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

(11) EP 4 129 569 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
26.03.2025 Bulletin 2025/13

(21) Application number: **21189546.1**

(22) Date of filing: **04.08.2021**

(51) International Patent Classification (IPC):
***B24B 13/01** (2006.01)* ***B24B 57/02** (2006.01)*
***B24B 1/00** (2006.01)*

(52) Cooperative Patent Classification (CPC):
B24B 13/012; B24B 57/02

(54) **POLISHING TOOL, POLISHING SYSTEM AND METHOD OF POLISHING**

POLIERWERKZEUG, POLIERSYSTEM UND VERFAHREN ZUM POLIEREN

OUTIL DE POLISSAGE, SYSTEME DE POLISSAGE ET PROCEDE DE POLISSAGE

(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

(43) Date of publication of application:
08.02.2023 Bulletin 2023/06

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EP-A2- 1 652 619 **WO-A1-2021/135452**
CN-A- 110 732 933

Description

1. Field of the invention

[0001] The present invention relates to a polishing tool for polishing a spectacle lens in a surface machining process. The present invention relates also to a system and a method with said polishing tool.

2. Technical background

[0002] It is an advantage of custom-made lenses that the optical power of such lens can locally vary to correspond more accurately with a person's actual needs for visual assistance. For example, a person may require a lens that improves near and far distance vision while little to no visual correction is required for distances in-between. Figure 2 shows an example for a custom-made lens (L) with such properties. Therein, the lens (L) is illustrated with a front surface (L2) and a specifically machined back surface (L1). The contour of the back surface (L1) follows a customized power map to facilitate different prescription values for different sections of the lens (L). For example, lower section (L13) comprises comparatively more material than other sections of the lens (L). Thereby, vision of objects in close proximity can be improved for a person looking through the lower section (L13). For reference, a dashed line (L15) is shown in Figure 2, which indicates the contour of the back surface (L1) of a lens without a localized power variation.

[0003] Generally, different methods of producing corrective lenses exist, such as an injection moulding, a casting or a machining process. Typically, in the casting process, a mould is used to produce stock lenses having a low to middle power range. The optical surfaces generated in this process are already polished. In comparison, in a machining process, individually calculated lenses are generated by a machine referred to as "lens generator". This process requires special tools for milling, turning and polishing to generate optical surfaces with a localized power variation and high quality.

[0004] As described, an important part of every lens generating process is the polishing step, in which the surface roughness of the lens is significantly reduced since surface roughness can have undesirable effects, such as scattering of light and specular reflection.

[0005] Figures 5 and 6 illustrate exemplarily a typical polishing process known in the prior art. In these Figures, a lens (L) is supported by a lens support unit (220) with a spindle (221) and a lens holder (222). Polishing of the lens (L) is performed with a soft polishing tool (510) and a polishing liquid (521) (often referred to as "slurry") that is supplied through an external nozzle (520). Typically, the polishing liquid (521) comprises a liquid with abrasive particles of defined particle sizes. Generally, polishing involves drawing polishing particles (grains) over the surface to be polished with or without the application of pressure. Thereby, roughness peaks of the surface can be abraded and thus levelled out. The polishing tool (510) is rotated about a rotational axis (indicated by arrow (513)) and linearly movable (indicated by arrow (512)). Further, the polishing tool (510) is covered by a soft coating (515), which is provided on a surface that comes into contact with the lens (L). During the polishing process, the lens (L) rotates about the rotation axis (RA2) of a spindle (221) and the polishing tool (510) may rotate about its own axis and may be tilted and/or moved across the optical surface (L1) of the lens (L). The polishing process illustrated in Figure 6 relies on the presence of polishing liquid (521) between lens surface (L1) and soft coating (515). In addition, it was found that the effectiveness, quality and heat management of the polishing process depends on a film of polishing liquid (521), which may form between lens surface (L1) and soft coating (515), having a defined thickness.

[0006] For example, if the thickness of the film is too high, the abrasive particles of the polishing liquid (521) do not come sufficiently into contact with the polishing tool (510). Thereby, the necessary mechanical interaction between polishing tool (510) and particles (and subsequently, between particles and optical lens surface (L1)) cannot be effected. Accordingly, the result from the polishing process may be insufficient. In comparison, if the thickness of the film is too low, the surfaces of the lens (L) and the polishing tool (510) are at risk of coming into direct contact with each other so that rotational energy is converted into heat instead of surface abrasion. However, this poses a risk of the lens (L) or the polishing tool (510) being damaged or deformed. Additionally, not enough heat may be transported away from the lens (L) by the polishing liquid (521) during the polishing process so that there is a risk of the lens (L) being deformed or damaged due to thermal overload.

[0007] In the prior art, attempts were made to address these problems by providing a multitude of nozzles (520) pointing onto the moving parts from different directions and projecting vast amounts of polishing liquid (521) towards lens (L) and polishing tool (510) to ensure a sufficient amount of polishing liquid (521) entering the gap between lens (L) and polishing tool (510). Therein, also the pressure, by which the polishing liquid (521) is fed through the nozzle (520), was adapted to increase the output of polishing liquid (521) through the nozzles (520). However, these known solutions are disadvantageous for various reasons: For example, the high rotational speeds of the moving components lead to an uncontrolled distribution of polishing liquid (521) in the working chamber while the film thickness cannot be controlled. Accordingly, a high quantity of polishing liquid (521) is needed for the polishing process while maintenance and cleaning times of the so configured machines are increased. Also, the size of the machines has to be increased as a large tank and a suitable pump are needed for assuring necessary flow rates and quantities of polishing liquid (521). Furthermore, the polishing liquid (521) has to be cooled in a chiller prior to being dispensed through the nozzle (520) to ensure sufficient cooling during the polishing process. Typically, the temperature of the polishing liquid (521) is kept at about 14 °C. Thus, the effectiveness, efficiency and resourcefulness of the polishing process of known prior art solutions is low, respectively.

[0008] EP 1 652 619 A2 shows a polishing tool according to the preamble of claim 1 with an additional polishing cover 9. CN 110 732 933 B shows a polishing tool with a flat polishing pad for large optical elements, such as an optical mirror for space applications.

[0009] Therefore, it is an object of the present invention to provide a polishing tool, system and method that overcome the aforementioned disadvantages of the prior art, respectively. Therein, it is a particular object of the invention to ensure a sufficient supply of polishing fluid in a region between the lens to be polished and the polishing tool throughout the polishing process. In addition, it is an object of the invention to reduce the amount of polishing liquid required in the polishing process while ensuring sufficient cooling in the polishing process and increasing the achievable quality of the finished lens.

3. Summary of the invention

[0010] These and other objects, which become apparent upon reading the description, are solved by the subject-matter of the independent claims. The dependent claims refer to preferred embodiments of the invention.

[0011] A first aspect of the invention relates to a polishing tool for polishing a spectacle lens in a surface machining process. The polishing tool comprises a tool body for being rotatably supported about a rotational axis. The tool body comprises a polishing surface being outwardly exposed at a first axial end of the tool body. The polishing surface is axially bulged convexly or concavely with respect to the rotational axis for polishing an optical surface of the spectacle lens. The tool body further comprises a channel extending axially through the tool body. The channel extends from an inlet to an outlet to supply the polishing surface with a polishing agent. The outlet (of the channel) is provided at the first axial end. The inlet (of the channel) is provided at a second axial end, which is opposite to the first axial end with respect to the rotational axis. The polishing surface comprises at least one groove that extends radially away from the outlet to the perimeter of the polishing surface to distribute the polishing agent across the polishing surface.

[0012] With other words, a tool for being used in a process of smoothening an optical surface of a spectacle lens by removing material therefrom can be provided. The polishing tool comprises a tool body that is suitable (configured) for being supported such that the tool body can be rotated about a rotational axis (e.g. its own axis or an axis offset thereto), for instance. The tool body comprises a first axial end and a second axial end, which is opposite to the first axial end with respect to the rotational axis. At the first axial end, the tool body comprises a polishing surface, such as, for example, an exterior (outside layer) that is accessible from (open to) the outside. The polishing surface is suitable for polishing a (typically curved) optical surface of the spectacle lens and, for example, forms a (with respect to the rotational axis) concavely or convexly curved shape sticking axially out from the tool body. The tool body comprises a(n internal) passage for delivering a polishing agent (e.g. a liquid, a suspension of solids and of a fluid or paste) to the polishing surface, which extends axially in (or inside) the tool body from an inlet to an outlet. The outlet is provided at the first axial end and is suitable (configured) for releasing the polishing agent onto the polishing surface. The polishing surface comprises at least one groove, such as a canal, passage or indentation, for example. The groove extends radially away from the outlet to the perimeter of the polishing surface (e.g. to an edge encompassing or surrounding the polishing surface) to deliver (and/or to administer) the polishing agent across the polishing surface. Preferably, the groove may be open to the outside and/or may be open on the side facing the lens surface during polishing.

[0013] The provision of an outlet and a groove in the polishing surface as well as making the polishing tool rotatable facilitate a uniform distribution of the polishing agent across the polishing surface. The polishing agent can enter the polishing surface directly through the outlet where centrifugal forces can drive the polishing agent through the groove to the outer edges of the polishing surface. Thereby, the polishing agent can be supplied directly where it is needed, i.e. onto and across the polishing surface, i.e. the surface of the polishing tool that effects smoothing of the optical surface of the lens (for example by entering into mechanical interaction therewith), so that the polishing agent can be used more effectively and efficiently. For example, it is possible to reduce the overall slurry displacement significantly and thereby, to reduce the amount of energy, consumption of polishing agent and generation of wastewater significantly. This allows designing machine components, such as pumps, pipes and tanks, considerably smaller. Also, the overall maintenance and cleaning times can be reduced by using this polishing tool. Further, the curved shape of the polishing surface supports the polishing effectiveness and efficiency of the lens surface.

[0014] Further, it can be ensured that a film of polishing agent forms between the polishing surface and the lens surface to be polished. This increases not only the life span of the polishing tool but also facilitates reliable cooling of the lens surface and the polishing tool with the polishing agent without having to provide an additional cooler for the polishing agent. Therein, it was found that the inventors managed to overcome a prejudice of the prior art that the formation of a film of suitable thickness would be incompatible with a fast rotation of the polishing tool relative to the lens as centrifugal forces would transport the polishing agent too quickly away from the polishing surface.

[0015] In addition, it was found that the quality and results of the polishing process can be improved with this polishing tool while maintaining rotational speeds at a high level. In experiments not disclosed to the public, it was found that the mere provision of one or more outlets on the polishing surface without the provision of the groove leads to polishing imprecisions and irregular lens surfaces. This is exemplarily illustrated in Figures 7 and 8. In the undisclosed experiments, different rotatable polishing tools (610, 620) were used having a tool body (611, 621) with a polishing surface (615, 625) being outwardly exposed at a first axial end of the tool body (611, 621), the polishing surface (615, 625) being axially bulged convexly or concavely with respect to their rotational axis for polishing an optical surface (L1, L2) of a spectacle lens (L). The tool body (611, 621) further comprised one or more channels (614, 624) extending axially through the tool body (611, 621) from one (or more) inlets (612, 622). The inlet(s) (612, 622) were provided at a second axial end being opposite to the first axial end with respect to the rotational axis. The channel(s) (614, 624) extended to one or more outlets (613, 623), which is/are provided at the first axial end, to supply the polishing surface (615, 625) with a polishing agent (521). The one or more outlets (613, 623) were distributed uniformly across the polishing surface (615, 625) (e.g. like a showerhead). For example, Figure 7 illustrates a configuration of the polishing tool (610) that was used in the experiments and had only a single outlet (613), the single outlet (613) was arranged centrally on the polishing surface (615). Unfortunately, the quality and results of the polishing process in the undisclosed experiments with such polishing tool (610) were unsatisfactory. This is because the mere provision of an opening (613) for the polishing agent (521) on the polishing surface (615) leads during operation to a localized increase of pressure in the area around the opening (613). Subsequently, the material of the polishing surface (615) around the opening (613) deforms locally and a free space (FS) or pocket filled with polishing agent (521) is formed leading to a blind spot of the polishing surface (615) that cannot effect any polishing interaction with the lens surface (L1). Figure 8 exemplarily illustrates an alternative configuration of a polishing tool (620) used in the experiments. Therein it was found that also the provision of multiple, distributed openings (623) in the polishing surface (625) could not overcome this issue but lead to the formation of multiple free spaces (FS) or pockets instead. When comparing these experimental and undisclosed polishing tools (610, 620) to the polishing tool according to the present invention, it can be found that with the additional provision of a groove, as suggested by the invention, the formation of a free space or pocket can be avoided and a film of polishing agent with uniform thickness can be established across the polishing surface, leading to higher quality and consistency of the polishing process.

