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(54) **Title**: METHODS AND APPARATUS FOR CLEANING BLOCKED OPHTHALMIC LENSES

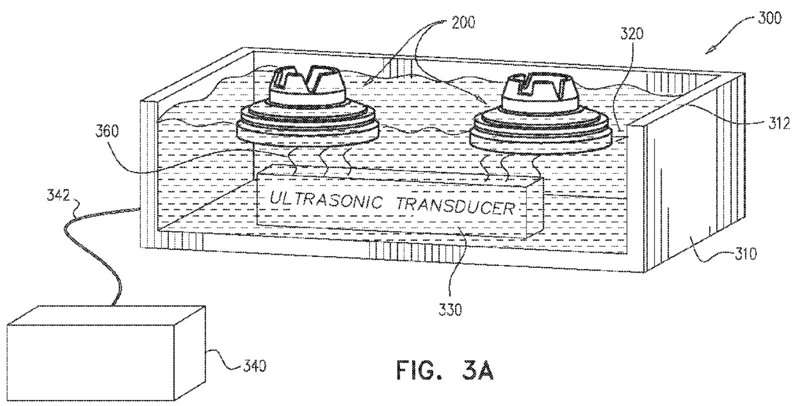


FIG. 3A

(57) **Abstract**: A blocked lens assembly suitable for on-block processing and cleaning includes a blocked lens and a sealing member disposed on at least a portion of an edge and/or surface defined by the blocked lens. The blocked lens further includes a lens blank having a front surface and a back surface, a lens blocking piece to hold the lens blank while processing the back surface of the lens blank, and an adhesive layer, disposed between the front surface of the lens blank and the lens blocking piece, to affix the lens blank to the lens blocking piece. The sealing member protects the blocked lens so as to facilitate cleaning of the blocked lens while the lens blocking piece is affixed to the front surface of the lens blank.

WO 2016/055866 A1

Methods and Apparatus for Cleaning Blocked Ophthalmic Lenses

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority benefit, under 35 U.S.C. §119(e), to each of the following U.S. provisional application: Serial No. 62/060,954, filed October 7, 2014, and entitled "METHODS AND APPARATUS FOR CLEANING BLOCKED OPHTHALMIC LENSES"; Serial No. 62/060,959 , filed October 7, 2014, and entitled "METHODS AND APPARATUS FOR REWORKING BLOCKED OPHTHALMIC LENSES"; and Serial No. 62/060,966, filed October 7, 2014, and entitled "METHODS AND APPARATUS FOR VISUAL INPSECTION OF BLOCKED OPHTHALMIC LENSES." Each of the prior applications identified above is hereby incorporated herein by reference in its entirety.

BACKGROUND

[0002] The advent of two technologies has enabled a streamlined method of producing complete prescription eyeglass lenses called on-block manufacturing (OBM). The first technology is a plastic and ultraviolet (UV) cured adhesive that allows lens blanks to be coupled with a lens blocking piece, also known as a block, a blocker, a lens chuck, or a surface block, that can hold lens blanks for machining. The second technology is the Full Back Side (FBS) digital surfacing technology, also referred to as free form technology or free form generation, which allows the entire prescription to be cut into the back (usually concave) surface of a lens. By convention, the back or rear surface of the lens is the surface closest to the wearer's eyes, and the front surface of the lens is the surface opposite the back surface. For a typical convex-concave lens, the front surface is convex and the back surface is concave. Other lenses may be biconcave or biconvex, with front and back surfaces that are both concave or both convex, respectively.

[0003] FIG. 1 illustrates a conventional OBM process. In this OBM process 100, based on a prescription, an appropriate lens blank with a fully processed front (usually convex) surface is first selected such that the OBM process only treats the back surface to save manufacturing time and streamline the manufacturing process. Then the lens blank is coupled to a lens block, in a step called blocking, by gluing the front surface of the lens blank to the lens block using a UV-cured adhesive. The lens block holds the lens blank while the concave surface of the lens blank is machined to fill the prescription. To further reduce manufacturing time, lens blanks can be pre-blocked, i.e., the lens blank can be affixed to the lens block before arriving at the OBM facility.

[0004] After the lens blank has been blocked (also referred to as lens on block), its back surface is machined in two phases: a coarse machining phase at step 110 to generate the overall shape and diameter (e.g., using a generator), and a fine machining phase at step 130 to polish the surface and achieve the desired surface qualities. An engraving step 120 can be performed between the coarse machining and the fining machining to engrave semi-visible and/or visible marks on the lens to, for example, guide subsequent manufacturing steps. After the back surface machining, the back surface is usually cleaned at step 140 and dried at step 150 before being coated with, for example, a hard coating at step 160 and/or an anti-reflection coating at step 170. Then the coated lens is removed, in a step 180 called deblocking, from the lens block for edging, which involves cutting the lens into an appropriate shape to fit the lens frame. An off-block inspection step 190 can be performed after the lens is removed from the block. If the quality of the de-blocked lens is satisfactory (e.g., no visible defect), the de-blocked lens can be sent for edging at step 192, at which step the de-blocked lens is machined to the desired shape to fit eyeglass frames.

[0005] The OBM process can normally produce a pair of eyeglass lenses in less than a business day or two. Depending on the business model, some OBM labs offer a guaranteed delivery time of less than 8 hours, less than 3 hours, or less than 90 minutes. The guaranteed delivery time can be measured from receiving a prescription to a point at which the framed eyeglasses are ready for shipment. In some OBM labs, for example in urban areas, the guaranteed delivery time can include the shipment as well.

[0006] Unfortunately, defects near (on or beneath) the back surface of the lens blank may render the finished lens unsuitable. These defects include but are not limited to scratches, dirt, cracks, smudges, or pieces of lint on the lens surface. Defects may be introduced during the machining process, the ultrasonic (US) cleaning process, or just from exposure to the surrounding environment during the OBM process. A hairline scratch on the lens surface introduced during the fine machining phase, for example, can cause a defective anti-reflection coating, reducing the manufacturing yields. To increase manufacturing yield, a lens may be cleaned before deblocking and subsequent coatings. Deblocking and reblocking consumes extra time and can disrupt the OBM process.

SUMMARY

[0007] Exemplary embodiments of the present invention include methods and systems of cleaning a blocked lens while the lens blank stays affixed on the lens blocking piece so as to avoid disrupting the otherwise streamlined manufacturing process and improve the manufacturing yield.

[0008] In one example, a blocked lens assembly suitable for on-block processing and cleaning includes a blocked lens comprising a lens blank having a front surface and a back surface, a lens blocking piece to hold the lens blank while processing the back surface of the lens blank, and an adhesive layer, disposed between the front surface of the lens blank and the lens blocking piece, to affix the lens blank to the lens blocking piece. The blocked lens assembly also includes a sealing member, disposed on at least a portion of an edge and/or surface defined by the blocked lens, to protect the blocked lens so as to facilitate cleaning of the blocked lens while the lens blocking piece is affixed to the front surface of the lens blank.

[0009] The lens blank can have a diameter approximately equal to a diameter of the lens blocking piece. In addition, the edge of the blocked lens can form at least a portion of an edge of the lens blank, an edge of the adhesive layer, and/or an edge of the lens blocking piece.

[0010] The sealing member may comprise a dampening material, which could include a high temperature polymer or a porous material. The sealing member may also include an elastic member, such as a rubber band, that substantially covers an edge of the adhesive layer. A portion of the sealing member may extend beyond the back surface of the blocked lens to support the blocked lens and to prevent contact between the back surface of the blocked lens and the surface. This portion of the sealing member can comprise at least one bumper and/or define at least one notch. The sealing member may also comprise a snap-on clamp, a quick-release clamp, and/or a locking mechanism to secure the sealing member to at least a portion of the edge of the blocked lens.

[0011] The adhesive layer and the sealing member comprise each comprise the same adhesive material. They can also comprise different adhesive materials (e.g., first and second adhesive materials). And the blocked lens can further include another adhesive layer to couple the sealing member to some or all of the edge of the blocked lens.

[0012] In another example, an apparatus for cleaning a blocked lens is disclosed. The blocked

lens includes a lens blocking piece affixed to a front surface of a lens blank via an adhesive layer. The blocked lens also defines an edge and/or surface substantially covered by a sealing member. The apparatus includes a container to hold a cleaning liquid, a holding member, mechanically coupled to the container, to hold at least a portion of the blocked lens in contact with the cleaning liquid during cleaning of the blocked lens, and an ultrasonic transducer, operably coupled to the container, to transmit an ultrasonic wave into the cleaning liquid so as to clean the blocked lens while the lens blank is affixed to the lens blocking piece.

[0013] The holding member may comprise a basket or other receptacle having a mesh surface to receive an end portion of the sealing member such that the back surface of the blocked lens is in contact with the cleaning liquid. The holding member may comprise a first end to receive the sealing member, a second end to couple the holding member to the container, and an arm, disposed between the first end and the second end, to hold the back surface of the blocked lens toward the cleaning fluid. In some cases, the arm may be a flexible arm that enables motion of the blocked lens during cleaning. The holding member may comprise a receptacle to secure the blocked lens at least partially underneath the cleaning liquid during cleaning. The holding member may also be configured to hold a surface of the lens blocking piece in contact with the cleaning fluid for cleaning the surface of the lens blocking piece.

[0014] The container may include a first container to hold a first cleaning liquid and a second container to hold a second cleaning liquid. The first cleaning liquid can be in contact with the back surface of the blocked lens and the second cleaning liquid can be in contact with a surface of the lens blocking piece. If desired, the first cleaning liquid may be different than the second cleaning liquid. Similarly, the ultrasonic transducer may comprises a first ultrasonic transducer element operably coupled to the first container and a second ultrasonic transducer element operably coupled to the second container.

[0015] The apparatus may include a nozzle, operably coupled to a pressurized fluid source, to provide a flow of liquid from the pressurized fluid source toward the back surface of the blocked lens.

[0016] In yet another example, a method of cleaning a blocked lens is disclosed. The blocked lens includes a lens blocking piece affixed to a front surface of a lens blank via an adhesive layer. The blocked lens defines an edge and/or surface substantially covered by a sealing member. The method includes disposing at least a portion of the blocked lens in contact with a cleaning solution while the lens blank is affixed to the lens blocking piece. The method also includes transmitting an ultrasonic wave at a frequency of about 20 kHz to about 250 kHz through the cleaning solution to clean the back surface while the lens blank is affixed to the lens blocking piece.

[0017] Before the blocked lens is placed in contact with the cleaning solution, the sealing member may be disposed on the edge, at least a portion of which forms at least a portion of an edge of the lens blank, an edge of the adhesive layer, and/or an edge of the lens blocking piece. This sealing member may comprise a water resistant film to protect the at least a portion of the blocked lens from damage.

[0018] At least a portion of the back surface of the blocked lens may be disposed in contact with the cleaning solution for cleaning the portion of the back surface. Likewise, at least a portion of the lens blocking piece may be disposed in contact with the cleaning solution so as to clean the portion of the lens blocking piece. This may involve disposing at least a portion of the back surface of the blocked lens in contact with a first cleaning solution and disposing at least a portion of the lens blocking piece in contact with a second cleaning solution to enable simultaneous cleaning of the back surface of the lens blank and the lens blocking piece.

[0019] The blocked lens can also be coupled, mounted, secured, or otherwise affixed to a container. Then the liquid level of the cleaning solution in the container can raised so as to dispose the cleaning solution in contact with the blocked lens. The cleaning solution can also be disposed above the back surface of the lens blank and, if desired, the ultrasonic wave may provide a liquid flow toward the back surface of the lens blank.

[0020] The cleaning solution may be prepared beforehand by mixing water with a detergent at a volume percentage of about 0.1% to about 10%, about 0.5% to about 6%, or about 1% to about 4%. The cleaning solution can be heated (or cooled) to a temperature of about 20 °C to about 60 °C (e.g., about 30 °C to about 50 °C) for cleaning.

[0021] The frequency of the ultrasonic wave may be set within a range from about 50 kHz to about 100 kHz (e.g., about 60 KHz to about 90 KHz). The frequency of the ultrasonic wave can be tuned so as to reduce the occurrence of hot spots, dead zones, and/or standing waves on the concave surface of the lens blank. The ultrasonic wave may be transmitted for about 50 seconds to about 500 seconds (e.g., about 100 seconds to about 250 seconds). And the power level of the ultrasonic wave may be about 10 Watts to about 2000 Watts.

[0022] In some examples, the ultrasonic wave may comprise a sequence of ultrasonic wave pulses that are generated and transmitted through the cleaning solution to the back surface of the lens blank. If desired, the back surface of the lens blank can at least partially withdrawn from the cleaning solution while the ultrasonic wave is propagating through the cleaning solution and at least partially re-submerged in the cleaning solution while the ultrasonic wave is propagating through the cleaning solution.

[0023] It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below (provided such concepts are not mutually inconsistent) are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein. It should also be appreciated that terminology explicitly employed herein that also may appear in any disclosure incorporated by reference should be accorded a meaning most consistent with the particular concepts disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The skilled artisan will understand that the drawings primarily are for illustrative purposes and are not intended to limit the scope of the inventive subject matter described herein. The drawings are not necessarily to scale; in some instances, various aspects of the inventive subject matter disclosed herein may be shown exaggerated or enlarged in the drawings to facilitate an understanding of different features. In the drawings, like reference characters generally refer to like features (e.g., functionally similar and/or structurally similar elements).

[0025] FIG. 1 illustrates a conventional on-block manufacturing (OBM) process.

[0026] FIG. 2 shows an exploded view of a blocked lens.

[0027] FIG. 3A shows a schematic view of a system for ultrasonic cleaning of blocked lenses.

[0028] FIG. 3B shows a schematic view of a system including an elastic holder for ultrasonic cleaning of blocked lenses.

[0029] FIG. 4A shows a schematic view of a seal disposed on a blocked lens for protecting the blocked lens during cleaning.

[0030] FIG. 4B shows a schematic view of a snap that can be used during blocked lens cleaning.

[0031] FIG. 4C shows a schematic view of a quick release seal that can be used during blocked lens cleaning.

[0032] FIG. 4D shows a seal with bumpers that can be used during blocked lens cleaning.

[0033] FIG. 5 shows a schematic view of a system including a basket for cleaning blocked lenses by partially submerging the blocked lens in a cleaning solution.

[0034] FIG. 6 shows a schematic view of a system including a flexible seal for cleaning blocked lenses.

[0035] FIG.7 shows a schematic view of a system including a fluid source for cleaning blocked lenses.

[0036] FIG.8 shows a system for cleaning blocked lenses with cleaning solutions above the blocked lens.

[0037] FIG.9 shows a schematic view of a system for ultrasonic cleaning of blocked lenses with the back surface of the blocked lens opposite the ultrasonic fluid surface.

[0038] FIG.10 shows a schematic view of a system for ultrasonic cleaning of blocked lenses with cleaning solution on both top and bottom sides of the blocked lenses.

[0039] FIG.11 shows a schematic view of a system for ultrasonic cleaning of multiple blocked lenses.

[0040] FIG.12 shows a schematic view of a system for cleaning blocked lenses using high pressure steams.

[0041] FIG.13 illustrates various types of defects that might appear on the back surface of a blocked lens.

[0042] FIG.14 illustrates a method of on-block cleaning of blocked lenses.

