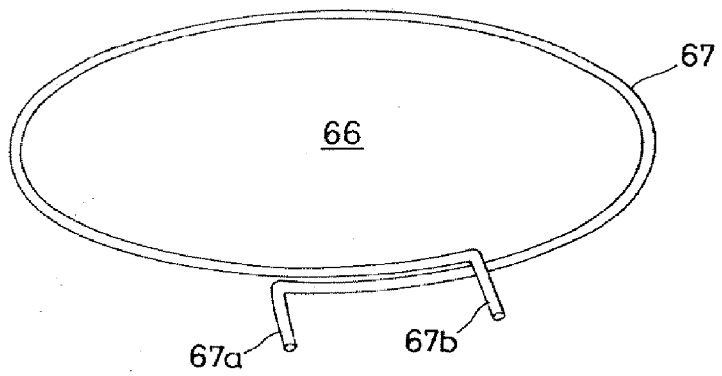
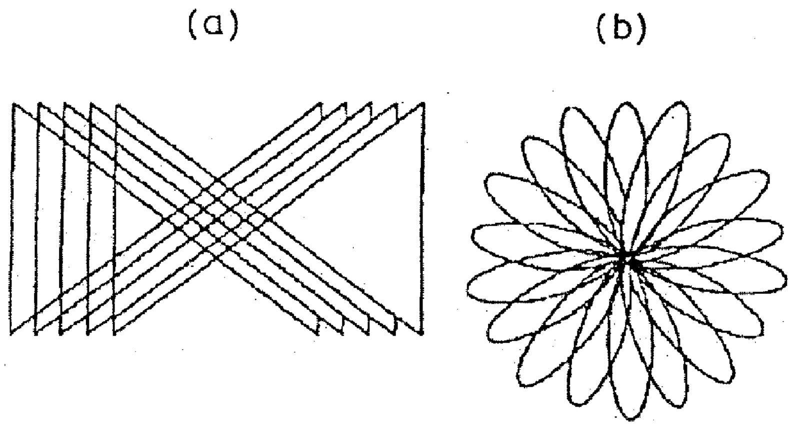


FIG. 8



REFERENCES CITED IN THE DESCRIPTION

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