[0016] According to a preferred embodiment, the groove may extend radially along a main extension direction. For example, the main extension direction may be a direction that may (primarily, i.e. to at least 50%, 60%, 70%, 80% or more) correspond with a direction pointing from the groove's starting point (e.g. the outlet) to the groove's end-point (a point on the perimeter). Preferably, the groove may extend radially always in directions having the same radial orientation. More preferred, the groove may extend (along the main extension direction) in a linear, straight, curved and/or arcuate manner, more preferred in a wave or zigzag manner.

[0017] Thereby, it is possible to tailor the flow rate and distribution of the polishing agent across the polishing surface to the specific polishing application. Accordingly, the thickness of the film of the polishing agent can be adapted to the individual application, such as the lens material, the rotational speeds, and/or the polishing agent used. Thus, the polishing result and efficiency can be improved even further.

[0018] According to a further preferred embodiment, the groove may comprise different sections (or differently configured sections). For example, the groove may comprise straight, angled, arcuate and/or curved sections.

[0019] Thus, by providing the groove with dissimilar sections the flow speed of the polishing agent can be different in each of the respective sections. Thereby, the design of the polishing tool can take effects of centrifugal or other dynamic operational forces into consideration.

[0020] Preferably, adjoining sections may extend circumferentially in opposite directions. Preferably, the sections may have the same radial orientation.

[0021] By alternating the extension direction of adjoining sections (only) circumferentially, flow of the polishing agent can be decelerated and thus, a constant film thickness can be ensured across the polishing surface during operation.

[0022] The adjoining sections may preferably be connected to each other by an arcuate portion that more preferred may form a gradual transition between the respective adjoining sections. For example, the groove may comprise a straight first section that connects the channel opening with a curved second section, and a third section that extends straight (or in a linear manner) from the second section to the perimeter of the polishing surface.

[0023] By avoiding sharp edges or corners at a transition between different sections of the groove, the accumulation of solid material (e.g. abrasion particles or abraded lens material) contained in the polishing agent can be prevented and thus, the risk of blockage of the groove during the polishing process can be reduced.

[0024] According to a preferred embodiment, the groove may have a width ranging from 0.1mm to 1.0mm, or from 0.2mm to 0.8mm, or from 0.4mm to 0.6mm, or of 0.5mm. Alternatively or additionally, the groove may have a depth ranging from 0.1mm to 1.0mm, or from 0.2mm to 0.8mm, or from 0.4mm to 0.6mm, or of 0.5mm.

[0025] By providing the cross-section of the groove with the above dimensions, the thickness of the film of polishing agent between the polishing surface and the lens surface is advantageous. Thereby, the results and quality of the polishing process can be improved.

[0026] According to a further preferred embodiment, the polishing tool may comprise a plurality of said grooves. Preferably, the grooves may radially diverge. Alternatively or additionally, the grooves may be (evenly) distributed about the outlet or the rotational axis. The grooves may preferably have the same or at least partially a different shape and/or cross-section (as seen along the main extension direction). Preferably, the cross-section may be triangular, rectangular, rounded and/or any other suitable shape. Preferably, the polishing tool (or the groove(s)) may be configured such that, in operation, the polishing agent may be distributed differently depending on the rotational direction.

[0027] By providing the polishing surface with a multitude of differently orientated and configured grooves, the thickness of the film of polishing agent between polishing surface and lens surface can be adjusted and the polishing tool can be optimized for specific applications. Hence, the quality of the polishing process can be improved.

[0028] According to a preferred embodiment, the tool body may comprise a layered structure and/or may comprise different components that preferably may be integrally provided. Alternatively or additionally, the different components (namely a below described base portion, holder portion and polishing film) may be connected to each other by gluing. For instance, the tool body may comprise one or more (different) sections, for example, a base portion, a holder portion and/or a polishing film. Preferably, the (three) sections may be arranged in the aforementioned order.

[0029] Thereby, portions (layers) of the polishing tool can be provided from different materials and with different characteristics while maintaining the polishing tool as a unit.

[0030] Preferably, the tool body may comprises a polishing film forming the first axial end of the tool body. More preferred, the polishing film may form the polishing surface. The polishing film may be configured to enter into contact with the optical surface of the lens. For example, during the surface machining process, the polishing tool may be pressed against the lens with the polishing film. Typically, in a surface machining process the lens and the polishing tool (with the polishing film) may be rotated in opposite directions to each other. By squeezing the polishing agent between polishing film and optical surface of the lens, mechanical abrasion may be effected due to the relative movement between the two surfaces (e.g. lens/polishing film). Preferably, the polishing film may comprise the outlet and the groove. The polishing film may preferably have a thickness ranging from 0.5mm to 2.5mm, or from 0.8mm to 2.0mm, or of 1.3mm. The polishing film may be provided as a coating and/or may be made of a soft material, such as plastic, e.g. polyurethane. Preferably, the polishing film may have a surface hardness ranging from 40 ShA up to 90 ShA. Therein, the numerical values with the unit "ShA" relate to the Shore A Hardness Scale.

[0031] Thereby, the polishing surface can be provided with properties required in a polishing process of a lens surface, like material flexibility, abrasion resistance and low adhesion.

[0032] For instance, the polishing film may correspond to a portion of prior art polishing tools that is commonly referred to as "carrier". However, this is only an example.

[0033] Alternatively or additionally, the tool body may comprise a base portion for rotatably supporting the polishing tool. The base portion may preferably form the second axial end and/or it may comprise the inlet. For example, the base portion may be made of a rigid material, such as metal or hard plastic, e.g. nylon. Preferably, the base portion may have a tensile strength between 50 MPa to 100 MPa. More preferred, the base portion may have a thickness (i.e. extension along the rotational axis) between 5 mm and 15 mm. Preferably, the base portion may be relatively stiff in comparison to other sections of the tool body. The base portion may be made of a rigid plastic or metal.

[0034] Thereby, the polishing tool can be provided with a rigid base that can be coupled to a motor for operating the polishing tool. In addition, the polishing tool can be provided with sufficient rigidity, e.g. to apply, if required, pressure onto the surface of the lens.

[0035] Preferably, the tool body may further comprise a holder portion. The holder portion may be attached to at least one of the polishing film and the base portion. Preferably, the holder portion may be sandwiched between the polishing film and the base portion. The holder portion may be deformable for adapting to the optical surface of the spectacle lens. For example, the holder portion may be made of a soft material, such as plastic. For instance, it is conceivable that the holder portion may be made of polyurethane or a closed cell rubber material, such as neoprene, EPDM (ethylene propylene diene monomer) or NBR (nitrile butadiene rubber). Preferably, the holder portion may have a modulus of elasticity ranging between 2 MPa and 12MPa. More preferred, the holder portion may have a thickness (i.e. extension along the rotational axis) between 10 mm and 25 mm. The holder portion may be relatively flexible in comparison to the base portion. Preferably, the holder portion may have a layered structure. For example, the holder portion may be made of different materials. Alternatively or additionally, the holder portion may comprise layers of the same material but different material configuration (e.g. density, air permeability, pore size).

[0036] Thereby, it is possible to provide the polishing tool with a barrier layer that prevents the polishing tool from absorbing polishing agent and protects the base portion from corroding. Further, the polishing tool can be provided with a layer from material having a balanced ratio between rigidity and flexibility to adapt to the shape (curvature) of the lens surface while maintaining the capability of the polishing tool of exerting pressure on the lens surface.

[0037] According to a further preferred embodiment, the channel may extend along the rotational axis of the polishing tool. Preferably, the channel may be coaxial with the rotational axis. More preferred, the outlet may be at the centre of the polishing surface. Alternatively or additionally, (as so far present) the channel may penetrate at least one, preferably each of the polishing film, the base portion and the holder portion. Preferably, the channel may have a diameter ranging from 0.1mm to 100mm, preferably 1.0mm to 20mm, most preferred 10mm. Preferably, the tool body (preferably the base portion (if present)) may comprise a port for fluidly connecting the channel with a polishing agent supply unit. More preferred, the port may comprises a gasket for radially sealing against the polishing agent supply unit to prevent the polishing agent from leakage and/or to enable only the polishing agent entering the channel via the inlet. The port may be a hose connector or a valve, for example.

[0038] Thereby, a sufficient and consistent supply of the polishing surface with polishing agent can be ensured. Furthermore, it is possible to connect the polishing tool removably with a polishing apparatus so that differently configured polishing tools can be used with the same polishing apparatus. Thus, this configuration improves the flexibility and applicability of the polishing tool.

[0039] A further aspect of the present invention relates to a system for polishing at least one optical surface of a spectacle lens. The system comprises a surface processing unit for processing the optical surface of the spectacle lens. Therein, the surface processing unit comprises the polishing tool as described above. Further, the surface processing unit comprises a polishing agent supply unit that is fluidly connected to the channel via the inlet of the polishing tool to supply the groove (or grooves) of the polishing surface with a polishing agent via the channel and the outlet. The system further comprises a lens support unit for supporting the spectacle lens during the polishing process. The system also comprises a drive unit to apply a relative motion between the polishing tool and the lens support unit at least by rotating the polishing tool about the rotational axis to allow polishing of the optical surface.

[0040] The system comprises all advantages and benefits that were described in detail above for the polishing tool. In addition, with the above described system, a highly customized spectacle lens having a customized power map (such as shown in Figure 2) can be generated and polished with the required accuracy and quality.

[0041] According to a preferred embodiment, the relative motion may comprise tilting, pivoting and/or linearly moving the polishing tool relatively to the lens support unit to apply the relative motion. Alternatively or additionally, the drive unit may be adapted to rotate the lens support unit about a second rotational axis (e.g. of a spindle) to apply the relative motion. Alternatively or additionally, the drive unit may be preferably adapted to displace the polishing tool relative to the lens support unit to obtain a defined distance between the polishing tool and the lens support unit (or preferably (the optical surface of) the spectacle lens). Preferably, the distance may be between 0.01micrometers to 0.5mm. More preferred, the size of the distance may depend on (or correspond with) the size of the particles in the polishing agent. However, it is also conceivable that the drive unit may be preferably adapted to displace the polishing tool relative to the lens support unit so that there is no gap (i.e. distance equal to or even below zero) between the polishing tool and the lens support unit (or preferably (the optical surface of) the spectacle lens). For example, it is conceivable that the polishing tool may be set to be in contact or in pressurized contact with the lens surface.

[0042] Thereby, it is possible to adjust movements of the polishing tool with high precision and flexibility as the thickness of the film of polishing agent forming between the lens surface and the polishing surface can be ensured in the system. Also, it is not necessary to reduce the velocity of the respective moving system components so that the polishing time can be maintained or even reduced while improving the quality of the polishing result. Further, it is not necessary to increase the size of pumps, pipes or a tank for delivering a sufficient amount of polishing agent between the polishing tool and the lens surface.

[0043] According to a further embodiment, the system may further comprise a control unit for controlling the relative motion by the drive unit. Preferably, the control unit may be suitable and/or configured to control said relative motion based on processing features. Such processing features may comprise, for example, type of lens to be generated, form and/or thickness of the lens, type of polishing tool, and/or type of polishing agent. Naturally, further processing features may be possible. Preferably, the control unit may be configured to adapt a relative rotational speed between the optical surface and the polishing tool. Alternatively or additionally, the control unit may be configured to adapt a pressure for supplying the polishing agent through the polishing tool and/or it may be configured to adapt a flow rate of the polishing agent.