DETAILED DESCRIPTION

[0043] Before detailed description of exemplary embodiments, clarification of terms and parameters used in this application may be helpful in understanding aspects of the disclosed technology. Unless otherwise stated, in this specification:

1) The concave surface of the lens blank can also be referred to as the back surface, the rear surface, the posterior surface, or the bottom of the lens;
2) The convex surface of the lens blank can also be referred to as the front surface;
3) “Near a surface” means on, below, and/or within the surface; for example, lenses coated with multiple layers, “near” means on, below, and/or within the coating

layers;

4) A coating system: a coating layer or a multi-layered structure comprising coating layers of various thicknesses and material properties (see, *e.g.*, FIG. 2);
5) Coating system on front side: coating application performed prior to blocking, that is prior to connecting the lens to block;
6) Blocked lens (also referred to as a lens block assembly, a Lens on Block (LOB), or a batch) refer to the assembly of a lens blank coupled to a lens block (also referred to as block piece, a blocking piece, or simply a block), including any adhesive layers between the lens blank and the lens block, coating systems on the front and/or rear surfaces of the lens blank, and any adhesive layers and coating systems on the lens block;
7) Damage to a coating layer can include, but is not limited to: cracking, abrasion, delaminating, and changes in the coating layer's mechanical, structural, thermal, or optical properties;
8) Damage to a coating system can include, but is not limited to: delaminating between coating layers, solvents (e.g., aqueous solutions and organic solutions) between coating layers, swelling of solvents into the matrixes of the coating layers, cosmetic defects (e.g., curing defects), changes to the physical interactions among coating layers, changes in mechanical, structural, thermal, or optical properties of the system, and undesired adhesion between the upper most layer of the coating system on the convex side of the lens blank and the lens block or other surface;
9) Damage to a coating layer and/or a coating system can include damage to the surfaces in which the coating layer and/or the coating system interacts, such as the lens convex surface, the lens concave surface, and/or the block surface.
10) The edge of the blocked lens (also referred to as the rim, lens edge, or edge surface) refers to the outside limit of the blocked lens, or the place or part of the blocked lens farthest away from the center of the blocked lens. As used herein, the edge comprises the surface and/or locus of points that define the circumference (or boundary) of the lens blank in a blocked lens, the circumference of the block piece in the blocked lens, and/or the circumference of the adhesive layer and the coating system between the lens blank and the block piece. In a side view (or cross section view), the blocked lens edge can be seen as the thickness of the lens, of the coating layer(s), of the adhesive layer and or the block lens mounting surface.

11) Surface contaminants on lens edge can include, but are not limited to: residue from the machining and/or polishing processes, aluminum oxide, airborne particles, and residual particles from the milling processes, swarf (i.e., fine chips or filings of stone, metal, or other material produced by a machining operation), bio-fouling, oil-based contamination, organic contamination from handling and or from material machining processes, mineral deposits based scale, particles and precipitations;
12) Damage to the UV-curable adhesive layer can include, but is not limited to changes in viscosity, glass transition temperature, transparency to visible light, color, tensile strength, Young's modulus, elongation at failure, yield stress, and other optical, thermal, and mechanical properties;
13) Properties of the adhesive layer after UV curing include tensile strength, Young's modulus, torque strength, peel strength, cross linking density, and heat capacity, wherein the adhesive layer is normally between upper most layer of the coating system on convex side and the block piece;
14) A prescription of a lens can include parameters that specify the desired properties of the lens and the processes of manufacturing the lens; a prescription can be the output of a prescriptor, which can convert a medical prescription provided by an eye care professional (ECP) into a detailed instruction of lens manufacturing, including optical power, surface shape, surface roughness, dimensions, material, coating type, color, machines to be used and their operating parameters, among others;
15) A rework step can refer to one or more repeats of any of the steps in the procedure of lens manufacturing, including machining, polishing, cleaning, tinting, and coating, among others. A rework step can be performed to correct a defect, to improve lens quality, or to prepare the lens for subsequent processing (e.g., cleaning rework); and
16) A rework loop can include one or more manufacturing steps and their repeats to produce a desired property of the lens. For example, a cleaning rework loop can include cleaning-inspection-cleaning cycles until the surface cleanliness satisfies certain standard.

[0044] Hereinafter, methods and systems for cleaning blocked lenses are described with reference to the accompanying drawings.

[0045] A Blocked Lens

[0046] FIG. 2 shows an exploded view of a blocked lens suitable for OBM processing (e.g., the process illustrated in FIG. 1). The blocked lens 200 includes a lens blank 210, coating layers 220 deposited on the lens blank 210, an adhesive layer 230, and a lens blocking piece 240 coupled with the lens blank 210 via the adhesive layer 230. The lens blank 210 has a back surface 212, a front surface 214, and a lens edge 216 between the back surface 212 and the front surface 214. The lens edge 216 typically has a finite thickness, e.g., about 5–13 mm, about 7–10 mm, etc., with manufacturing tolerances of about 0.05 mm.

[0047] The front surface 214 of the lens blank is coated with the coating layers 220, which can further include, for example, a hard coating 222, an anti-reflection coating 224, a hydrophobic top coating 226, and a grip coating 228, among others. Additional coatings may include an anti-fog coating, a mirror coating, or a polarization coating (not shown in FIG. 2). Since the coating layers 220 and the front surface 214 in most cases are firmly bonded together (e.g., via deposition processes), the front surface 214, when appearing in this specification, normally includes the coating layers 220 unless otherwise specified. Accordingly, the lens blank 210, when appearing in this specification, normally also includes the coating layers 220 unless otherwise specified.

[0048] In an embodiment, the diameters of the lens 210, the block 240, and the adhesive layer 230 are substantially the same. In some cases, the blocked lens 200 is machined during the coarse machining phase at step 110 so that the diameters of the lens 210, the block 240 and the adhesive layer 230 are the same or about the same.

[0049] The front surface 214 (including the coating layers 220) is affixed to the lens blocking piece 240 with the adhesive layer 230, which can, for example, include an opaque resin dispersed with carbon powders. More specifically, the adhesive layer 230 is disposed in contact with the front surface 214 (or, more precisely, with the top most coating layer, e.g., the grip coating 228 on the front surface 214) and a receiving surface 244 defined by the lens blocking piece 240 so as to couple the lens blank 210 with the lens blocking piece 240. In one example, the adhesive layer 230 is cured with ultraviolet (UV) light transmitted through the lens blank 210. In another example, the adhesive layer 230 can be cured with UV light transmitted through the lens blocking piece 240 from the bottom. In this case, the lens blocking piece 240 defines an exposed surface 242, through which the UV light can transmit and reach the adhesive layer 230.

[0050] As shown in FIG. 2, the lens blank 210 defines the lens edge 216, the adhesive layer 230 defines an adhesive layer edge 232, and the blocking piece 240 defines a block edge 246. During lens manufacturing, these edges are typically exposed to the surrounding environments (e.g., manufacturing machines, cleaning solutions, drying air and/or heat, or dust, among others) and are therefore susceptible to damage induced by the surrounding environments.

[0051] In current industry practices, most of the lens blanks 210 have a convex front surface 214 and a concave back (rear) surface 212. However, in some cases, the lens blank 210 may have a bi-convex or bi-concave configuration, in which both surfaces 212 and 214 are convex, or concave, respectively. Or, the lens blank 210 may have a concave front surface 214 and a convex back surface 212. Conventionally, back surface 212 of a lens blank means the surface closer to human eyes under normal wearing of eyeglasses, and front surface 214 refers to the surface opposite the back surface. Methods and apparatus described in this application can be applied to all configurations of lens surfaces, although some modifications (e.g., altering the surface of the lens blocking piece to receive lens blank) may be helpful.

[0052] **Cleaning a Lens Blank during Lens Manufacturing**

[0053] Cleaning of lens blank, the lens blocking piece, or both can be very helpful in lens manufacturing after polishing. For example, the lens polishing process typically involves a chemical mechanical process in which slurry is used to abrade and smooth the surface of the lens. The slurry tends to leave minute residue and particles that adhere to the concave surface. Therefore, it is beneficial to clean the residues in promptly before the residues adhere to the surface. It is also helpful to clean the residue gently since an aggressive cleaning process (e.g., scrubbing the lens surface) can degrade the polished surface of the lens which normally does not have any protective coating immediately after polishing.

[0054] It is also very helpful to clean the lens immediately prior to coating because even small debris, dust, contaminants, or oils may affect the coating process and/or the quality of the resulting coatings. There is also an advantage to conduct more than one cleaning step in proximity to the coating process. In some cases cleaning steps can be conducted in the coating machine itself.

[0055] A manual cleaning process (e.g., water-soap based using cloths, sponges, brushes scrub the surfaces of the lenses) can be employed to clean the lens blank during on-block lens manufacturing. However, manual processes may introduce additional defects, such as scratches, on the final lens product. Residues that are not removed may compromise the coating layer that is applied after the cleaning processes. Reworking the lens after coating may remedy such defects, but reworking may be time consuming and expensive. Manual cleaning also often involves multiple steps and can be both time consuming and ineffective.

[0056] An alternative to manual cleaning can be ultrasonic cleaning (also referred to as US cleaning) of lens during manufacturing and post manufacturing. However, lenses manufactured on a block (OBM) are typically taken off the block for ultrasonic cleaning to avoid damage. After cleaning, the cleaned lens blanks are usually re-blocked so as to allow subsequent processing steps, such as coating, tinting, and edging, among others.

[0057] Submerging the LOB in an ultrasonic bath (also referred to as a container, or a tank), or in a basket designed to support the LOB in the ultrasonic fluid (also referred to as a cleaning liquid, or a cleaning solution) can expose the lenses to high frequency vibrations which can lead to collision of the lenses with surrounding objects, including other LOBs and the containing basket, causing damage in the form of chips, cracks, etc. This problem can be exacerbated by the weight of the lens blocking piece, which can increase the friction force (or impact, momentum) at the point of contact between the lenses and other hard surfaces.

[0058] Normally, lens cleaning is performed after the back surface of the lens blank is machined. At this point in the production process, the lens can be more susceptible to damage since the edges of the lens blanks are thinned and therefore are more easily cracked. The damage may also be more significant since it may be within the edging perimeter (i.e., within the portion to be fitted into eyeglass frames).

[0059] Ultrasonic cleaning may also cause damage on both micro scale and macro scale to the various layers between the front surface of the lens blank and the lens blocking piece. On the micro scale (from about sub-micron to about 100 microns), cavitation bubbles and the subsequent collapse (implosion) of these bubbles may damage several surfaces, including the adhesive surface (e.g., 230), hard coating surface (e.g., 222) and anti-reflection coating surface (e.g., 224). For example, minute changes in adhesive properties within the adhesive layer and or small vacancies in the adhesive layer may cause stress concentration areas during the US cleaning process. The stress concentration areas may cause delimitation in nearby layers.

Larger magnitude vibration of the LOB system may affect the lens, coatings, and/or adhesive at a scale from about 1 millimeter to about 80 millimeters. For example, delamination may occur across the entire lens diameter, which can be about 80 millimeters.

[0060] The coating on the convex side of the lens, including the adhesion layer, may be especially susceptible to delamination. The damage can be initiated when the edge of the LOB and the perimeter of the coating and adhesion layer are exposed to the cavitation bubbles induced by ultrasonic high frequency pressure on waves to agitate the liquid. The damage includes delamination and or peeling of the coating system, within the coating system layers and of the adhesion layer.

[0061] The damage may manifest in concentric distortions on the convex side of the lens in the central portion of the lens. The damage can sometimes be visible to naked eyes, e.g. through the concave surface, by viewing the LOB edges or from the block aspect. The defects may be irreparable, i.e. rework does not cure the defects in these cases.

[0062] FIG. 13 illustrates various forms of recurring defects that may develop during conventional ultrasonic cleaning of blocked lenses (e.g., at the cleaning step 140). Some of the defects can be unique to ultrasonic cleaning on the block. Stated differently, when lenses are cleaned off the block, these defects can be rare. Defects shown in FIG. 13 include: delamination of the coating system 220 on the convex surface, damage of the coating system 220 in proximity to the lens edge 1310 as seen from the concave surface, damage of the coating system 220 on the convex surface, damage in the center regions of the lens 1340 as seen from the concave surface, delamination 1330 of the adhesive layer 230 from the convex side coating layers 220 or the block mounting surface, a hairline crack or chipping on the concave surface 1350, and/or a hairline crack, or chipping on the lens edge surface 1360.

[0063] On-Block Lens Cleaning During OBM

[0064] In an exemplary On Block Manufacturing (OBM) process, the rear surface of the lens blank 200 can be cleaned without removing the lens blank from the lens block. Faster manufacturing of eyeglass lenses can be achieved by eliminating the de-blocking and re-blocking steps. In one example, the cleaning can be performed by an ultrasonic cleaner. In another example, a steam flow can be applied to the lens back surface to clean residues. In yet another example, both ultrasonic and steam cleaning can be deployed in a sequence. In yet another example, water and soap can be used to supplement the ultrasonic and/or steam cleaning.

[0065] FIGS. 3A-3B illustrate ultrasonic cleaning systems that uses ultrasound (usually from 20–400 kHz) and an appropriate liquid cleaning solvent to clean the back surface of the lens block while it is on a block. In FIG. 3A, the system 300 includes two blocked lenses 200 partially submerged in a cleaning solution 320 disposed in a container 310 (also referred to as a tank or a bath) having a rim 312. The back surfaces of the blocked lens 200 are in contact with the cleaning solution 320. An ultrasound generating transducer 330 built into the chamber, or lowered into the fluid, then produces ultrasonic waves in the fluid, creating compression waves 360 in the liquid to 'tear' the liquid apart and leaving behind many millions of microscopic 'voids' or 'partial vacuum bubbles' (cavitation). These bubbles may release enormous energy when collapsing: local temperatures and pressures on the order of 5,000 K and 20,000 lbs. per square inch can be achieved. The system 300 can further include an ultrasonic generator 340 operably coupled to the ultrasonic transducer 330 via a cable 342. Without being bound by any theory or mode of operation, the ultrasonic waves induce cavitation that agitates the cleaning solvent. The agitation can then produce high forces on contaminants adhering to substrates like metals, plastics, glass, rubber, and ceramics. The ultrasonic waves are also effective in cleaning contaminants in cracks and recesses.

[0066] To mitigate, reduce, or eliminate damage induced by vibration, the blocked lens 200 can be supported by an elastic holder that dampens the high frequency vibration, as shown in FIG. 3B. The system 300 includes a blocked lens 200 supported by an elastic holder 332 that dampens the high frequency vibration. For example, the elastic holder may comprise a mechanical spring. Alternatively, the elastic holder can include a component with hardness in the range of about 30 A Shore to about 60 A Shore. The elastic holder may also reduce low-frequency vibration such as shaking. In one example, two types of holders may be used in combination. For instance, during an ultrasonic cleaning mode in which more than one ultrasound frequency is used, different holders may be used to address each applied frequency.

[0067] In one example, only the back surface of the lens blank in a LOB system is submerged in the solution, while the rest of the system is either protruding from the solution (e.g., see FIGS. 3A-3B) or protected by a cover. For example, the LOB can be disposed above the ultrasonic cleaning chamber such that primarily the back surface of the lens blank is in contact with the cleaning solution, and substantially the rest of the LOB is held above the cleaning solution, as shown in FIG. 3B.

