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(54) Process for hydrating soft contact lenses

Verfahren zur Hydration von schwachen Kontaktlinsen

Procédé pour l'hydratation de lentilles souples de contact

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Description

The present invention relates to a process for removing leachable substances from polymeric contact lenses, and more particularly, for hydrating soft contact lenses by exchanging leachable substances for water, and still more particularly, for conducting the leaching or dydrating of contact lenses while maintaining the orientation of the lens throughout the process to reduce the need for physical handling of the lens.

Background of the Invention

Soft contact lenses can be made from hydrophilic polymers also known as hydrogels by many processes, for example, by molding, spin casting or lathe cutting.

During the initial steps of manufacturing hydrogel lenses by lathe cutting, the hydrogel is maintained in a dry state so that it may be manipulated on the lathe to cut the desired optical surfaces. It is then polished, removed from the lathe, hydrated, inspected and packaged. Spin cast lenses can be made by subjecting a liquid monomer to a centrifical force in a mold which has the same shape as the desired optical surfaces of the lens. As the mold spins, the monomer is cured to form the lens. The lens is then typically polished in the mold, hydrated from the mold, inspected and packaged. Other lenses may be molded from liquid monomer and catalyst confined in a space between two mold halves which control the shape of the lens. The monomer is cured, the mold halves separated and the lens is hydrated, inspected and packaged. The hydration step in all of these processes can be time consuming, difficult to control and somewhat unpredictable so that the manufacturing process can be inefficient and sometimes expensive.

In carrying out many of the processes for making contact lenses, significant amounts of manual handling of the lens may be required. Handling the lens in the dry state can dirty or scratch the lens. Handling the lens in the delicate wet state can cause tears and other imperfections. It would be particularly useful to have a lens manufacturing process which would minimize the handling of the lens.

When removing a lens from a final package, a user often has difficulty orienting the lens properly for placement on the cornea of the eye. Sometimes the lens inverts or rolls over so that the user can inadvertently put the wrong surface of the lens facing the cornea. It would be desirable to have a process in which one could control the orientation of the lens throughout the process and uniformly place the lens in the package so that it could be consistently removed by the user in the proper orientation for placement on the cornea. It would also be useful to have a package specially designed to maintain the orientation of the lens during storage and shipping.

The Assignee of the present invention molds its contact lenses in two-part molds like those shown in U.S. Patents Nos. 4,565,348 and 4,640,489. Liquid monomer is placed in a concave mold surface and then covered with a lid and cured, for example, by ultraviolet light. During polymerization, particularly of hydrogels, the lens tends to shrink. To reduce shrinkage, the monomer is polymerized in the presence of an inert diluent like boric acid ester as described in U.S. Patent No. 4,495,313. The inert diluent fills up the spaces in the hydrogel lens during polymerization. The diluent is subsequently exchanged for water during the hydration process. Since the boric acid ester is inert but water soluble, it can be used to fill up the spaces in the hydrogel during polymerization to minimize shrinkage of the lens during polymerization and then exchanged for water to hydrate the lens. This process significantly improves the reliability of the manufacturing process and increases the ability to predict and maintain the dimensions of the lens during processing.

The process of exchanging the diluent for water and hydrating the lens can be very time consuming. The two-part mold is opened or demolded and the lenses are assembled in large groups and placed in a leaching tank for several hours. The leach tank includes heated water, small amounts of surface-active agents (surfactants) and salts. When the lenses are inserted in the leach tank they immediately expand in the presence of water and release from the mold in which they were molded. The boric acid enter diluent hydrolyzes into glycerol and boric acid leaving the water behind in the matrix of the lens to thus exchange diluent for water to partially hydrate the lens.

Salts and a ph buffer are used in the water so that the water placed in the lens has osmolality and ph substantially similar to that of human tears so that the lens will not irritate the eye when it is inserted by the user. If the polymer from which the lens is made has ionic characteristics the buffer neutralizes any ionic species in the lens. That neutralization causes some temporary destabilization of the dimensions of the lens and requires an extended period of time to complete.

The leach solution is then drained and the lenses are transferred to a rinse tank where the removal of diluent and surfactant continues for another extended period of time. The rinse solution is then drained and the lenses are transferred to a large equilibration tank filled with heated water and salts for completion of diluent and surfactant removal and equilibration of the lens for several more hours. The equilibration step entails completion of the neutralization of any ionic species in the polymer from which the lens is made and final hydration to the final water content and final dimensionals. The lens is then removed from the equilibration tank and rinsed in clean saline and transferred for inspection and then packaging.