[0044] Thereby, it is possible to accurately adjust the thickness of the film between the lens surface and the polishing surface in correlation with the relative position and/or movement of the polishing tool to the lens surface. Thus, polishing can be completed without undue kinematic constraints and with high quality.

[0045] Preferably, the polishing agent may comprise a fluid (preferably comprising water and/or a cooling agent,) and solid (metal (e.g. aluminium), diamond powder, minerals, silicon or plastic) particles with a grain size ranging from 1 to 2 micrometres.

[0046] Thereby, it is possible to smooth and level the surface of the lens with high precision so that scattering of light through the lens and specular reflection can be reduced.

[0047] According to a preferred embodiment, the polishing agent supply unit may be fluidly connected to the polishing tool through the port (of the tool body, preferably provided at the base portion). Therein, a or said gasket may radially seal against the polishing agent supply unit to prevent the polishing agent from leakage and to enable the polishing agent entering the channel only via the inlet. Preferably the polishing agent supply unit may comprise a pump and a tank for supplying the polishing agent.

[0048] Thereby, fast processing times can be achieved as the polishing tool can be quickly and reliably connected and disconnected from the surface processing unit.

[0049] A further aspect of the present invention relates to a process of polishing an optical surface of a spectacle lens. The process comprises the step of providing a system for surface processing having a polishing tool as described above. Alternatively or additionally, the process comprises the step of providing the system described above. A spectacle lens is seated in a lens support unit of the system (either of the aforementioned systems). The polishing tool is relatively rotated with respect to the spectacle lens. A polishing agent is delivered through the channel (of the polishing tool) to the polishing surface (of the polishing tool), which faces an optical surface of the spectacle lens to be polished, so that the polishing agent is delivered through the grooves radially outwards from the outlet (of the polishing tool) to distribute the polishing agent across the polishing surface for polishing the optical surface.

[0050] Preferably, the process further comprises the step of controlling a thickness of a layer of the polishing agent between the optical surface and the polishing surface (with the control unit) by adapting one or more processing parameters. The processing parameters may be a flow rate or a supply pressure of the polishing agent. The processing parameters may be preferably (additionally) one or more of the group of distance between the polishing surface and the optical surface, rotational velocities of the lens and polishing tool, and/or the polishing tool's translational moving speed(s) relative to the lens. The processing parameters may be adapted based on a rotational speed of either or both of the polishing tool and the spectacle lens.

[0051] With such configurations of the method, it is possible to achieve all advantages and benefits that were described in detail above. Also, it is possible to improve the quality and accuracy of the lens generated in the polishing process.

[0052] A further aspect of the present invention relates to a use of a polishing tool as described above for polishing an optical surface of a spectacle lens with a polishing agent. Preferably, the spectacle lens is a progressive lens.

4. Brief description of drawings

[0053] Further features, advantages and objects of the invention will become apparent for the skilled person when reading the following detailed description of embodiments of the invention and when taking in conjunction with the figures of the enclosed drawings. In case numerals have been omitted from a figure, for example for reasons of clarity, the corresponding features may still be present in the figure.

Figure 1 shows schematically a lens in a front view and a side view.

Figure 2 shows schematically a customized lens in a side view at the end of a surface machining process.

Figure 3 shows schematically a side view of the connection between a lens and a lens support at the beginning of a surface machining process.

Figure 4 shows schematically a side view of a customized lens in a lens support during a surface machining process.

Figures 5 and 6 show schematically a side view of a customized lens in a lens support being polished in a surface machining process of the prior art.

Figures 7 and 8 show schematically a side view of an experimental setup for testing polishing tools for polishing a customized lens in a lens support, respectively.

Figure 9 shows a schematic sectional view of an embodiment of a polishing tool according to the present invention.

Figure 10 shows a schematic front view of an embodiment of a polishing tool according to the present invention.

Figure 11 shows a schematic view of an embodiment of a system according to the present invention with the polishing tool of Figure 9.

5. Detailed description

[0054] Figure 1 shows exemplary a profile of a lens L before the start of a surface machining process. Figure 2 shows an example of a customized lens L at the end of a surface machining process. Figures 3 and 4 show different steps of a lens generating process. Figures 5 and 6 highlight known problems existing in the prior art. Each of Figures 7 and 8 illustrates an experimental setup for identifying problems existing in polishing processes. Figures 9 to 11 show different views and aspects of embodiments of the invention.

[0055] For instance, a first aspect of the invention relates to a polishing tool 100 for polishing a spectacle lens L in a surface machining process. Embodiments of the polishing tool 100 are exemplarily illustrated in Figures 7 to 9.

[0056] Generally, a "lens" may be understood, for example, as any transmissive optical device that is adapted to change the course of light by refraction. For example, the lens L may be an ophthalmologic lens, such as corrective or prescription lenses. Figures 1 and 2 show examples for the lens L. The lens L may have two opposite optical (side) surfaces L1, L2 and a circumferential edge L3. The optical (side) surfaces L1, L2 may be convex and/or concave. Typically, the lenses L may be made of a transparent and/or translucent material, e.g. a plastic material for spectacle lenses, such as polycarbonate, or glass.

[0057] In a surface machining process, typically only one of the two optical surfaces L1, L2 may be processed while the other one of the two side surfaces L1, L2 of the lens L is supported by a lens support unit 220. This is exemplarily illustrated in Figures 3 to 6 and 11. Naturally, either or both of the two side surfaces L1, L2 of the lens L may be processed in the surface machining process.

[0058] The surface machining process may be started by choosing a lens blank, such as the lens L exemplarily shown in Figure 1, with a front surface L2 most suitable for the vision enhancing application, which may remain unchanged. In comparison, the rear surface L1 of the lens blank L may be processed to generate a customized (progressive) lens L, as exemplarily shown in Figure 2.

[0059] The surface machining process may typically comprise, for example, any surfacing or manufacturing step(s) for the generation of optical devices, such as cribbing (i.e. reducing an outer diameter of the lens blank L in a milling process), roughing (i.e. grinding one of the optical surfaces L1, L2 to the approximate curvature and thickness), smoothing (i.e. grinding one of the optical surfaces L1, L2 to the exact curvature and thickness), bevelling (i.e. cutting the lens L to the shape of eyeglass frames) and polishing (i.e. making the lens L smooth; providing regular transmission and reduce specular reflection). However, these are only examples and not a complete enumeration.

[0060] The polishing tool 100 is suitable (and configured) for being used in such a surface machining process, for example. Further, the polishing tool 100 is suitable (and configured) for polishing spectacle lenses; consequently, the polishing tool 100 may be suitable for following curvatures typically existing with spectacle lenses and for processing typical materials used for spectacle lenses.

[0061] The polishing tool 100 comprises a tool body 110 for being rotatably supported about a rotational axis RA1. This is exemplarily indicated in Figures 9 and 11. The rotational axis RA1 may be a body axis or a symmetry axis of the tool body 110 and/or an axis offset from the polishing tool 100.

[0062] The tool body 110 comprises a first axial end 101 and a second axial end 102, which is provided opposite to the first axial end 101 with respect to the rotational axis RA1. Preferably, the tool body 110 may extend (continuously) along (with) the rotational axis RA1 from the first axial end 101 to the second axial end 102. Figures 9 and 11 show this exemplarily. The tool body 110 may have any shape or form, such as a cylindrical shape. For example, the tool body 110 may be coaxial with the rotational axis RA1.

[0063] The tool body 110 may comprise a layered and/or a continuous structure, for example. In Figures 9 and 11, the tool body 110 is exemplarily shown as being composed of different layers. The tool body 110 may comprise any number of layers. The respective layers may be connected to each other by adhesive bond, like gluing, or by a mechanical connection, such as a screw. However, these are only examples and not a complete enumeration.

[0064] At the first axial end 101, the tool body 110 comprises a polishing surface 130, which is exposed to the outside. Figure 11 illustrates exemplarily how the outwardly exposed configuration of the polishing surface 130 can facilitate an interaction between the polishing tool 100 and the lens surface L1. The polishing surface 130 is axially bulged convexly or concavely with respect to the rotational axis RA1 for polishing an optical surface L1, L2 of the lens L. For example, depending on the type of the lens L, e.g. a converging or diverging lens, the polishing surface 130 may have a curved (round) shape projecting outwardly (convex) or retracting inwardly (concave). Figures 9 and 11 show the polishing surface 130 exemplarily being axially bulged convexly with respect to the rotational axis RA1. Preferably, the polishing surface 130 may be bulged such that the polishing surface 130 may have a curvature at least similar or higher than the optical surface L1, L2. More preferred, the polishing surface 130 may be smaller in size than the optical surface L1, L2 of the lens L. For example, the polishing surface 130 may cover 1/50, 1/20, 1/10, 1/8, 1/5, or 1/4 of the (entire) area of the optical surface L1, L2. The polishing surface 130 may form an (axial) end face of the polishing tool 100. Further, the polishing surface 130 may face in a direction away from the second axial end 102. The polishing surface 130 may have any shape or form. For example, the polishing surface 130 may be circular or oval when seen along the rotational axis RA1. However, these are only examples and not a complete enumeration.

[0065] Preferably, the polishing surface 130 may be formed by a polishing film 113 of the tool body 110. The polishing film 113 may form the first axial end 101. The polishing film 113 may be one of the layers of the tool body 110. For example, the polishing film 113 may be made of soft a material to avoid damaging the optical surface L1, L2 of the lens L in a polishing process. For instance, the polishing film 113 may be made of polyurethane. Naturally, other materials can be used for forming the polishing film 113. The polishing film 113 may be provided as a coating or a film. Preferably, the polishing film 113 may have a thickness ranging from 0.5mm to 2.5mm, or from 0.8mm to 2.0mm, or of 1.3mm. The polishing film 113 may comprise a projecting edge 133 that protrudes radially from the tool body 110 as exemplarily illustrated in Figure 9. Thereby, excessive operational forces when by entering the optical surface L1 in the polishing process can be avoided.

[0066] The second axial end 102 of the tool body 110 may preferably be formed by a base portion 111. The base portion 111 may be one of the layers of the tool body 110. The base portion 111 may be suitable (or configured) for rotatably supporting the polishing tool 100, for example, in a tool holder of a lens generator for a surface machining process. This is exemplarily indicated in the schematic illustration of Figure 11. For this, the base portion 111 may be made of a preferably rigid material, such as metal or hard plastic, like nylon. However, this is only an example and it is conceivable to use other materials.

[0067] Preferably, the tool body 110 may also comprise a holder portion 112, which may be arranged between the polishing film 113 and the base portion 111. The holder portion 112 may be one of the layers of the tool body 110. The holder portion 112 may be capable of adapting axially to the contour of the optical surface L1, L2 of the lens L. For this, the holder portion 112 may be configured to be reversibly deformable under pressure. For example, the holder portion 112 may be made of plastic, e.g. a closed cell rubber material, such as neoprene, EPDM or NBR.

[0068] The tool body 110 further comprises a channel 140, which extends axially (along or coaxially with the rotational axis RA1) through the tool body 110. Therein, the channel 140 may penetrate the polishing film 113, the base portion 111 and the holder portion 112, respectively, as exemplarily illustrated in Figures 9 and 11. The channel 140 may have a constant, stepwise or continuously increasing/decreasing diameter along its extension direction. Preferably, the channel 140 may have a cross-section of any shape or form, for example a circular or rectangular cross-section. The channel 140 may be formed by the passages formed in the respective sections of the tool body 110 or it may be formed by providing a tube or hose extending through these passages. However, these are only examples and not a complete enumeration.