[0068] In another example, the circumference of the interface between the lens blank and the lens blocking piece can be wrapped with a layer of dampening material, such as sponge like materials, plastic sheets, or other materials known in the art, while leaving the surface to be cleaned exposed to the ultrasonic chamber medium. The dampening material can also comprise rubber, rubber-tar mixture, or other high temperature polymers (e.g., polymers capable of withstanding temperatures of 40 to 120 deg. Celsius, 60 to 90 deg. Celsius, etc.). In operation, the dampening materials can absorb incident ultrasound waves, thereby protecting the components behind the dampening materials (i.e., the blocked lens, including the adhesive layers and coating layers).

[0069] The cleaning solution 320 as shown in FIGS. 3A-3B can be either aqueous or organic solutions. In aqueous cleaners, the chemical added can be a surfactant (e.g., laundry detergent) which can break down the surface tension of the water base. The cleaning solution 320 can include mixture of detergent and water, with a detergent concentration by volume of 0.1–10%, 0.5–6%, or 1–4%. In one example, the detergent can be, for example, Deconex OP 171, and de-ionized (DI) water may be used as the base for the solution. Depending on the contamination type and size, the detergent type and concentration may be adjusted to achieve desired cleaning. Additional additives can also be included in the solution to modify the fluid color.

[0070] In addition to the cleaning solution in the ultrasonic cleaner chamber, other parameters that can be tuned to improve the cleaning or reduce potential damage to the LOB include, but are not limited to: the frequency of the ultrasound, operation mode, cleaning time, ultrasound power, and cleaning temperature.

[0071] In operation, frequency of the ultrasound can determine the spacing between the cavitation points. More specifically, higher frequencies (or shorter wavelengths) produce smaller spacing, which allows for cleaning of more intricate features. In one example, the ultrasound frequency used for cleaning a LOB can be from about 20 KHz to about 250 KHz, from about 50 KHz to about 100 KHz, or from about 60 KHz to about 90 KHz, depending, at least in part, on the lens surface quality, contaminant size and type.

[0072] Different operation modes of the ultrasonic cleaner may be implemented to further improve cleaning by targeting specific contamination type and size. For example, in a normal mode, a fixed ultrasonic frequency is applied throughout the entire cleaning process to achieve general cleaning. In a sweep frequency mode, continuous slight variation of ultrasonic frequency can be employed to eliminate hot spots, dead zones, and standing waves. To remove entrained air or other gases from liquids, intermittent operation of ultrasonic power can be performed, e.g., as in a degas mode. As to stubborn contaminants or degas solution, a pulse mode that produces intense bursts of ultrasonic power can be selected. In operation, multiple modes may be used in combination to further improve cleaning.

[0073] Ultrasonic cleaning time, in one exemplary embodiment, can be from about 15 seconds to about 1000 seconds, from about 50 seconds to about 500 seconds, or from about 100 seconds to about 250 seconds. In a streamlined process of lens manufacturing, shortening the cleaning time without compromising the cleaning results can be desirable. Moreover, excessive exposure to ultrasonic cavitation and implosion may cause part damage. Reduced cleaning time may be achieved by tuning other parameters such as solution composition, solution temperature, cleaning mode, ultrasound frequency, or any other parameters known in the art.

[0074] The power of the ultrasound normally determines the amplitude of the sound waves generated and further determines the agitation. More specifically, higher power can produce more aggressive agitation, which can accordingly remove contaminants at a faster speed. A practical range of ultrasound powers used in LOB cleaning can be from 10 Watts to about 2000 Watts, within which the power can be about 30 Watts to about 80 Watts, or from 80 Watts to about 800 Watts, depending, for example, on the operation mode.

[0075] Cleaning temperature in LOB cleaning can be the temperature of the liquid solution, or the temperature of the LOB itself. In operation, it may be more convenient to change the solution temperature. The fluid temperature in LOB cleaning can be from about 20 degrees Celsius (°C) to about 90 °C, from about 20 °C to about 60 °C, or from about 30 °C to about 50 °C (e.g., 35 °C, 40 °C, 45 °C, etc.). Generally, higher temperature leads to faster molecular or atomic movement and therefore faster cleaning. However, high fluid temperature may also corrode, degrade, or damage the rest of the system, such as adhesive layer, lens coating system, or the lens block. As a result, there usually exists a range at which the ultrasonic cleaning can remove contaminants without damaging the LOB.

[0076] Since the ultrasonic cleaning parameters (e.g., solution composition, frequency of the ultrasound, operation mode, cleaning time, ultrasound power, and solution temperature) can interact with each other, a reduction in the magnitude of one parameter can, to a point, be overcome by changing another parameter. For example, increasing temperature or changing solution composition may reduce the time required for ultrasonic cleaning. Furthermore, LOB cleaning or the overall lens manufacturing processes may have constraints on one or more variable. In one case, for example, cleaning may be accomplished with a chemical that has a pH of about 7 ± 1 for compatibility with the material of the lens blank or lens block. In another, the total cleaning time might be about 2 minutes or less to meet the desired production speed or yield. In yet another, the temperature may be less than about 100 °C, 90 °C, 80 °C, 70 °C, or 60 °C, depending at least on the LOB materials and cleaning solution, to prevent damage to the LOB system

[0077] Potential damage to the blocked lens during ultrasonic cleaning may be mitigated or minimized by developing an optimized US cleaning process recipe (e.g., a collection of parameters used in ultrasonic cleaning). The recipe may accomplish two goals simultaneously: effective and efficient cleaning of the lens blank while mitigating damage to the coatings and/or adhesion layer of the convex side of the lens.

[0078] However, it may not be always easy or straightforward to develop this recipe. Furthermore, properties of the LOB material, the lens material, the adhesion layer, and the coating system in each individual blocked lens may be slightly different from another individual blocked lens. In some cases, the difference can be due to different lens prescriptions and/or lens material. In some other cases, the difference occurs due to different shelf life of the blocked lens or any of its components. For example, the adhesion layer properties may vary with age of the adhesion material.

[0079] Any difference in the properties may render the optimized ultrasonic cleaning parameters for one blocked lens or one group of blocked lenses out of the optimal parameter window. Minute changes due to, for example, aging of the adhesion layer, or coating system properties, may be insignificant for some manufacturing processes. However, they can be significant for the ultrasonic cleaning processes.

[0080] On-block Ultrasonic Lens Cleaning Using a Sealing Member

[0081] Potential damage to the blocked lens during on-block ultrasonic cleaning may be mitigated or minimized by creating a physical barrier on the edge of the blocked lens and/or the perimeter of the coating and adhesion layers so as to prevent contact with the cleaning solution in ultrasonic cleaning processes. The damage may be also be mitigated or minimized, by partially submerging the LOB into the ultrasonic solution, such that the coating and adhesive layers on the convex side the lens do not come in contact with the cleaning solution.

[0082] FIG. 4A shows a schematic view of a blocked lens assembly 400 that can mitigate potential damage to blocked lenses during on-block ultrasonic cleaning. The assembly 400 includes a blocked lens that includes a lens blank with a front surface (not shown in FIG. 4A) and a back surface 212, a lens blocking piece 240 to hold the lens blank while processing the back surface of the lens blank, and an adhesive layer, disposed between the front surface of the lens blank and the lens blocking piece 240, to affix the lens blank to the lens blocking piece. The assembly 400 also includes a sealing member 420, disposed on at least a portion of an edge 440 defined by the blocked lens, to protect the blocked lens so as to facilitate cleaning of the blocked lens while the lens blocking piece is affixed to the front surface of the lens blank. The inner surface 412 of the sealing member 420 is in contact with the edge 440.

[0083] The edge 440 includes an edge 216 of the lens blocking piece 240, the edge 232 of the adhesive layer, and the edge 246 of the lens blank. In this case, the sealing member 420 can substantially protect the adhesive layer from contacting with the cleaning solution during ultrasonic cleaning processes.

[0084] The sealing member 420 has a first end portion 430 that protrudes beyond the back surface 212 of the lens blank. In this case, when the LOB is placed on an object with the back surface 212 facing the object, the first end portion 430 can support the LOB and prevent contact between the back surface 212 and the object so as to protect the optical surface of the back surface 212. The sealing member 420 also has a second end portion 410 that can also protrude beyond the perimeter of the edge 216 of the block 240.

[0085] In some examples, the sealing member 420 can include at least one notch 435 (e.g., v-shaped recesses) in the first end portion 430 such that only a portion of the first end portion 430 is touching the surface on which LOB system 400 is placed (e.g., ground). The notch 435 may also allow liquid to flow into and out of the space defined by the first end portion 430 and the back surface 212 of the lens blank. In some examples, the height (or depth) of the notch 435 is up to the line defining the contact between the back surface 212 and the sealing member 420, such that the edge of the LOB and/or the perimeter of the coating and adhesion layer does not contact the liquid while also allowing the cleaning solution to reach the back surface 212 of the lens when positioned face down in the cleaning solution.

[0086] In some examples, the sealing member can comprise a rubber or rubber like material as known in the art. In some examples, the sealing member 420 can be, for example, a rubber band and can be mounted onto the blocked lens by stretching the sealing member 420. In some examples, the sealing member 420 can comprises a heat shrink material and can be applied to the blocked lens via heating. In some examples, the sealing member is further reinforced with an adhesive such that its bonding with the blocked lens is stronger.

[0087] In some examples, the sealing member 420 is porous, partially porous, or porous in some sections such that the sealing member 420 can absorb energy released during the imploding of cavitation bubbles in ultrasonic cleaning. In some examples, the sealing member 420 comprises multiple layers and or materials. The choice of materials can be dependent, for example, on the block and lens material. In some examples, the sealing member 420 comprises a material that is the same material used in the adhesive layer between the lens and the block. In some examples, the sealing member 420 can be applied in the same process to apply the adhesive material. In some examples, the blocking of the lens blank onto the lens blocking piece can be conducted within a ring that can constrain the overflow of the adhesive material and shape the adhesive material around the blocked lens so as to form the sealing member 420.

[0088] FIG. 4B shows a schematic view of a snap-on clamp 460 with a tooth locking mechanism 460 to secure the clamp 460 to a blocked lens. The inner surface 412 of the snap-on clamp 460 can seal the blocked lens from potential damage during ultrasonic cleaning.

[0089] FIG. 4C shows a schematic view of a quick release clamp 480 with a locking mechanism 484. The quick release clamp 480 can also include a plurality of notches 485.

[0090] FIG. 4D shows a schematic view of a sealing member 490 including a plurality of bumpers 494 (also referred to as cushioning mechanism) on the rim of the sealing member 490. The bumpers 494 can provide additional protection for the back surface 212 when the blocked lens is placed, for example, on a surface with the back surface 212 facing the surface. The clamps shown in FIGS. 4B – 4D are about 1–5 mm larger than the thickness of the lens. But the clamps can also be smaller than the thickness of the lens. For example, the clamps' heights could be about 0.5–20 mm, 0.5–5 mm, 4–10 mm, 8–15 mm, 10–20 mm, etc.

[0091] Examples of On-block Ultrasonic Lens Cleaning Systems

[0092] FIG. 5 shows a schematic view of a system to implement on-block ultrasonic cleaning of blocked lenses. The blocked lens 400 includes a lens blocking piece affixed to a front surface of a lens blank via an adhesive layer. The blocked lens also defines an edge substantially covered by a sealing member 420. The system includes a container 310 to hold a cleaning liquid 320, a holding member 500, mechanically coupled to the container 310, to hold at least a portion of the blocked lens 400 in contact with the cleaning liquid 320 during cleaning of the blocked lens. The system also includes an ultrasonic transducer 330, operably coupled to the container 310, to transmit an ultrasonic wave into the cleaning liquid 320 so as to clean the blocked lens 400 while the lens blank is affixed to the lens blocking piece.

[0093] In one example, the sealing member 420 can be removed before, for example, coating. In this case, the sealing member 420 can be bonded to the blocked lens 400 via a light adhesive. Possible residues on the edge can be cleaned before coating. In another example, the blocked lens 400 can undergo coating with the sealing member 420, which can cover residue on the edge.

[0094] In some examples, the blocked lens 400 can be mounted onto a flexible sealing member 420 which can be further mounted onto the container 310. The flexible sealing member 420 can secure the blocked lens 400 to the container 310 while at the same time providing the blocked lens 400 with some degrees of motion during the ultrasonic cleaning process.

[0095] In some examples, the holding member 500 can include a receptacle, such as basket having a mesh bottom surface 510, for holding the blocked lens 400 in the cleaning solution. In some embodiments, the basket 500 is made of steel and/or other metal. The basket and specifically the mesh can also be made of a polymer material. The basket may be designed such that it can be placed on the container 310, such that the bottom of the mesh is lower than the container rim while other portions of the basket's frame or structure are in contact with the container rim and support the basket. In some examples, air or gas bubbles may be trapped in the volume defined by back surface of the lens and the seal, as in an upside down cup when it is lowered into a liquid. The trapped gas bubbles may reduce the effectiveness of the US cleaning process.

[0096] The basket 500 with the blocked lens 400 can be placed in the fluid at an angle such that fluid may displace trapped gas bubbles before starting the US cleaning process. In some embodiments, the blocked lens 400 is vibrated and or slightly tilted during the cleaning process such that gas bubbles are displaced by fluid.. In some examples, the basket 500 with the blocked lens 400 is agitated such that the cleaning fluid 320 can contact the back surface 212 of the lens blank prior to applying the ultrasonic power. In some examples, the blocked lens 400 can be placed in the basket 500 at an angle such that such that the fluid can contact the concave aspects of the lens.

[0097] FIG. 6 shows a schematic view of a system for ultrasonic cleaning of blocked lens using flexible holding members. The system includes a blocked lens 400 protected by a sealing member 420, which is further fastened to the rim of a container 310 via an end portion 610 of a holding member 600. The holding member 600 can be made of flexible materials such as rubber, plastic, or any other flexible materials known in the art, that are formed or positioned to hold the blocked lens 400 at least partially with the cleaning solution. The holding member 600 can allow flexible movement of the blocked lens 400 before, during, or after ultrasonic cleaning processes. In this configuration the blocked lens is not in direct contact with any hard surfaces. The flexible holding member 600 enables the use of containers with variable dimensions (e.g., width / diameter), depending on the elasticity of the seal. Gravity or a pressure force exerted from above the blocked lens can achieve the submersion of the concave side of the lens into the fluid.

[0098] In some examples, the blocked lens 400 can be pressed into the sealing member 420 after the holder member 600 is mounted to the container 310. In some examples, the blocked lens 400 can be pressed into the sealing member 420 before the holder member 600 is mounted to the container 310.

[0099] In some examples, the blocked lens 400 can be pressed onto a flexible sealing member 420 wherein the flexible sealing member 420 is primarily in contact with the lens outer diameter. In some examples, the blocked lens can be pressed onto a flexible sealing member 420 wherein the flexible sealing member 420 has a diameter that is smaller than that of the lens and the sealing member 420 is pressed onto the perimeter of the concave surface. In some examples, the sealing member 420 and the holding member 600 can be integrated as a single unit. In some examples, the sealing member 420 and the holding member 600 can be separable.

[0100] FIG. 7 shows a schematic view of a system for on-block ultrasonic cleaning of blocked lens with a pressured fluid source. The system includes a blocked lens 400 fastened to the rim of a container via a rigid holding member 700. More specifically, the holding member 700 includes a first end 710 connected to the rim of the container and a second end 715 connecting to the sealing member 420 enclosing the edge of the blocked lens 400. The system also includes a pressurized fluid source 720 with a nozzle 722 to provide fluid to the container or fluid flow to clean the back surface 212 of the blocked lens.