It would be desirable to have a process for hydrating lenses that would reduce the amount of water, associated chemicals, like surfactants and salts, and the amount of time necessary to complete hydration and control the orientation of the lens.

It would also be useful to control the orientation of the lens during the hydration process so that it could consistently be placed in the package with the correct orientation.

Summary of the Invention

The present invention alleviates many of the problems of the prior art by providing a process for hydrating contact lenses which is much faster, cheaper and predictable than the methods previously used. When used to hydrate a lens made in a two-part mold like those disclosed in U.S. Patent Nos. 4,564,348 and 4,640,489 in the presence of a diluent like that disclosed in U.S. Patent 4,495,313, the present process results in significant time and cost savings for hydrolyzing the diluent and exchanging it for water.

The process of the present invention may be used for extracting leachable substances from a polymeric contact lens blank which has an anterior and a posterior surface. The lens blank is placed in a first carrier element with the anterior surface of the lens blank oriented toward a first surface of the first carrier element. The first carrier element and the lens blank are then covered with a second carrier element. The first and second carrier elements cooperate to define a cavity to confine the lens blank and maintain the orientation of the lens blank without permitting it to invert or roll over. A fluid flow is then introduced into the cavity about the anterior and/or posterior surfaces of the lens and then permitted to flow out of the cavity to flush the leachable substances out of the lens blank. In this way, it is possible to extract a variety of substances like unreacted or partially reacted monomer or inhibitors using a variety of solvents like water, alcohol, a mixture of water and alcohol or any other organic solvent depending upon the material one wishes to leach from the lens blank.

The use of the first and second carrier elements to confine the lens in a cavity permits the removal of the leachable substance or the diluent exchange and hydration and washing to be conducted in a step-wise fashion simultaneously. A small quantity of clean fresh leaching fluid or hydrating water can be introduced into the cavity for a short period of time and then be flushed out to be replaced by a second quantity of clean, fresh fluid.

Since the mechanism for removal of leachable substances is mass transfer, this step-wise extraction maintains the mass concentration gradient high to speed up extraction.

This step-wise fluid introduction and flushing can be done any desired number of times. This significantly reduces the amount of solution that is needed and improves the efficiency of the leaching and hydration.

The process of the present invention is particularly well suited to lenses which are manufactured in a two-part mold like those described in U.S. Patent Nos. 4,565,348 and 4,640,489 in the presence of a diluent like that described in U.S. Patent 4,485,313. If the diluent used is a boric acid ester, the fluid used can be water. The ester is hydrolyzed in the presence of water to exchange the diluent for water and thus hydrate and wash the lens. When hydrating this type of lens, the hydration/washing/diluent extraction is preceded by the steps of opening the two-part mold leaving the lens blank in either the concave or convex mold part. The mold part in which the lens blank is left is then covered with the first carrier elements so that an optical surface of the lens blank is oriented toward a first surface of the first carrier element. The lens blank is then released from the mold part in which it was left, preferably by submerging the mold part in which the lens blank was left and the first carrier element together in water so as to initially hydrate the lens blank and cause it to separate from the mold part. It is desirable but not required that the mold part and the first carrier element be submerged at an angle to the horizontal so that the lens blank moves under the force of gravity from the mold part in which it was left to the first carrier element without trapping air between the lens blank and the first carrier element first surface and without permitting the lens blank to invert or roll over.

After the lens blank is released into the first carrier element, the first carrier element is covered with the second carrier element as described above and a fluid flow is introduced to flush leachable substances from the contact lens and to wash and hydrate the lens.

After the flushing, the lens can be deposited into an inspection carrier by one of two methods. The first of the two methods is to partially drain the cavity formed by the first and second carrier elements to deposit the lens blank in one of them. The remaining of the first or second carrier element is then removed and a third carrier element is introduced to which the lens is transferred by compressed air, gravity or a fluid flow and attached by, for example, surface tension. The third carrier element is then separated from the remaining of the first or second carrier elements and the third carrier element is oriented over an inspection carrier. The third carrier element is submerged in the inspection carrier so as to break the surface tension which hold the lens on the third carrier element and allow the lens to float freely into the inspection carrier. This third carrier element preferably has a convex surface to which the posterior surface of the lens blank is attached by surface tension. The dimensions of the convex surface of the third carrier element are chosen so that they can be easily submerged in the inspection carrier.