[0069] The channel 140 comprises an inlet 142, preferably for feeding a polishing agent into the channel 140. This is exemplarily illustrated in Figures 9 and 11. The inlet 142 is provided at the second axial end 102. Preferably, the base portion 111 may comprise the inlet 142. More preferred, the inlet 142 may be formed as an opening, for example in (the tool body 110 or) the base portion 111. The inlet 142 may have a cross-section with the same or a different shape as the channel 140. The channel 140 may expand radially towards or at the inlet 142. Figures 9 and 11 show this exemplarily.

[0070] The tool body 110 (or the base portion 111) may further comprise a port 143 for fluidly connecting the channel 140 with a polishing agent supply unit 240 (such as illustrated in Figure 11). This is exemplarily illustrated in Figures 9 and 11. The port 143 may be a valve, hose connector, pipe or hose. Preferably, the port 143 may have the same size as the inlet 142. More preferred, the port 143 may be removeably connected to the inlet 142. The port 143 may be press-fitted into the inlet 142. Preferably, the port 143 may comprise a gasket 144 for radially sealing against the polishing agent supply unit 240 (cf. Figure 11) to prevent the polishing agent from leaking and to enable only the polishing agent entering the channel 140 via the inlet 142. This is exemplarily shown in Figures 9 and 11. The gasket 144 may be made of rubber and/or may be an O-ring. However, these are only examples and not a complete enumeration.

[0071] The channel 140 further comprises an (preferably a single) outlet 141 to supply the polishing surface 130 with a polishing agent (preferably, the polishing agent fed through the inlet 142). The outlet 141 is provided at the first axial end 101. Preferably, the outlet 141 may be provided at the centre of the polishing surface 130 (such as exemplarily illustrated in Figures 9 to 11). Preferably, the outlet 141 may be coaxial with the rotational axis RA1. However, it is also conceivable to provide the outlet 141 at a different position. For example, the outlet 141 may be provided in a section immediately (e.g. radius <10mm) surrounding the rotational axis RA1 (or the centre of the polishing surface 130). Preferably, the polishing film 113 may comprise the outlet 141. This is exemplarily illustrated in Figures 9 to 11. The outlet 141 may have any shape or form. For example, the outlet 141 may be circular, and/or may expand or reduce in diameter towards the first axial end 101. Preferably, the outlet 141 may be formed (to provide the same functionality) as a nozzle or throttle. The outlet 141 may have a diameter significantly smaller than the diameter of the polishing surface 130 (delimited by the perimeter), i.e. 1/100, 1/80, 1/50, 1/20, 1/10, 1/8, or 1/5 of the diameter of the polishing surface 130.

[0072] The polishing agent may be a mixture between a liquid and solid particles, for example. The liquid may comprise water and/or a cooling agent. The solid particles may be made of metal (e.g. aluminium oxide), silicon or plastic. Preferably, the solid particles may have a grain size ranging from 1 to 2 micrometres.

[0073] The polishing surface 130 comprises at least one groove 150. Preferably, the polishing film 113 may comprise the groove 150. Figures 9 to 11 show this exemplarily.

[0074] As indicated exemplarily in Figure 10, the polishing surface 130 may comprise a plurality of said grooves 150 (i.e. more than one of the groove 150). If in the following reference is made to "the groove 150", the respective description also applies to the "plurality of grooves 150" unless specified otherwise. The grooves 150 may have the same or a different configuration. For example, the grooves 150 may be identical or they may have at least partially a different shape and/or cross-section.

[0075] The groove 150 extends radially away from the outlet 141 to the perimeter of the polishing surface 130 to distribute the polishing agent across the polishing surface 130. The groove 150 may have any shape or form. For instance, the groove 150 may extend radially along a main extension direction. Therein, the groove 150 may extend such that its path does not turn back in a radial direction towards the outlet 141 (but instead, the groove 150 may proceed extending radially outwards). The groove 150 may extend in a linear, straight, curved and/or arcuate manner.

[0076] Alternatively or additionally, as exemplarily shown in Figure 10, the groove 150 may extend in a wave or zigzag manner. Therein, the groove 150 may comprise different sections. The different sections may be connected to each other to form a continuous flow path for the polishing agent. Preferably, adjoining sections may be connected to each other by an arcuate portion. More preferred, the connecting portions, e.g. the arcuate portions, may form a gradual transition between the respective adjoining sections. Thereby, a continuous flow in the groove 150 can be achieved and blockages can be avoided. Preferably, the respective section (one of the different sections) may be straight, angled, arcuate and/or curved. Adjoining sections may extend circumferentially in opposite directions. An example for the different sections is provided in Figure 10, where the groove 150 is exemplarily illustrated as comprising a straight first section 151 that connects the outlet 141 with a curved second section 152, and a third section 153 that extends straight from the curved second section 152 to the perimeter of the polishing surface 130 (polishing film 113). It is further conceivable that the groove 150 may have branches and/or may diverge into other (neighbouring) groove(s) 150.

[0077] The groove 150 may have a circular or rectangular cross-section when seen along the main extension direction and/or along a flow direction. Preferably, the groove 150 may have a width W ranging from 0.1mm to 1.0mm, or from 0.2mm to 0.8mm, or from 0.4mm to 0.6mm, or of 0.5mm (cf. Figure 10). Alternatively or additionally, the groove 150 may have a depth T ranging from 0.1mm to 1.0mm, or from 0.2mm to 0.8mm, or from 0.4mm to 0.6mm, or of 0.5mm (cf. Figure 9).

[0078] Different grooves 150 may preferably be provided on the polishing surface 130 as radially diverging. Alternatively or additionally, the plurality of grooves 150 may be (evenly) distributed about the outlet 141 (or the rotational axis RA1). For example, based on the arrangement and/or configuration of the grooves 150 (e.g. circumferential orientation, curved sections etc.), the polishing tool 100 may be used only in one rotational direction about the rotational axis RA1 in order to work properly.

[0079] A further aspect of the present invention relates to a system 200 for polishing of at least one of the optical surfaces L1, L2 of the spectacle lens L. Figure 11 shows this exemplarily.

[0080] The system 200 comprises a surface processing unit 210 for processing the optical surface L1, L2 of the spectacle lens L. Therein, the surface processing unit 210 comprises the above described polishing tool 100. For example, it is also conceivable that the surface processing unit 210 may comprise a linearly movable (indicated by arrows 410, 420) cutter 400, such as illustrated exemplarily in Figure 4.

[0081] The surface processing unit 210 comprises further a polishing agent supply unit 240 to supply the polishing surface 130 with a polishing agent. The polishing agent supply unit 240 is fluidly connected to the channel 140 (through the port 143) via the inlet 142 of the polishing tool 100 to supply the groove(s) 150 with polishing agent through the outlet 141. Preferably, the above described gasket 144 may radially seal the connection to prevent the polishing agent from leakage and to enable the polishing agent entering the channel 140 only via the inlet 142. Thus, for example, the polishing agent may be pumped by a pump 241 of the polishing agent supply unit 240 from a voluminous tank 242 of the polishing agent supply unit 240 through a pipe 213 to the port 143 and, subsequently, to the inlet 142. From the inlet 142, the polishing agent may flow through the channel 140 to the outlet 141 and to the groove(s) 150. For example, in the state of rotating the polishing tool 100 about the rotational axis RA1, the polishing agent is pushed radially outwards towards the perimeter of the polishing surface 130. Simultaneously existing circumferential forces may drive the polishing agent out of the grooves 150 so that the polishing agent is distributed across the (entire) polishing surface 130. The different configuration of the sections of the grooves 150 may cause the polishing agent to flow with different speeds. In particular, gradual transitions between adjoining sections may be useful for lowering the speed of flow of the polishing agent flowing through parts of the groove 150 that are radially further away from the outlet 141. Thus, effects of the centrifugal acceleration can be reduced.

[0082] The system 200 comprises further a lens support unit 220 (mentioned before in relation to Figures 3 to 6) for supporting the lens L during the polishing process. For this, the lens support unit 220 may comprise a lens holder 222 that may apply a suction force onto the lens L. Additionally, the lens support unit 220 may comprise a spindle 221 that rotates about a second rotational axis RA2 (indicated by arrow 223). Figures 3 to 6 and 11 show this exemplarily.

[0083] The system 200 comprises also a drive unit to apply a relative motion between the polishing tool 100 and the lens support unit 220. Therein, the relative motion comprises at least rotating the polishing tool 100 about the rotational axis RA1 to facilitate polishing of the optical surface L1, L2 with the polishing tool 100. This is exemplarily indicated by arrow 213 of Figure 11. Additionally, the relative motion may comprise tilting, pivoting and/or linearly moving (as indicated by arrows 211 and 212 in Figure 11) the polishing tool 100 relatively to the lens support unit 220 to apply the relative motion. Preferably, the drive unit may be adapted to displace the polishing tool 100 relative to the lens support unit 220 in order to obtain a defined distance therebetween.

[0084] It is also conceivable that the drive unit comprises and/or drives the spindle 221. Therein, the drive unit may be preferably adapted to rotate the lens support unit 220 about the second rotational axis RA2 to effect the (additional) relative motion (e.g. arrow 223). The drive unit may be part of the surface processing unit 210 or vice versa. Figure 11 shows this exemplarily.

[0085] The system 200 may further comprise a control unit 230 for controlling the relative motion by the drive unit and/or the surface processing unit 210. The control unit 230 may control the system 200 based on processing features, like the lens type, form and thickness, the polishing tool type, the polishing agent type. Therein, the control unit 230 preferably may be configured to adapt a relative rotational speed between the optical surface L1, L2 and the polishing tool 100. Alternatively or additionally, the control unit 230 may be configured to adapt a pressure for supplying the polishing agent to the polishing tool 100 and/or a flow rate of the polishing agent (through the channel 140).

[0086] A further aspect of the present invention relates to a process of polishing at least one of the optical surfaces L1, L2 of the (spectacle) lens L. In the process, the above system 200 is provided. Alternatively, it is also conceivable to provide a different system for surface processing having the above described polishing tool 100.

[0087] The (spectacle) lens L is seated in said (or a) lens support unit 220. The polishing tool 100 is relatively rotated with respect to the lens L. A polishing agent is delivered through the channel 140 to the polishing surface 130, which faces an optical surface L1, L2 of the lens L to be polished. Through the rotation, for example, the polishing agent is delivered through the grooves 150 radially outwards from the outlet 141 so that the polishing agent is distributed across the polishing surface 130 for polishing the optical surface L1, L2.

[0088] For example, in a surface machining process, typically the lens L and the polishing tool 100 (with the polishing film 113) may be rotated relatively to each other in opposite directions from each other. By supplying polishing agent through the channel 140 into the grooves 150, the polishing agent can be transported (and squeezed) between the polishing surface 130 (the polishing film 113) and the optical surface L1, L2 of the lens L. Thereby, mechanical abrasion can be effected as the abrasive particles contained in the polishing agent can be moved due to the relative movement between the two surfaces (e.g. optical surface L1, L2/polishing surface 130). For example, it may be advantageous to provide a plurality of grooves 150 across the polishing surface 130 so that the polishing agent can be distributed uniformly. Generally, by directing/routing the polishing agent through the (pathway of the) grooves 150, it may be possible to control the exposure of the polishing agent to circumferential and radial acceleration (depending on its position in the groove 150). Thereby, the distribution of the polishing agent across the polishing surface 130 may be improved as it becomes possible to control how the polishing agent travels across the polishing surface 130 (i.e. where and when it travels with respect to being dispensed from the outlet 141).

[0089] The process may further comprise the step of controlling a thickness of a layer (film) of the polishing agent between the optical surface L1, L2 and the polishing surface 130 by adapting a flow rate and/or a supply pressure of the polishing agent based on a rotational speed of the polishing tool 100 and/or the spectacle lens L. However, it is also conceivable to consider (in addition) other parameters, such as the desired smoothness of the lens L or the consistency and composition of the polishing agent.

[0090] The invention is not limited by the embodiments as described hereinabove, as long as being covered by the appended claims.