[0101] In some examples, the blocked lens is mounted above the pressurized fluid source nozzle 722 such that the flow of pressurized fluid expels gas trapped near the concave surface of the lens. In some examples, the container may have a window or gauge (not shown) to monitor the fluid level. In some examples, a pressure relief valve 725 in the holding member 700 can be used to relieve pressure in the container when necessary. The pressure relief methods can be accomplished with various mechanisms, located in various positions in the system, for example, in the wall of the tank 310.

[0102] In_some examples, the system can further include a gas diaphragm (e.g., a balloon, or any other flexible cavity with expandable volume) which can be expanded or deflated so as to adjust the liquid level in the container. The diaphragm can be mounted within the container. In some examples, the diaphragm can be submerged in the container. In some examples, an external pump can be used to control the gas pressure within the diaphragm and therefore the diaphragm size. An expansion of the diaphragm can raise the fluid level toward the concave surface of the lens. In some examples, there is a pressurized fluid source connected to the tank. Once the lens is mounted and sealed, the tank is filled with fluid.

[0103] FIG. 8 shows a schematic view of a system for on-block ultrasonic cleaning of blocked lens with cleaning fluids above the back surface of the blocked lenses. The sealed blocked lens (i.e., blocked lens with a sealing member) is mounted in a receiving fixture (receptacle) 815, which is constructed using a material designed to grip the seal. The fixture 815 can be at the bottom of the container. In operation, after the concave surface of the lens has been sealed and mounted, the container can be rotated above a rotation axis that can be a horizontal line in the paper plane. The rotation can be carried out using a pivot 820 such that the concave surface of the lens functions as part of the bottom of the container. In an embodiment, the blocked lens can be mounted when the container is empty and then the container can be rotated to fill the cleaning fluid. Once the system is rotated the fluid level no longer has to be raised to the lens since the lens is at the lowest point in the system. This system configuration may use less fluid than other “blocking piece facing up” system configurations. In addition, the gravity force of the cleaning liquid may increase the efficiency of cleaning.

[0104] FIG. 9 shows a schematic view of a system for cleaning the lens blocking piece. Coating processes in lens manufacturing normally are performed in a clean environment. The coating machine is typically sealed and transfers the parts to be cleaned between internal stations deploying sub processes related to the coating processes such as: rinsing, drying, surface preparation, and coating, among others. In some cases, prior to placing the blocked lens in the coating machine, a cleaning step can be performed to clean the lens blocking piece. The system shown in FIG. 9 includes a blocked lens fastened to the rim of the container with a flexible seal (including both a sealing member 420 and a holding member 600) that protects the interface between the lens blank and the lens blocking piece. The lens blocking piece is submerged in the cleaning solution for ultrasonic cleaning. All techniques described above can be applied in this example to clean the lens blocking piece. For example, the blocked lens 400 can be held in any of the methods described above such that the lens blocking piece can be in contact with the cleaning fluid.

[0105] FIG. 10 shows a schematic view of a system for ultrasonic cleaning of both the lens blank and the lens blocking piece. In FIG. 10, the blocked lens can be disposed in any of the methods described above such that the lens blocking piece is in contact with the cleaning fluid in one container and the lens blank is disposed in contact with the cleaning fluid in a different container. The two containers can be aligned and/or connected without exposing the lens edge and/or the perimeter of the coating and/or adhesion layer to the cavitation bubbles in ultrasonic cleaning.

[0106] In some examples, the lens blank and the lens blocking piece can be cleaned simultaneously. In some examples, the lens blank and the lens blocking piece can be cleaned in a sequence without physically moving the blocked lens.

[0107] In some examples, the two containers can hold the same cleaning liquid. In some examples, the two containers can hold different cleaning liquids. For example, one cleaning liquid can be particularly for cleaning the lens surface which can be glass while the other cleaning liquid can be particularly for cleaning the lens blocking piece which can be plastic or polymer.

[0108] The system shown win FIG. 10 can saves time during lens manufacturing by eliminating the need of, for example, moving the blocked lens from one container to another or flipping the blocked lens so as to clean the lens blocking piece. The system shown in FIG. 10 may also save space by, for example, vertically stacking the two containers.

[0109] In some examples, the ultrasonic cleaning liquid can be heated so as to adjust the cleaning efficiency. For example, a heating element , such as a heating resistor, can be installed near the wall of the container.

[0110] FIG. 11 shows a schematic view of a system for on-block ultrasonic cleaning of a plurality of blocked lenses. In FIG. 11, multiple blocked lenses with protective sealing members can be submerged in the cleaning fluid and supported by a basket or perforated tray substantially like the one shown in FIG. 5. The edges of the lenses are protected from impact and ultrasonic interference by the sealing members. Any of the above methods (e.g., as shown in FIGS. 5–10) can be applied on two or more blocked lenses here.

[0111] In some embodiments, the ultrasonic cleaning system is enclosed within the coating equipment. In some embodiments the US cleaning system is an integral part of the coating equipment, controlled by the machine control system. In some embodiments, the ultrasonic cleaning system can function externally and/or internally, with respect to the coating equipment, such that a first cleaning can be applied externally to the coating equipment and a second cleaning, within the coating machine enclosure and clean environment.

[0112] Several methods can be employed to reduce or even eliminate possible damage to the LOB system during ultrasonic cleaning. In one example, repeated submerging of the LOB into the chamber can be employed. Instead of keeping the LOB system soaked in the cleaning solution, the LOB may be pulled out of the solution from time to time to reduce the total interaction time with the solution, therefore reducing the potential for damage caused by the solution.

[0113] In some examples, the ultrasonic cleaning process can be integrated with additional cleaning processes such as rinse and dry, or pressurized steam cleaning. In some examples, the additional cleaning steps can be conducted in the same container as used in ultrasonic cleaning, e.g., by evacuating the ultrasonic cleaning fluid after ultrasonic cleaning and introducing rinsing fluid into the container. In some examples, the blocked lens with or without the sealing member are moved to different stations where rinse, dry and similar processes can be performed.

[0114] FIG. 12 shows a schematic view of a system in which the concave surface of the lens on block is cleaned with high pressure steam. The system includes a blocked lens 300 mounted to a container via a holding member 700. The back surface 212 of the blocked lens is toward a plurality of steam nozzles 1240 that can provide high pressure steams 1250 to clean the back surface 212.

[0115] A steam cleaner normally uses steam expansion to accelerate fluid droplets, at the boiling point, to a high velocity for cleaning. The closer the steam cleaner nozzle 1240 is to the surface to be cleaned, the higher the temperature and velocity of the fluid/steam mixture, and the more rapid the cleaning action. The temperature of the fluid/steam mixture may drop quickly as the distance between the nozzle and the surface to be cleaned increases. In an embodiment, the distance between the nozzle and the surface to be cleaned is determined based on the lens material and/or residue properties.

[0116] The cleaning can be performed either before coating, after coating, or both depending on specific needs. For example, to ensure high quality coating, cleaning can be performed before coating. Or, to inspect the anti-reflection coating or hard coating for quality assurance, cleaning can be performed after coating. Furthermore, cleaning, followed by an inspection, can also be carried out before edging, since it can be more difficult to rework the concave surface if defects are identified after edging.

[0117] In FIG. 12 the lens is cleaned with pressurized steam 1250. In one example, the steam cleaning process can be applied before the ultrasonic cleaning. In another example, the steam cleaning process can be applied after the ultrasonic cleaning.

[0118] In some examples, the blocked lens can be mounted within a holder, such that the concave surface 212 of the lens blank is facing toward the incident steam 1250 flow used for cleaning. The holder 700 includes components that are in contact with the circumference of the blocked lens such that fluid or gas flow can be obstructed from the rest of the system behind the concave surface. In some examples, a high pressure steam nozzle 1240 can be positioned primarily below the concave surface 212 of the lens on block 200, such that the pressurized steam is directed in the direction of the concave surface. In some examples, the blocked lens can be rotated around its geometric axis such that the steam can be applied more uniformly over the concave surface for cleaning. Alternatively, the nozzle 1240 can also rotate to achieve uniform cleaning. Moreover, the LOB 200 system can undergo a precession movement to clean surface areas further away from the center.

[0119] To further improve cleaning, the distance between the nozzle 1240 and the concave surface 212 can be adjusted to tune the speed, temperature, and chemical concentration of the cleaning steam. The steam flow 1250 can be substantially perpendicular to the concave surface for cleaning. Or, the steam flow 1250 can be directed upon the concave surface 212 at an incident angle from about 90 degrees (normal incidence) to about 5 degrees (grazing incidence).

[0120] FIG. 14 shows a flowchart that illustrates one example method of on-block ultrasonic cleaning of blocked lenses in a OBM process. The method 1400 can start from polishing at step 130, after which the blocked lens is mounted in a sealing member at step 1410. The sealing member can be, for example, a snap on seal 460, or a quick release seal 480 as described before. Then the sealed blocked lens can be mounted to a container that can hold cleaning solutions at step 1420. At step 1430, the blocked lens is brought into contact with the cleaning solution. For example, the liquid level of the cleaning solution in the container can be raised so as to reach the blocked lens. The selected solution can be, for example, DECONEX detergent, 12PA-x, elam lab clean A25, elam lab clean S20, or any other suiable solution.

[0121] At step 1440, ultrasonic waves are applied toward the blocked lens, with parameters optimally selected (e.g., at a frequency of 80 kHz and 50% of maximal power). The blocked lens is then removed from the seal for rinsing at step 1460 (e.g., using tap water to remove residues of the cleaning solution in ultrasonic cleaning). The blocked lens can also undergo several optional cleaning cycles before removing the seal at step 1470. At step 140, the blocked lens removed from the seal can be dried, for example, using heat air or cold air flow.

[0122] Conclusion

[0123] While various inventive embodiments have been described and illustrated herein, those of ordinary skill in the art will readily envision a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein, and each of such variations and/or modifications is deemed to be within the scope of the inventive embodiments described herein. More generally, those skilled in the art will readily appreciate that all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the inventive teachings is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific inventive embodiments described herein. It is, therefore, to be understood that the foregoing embodiments are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, inventive embodiments may be practiced otherwise than as specifically described and claimed. Inventive embodiments of the present disclosure are directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the inventive scope of the present disclosure.

[0124] The above-described embodiments can be implemented in any of numerous ways. For example, embodiments of designing and making the coupling structures and diffractive optical elements disclosed herein may be implemented using hardware, software or a combination thereof. When implemented in software, the software code can be executed on any suitable processor or collection of processors, whether provided in a single computer or distributed among multiple computers.

[0125] Further, it should be appreciated that a computer may be embodied in any of a number of forms, such as a rack-mounted computer, a desktop computer, a laptop computer, or a tablet computer. Additionally, a computer may be embedded in a device not generally regarded as a computer but with suitable processing capabilities, including a Personal Digital Assistant (PDA), a smart phone or any other suitable portable or fixed electronic device.

[0126] Also, a computer may have one or more input and output devices. These devices can be used, among other things, to present a user interface. Examples of output devices that can be used to provide a user interface include printers or display screens for visual presentation of output and speakers or other sound generating devices for audible presentation of output. Examples of input devices that can be used for a user interface include keyboards, and pointing devices, such as mice, touch pads, and digitizing tablets. As another example, a computer may receive input information through speech recognition or in other audible format.

[0127] Such computers may be interconnected by one or more networks in any suitable form, including a local area network or a wide area network, such as an enterprise network, and intelligent network (IN) or the Internet. Such networks may be based on any suitable technology and may operate according to any suitable protocol and may include wireless networks, wired networks or fiber optic networks.

[0128] The various methods or processes (e.g., of designing and making the coupling structures and diffractive optical elements disclosed above) outlined herein may be coded as software that is executable on one or more processors that employ any one of a variety of operating systems or platforms. Additionally, such software may be written using any of a number of suitable programming languages and/or programming or scripting tools, and also may be compiled as executable machine language code or intermediate code that is executed on a framework or virtual machine.

[0129] In this respect, various inventive concepts may be embodied as a computer readable storage medium (or multiple computer readable storage media) (e.g., a computer memory, one or more floppy discs, compact discs, optical discs, magnetic tapes, flash memories, circuit configurations in Field Programmable Gate Arrays or other semiconductor devices, or other non-transitory medium or tangible computer storage medium) encoded with one or more programs that, when executed on one or more computers or other processors, perform methods that implement the various embodiments of the invention discussed above. The computer readable medium or media can be transportable, such that the program or programs stored thereon can be loaded onto one or more different computers or other processors to implement various aspects of the present invention as discussed above.

[0130] The terms “program” or “software” are used herein in a generic sense to refer to any type of computer code or set of computer-executable instructions that can be employed to program a computer or other processor to implement various aspects of embodiments as discussed above. Additionally, it should be appreciated that according to one aspect, one or more computer programs that when executed perform methods of the present invention need not reside on a single computer or processor, but may be distributed in a modular fashion amongst a number of different computers or processors to implement various aspects of the present invention.

[0131] Computer-executable instructions may be in many forms, such as program modules, executed by one or more computers or other devices. Generally, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. Typically the functionality of the program modules may be combined or distributed as desired in various embodiments.

[0132] Also, data structures may be stored in computer-readable media in any suitable form. For simplicity of illustration, data structures may be shown to have fields that are related through location in the data structure. Such relationships may likewise be achieved by assigning storage for the fields with locations in a computer-readable medium that convey relationship between the fields. However, any suitable mechanism may be used to establish a relationship between information in fields of a data structure, including through the use of pointers, tags or other mechanisms that establish relationship between data elements.

[0133] Also, various inventive concepts may be embodied as one or more methods, of which an example has been provided. The acts performed as part of the method may be ordered in any suitable way. Accordingly, embodiments may be constructed in which acts are performed in an order different than illustrated, which may include performing some acts simultaneously, even though shown as sequential acts in illustrative embodiments.

[0134] All definitions, as defined and used herein, should be understood to control over dictionary definitions, definitions in documents incorporated by reference, and/or ordinary meanings of the defined terms.

[0135] The indefinite articles "a" and "an," as used herein in the specification and in the claims, unless clearly indicated to the contrary, should be understood to mean "at least one."

[0136] The phrase "and/or," as used herein in the specification and in the claims, should be understood to mean "either or both" of the elements so conjoined, i.e., elements that are conjunctively present in some cases and disjunctively present in other cases. Multiple elements listed with "and/or" should be construed in the same fashion, i.e., "one or more" of the elements so conjoined. Other elements may optionally be present other than the elements specifically identified by the "and/or" clause, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, a reference to "A and/or B", when used in conjunction with open-ended language such as "comprising" can refer, in one embodiment, to A only (optionally including elements other than B); in another embodiment, to B only (optionally including elements other than A); in yet another embodiment, to both A and B (optionally including other elements); etc.