The second means for transferring the lens blank to the inspection carrier is to drain the cavity defined between the first and second elements and then to use air pressure to transfer the lens to the one of the first or second carrier elements that has a convex surface that will mate with the posterior surface of the lens. The transferring is done preferably by air pressure so that the lens attaches by surface tension to the appropriate carrier element. The appropriate carrier element is then aligned over an inspection carrier and transferred to the inspection carrier by a flow of compressed air or a flow of liquid.

It is preferred that the water used to hydrate the lens and which is used throughout the process of releasing the lens and hydrating and inspecting the lens is deionized water without any salts so that the time consuming ionic neutralization of the polymer from which the lens blank may be made does not have to occur during the hydration process.

When deionized water is used, the final step of the process is to introduce buffered saline solution to the inspection carrier after the inspection has been completed. The inspection carrier which may also be the final package for the lens is then sealed and final lens equilibration (ionic neutralization, final hydration and final lens dimensioning) is accomplished in the package at room temperature or during sterilization.

The use of deionized water is an important step in this process because it allows the time consuming ionic neutralization to be done essentially outside the hydration process after the lens has been packaged and sealed.

These and other features and advantages of the present invention will become more apparent when taken in conjunction with the following detailed description of the preferred embodiments and the following drawings.

Brief Description of the Drawings

Fig. 1 shows a schematic representation of the entire process;

Figure 2 shows a perspective view of a lens made in a multiple cavity mold shown in perspective and partly in phantom ready for assembly to a set of first carrier elements shown in perspective for use during the mold release steps of the process;

Figure 3 shows a perspective view of a set of second carrier elements to be assembled with the first carrier elements and to be used during the hydration steps of the process;

Figure 4 shows a perspective view of a single one of the first carrier elements shown in Fig. 1;

Figure 5 shows a cross-sectional view of a single one of the first carrier elements shown in Fig. 2 and the second carrier element shown in Fig. 3 assembled together with a lens placed in the cavity defined between the first and second carrier elements; and

Fig. 6 shows a perspective view of a third carrier element used to transfer the hydrated lens to an inspection carrier which also serves as part of the final package of the lens.

Detailed Description of the Preferred Embodiment

Referring now to Fig. 1, there is shown a schematic representation of the entire process of the present invention which has three major components, namely: release of the lens from the mold in which it is made; hydration, washing and diluent extraction of the lens; and, the inspection and packaging of the lens.

The present process is used most beneficially in connection with lenses that are manufactured in two-part molds of the kind shown in U.S. Patent Nos. 4,565,348 and 4,640,489 in the presence of a diluent, according to the process disclosed in is U.S. Patent No. 4,495,313. As will be disclosed later, it is also possible to use the hydration step to hydrate dry hydrogel lens blanks made by lathe cutting or spin casting or other manufacturing processes.

The overall process of the present invention will now be discussed in connection with the schematic representation of the various steps of the process shown in Fig. 1 together with reference, when necessary, to the remaining figures which show some of the important apparatus used to carry out the process.

Contact lens blank are made in two-part molds like those shown in U.S. Patent Nos. 4,565,348 and 4,640,489, by polymerizing monomer in the presence of a catalyst and a diluent with ultra violet light or heat according to the process described in U.S. Patent No. 4,495,313. After the polymerizatior process is completed, the two halves of the mold are separated (this is called demolding) typically leaving the contact lens blank 10 in concave lens part 12 (see Fig. 2). Fig. 2 shows a mold frame 14 with eight concave mold cavities in which eight lenses can be made at once. For convenience in Fig. 1, the concave mold frame 14 is shown in an end view so only two mold cavities 12 are shown in Fig. 1. Any convenient number of mold cavities could be used on frame 14. There is also a convex mold frame having a similar number of mold parts which is not shown in the present application but is shown in U.S. Patent No. 4,565,348. The first step after demolding is the first station in the process outlined in Fig. 1 and is identified by reference character 20.

At the second station 30 in the process of Fig.1, a first carrier frame 16 carrying eight first carrier elements 18 is assembled over concave mold frame 14 so that each first carrier element 18 fits over each concave mold part 12 to confine each of lens blanks 10 in a cavity which is small enough to prevent the lens from rolling over or inverting during subsequent processing steps.