[0091] For example, it is also conceivable that the tool body 110 may comprise a plurality of channels 140 extending through the tool body 110. The plurality of channels 140 may connect one or more of the inlet 142 with one or more of the outlet 141. For example, each of the plurality of channels 140 may correspond with one inlet 142 and one outlet 141. However, each of the plurality of channels 140 may extend between the same inlet 142 and a plurality of outlets 142 that may be provided on the polishing surface 130. Each of the plurality of outlets 141 may be provided with one or more grooves 150 extending therefrom radially away to the perimeter of the polishing surface 130 to distribute the polishing agent across the polishing surface 130. For example, the plurality of outlets 141 may be distributed uniformly across the polishing surface 130. For instance, (larger) gaps between the grooves 150 as shown exemplarily in Figure 10, may be provided with additional outlets 141 and additional grooves 150 (not illustrated).

Claims

1. A polishing tool (100) for polishing a spectacle lens (L) in a surface machining process, comprising a tool body (110) for being rotatably supported about a rotational axis (RA1),

   wherein the tool body (110) comprises a polishing surface (130) being outwardly exposed at a first axial end (101) of the tool body (110), the polishing surface (130) being axially bulged convexly or concavely with respect to the rotational axis (RA1) for polishing an optical surface (L1, L2) of the spectacle lens (L),

wherein the tool body (110) comprises a channel (140) extending axially through the tool body (110) from an inlet (142), which is provided at a second axial end (102) being opposite to the first axial end (101) with respect to the rotational axis (RA1), to an outlet (141), which is provided at the first axial end (101), to supply the polishing surface (130) with a polishing agent,

characterized in that

the polishing surface (130) comprises at least one groove (150) that extends radially away from the outlet (141), the outlet (141) being the groove's (150) starting point, to the perimeter of the polishing surface (130) to distribute the polishing agent across the polishing surface (130).

2. The polishing tool (100) according to claim 1, wherein the groove (150) extends radially along a main extension direction, preferably in a linear, straight, curved and/or arcuate manner, more preferred in a wave or zigzag manner.

3. The polishing tool (100) according to claim 1 or claim 2, wherein the groove (150) comprises different sections, preferably straight, angled, arcuate and/or curved sections, wherein adjoining sections extend circumferentially in opposite directions, wherein preferably the adjoining sections are connected to each other by an arcuate portion that more preferred forms a gradual transition between the respective adjoining sections.

4. The polishing tool (100) according to any one of the preceding claims, wherein the groove (150) has a width (W) ranging from 0.1mm to 1.0mm, or from 0.2mm to 0.8mm, or from 0.4mm to 0.6mm, or of 0.5mm, and/or

wherein the groove (150) has a depth (T) ranging from 0.1mm to 1.0mm, or from 0.2mm to 0.8mm, or from 0.4mm to 0.6mm, or of 0.5mm.

5. The polishing tool (100) according to any one of the preceding claims, comprising a plurality of the said grooves (150), wherein the grooves (150) are preferably radially diverging and/or preferably distributed, more preferred evenly distributed about the outlet (141) or the rotational axis (RA1), wherein the grooves (150) preferably have the same or at least partially a different shape and/or cross-section.

6. The polishing tool (100) according to any one of the preceding claims, wherein the tool body (110) comprises a polishing film (113) forming the first axial end (101) of the tool body (110), wherein the polishing film (113) comprises the outlet (141) and the groove (150), and wherein preferably the polishing film (113) has a thickness ranging from 0.5mm to 2.5mm, or from 0.8mm to 2.0mm, or of 1.3mm.

7. The polishing tool (100) according to any one of the preceding claims, wherein the tool body (110) comprises a base portion (111) for rotatably supporting the polishing tool (100), wherein the base portion (111) preferably comprises the inlet (142), and wherein preferably the tool body (110) further comprises a holder portion (112) being sandwiched between the polishing film (113) and the base portion (111), wherein preferably the holder portion (112) is deformable for adapting to the optical surface (L1, L2) of the spectacle lens (L).

8. The polishing tool (100) according to any one of the preceding claims, wherein the channel (140) extends along the rotational axis (RA1) of the polishing tool (100) and preferably, if present, penetrating the polishing film (113), the base portion (111) and the holder portion (112), respectively.

9. The polishing tool (100) according to any one of the preceding claims, wherein the tool body (110), preferably the base portion (111) if present, comprises a port (143) for fluidly connecting the channel (140) with a polishing agent supply unit (240),

wherein preferably the port (143) comprises a gasket (144) for radially sealing against the polishing agent supply unit (240) to prevent the polishing agent from leakage and to enable only the polishing agent entering the channel (140) via the inlet (142).

10. A system (200) for polishing of at least one optical surface (L1, L2) of a spectacle lens (L), comprising

- a surface processing unit (210) for processing the optical surface (L1, L2) of the spectacle lens (L), wherein the surface processing unit (210) comprises
  - ◦ the polishing tool (100) according to any one of the preceding claims 1 to 9, and
  - ◦ a polishing agent supply unit (240) being fluidly connected to the channel (140) via the inlet (142) of the polishing tool (100) to supply the groove (150) or grooves (150) of the polishing surface (130) with a polishing agent via the channel (140) and the outlet (141),
- a lens support unit (220) for supporting the spectacle lens (L) during the polishing process, and
- a drive unit to apply a relative motion between

the polishing tool (100) and the lens support unit (220) at least by rotating the polishing tool (100) about the rotational axis (RA1) to allow polishing of the optical surface (L1, L2).

11. The system (200) according to claim 10, wherein the relative motion further comprises tilting, pivoting and/or linearly moving the polishing tool (100) relatively to the lens support unit (220) to apply the relative motion, and/or

wherein the drive unit is preferably adapted to rotate the lens support unit (220) about a second rotational axis (RA2) to apply the relative motion, and/or
wherein the drive unit is preferably adapted to displace the polishing tool (100) relative to the lens support unit (220) to obtain a defined distance therebetween.

12. The system (200) according to claim 10 or 11, further comprising a control unit (230) for controlling the relative motion by the drive unit based on processing features, like the lens type, form and thickness, the polishing tool type, the polishing agent type,
wherein preferably the control unit (230) is configured to adapt a relative rotational speed between the optical surface (L1, L2) and the polishing tool (100), and/or a pressure for supplying the polishing agent to the polishing tool (100), and/or a flow rate of the polishing agent.

13. The system (200) according to any one of claims 10 to 12, wherein the polishing agent supply unit (240) is fluidly connected to the polishing tool (100) through the port (143), wherein preferably the gasket (144) radially seals against the polishing agent supply unit (240) to prevent the polishing agent from leakage and to enable the polishing agent entering the channel (140) only via the inlet (142).

14. A process of polishing an optical surface (L1, L2) of a spectacle lens (L) comprising:

- providing a system (200) for surface processing having a polishing tool (100) according to any one of claims 1 to 9, preferably a system (200) according to any one of claims 10 to 13,
- seating a spectacle lens (L) in a lens support unit (220) of the system (200),
- relatively rotating the polishing tool (100) with respect to the spectacle lens (L),
- delivering a polishing agent through the channel (140) to the polishing surface (130) facing an optical surface (L1, L2) of the spectacle lens (L) to be polished, so that the polishing agent is delivered through the grooves (150) radially outwards from the outlet (141) to distribute the polishing agent across the polishing surface (130) for polishing the optical surface (L1, L2).

15. The process of claim 14, further comprising controlling a thickness of a layer of the polishing agent between the optical surface (L1, L2) and the polishing surface (130) by adapting a flow rate and/or supply pressure of the polishing agent based on a rotational speed of the polishing tool (100) and/or the spectacle lens (L).

Patentansprüche

1. Ein Polierwerkzeug (100) zum Polieren eines Brillenglases (L) in einem Oberflächenbearbeitungsverfahren, aufweisend einen Werkzeugkörper (110), der um eine Drehachse (RA1) drehbar gelagert ist,

wobei der Werkzeugkörper (110) eine Polierfläche (130) aufweist, die an einem ersten axialen Ende (101) des Werkzeugkörpers (110) nach außen freiliegt, wobei die Polierfläche (130), zum Polieren einer optischen Oberfläche (L1, L2) des Brillenglases (L), in Bezug auf die Drehachse (RA1) axial konvex oder konkav gewölbt ist,
wobei der Werkzeugkörper (110) einen Kanal (140) aufweist, der sich axial durch den Werkzeugkörper (110) von einem Einlass (142), der an einem dem in Bezug auf die Rotationsachse (RA1) ersten axialen Ende (101) gegenüberliegenden zweiten axialen Ende (102) vorgesehen ist, zu einem an dem ersten axialen Ende (101) vorgesehenen Auslass (141) erstreckt, um die Polierfläche (130) mit einem Poliermittel zu versorgen,
dadurch gekennzeichnet, dass
die Polierfläche (130) zumindest eine sich radial vom Auslass (141) weg erstreckende Rille (150) aufweist, wobei der Auslass (141) der Ausgangspunkt der Rille (150) ist, welche sich zum Umfang der Polierfläche (130) hin erstreckt, um das Poliermittel über die Polierfläche (130) zu verteilen.

2. Das Polierwerkzeug (100) nach Anspruch 1, wobei sich die Rille (150) radial entlang einer Haupterstreckungsrichtung erstreckt, vorzugsweise in einer linearen, geraden, gekrümmten und/oder bogenförmigen, besonders bevorzugt wellen- oder zickzackförmigen Weise.

3. Das Polierwerkzeug (100) nach Anspruch 1 oder Anspruch 2, wobei die Rille (150) unterschiedliche Abschnitte aufweist, vorzugsweise gerade, abgewinkelte, bogenförmige und/oder gekrümmte Abschnitte, wobei sich angrenzende Abschnitte in Umfangsrichtung in entgegengesetzter Richtung erstrecken, wobei vorzugsweise die angrenzenden Abschnitte durch einen bogenförmigen, zwischen den jeweiligen angrenzenden Abschnitten bevorzugt einen graduellen Übergang bildenden Abschnitt miteinander verbunden sind.

4. Das Polierwerkzeug (100) nach einem der vorherigen Ansprüche, wobei die Rille (150) eine Breite (W) im Bereich von 0,1 mm bis 1,0 mm, oder von 0,2 mm bis 0,8 mm, oder von 0,4 mm bis 0,6 mm, oder von 0,5 mm aufweist, und/oder
wobei die Rille (150) eine Tiefe (T) im Bereich von 0,1 mm bis 1,0 mm, oder von 0,2 mm bis 0,8 mm, oder von 0,4 mm bis 0,6 mm, oder von 0,5 mm aufweist.

5. Das Polierwerkzeug (100) nach einem der vorherigen Ansprüche, aufweisend eine Mehrzahl der genannten Rillen (150), wobei die Rillen (150) vorzugsweise radial divergierend und/oder vorzugsweise verteilt, besonders bevorzugt gleichmäßig um den Auslass (141) oder die Rotationsachse (RA1) verteilt sind, wobei die Rillen (150) vorzugsweise die gleiche oder zumindest nur teilweise eine unterschiedliche Form und/oder einen unterschiedlichen Querschnitt aufweisen.

6. Das Polierwerkzeug (100) nach einem der vorherigen Ansprüche, wobei der Werkzeugkörper (110) einen das erste axiale Ende (101) des Werkzeugkörpers (110) bildenden Polierfilm (113) aufweist, wobei der Polierfilm (113) den Auslass (141) und die Rille (150) aufweist, und wobei vorzugsweise der Polierfilm (113) eine Dicke im Bereich von 0,5 mm bis 2,5 mm, oder von 0,8 mm bis 2,0 mm, oder von 1,3 mm aufweist.

7. Das Polierwerkzeug (100) nach einem der vorherigen Ansprüche, wobei der Werkzeugkörper (110), zum drehbaren Tragen des Polierwerkzeuges (100), einen Basisabschnitt (111) aufweist, wobei der Basisabschnitt (111) vorzugsweise den Einlass (142) umfasst, und
wobei vorzugsweise der Werkzeugkörper (110) ferner einen zwischen dem Polierfilm (113) und dem Basisabschnitt (111) angeordneten Halterabschnitt (112) umfasst, wobei vorzugsweise der Halterabschnitt (112) verformbar ist, um sich an die optische Oberfläche (L1, L2) des Brillenglases (L) anzupassen.