[0137] As used herein in the specification and in the claims, "or" should be understood to have the same meaning as "and/or" as defined above. For example, when separating items in a list, "or" or "and/or" shall be interpreted as being inclusive, i.e., the inclusion of at least one, but also including more than one, of a number or list of elements, and, optionally, additional unlisted items. Only terms clearly indicated to the contrary, such as "only one of" or "exactly one of," or, when used in the claims, "consisting of," will refer to the inclusion of exactly one element of a number or list of elements. In general, the term "or" as used herein shall only be interpreted as indicating exclusive alternatives (i.e. "one or the other but not both") when preceded by terms of exclusivity, such as "either," "one of," "only one of," or "exactly one of." "Consisting essentially of," when used in the claims, shall have its ordinary meaning as used in the field of patent law.

[0138] As used herein in the specification and in the claims, the phrase "at least one," in reference to a list of one or more elements, should be understood to mean at least one element selected from any one or more of the elements in the list of elements, but not necessarily including at least one of each and every element specifically listed within the list of elements and not excluding any combinations of elements in the list of elements. This definition also allows that elements may optionally be present other than the elements specifically identified within the list of elements to which the phrase "at least one" refers, whether related or unrelated to those elements specifically identified. Thus, as a non-limiting example, "at least one of A and B" (or, equivalently, "at least one of A or B," or, equivalently "at least one of A and/or B") can refer, in one embodiment, to at least one, optionally including more than one, A, with no B present (and optionally including elements other than B); in another embodiment, to at least one, optionally including more than one, B, with no A present (and optionally including elements other than A); in yet another embodiment, to at least one, optionally including more than one, A, and at least one, optionally including more than one, B (and optionally including other elements); etc.

[0139] In the claims, as well as in the specification above, all transitional phrases such as "comprising," "including," "carrying," "having," "containing," "involving," "holding," "composed of," and the like are to be understood to be open-ended, i.e., to mean including but not limited to. Only the transitional phrases "consisting of" and "consisting essentially of" shall be closed or semi-closed transitional phrases, respectively, as set forth in the United States Patent Office Manual of Patent Examining Procedures, Section 2111.03.

CLAIMS

1. A blocked lens assembly comprising:

a blocked lens comprising:

a lens blank having a front surface and a back surface;

a lens blocking piece; and

an adhesive layer, disposed between the front surface of the lens blank and the lens blocking piece, to affix the lens blank to the lens blocking piece; and

a sealing member, disposed along at least a portion of an edge of the blocked lens, to facilitate cleaning of the blocked lens.

2. The blocked lens assembly of claim 1, wherein the lens blank has a diameter approximately equal to a diameter of the lens blocking piece.

3. The blocked lens assembly of claim 1, wherein at least a portion of the edge of the blocked lens forms at least a portion of an edge of the lens blank, an edge of the adhesive layer, and/or an edge of the lens blocking piece.

4. The blocked lens assembly of claim 1, wherein the sealing member comprises a dampening material.

5. The blocked lens assembly of claim 4, wherein the dampening material comprises at least one of a high temperature polymer or a porous material.

6. The blocked lens assembly of claim 1, wherein the sealing member comprises an elastic member substantially covering an edge of the adhesive layer.

7. The blocked lens assembly of claim 1, wherein the adhesive layer comprises an adhesive material and the sealing member comprises the adhesive material.

8. The blocked lens assembly of claim 1, wherein the adhesive layer comprises a

first adhesive material and the sealing member comprises a second adhesive material different than the first adhesive material.

9. The blocked lens assembly of claim 1, wherein a portion of the sealing member extends beyond the back surface of the blocked lens to support the blocked lens and to prevent contact between the back surface of the blocked lens and the surface.

10. The blocked lens assembly of claim 9, wherein the portion of the sealing member comprises at least one bumper.

11. The blocked lens assembly of claim 9, wherein the portion of the sealing member defines at least one notch.

12. The blocked lens assembly of claim 1, further comprising:

another adhesive layer to couple the sealing member to the at least a portion of the edge of the blocked lens.

13. The blocked lens assembly of claim 1, wherein the sealing member comprises a snap-on clamp.

14. The blocked lens assembly of claim 1, wherein the sealing member comprises a quick-release clamp.

15. The blocked lens assembly of claim 1, wherein the sealing member comprises a locking mechanism to secure the sealing member to the at least a portion of the edge of the blocked lens.

16. An apparatus for cleaning a blocked lens comprising a lens blocking piece affixed to a front surface of a lens blank via an adhesive layer, the blocked lens defining an edge substantially covered by a sealing member, the apparatus comprising:

at least one container to hold a cleaning liquid;

a holding member to hold at least a portion of the blocked lens in contact with the cleaning liquid during cleaning of the blocked lens; and

an ultrasonic transducer, acoustically coupled to the at least one container, to transmit an ultrasonic wave into the cleaning liquid so as to clean the blocked lens while the lens blank is affixed to the lens blocking piece.

17. The apparatus of claim 16, wherein the holding member comprises a basket having a mesh surface to receive an end portion of the sealing member such that the back surface of the blocked lens is in contact with the cleaning liquid.

18. The apparatus of claim 16, wherein the holding member comprises:

a first end to receive the sealing member;

a second end to couple the holding member to the container; and

an arm, disposed between the first end and the second end, to hold the back surface of the blocked lens toward the cleaning fluid

19. The apparatus of claim 18, wherein the arm is a flexible arm to enable motion of the blocked lens during cleaning.

20. The apparatus of claim 16, further comprising:

a nozzle, operably coupled to a pressurized fluid source, to provide a flow of liquid from the pressurized fluid source toward the back surface of the blocked lens.

21. The apparatus of claim 16, wherein the holding member comprises a receptacle to secure the blocked lens at least partially underneath the cleaning liquid during cleaning.

22. The apparatus of claim 16, wherein the holding member is configured to hold a surface of the lens blocking piece in contact with the cleaning fluid for cleaning the

surface of the lens blocking piece.

23. The apparatus of claim 16, wherein the at least one container comprises:

a first container to hold a first cleaning liquid in contact with the back surface of the blocked lens, and

a second container to hold a second cleaning liquid in contact with a surface of the lens blocking piece.

24. The apparatus of claim 23, wherein the first cleaning liquid is different than the second cleaning liquid.

25. The apparatus of claim 23, wherein the ultrasonic transducer comprises a first ultrasonic transducer operably coupled to the first container and a second ultrasonic transducer operably coupled to the second container.

26. A method of cleaning a blocked lens comprising a lens blocking piece affixed to a front surface of a lens blank via an adhesive layer, the blocked lens defining an edge substantially covered by a sealing member, the method comprising:

A) disposing at least a portion of the blocked lens in contact with a cleaning solution while the lens blank is affixed to the lens blocking piece; and

B) transmitting an ultrasonic wave at a frequency of about 20 kHz to about 250 kHz through the cleaning solution to clean the back surface while the lens blank is affixed to the lens blocking piece.

27. The method of claim 26, further comprising:

before A), disposing the sealing member on the edge, wherein at least a portion of the edge forms at least a portion of an edge of the lens blank, an edge of the adhesive layer, and/or an edge of the lens blocking piece.

28. The method of claim 26, wherein the sealing member comprises a water resistant

film to protect the at least a portion of the blocked lens from damage.

29. The method of claim 26, wherein A) comprises:

disposing at least a portion of the back surface of the blocked lens in contact with the cleaning solution so as to clean the at least a portion of the back surface.

30. The method of claim 26, wherein A) comprises:

disposing at least a portion of the lens blocking piece in contact with the cleaning solution so as to clean the at least a portion of the lens blocking piece.

31. The method of claim 26, wherein A) comprises:

disposing at least a portion of the back surface of the blocked lens in contact with a first cleaning solution; and

disposing at least a portion of the lens blocking piece in contact with a second cleaning solution to enable simultaneous cleaning of the back surface of the lens blank and the lens blocking piece.

32. The method of claim 26, wherein A) comprises:

A1) operably coupling the blocked lens with a container; and

A2) raising a liquid level of the cleaning solution in the container so as to dispose the cleaning solution in contact with the blocked lens.

33. The method of claim 26, further comprising, before A):

mixing water with a detergent at a volume percentage of about 0.1% to about 10% to form the cleaning solution.

34. The method of claim 33, wherein the volume percentage of the detergent is about 0.5% to about 6%.

35. The method of claim 33, wherein the volume percentage of the detergent is about

1% to about 4%.

36. The method of claim 26, wherein A) comprises providing the cleaning solution at a temperature of about 20 °C to about 60 °C.

37. The method of claim 26, wherein A) comprises providing the cleaning solution at a temperature of about 30 °C to about 50 °C.

38. The method of claim 26, wherein B) comprises setting a frequency of the ultrasonic wave within a range from about 50 kHz to about 100 kHz.

39. The method of claim 26, wherein B) comprises setting a frequency of the ultrasonic wave within a range from about 60 KHz to about 90 KHz.

40. The method of claim 26, wherein B) comprises transmitting the ultrasonic wave for about 50 seconds to about 500 seconds.

41. The method of claim 26, wherein B) comprises transmitting the ultrasonic wave for about 100 seconds to about 250 seconds.

42. The method of claim 26, wherein B) further comprises transmitting the ultrasonic wave at a power level of about 10 Watts to about 2000 Watts.

43. The method of claim 26, wherein B) further comprises:

tuning the frequency of the ultrasonic wave so as to reduce the occurrence of hot spots, dead zones, and/or standing waves on the concave surface of the lens blank.

44. The method of claim 26, wherein B) comprises:

generating a sequence of ultrasonic wave pulses; and

transmitting the sequence of ultrasonic wave pulses through the cleaning solution to the back surface of the lens blank.

45. The method of claim 26, wherein B) further comprises:

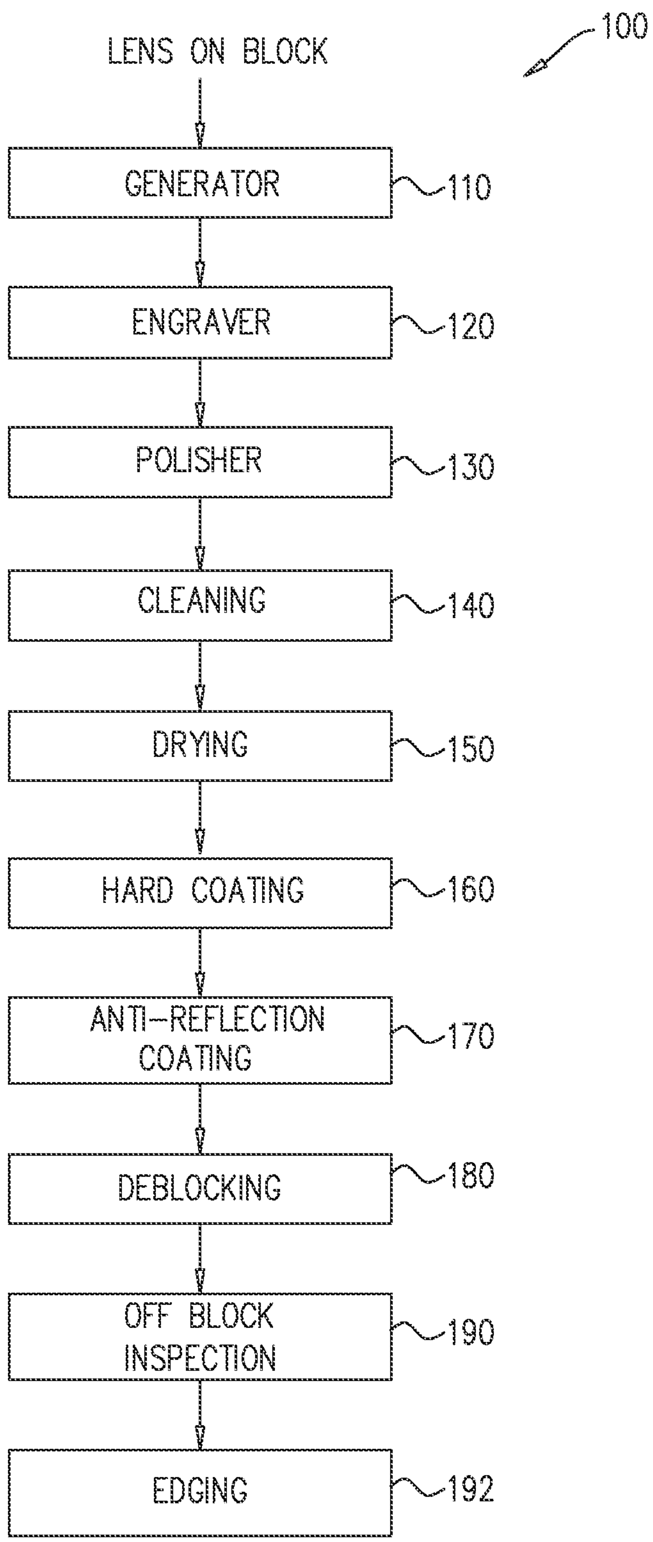
at least partially withdrawing the back surface of the lens blank from the cleaning solution while the ultrasonic wave is propagating through the cleaning solution; and

at least partially re-submerging the back surface of the lens blank in the cleaning solution while the ultrasonic wave is propagating through the cleaning solution.

46. The method of claim 26, wherein A) comprises:

disposing the cleaning solution above the back surface of the lens blank.

47. The method of claim 26, wherein A) comprises disposing the back surface of the lens blank in contact with the cleaning solution, wherein B) further comprises providing a liquid flow toward the back surface of the lens blank.