First carrier element 18 is shown in perspective in Fig. 4 as an individual element which can be assembled into first carrier frame 16 shown in phantom in Fig. 4. First carrier element 18 has a generally cylindrical shape defined by a surrounding side wall 22 in which is placed a plurality of openings 24 whose purpose will be explained later in the application. Openings 24 are preferably circular or slots but can be any convenient shape. First carrier element 18 has a convex surface 26 which combines with the interior surface 28 of surrounding side wall 22 to form a recess 32. First carrier element 18 has a boss 34 which fits into a corresponding bore 36 in first carrier frame 16. Recess 32 in first carrier element 18 combines with the outer flange of mold part 12 to form a cavity confining lens blank 10. First carrier element 18 has a bore 38 extending through boss 34 and convex surface 26 to provide fluid communication through first carrier element 18 into recess 32 as will be explained later in the application when discussing the hydration/washing/extraction steps of the process.

At the next station 40 in the process, first carrier frame 16 and concave mold frame 14 are rotated approximately 135° the counterclockwise direction so that first carrier frame 16 is below concave mold frame 14, but the two are oriented at an angle of approximately 45° to the horizontal. They are then submerged in a tank 42 of deionized water at a temperature greater than the glass transition temperature of the material from which lens blank 10 is made.

In the present invention, the lens blank is preferably made of HEMA (hydroxyethylmethacrylate). The deionized water also includes small amounts of sufactants to assist in releasing lens blank 10 from concave mold part 12. As lens blank 10 is submerged, it immediately swells in the presence of the deionized water and the swelling helps release lens blank 10 from contact with concave mold part 12. The reason for orienting frames 14 and 16 in an angle of approximately 45° to the horizontal is to permit lens blank 10 to drop downwardly from concave mold part 12 onto the convex surface 26 of first carrier element 18 without trapping air between the posterior surface of lens blank 10 and convex surface 26 of first carrier element 18. These angles are preferred but any convenient angle may be used.

The use of deionized water in release tank 42 is particularly important when using lens blanks 10 made of materials which have ionic characteristics. If one were to use water laden with various salts, one would start the neutralization process of any ionic species in the lens material. This neutralization takes an extended period of time and causes some temporary instability in the dimension of the lens.

After a specified period of time when the lens has reached stable dimensions, preferably about five (5) minutes, the assembly of concave mold frame 14 and first carrier frame 16 are removed from release tank 42 and held at an angle for a short period of time to permit the drainage of excess water from the cavity defined between each first carrier element 18 and its corresponding concave mold part 12. The water drains out of first carrier elements 18 through holes 24 in the side wall of each first carrier element 18. The posterior surface of lens blank 10 thus attaches itself by surface tension to convex surface 26 of first carrier element 18.

At the next station 50 in the process, first carrier frame 16 is rotated back so it is on top of concave mold frame 14. Concave mold frame 14 is dropped from first carrier frame 16 leaving lens blank 10 attached to convex surface 26 of each first mold carrier 18.

At the next station 60 of the process, a second carrier element frame 44 is placed under first carrier element frame 16 and aligned to form a cavity confining lens blank 10 so that it may not roll over or invert during subsequent processing steps. Second carrier element frame 44 is shown in more detail in Fig. 3. Second lens carrier frame 44 holds an array of preferably eight second carrier elements 46, but any convenient number of second carrier elements 46 can be used. Referring now to Fig. 5, it can be seen that second carrier element 46 has a generally cylindrical shape with a surrounding side wall 48 and a concave surface 52 defining a recess 54 (See Fig. 3).

The carrier elements 18 and 46 and carrier frames 16 and 44 used in this process are more particularly described in EP-A-0453232.

Referring again to Fig. 5, it can be seen that the inside diameter of surrounding side wall 48 of second carrier element 46 receives the outside diameter of surrounding side wall 22 of first carrier element 18 in a close fit. Openings 24 in side wall 22 of first carrier 18 extend above the upper surface of 56 of surrounding side wall 48 of second carrier element 46. The confronting convex surface 26, inside wall 28 and concave surface 52 provide a cavity 55 for confining lens blank 10 so that it will not roll over or invert during subsequent processing steps. Second carrier element 46 includes a cylindrical boss 58 similar to boss 34 of first carrier element 18 to permit second carrier element 46 to be assembled easily to second carrier frame 44. Second carrier element 46 includes a bore 62 extending through boss 58 and concave surface 52 into recess 54. It can be appreciated from Fig. 5 that the cavity 55 defined by the confronting surfaces of first and second carrier elements 18 and 46 can be connected to a source of fluid through either or both of bores 38 and 62 which fluid can exit cavity 55 through openings 24 in side wall 22 of first carrier 18. The direction of flow can be varied according to the requirements of the process.