8. Das Polierwerkzeug (100) nach einem der vorherigen Ansprüche, wobei sich der Kanal (140) entlang der Rotationsachse (RA1) des Polierwerkzeugs (100) erstreckt und vorzugsweise, falls vorhanden, den Polierfilm (113), den Basisabschnitt (111) bzw. den Halterabschnitt (112) durchdringt.

9. Das Polierwerkzeug (100) nach einem der vorherigen Ansprüche, wobei der Werkzeugkörper (110), vorzugsweise der Basisabschnitt (111), falls vorhanden, zur Fluidverbindung des Kanals (140) mit einer Poliermittelzuführeinheit (240), eine Öffnung (143) aufweist,
wobei vorzugsweise die Öffnung (143), zur radialen Abdichtung gegen die Poliermittelzuführeinheit (240), um ein Auslaufen des Poliermittels zu verhindern und das Poliermittel nur über den Einlass (142) in den Kanal (140) eintreten zu lassen, eine Dichtung (144) aufweist.

10. Ein System (200) zum Polieren zumindest einer optischen Oberfläche (L1, L2) eines Brillenglases (L), aufweisend

- eine Oberflächenbearbeitungseinheit (210) zum Bearbeiten der optischen Oberfläche (L1, L2) des Brillenglases (L), wobei die Oberflächenbearbeitungseinheit (210) umfasst

  ◦ das Polierwerkzeug (100) nach einem der vorherigen Ansprüche 1 bis 9, und
  ◦ eine Poliermittelzuführeinheit (240), die über den Einlass (142) des Polierwerkzeugs (100) mit dem Kanal (140) fluidisch verbunden ist, um die Rille (150) oder Rillen (150) der Polierfläche (130) über den Kanal (140) und den Auslass (141) mit einem Poliermittel zu versorgen,

- eine Linsenhalteeinheit (220) zum Halten der Brillenlinse (L) während des Poliervorganges, und
- eine Antriebseinheit, um, zumindest durch Drehen des Polierwerkzeugs (100) um die Drehachse (RA1), eine relative Bewegung zwischen dem Polierwerkzeug (100) und der Linsenhalteeinheit (220) zu erzeugen, um das Polieren der optischen Oberfläche (L1, L2) zu ermöglichen.

11. Das System (200) nach Anspruch 10, wobei die Relativbewegung ferner ein Kippen, Schwenken und/oder lineares Bewegen des Polierwerkzeugs (100) relativ zu der Linsenhalteeinheit (220) umfasst, um die Relativbewegung aufzubringen, und/oder wobei die Antriebseinheit vorzugsweise dazu ausgebildet ist, die Linsenhalteeinheit (220) um eine zweite Drehachse (RA2) zu drehen, um die Relativbewegung aufzubringen, und/oder wobei die Antriebseinheit vorzugsweise geeignet ist, das Polierwerkzeug (100) relativ zu der Linsenhalteeinheit (220) zu verschieben, um dazwischen einen definierten Abstand zu erhalten.

12. Das System (200) nach Anspruch 10 oder 11, ferner aufweisend eine Steuereinheit (230) zur Steuerung

der Relativbewegung durch die Antriebseinheit auf der Grundlage von Verarbeitungsmerkmalen, wie dem Linsentyp, der Form und der Dicke, dem Polierwerkzeugtyp, dem Poliermitteltyp,
wobei vorzugsweise die Steuereinheit (230) ausgebildet ist, um eine relative Drehgeschwindigkeit zwischen der optischen Fläche (L1, L2) und dem Polierwerkzeug (100) und/oder einen Druck zum Zuführen des Poliermittels zu dem Polierwerkzeug (100) und/oder eine Durchflussrate des Poliermittels einzustellen.

13. Das System (200) nach einem der Ansprüche 10 bis 12, wobei die Poliermittelzuführeinheit (240) über die Öffnung (143) mit dem Polierwerkzeug (100) in Fluidverbindung steht, wobei vorzugsweise die Dichtung (144) radial gegen die PoliermittelZuführeinheit (240) abdichtet, um ein Auslaufen des Poliermittels zu verhindern und zu ermöglichen, dass das Poliermittel nur über den Einlass (142) in den Kanal (140) eintritt.

14. Ein Verfahren zum Polieren einer optischen Oberfläche (L1, L2) eines Brillenglases (L), aufweisend:

- Bereitstellen eines Systems (200) zur Oberflächenbearbeitung mit einem Polierwerkzeug (100) nach einem der Ansprüche 1 bis 9, vorzugsweise eines Systems (200) nach einem der Ansprüche 10 bis 13,
- Aufnehmen eines Brillenglases (L) in einer Linsenhalteeinheit (220) des Systems (200),
- relatives Drehen des Polierwerkzeugs (100) in Bezug auf das Brillenglas (L),
- Zuführen, über den Kanal (140), eines Poliermittels zu der einer optischen Oberfläche (L1, L2) des zu polierenden Brillenglases (L) gegenüberliegenden Polieroberfläche (130), so dass das Poliermittel von dem Auslass (141) durch die Rillen (150) radial nach außen zugeführt wird, um, zum Polieren der optischen Oberfläche (L1, L2), das Poliermittel über die Polieroberfläche (130) zu verteilen.

15. Das Verfahren nach Anspruch 14, ferner aufweisend das Steuern der Dicke einer Schicht des Poliermittels zwischen der optischen Oberfläche (L1, L2) und der Polieroberfläche (130) durch Anpassen der Durchflussrate und/oder des Zuführdrucks des Poliermittels auf der Grundlage der Drehgeschwindigkeit des Polierwerkzeugs (100) und/oder des Brillenglases (L).

Revendications

1. Outil de polissage (100) pour polir un verre de lunettes (L) dans un processus d'usinage de surface, comprenant un corps d'outil (110) destiné à être supporté en rotation autour d'un axe de rotation (RA1),

dans lequel le corps d'outil (110) comprend une surface de polissage (130) exposée vers l'extérieur au niveau d'une première extrémité axiale (101) du corps d'outil (110), la surface de polissage (130) étant bombée axialement de manière convexe ou de manière concave par rapport à l'axe de rotation (RA1) pour polir une surface optique (L1, L2) du verre de lunettes (L), dans lequel le corps d'outil (110) comprend un canal (140) s'étendant axialement à travers le corps d'outil (110) à partir d'une entrée (142), qui est prévue au niveau d'une deuxième extrémité axiale (102) opposée à la première extrémité axiale (101) par rapport à l'axe de rotation (RA1), vers une sortie (141), qui est prévue au niveau de la première extrémité axiale (101), pour alimenter la surface de polissage (130) en agent de polissage,
caractérisé en ce que
la surface de polissage (130) comprend au moins une rainure (150) qui s'étend radialement à distance de la sortie (141), la sortie (141) étant le point de départ de la rainure (150), vers le périmètre de la surface de polissage (130) pour distribuer l'agent de polissage sur toute l'étendue de la surface de polissage (130).

2. Outil de polissage (100) selon la revendication 1, dans lequel la rainure (150) s'étend radialement le long d'une direction d'extension principale, de préférence de manière linéaire, rectiligne, courbée et/ou arquée, plus préférentiellement de manière ondulée ou en zigzag.

3. Outil de polissage (100) selon la revendication 1 ou la revendication 2, dans lequel la rainure (150) comprend différentes sections, de préférence des sections rectilignes, en angle, arquées et/ou courbées, dans lequel les sections adjacentes s'étendent de manière circonférentielle dans des directions opposées, dans lequel de préférence les sections adjacentes sont reliées les unes aux autres par une partie arquée qui plus préférentiellement forme une transition progressive entre les sections adjacentes respectives.

4. Outil de polissage (100) selon l'une quelconque des revendications précédentes, dans lequel la rainure (150) présente une largeur (W) dans la plage de 0,1 mm à 1,0 mm, ou de 0,2 mm à 0,8 mm, ou de 0,4 mm à 0,6 mm, ou de 0,5 mm, et/ou
dans lequel la rainure (150) présente une profondeur (T) dans la plage de 0,1 mm à 1,0 mm, ou de 0,2 mm à 0,8 mm, ou de 0,4 mm à 0,6 mm, ou de 0,5 mm.

5. Outil de polissage (100) selon l'une quelconque des revendications précédentes, comprenant une pluralité desdites rainures (150), dans lequel les rainures (150) sont de préférence radialement divergentes et/ou de préférence réparties, plus préférentiellement réparties uniformément autour de la sortie (141) ou l'axe de rotation (RA1), dans lequel les rainures (150) présentent de préférence la même forme et/ou section transversale ou au moins en partie une forme et/ou section transversale différente.

6. Outil de polissage (100) selon l'une quelconque des revendications précédentes, dans lequel le corps d'outil (110) comprend un film de polissage (113) formant la première extrémité axiale (101) du corps d'outil (110), dans lequel le film de polissage (113) comprend la sortie (141) et la rainure (150), et dans lequel de préférence le film de polissage (113) présente une épaisseur dans la plage de 0,5 mm à 2,5 mm, ou de 0,8 mm à 2,0 mm, ou de 1,3 mm.

7. Outil de polissage (100) selon l'une quelconque des revendications précédentes, dans lequel le corps d'outil (110) comprend une partie de base (111) pour supporter en rotation l'outil de polissage (100), dans lequel la partie de base (111) comprend de préférence l'entrée (142), et
dans lequel de préférence le corps d'outil (110) comprend en outre une partie de retenue (112) prise en sandwich entre le film de polissage (113) et la partie de base (111), dans lequel de préférence la partie de retenue (112) est déformable pour s'adapter à la surface optique (L1, L2) du verre de lunettes (L).

8. Outil de polissage (100) selon l'une quelconque des revendications précédentes, dans lequel le canal (140) s'étend le long de l'axe de rotation (RA1) de l'outil de polissage (100) et de préférence, s'ils sont présents, pénètre dans le film de polissage (113), la partie de base (111) et la partie de retenue (112), respectivement.

9. Outil de polissage (100) selon l'une quelconque des revendications précédentes, dans lequel le corps d'outil (110), de préférence la partie de base (111) si elle est présente, comprend un orifice (143) pour relier fluidiquement le canal (140) à une unité d'alimentation en agent de polissage (240),
dans lequel de préférence l'orifice (143) comprend un joint d'étanchéité (144) pour assurer radialement une étanchéité par rapport à l'unité d'alimentation en agent de polissage (240) pour empêcher l'agent de polissage de fuir et pour permettre uniquement à l'agent de polissage d'entrer dans le canal (140) par l'entrée (142).

10. Système (200) pour le polissage d'au moins une surface optique (L1, L2) d'un verre de lunettes (L), comprenant

- une unité de traitement de surface (210) pour traiter la surface optique (L1, L2) du verre de lunettes (L), dans lequel l'unité de traitement de surface (210) comprend

  ○ l'outil de polissage (100) selon l'une quelconque des revendications précédentes 1 à 9, et
  ○ une unité d'alimentation en agent de polissage (240) reliée fluidiquement au canal (140) par l'entrée (142) de l'outil de polissage (100) pour alimenter la rainure (150) ou les rainures (150) de la surface de polissage (130) en agent de polissage par le biais du canal (140) et de la sortie (141),

- une unité de support de lentille (220) pour supporter le verre de lunettes (L) pendant le processus de polissage, et
- une unité d'entraînement pour appliquer un mouvement relatif entre l'outil de polissage (100) et l'unité de support de lentille (220) au moins par rotation de l'outil de polissage (100) autour de l'axe de rotation (RA1) pour permettre le polissage de la surface optique (L1, L2).