100
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ENGRAVER
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POLISHER
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CLEANING
140
DRYING
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ANTI-REFLECTION COATING
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DEBLOCKING
180
OFF BLOCK INSPECTION
190
EDGING
192

FIG. 1

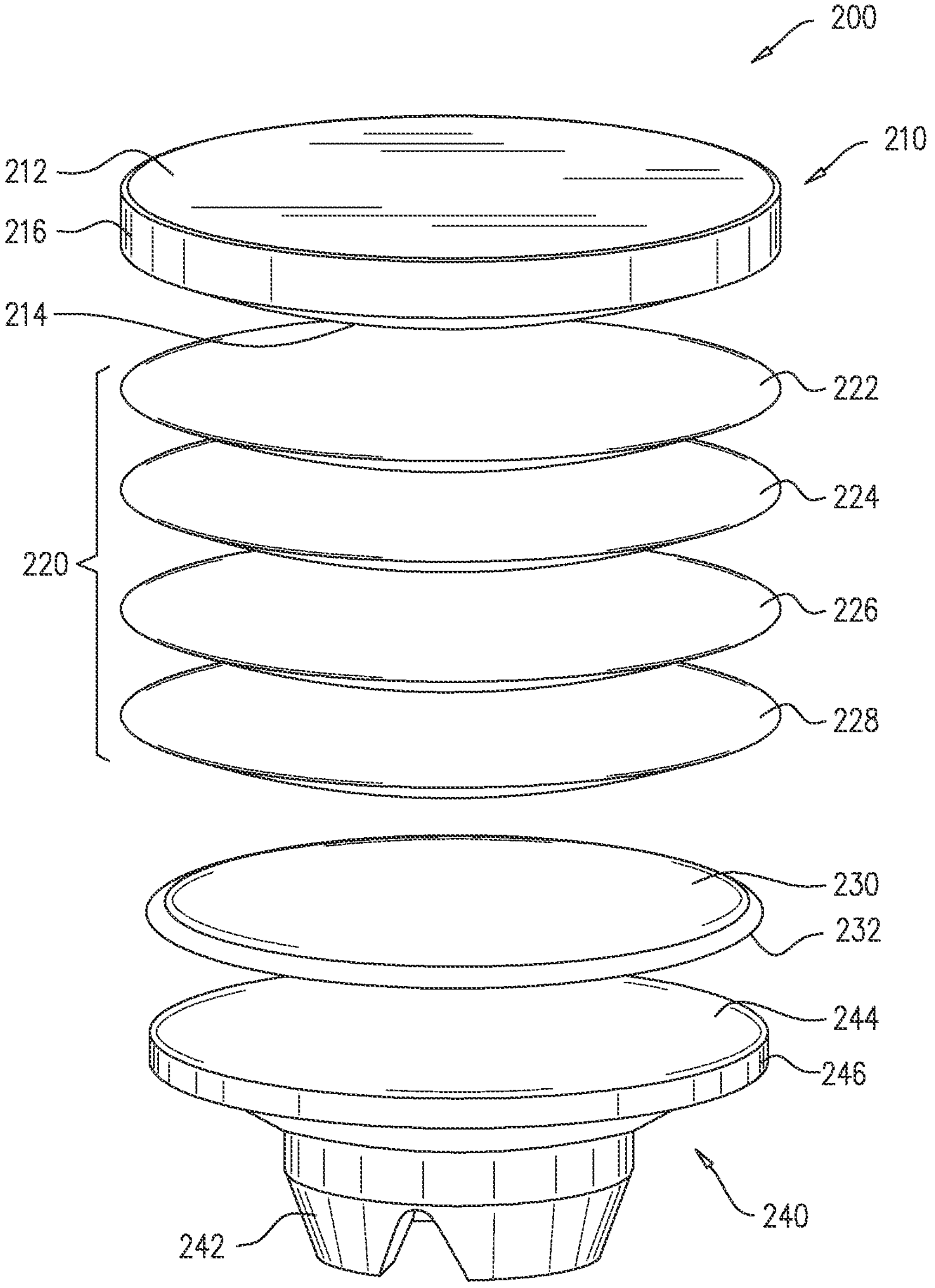

FIG. 2

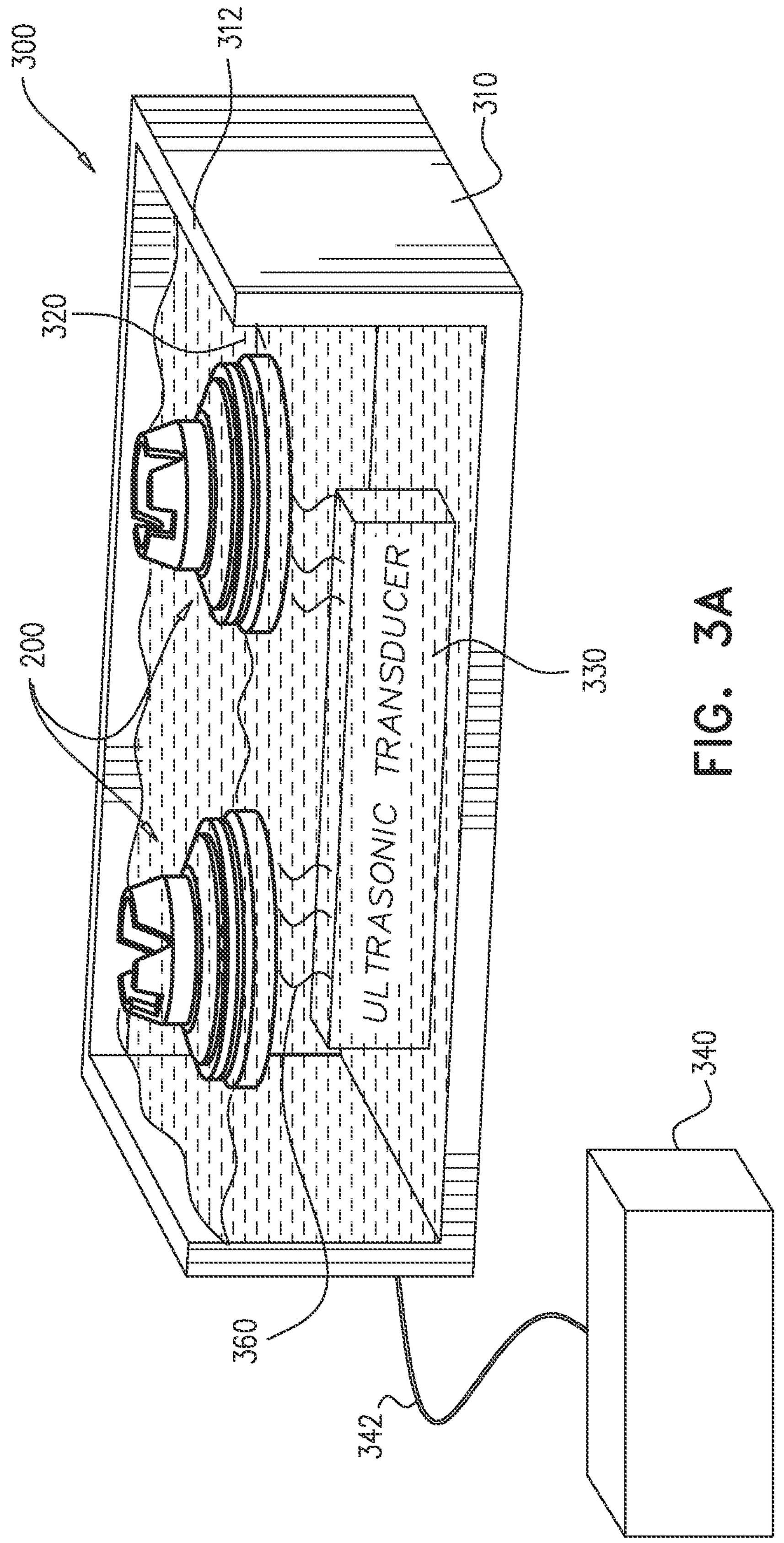

FIG. 3A

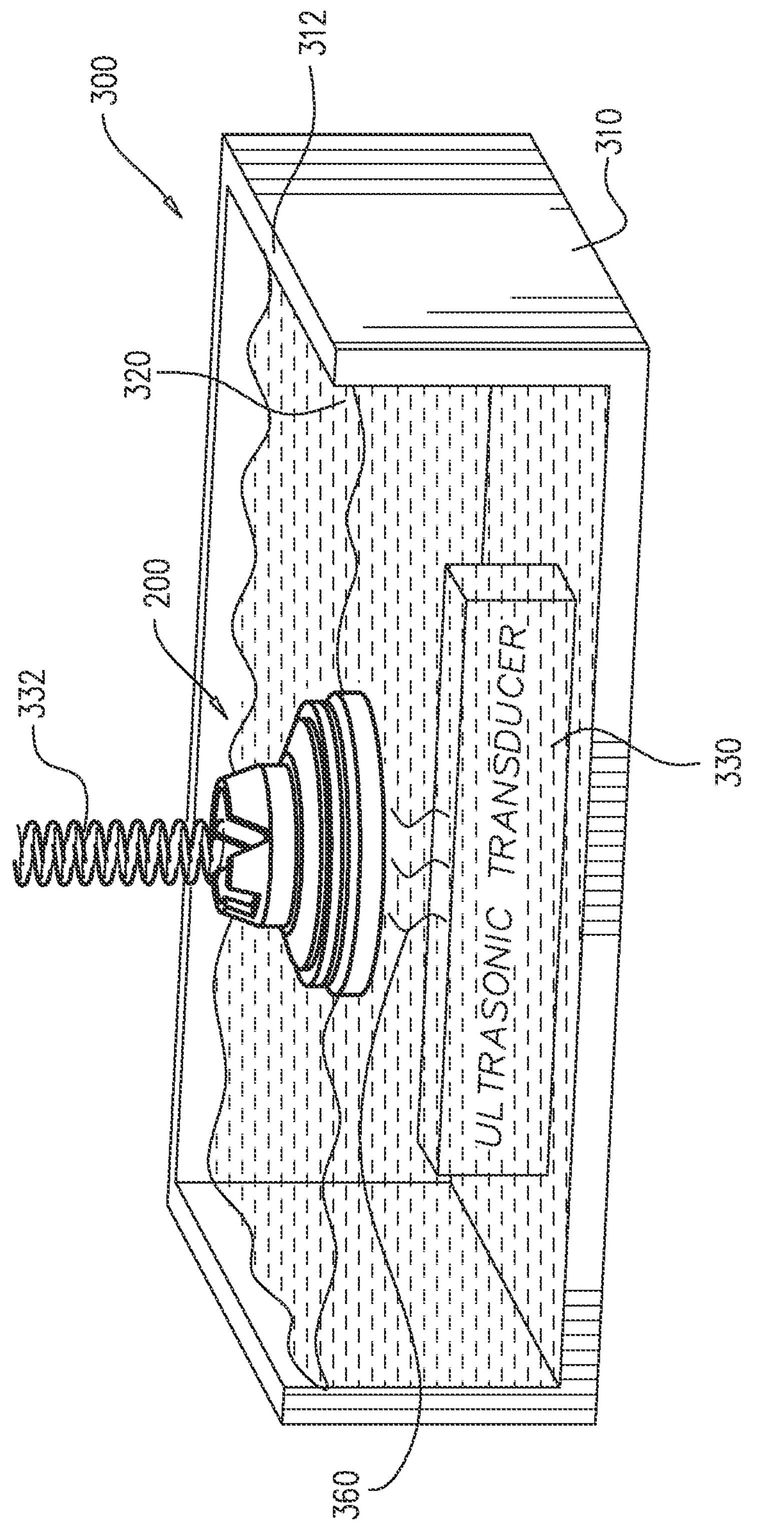

FIG. 3B

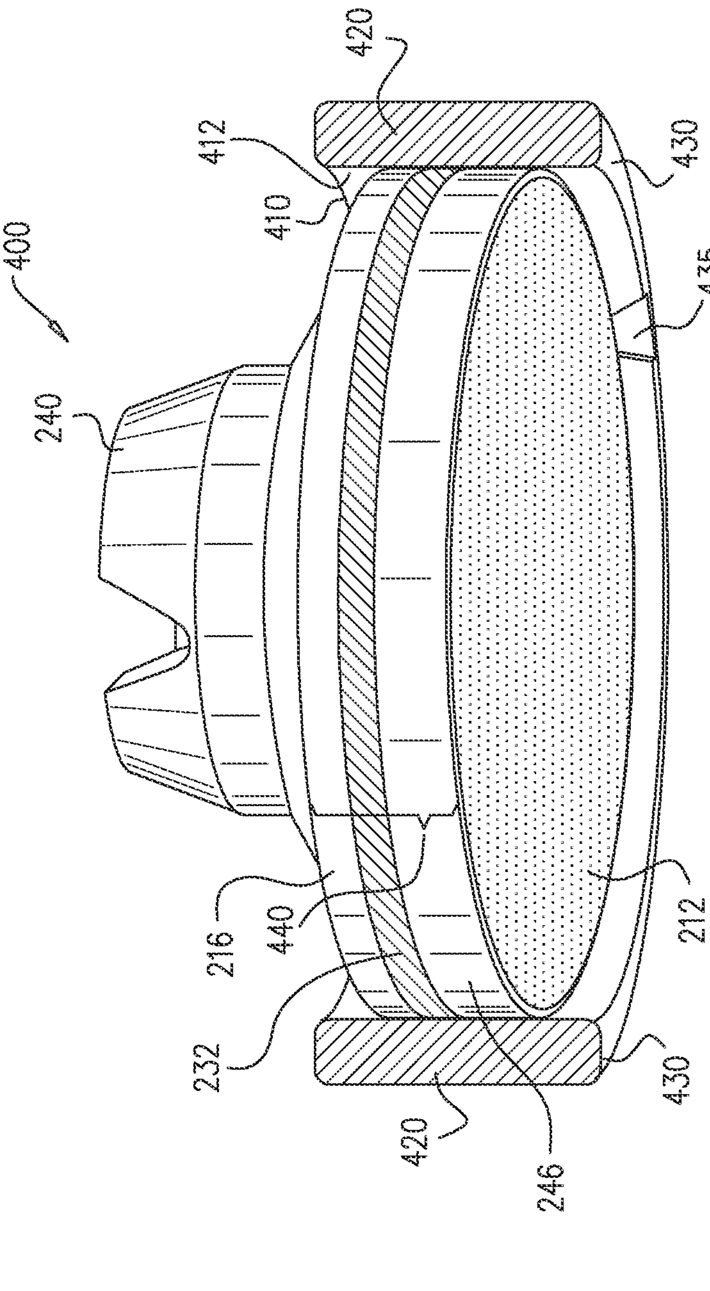

FIG. 4A

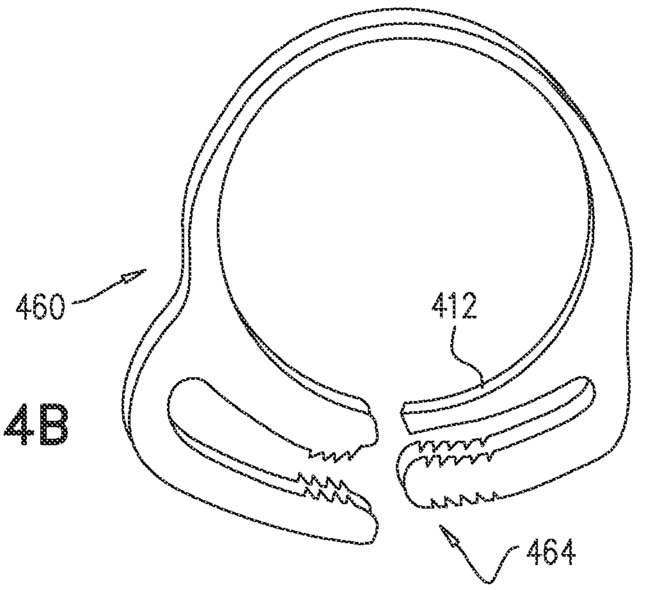

FIG. 4B

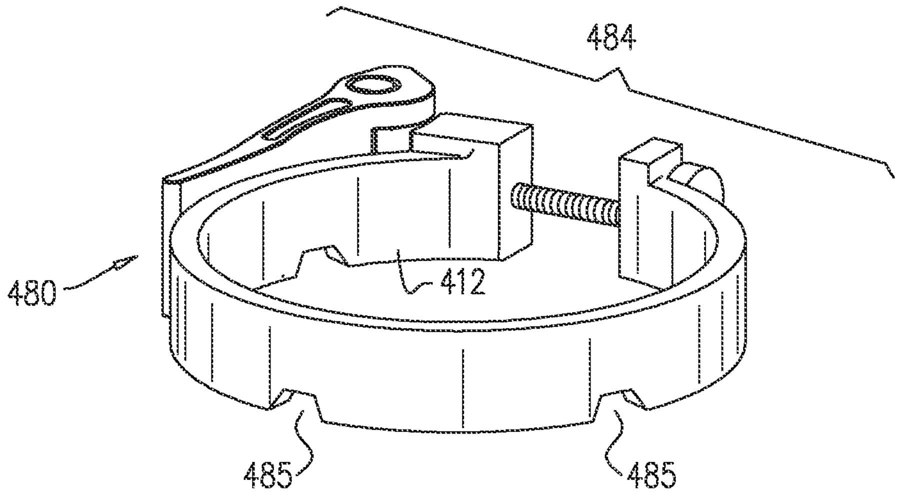

FIG. 4C

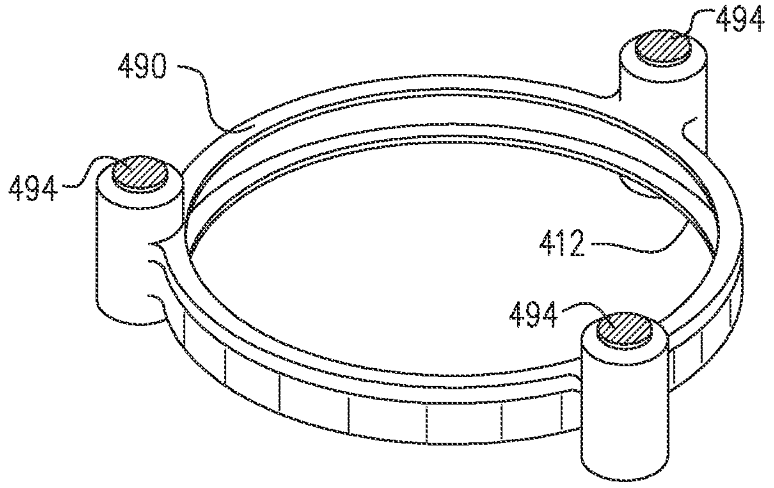

FIG. 4D

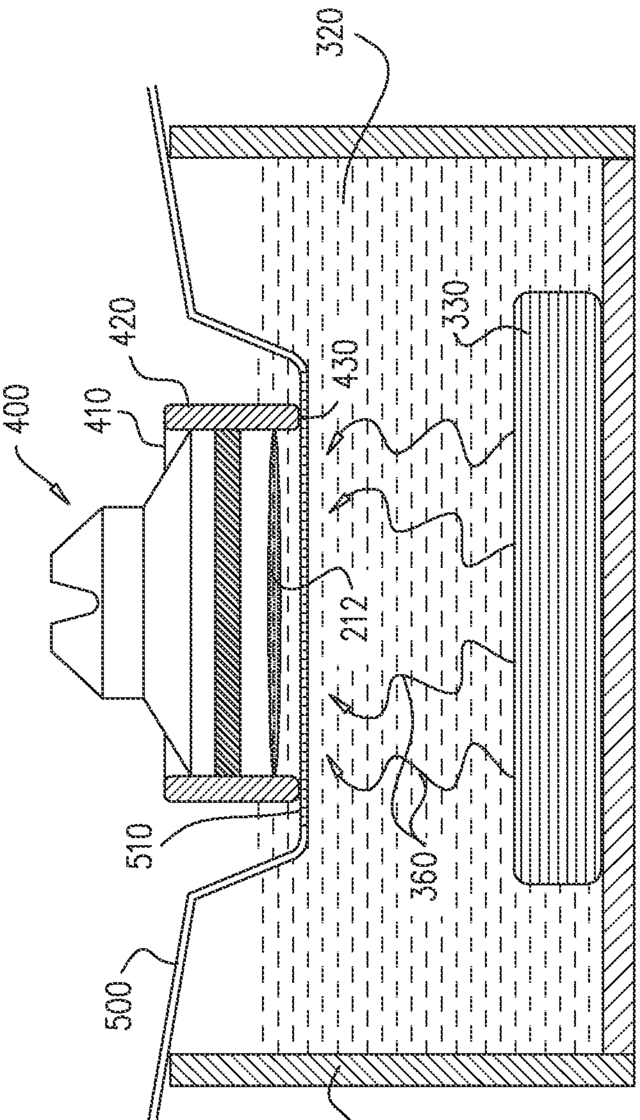

FIG. 5

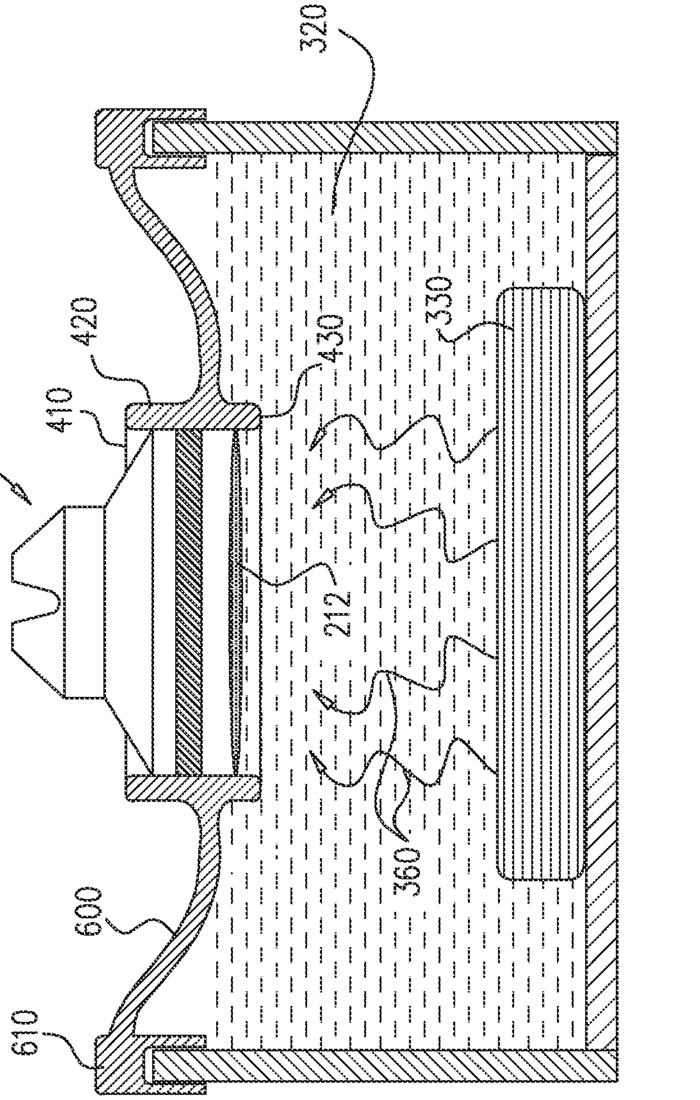

FIG. 6