11. Système (200) selon la revendication 10, dans lequel le mouvement relatif comprend en outre l'inclinaison, le pivotement et/ou le mouvement linéaire de l'outil de polissage (100) par rapport à l'unité de support de lentille (220) pour appliquer le mouvement relatif, et/ou

dans lequel l'unité d'entraînement est de préférence adaptée pour faire tourner l'unité de support de lentille (220) autour d'un deuxième axe de rotation (RA2) pour appliquer le mouvement relatif, et/ou
dans lequel l'unité d'entraînement est de préférence adaptée pour déplacer l'outil de polissage (100) par rapport à l'unité de support de lentille (220) pour obtenir une distance définie entre ceux-ci.

12. Système (200) selon la revendication 10 ou 11, comprenant en outre une unité de commande (230) pour commander le mouvement relatif par l'unité d'entraînement sur la base de caractéristiques de traitement, telles que le type, la forme et l'épaisseur de la lentille, le type d'outil de polissage, le type d'agent de polissage,
dans lequel de préférence l'unité de commande (230) est configurée pour adapter une vitesse de

rotation relative entre la surface optique (L1, L2) et l'outil de polissage (100), et/ou une pression pour amener l'agent de polissage à l'outil de polissage (100), et/ou un débit de l'agent de polissage.

13. Système (200) selon l'une quelconque des revendications 10 à 12, dans lequel l'unité d'alimentation en agent de polissage (240) est relié fluidiquement à l'outil de polissage (100) par l'intermédiaire de l'orifice (143), dans lequel de préférence le joint d'étanchéité (144) assure une étanchéité radiale par rapport à l'unité d'alimentation en agent de polissage (240) pour empêcher l'agent de polissage de fuir et pour permettre à l'agent de polissage d'entrer dans le canal (140) uniquement par l'entrée (142).

14. Processus de polissage d'une surface optique (L1, L2) d'un verre de lunettes (L) comprenant :

- la fourniture d'un système (200) pour un traitement de surface présentant un outil de polissage (100) selon l'une quelconque des revendications 1 à 9, de préférence un système (200) selon l'une quelconque des revendications 10 à 13,
- le placement d'un verre de lunettes (L) dans une unité de support de lentille (220) du système (200),
- la rotation relative de l'outil de polissage (100) par rapport au verre de lunettes (L),
- la distribution d'un agent de polissage à travers le canal (140) à la surface de polissage (130) tournée vers une surface optique (L1, L2) du verre de lunettes (L) à polir, de sorte que l'agent de polissage est distribué à travers les rainures (150) radialement vers l'extérieur à partir de la sortie (141) pour distribuer l'agent de polissage sur toute l'étendue de la surface de polissage (130) pour polir la surface optique (L1, L2).

15. Processus selon la revendication 14, comprenant en outre la commande d'une épaisseur d'une couche de l'agent de polissage entre la surface optique (L1, L2) et la surface de polissage (130) par adaptation d'un débit et/ou d'une pression d'alimentation de l'agent de polissage sur la base d'une vitesse de rotation de l'outil de polissage (100) et/ou du verre de lunettes (L).

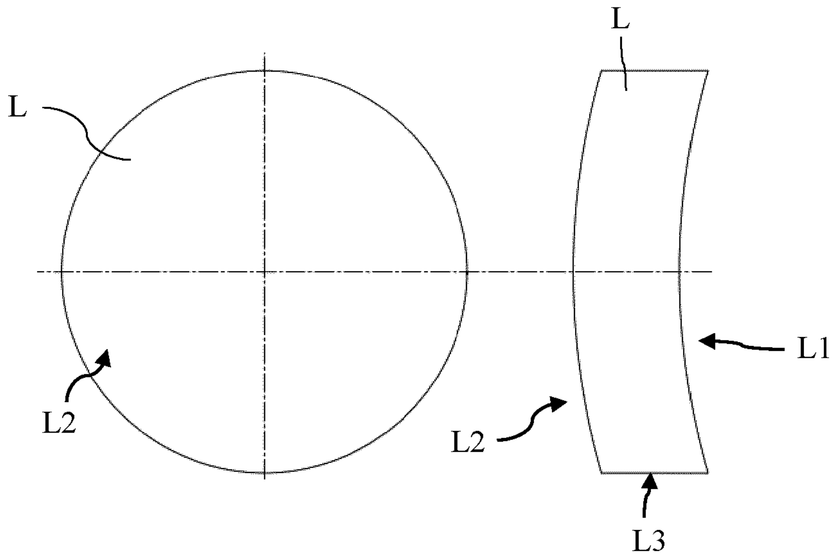

FIG 1

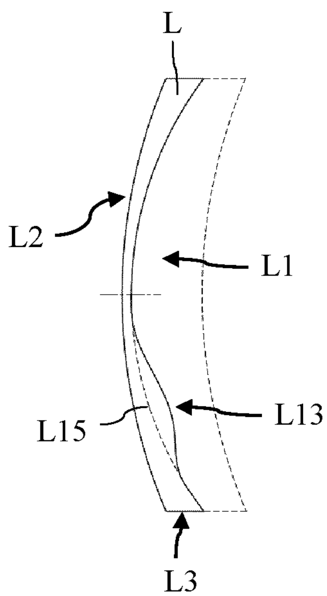

FIG 2

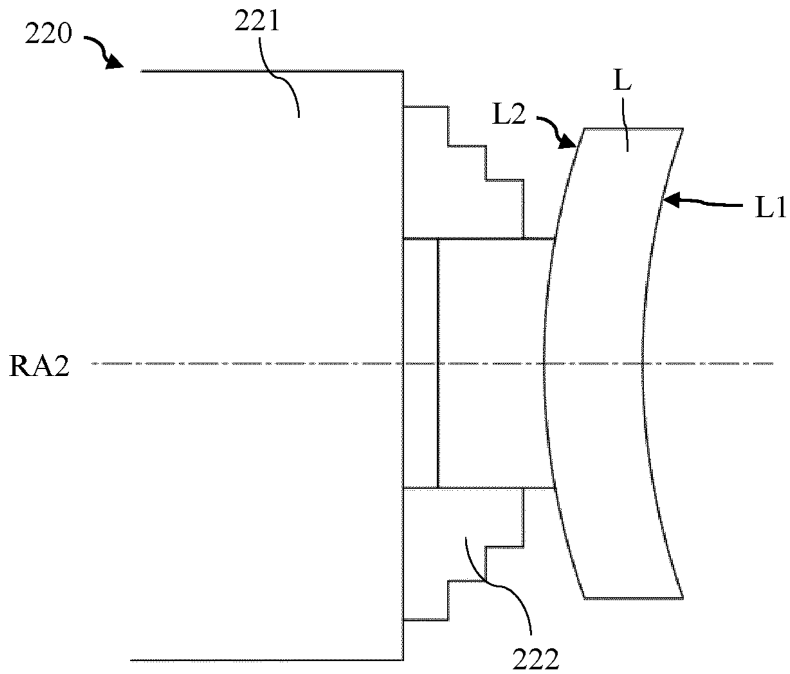

FIG 3

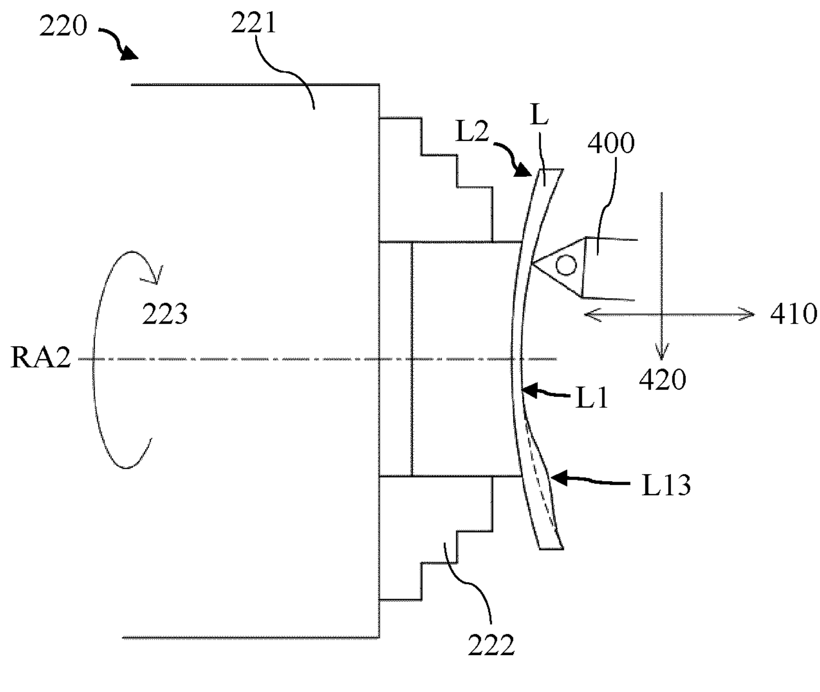

FIG 4

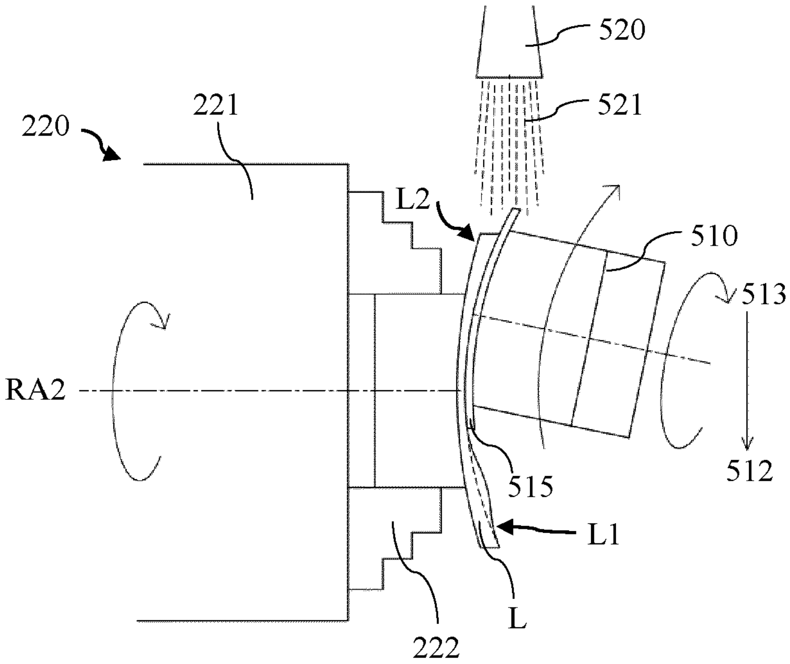

FIG 5 (PRIOR ART)

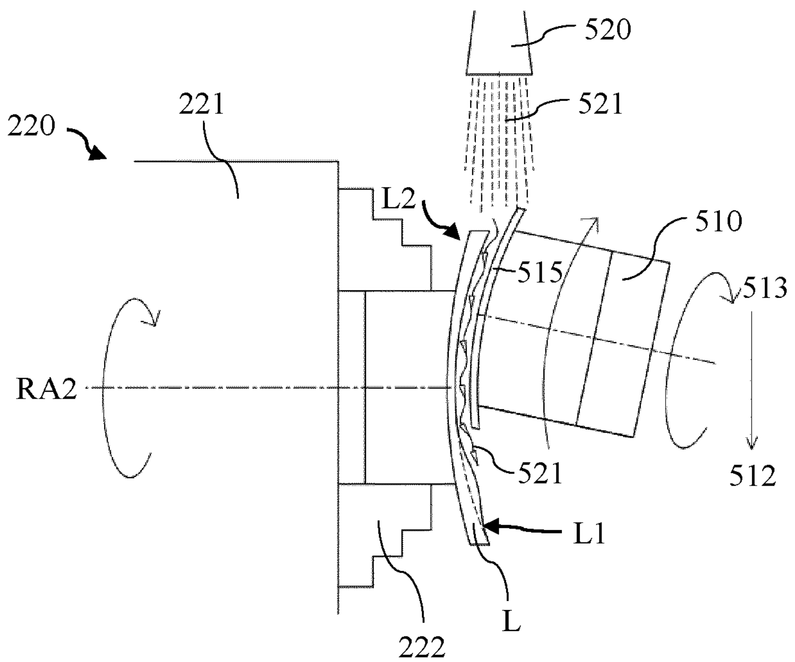

FIG 6 (PRIOR ART)