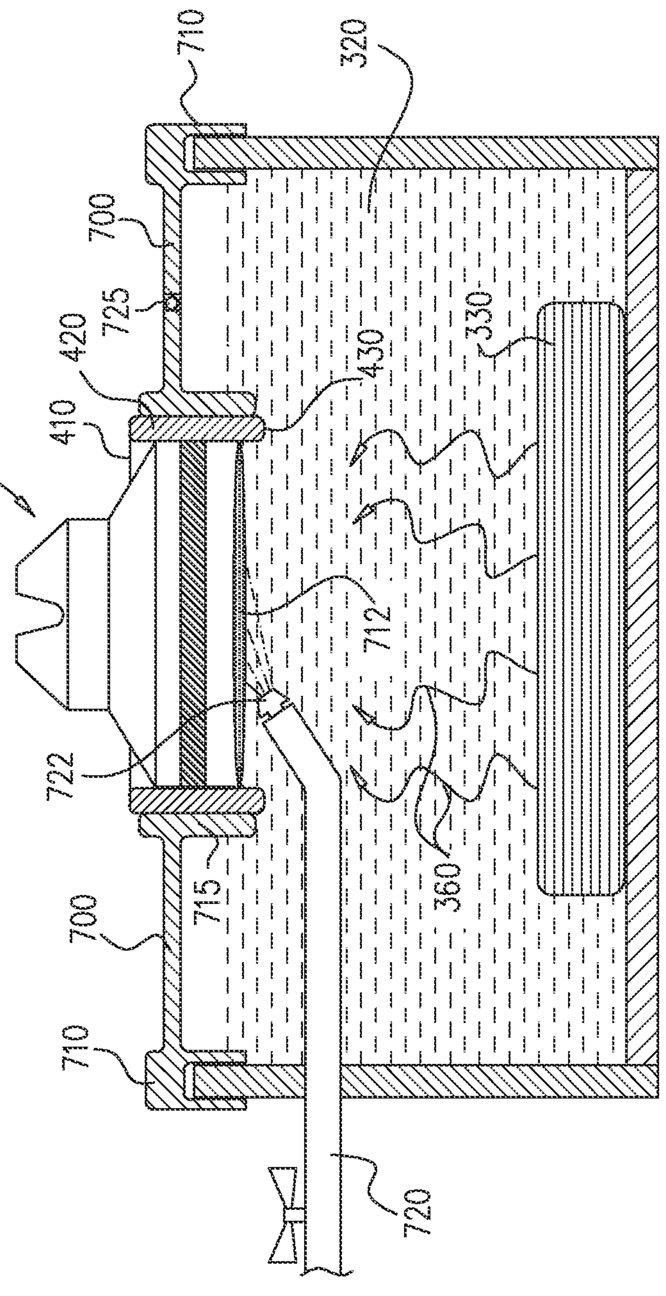

FIG. 7

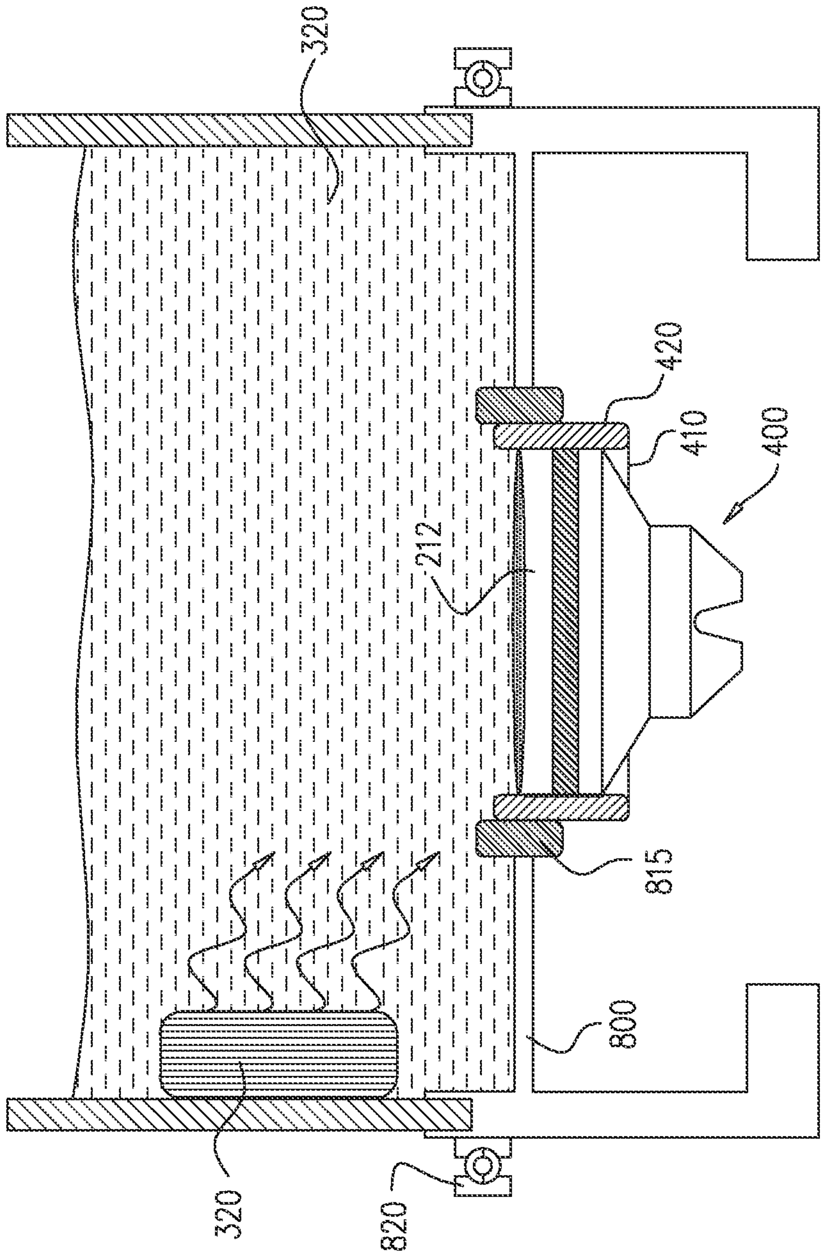

FIG. 8

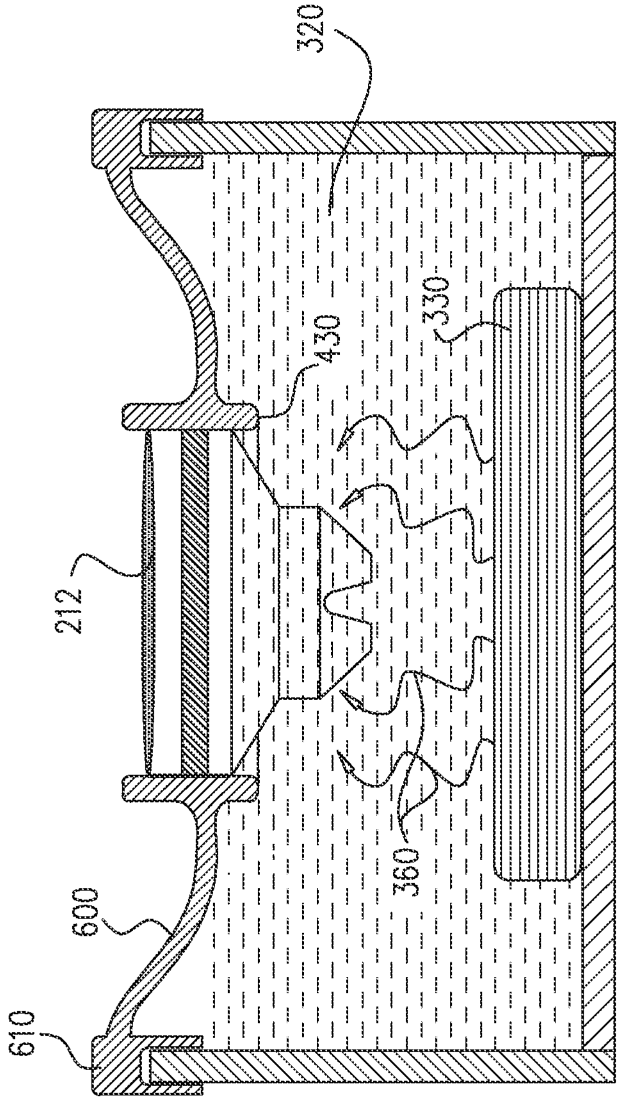

FIG. 9

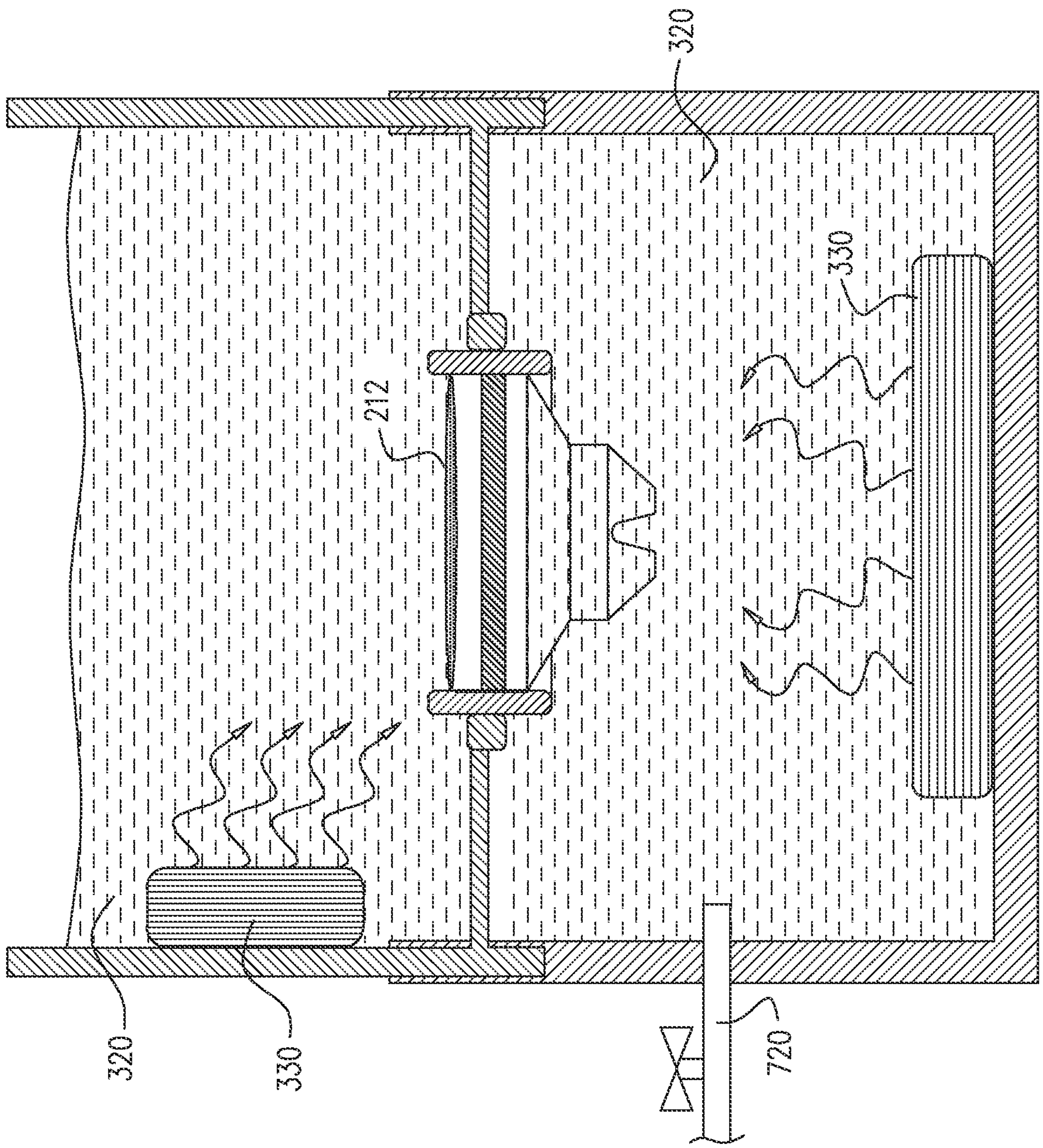

FIG. 10

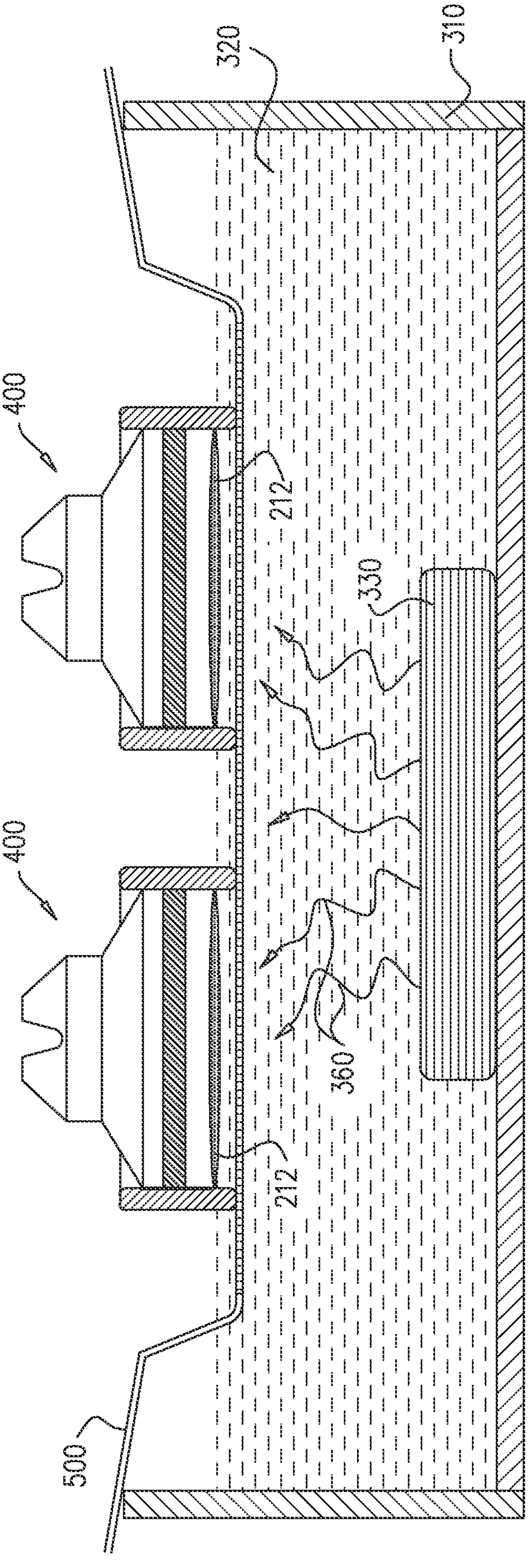

FIG. 11

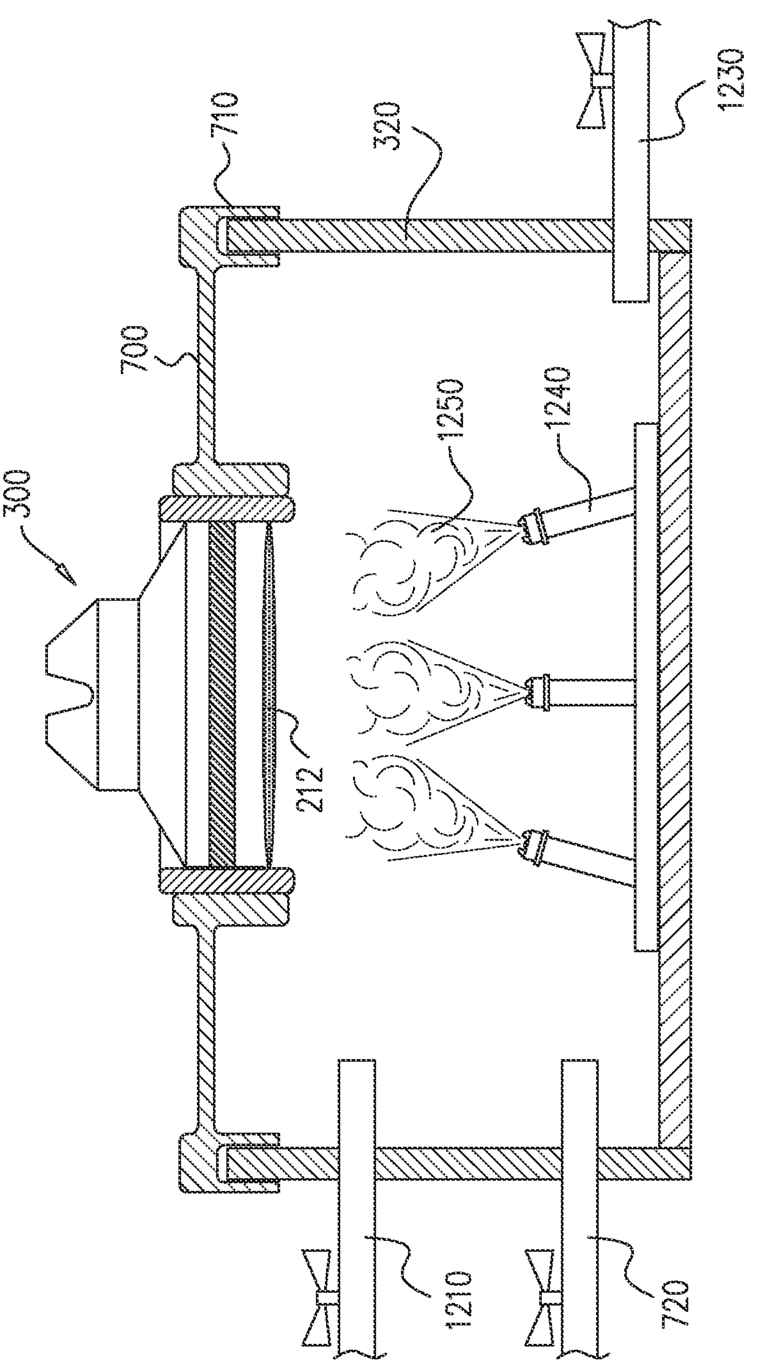

FIG. 12

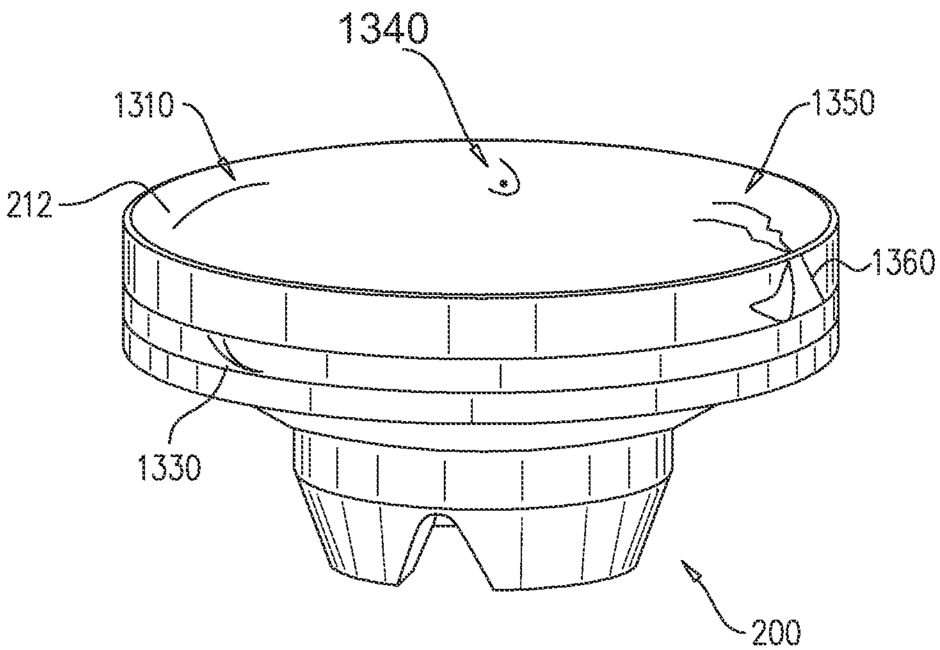

FIG. 13

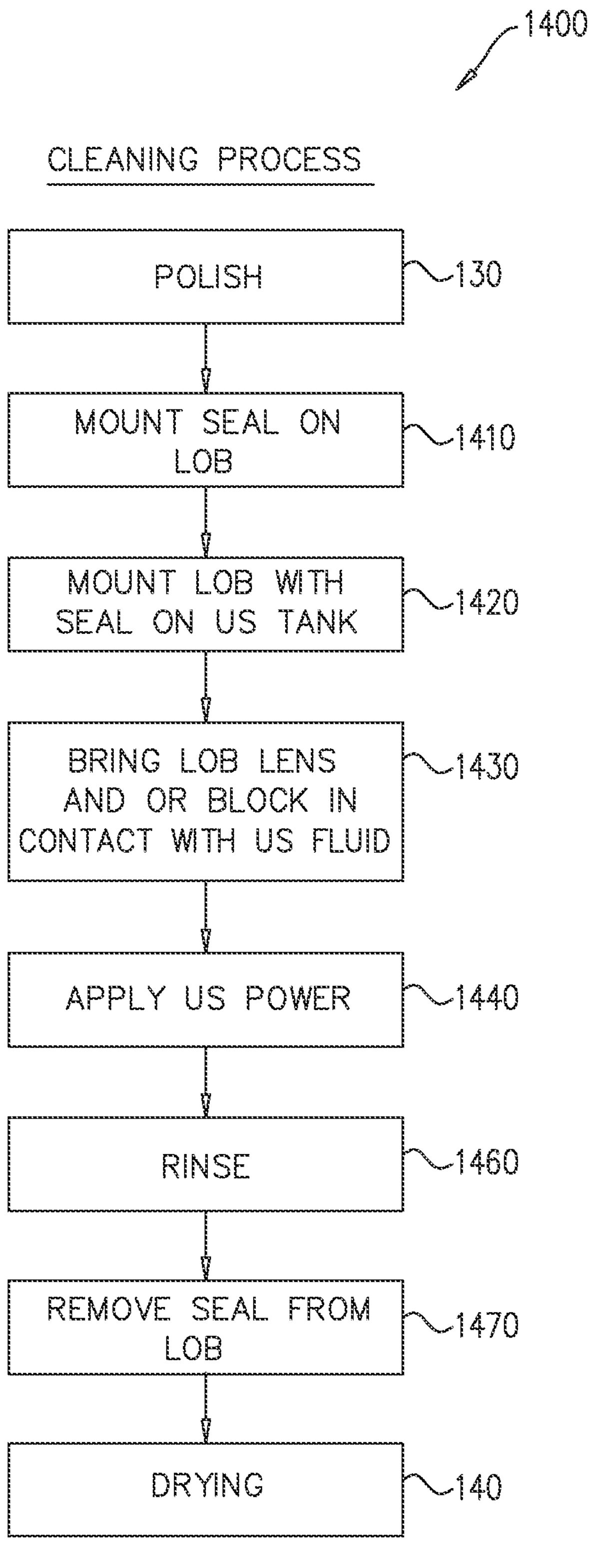
1400
CLEANING PROCESS
POLISH
130
MOUNT SEAL ON LOB
1410
MOUNT LOB WITH SEAL ON US TANK
1420
BRING LOB LENS AND OR BLOCK IN CONTACT WITH US FLUID
1430
APPLY US POWER
1440
RINSE
1460
REMOVE SEAL FROM LOB
1470
DRYING
140

FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2015/002137

A. CLASSIFICATION OF SUBJECT MATTER
IPC (2016.01) B29D 11/00, B24B 13/00, B24B 9/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC (2016.01) B29D 11/00, B24B 13/00, B24B 9/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Databases consulted: Esp@cenet, FamPat database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011033615 A1 BREME FRANK; JORDI LAURENT; MCPHERSON EDWARD; SCH? FER STEFAN; SAVOIE MARC; SATISLOH AG 10 Feb 2011 (2011/02/10) The whole document	1,2
A	The whole document	3-47
A	US 3846889 A REISMAN J,US 12 Nov 1974 (1974/11/12) The whole document	1-47
A	US 3049766 A TEXTRON INC 21 Aug 1962 (1962/08/21) The whole document	1-47

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 Feb 2016	28 Feb 2016

Name and mailing address of the ISA:	Authorized officer
Israel Patent Office Technology Park, Bldg.5, Malcha, Jerusalem, 9695101, Israel Facsimile No. 972-2-5651616	BITTON Oren Telephone No. 972-2-5657812

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2015/002137

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