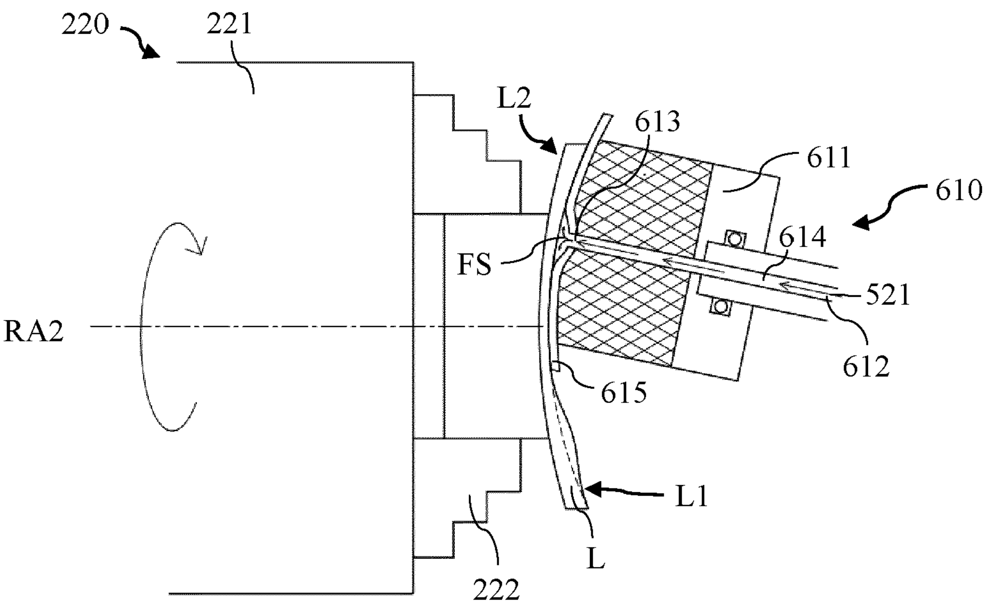
220
221
L2
613
611
610
FS
614
521
RA2
612
615
L1
L
222

FIG 7

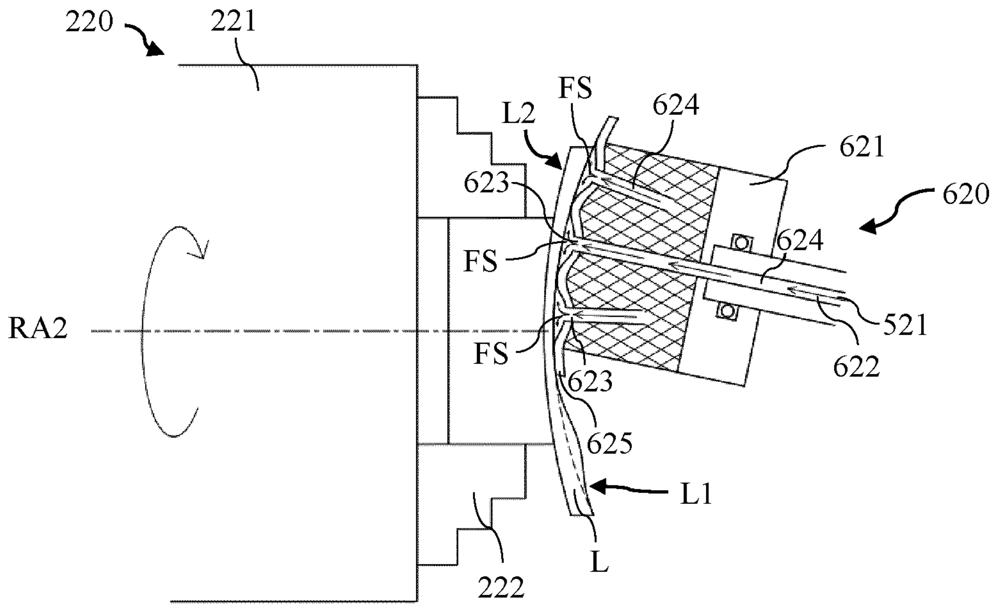
220
221
FS
624
L2
621
620
623
624
FS
521
RA2
622
FS
623
625
L1
L
222

FIG 8

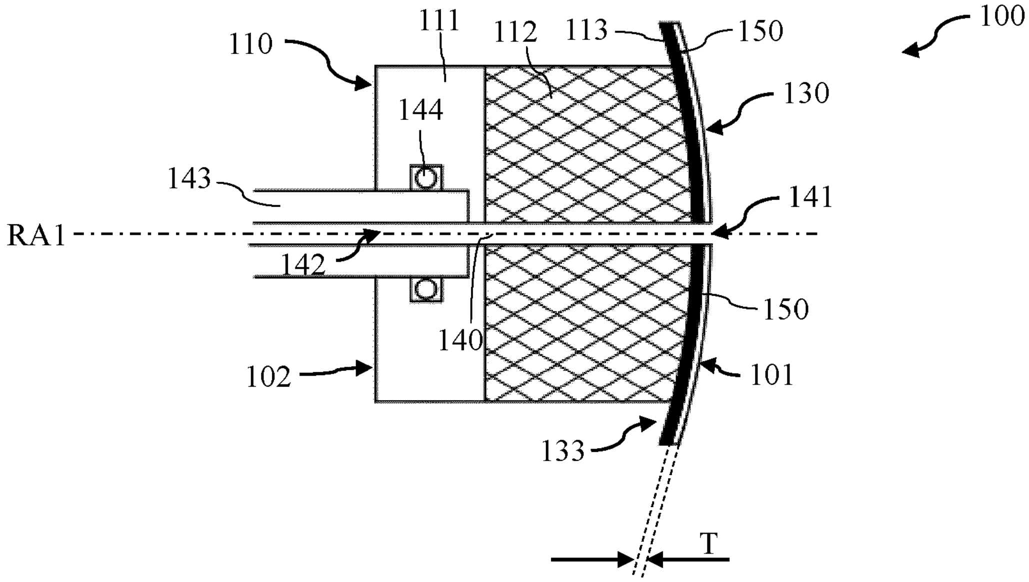
110
111
112
113
150
100
144
130
143
141
RA1
142
140
150
102
101
133
T

FIG 9

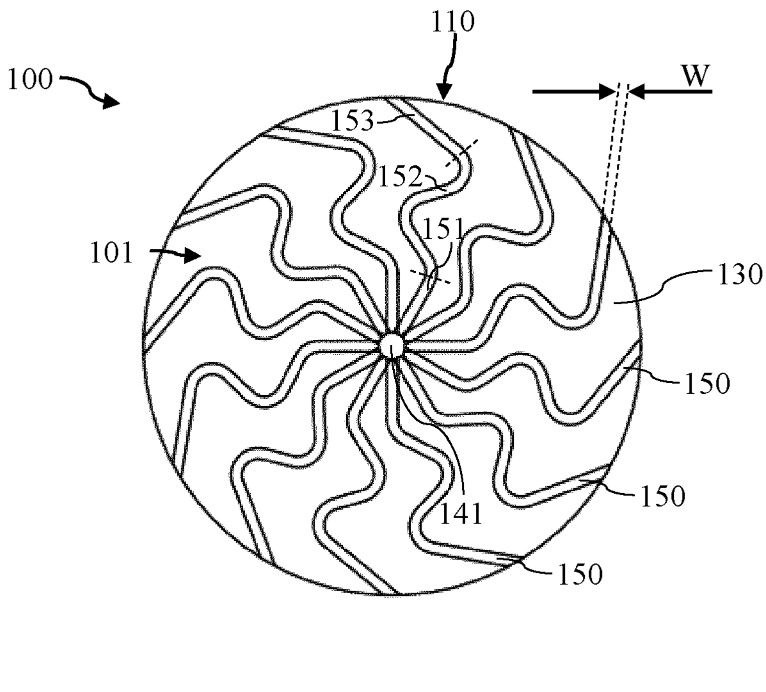
110
W
100
153
152
151
101
130
150
150
141
150

FIG 10

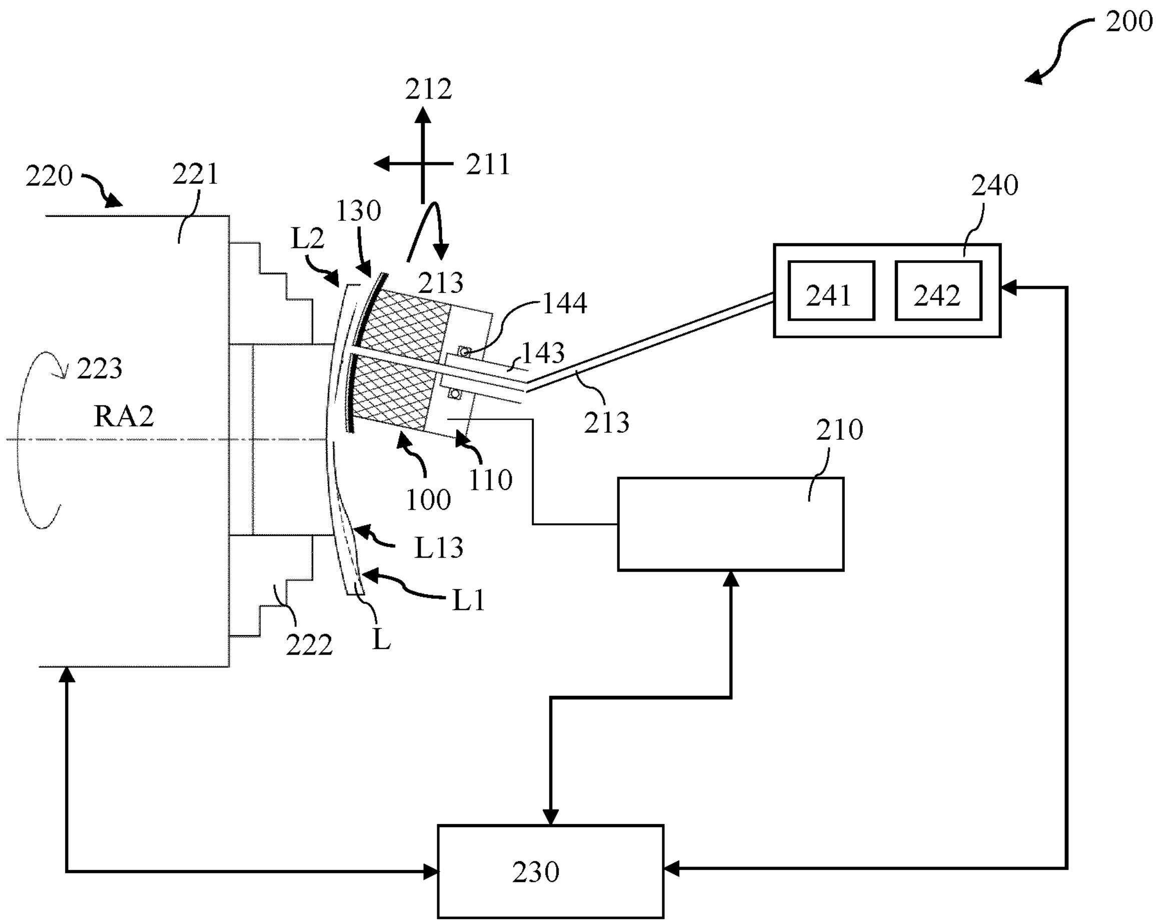
200
212
211
220
221
240
130
L2
213
241
242
144
143
223
213
RA2
210
100
110
L13
L1
222
L
230

FIG 11

REFERENCES CITED IN THE DESCRIPTION

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