At the next station 70 in the process of the present invention, deionized water is introduced through bores 38 and 62 simultaneously to fill cavity 55 to permit the extraction of impurities from lens blank 10. In the preferred embodiment, lens blank 10 contains an inert but water soluble diluent, for example, a boric acid ester of the kind described in U.S. Patent No. 4,495,313. For diluent containing lenses, the purpose of the hydration/washing/extraction step is also to exchange the diluent for water. When the diluent containing lens blank 10 is exposed to deionized water, the ester hydrolizes to glycerol and boric acid which leave lens blank 10 and goes into the fluid contained in cavity 55. This exchange is driven by the physical phenomenon of mass transfer and depends on the concentration gradient of the impurities and the products of hydrolysis between lens blank 10 and the fluid in the cavity 55. As the extraction continues the concentration gradient diminishes and the process slows down. Thus, it has been found useful to conduct the hydration/washing/extraction in a series of discrete steps where a quantity of fresh liquid is introduced into cavity 55 through one or both of bores 38 and 62 and leaving the liquid in cavity 55 by blocking the flow through bores 38 and 62.

After the hydratation/washing/extraction has proceeded for a period of time, on the order of a few minutes, preferably about two minutes, openings 38 and 62 are unblocked permitting a new quantity of fluid to be introduced into cavity 55 while flushing the old fluid out of openings 24. When cavity 55 is filled with fresh deionized water, openings 38 and 62 are again blocked and lens blank 10 is permitted to hydrate for a further period of time in the deionized water confined in cavity 55. This step-wise extraction continues for a predetermined number of times until the extraction of diluent and impurities is complete. The number of extractions is dependent on the quantity of fluid used and the time the lens is allowed to soak prior to the next extraction. I have found that six extractions in deionized water will satisfactorily complete the extraction using approximately 2.5 ml of water. I have determined experimentally that the glycerol concentration in the deionized water after extraction lens blank 10 is reduced well below detectable limits by the sixth extraction.

It would also be possible to have a continuous flow of deionized water through cavity 55 and I believe that that would provide satisfactory results, however, I prefer to use the step-wise extraction discussed above.

This extraction step could also be used to remove any leachable substance from any contact lens blank, whether the lens blank was made by lathe cutting, spin casting, molding or some other method. Dry lathe cut or spin cast lens blanks 10 could be leached starting at station 50 in this process and continuing through stations 60 and 70. Dry lens blanks 10 can be placed in first carrier frame 16 and then covered with second carrier frame 44 and subjected to extraction with a desired solvent which can be water, alcohol, a mixture of water and alcohol or any organic solvent suitable to remove the substance one wishes to leach from the lens blank. Once the leaching is accomplished, the process can continue through additional processing steps.

One proceeds from station 70 where the hydration/washing/extraction is accomplished to stations 80, 90, 100 and 110 where lens blank 10 is transferred to an inspection carrier 74 which may be part of the final package for lens blank 10. At station 80, first carrier frame 16 is removed leaving the hydrated lens blank 10 settled in concave carrier element 46. Then second carrier frame 44 is moved to station 90 where it is covered with a third carrier frame 63 which contains a number of third carrier elements 64 shown particularly in Fig. 6.

Third carrier element 64 is generelly cylindrical and has a convex surface 66, a boss 68 for attaching it to its third carrier frame 63 and a bore 72 extending through boss 72 and convex surface 66 to permit the flow of fluid through third carrier element 64. It will be noted that third carrier element 64 has no surrounding side wall so that, as will be explained later, concave surface 66 can be submerged within inspection carrier 74. If third carrier element 64 were to have a surrounding side wall, that side wall would make it more difficult to place the lens into inspection carrier 74.

As shown at station 90 in Fig. 1, lens blank 10 is then transferred from the concave surface 52 of second carrier element 46 by for example, a flow of pressurized fluid. I prefer compressed air. Lens blank 10 then attaches itself by surface tension to convex surface 66 of third carrier elements 64 on third carrier frame 63. Second carrier frame 44 is then removed and third carrier frame 63 is transferred to station 100 and oriented above inspection carrier 74 which contains a plurality of individual packages 76 defining recesses 78. A quantity of deionized water is then introduced through bores 72 to transfer lens blank 10 to recesses 78 of inspection carrier 74.

The process at stations 80, 90 and 100 may be modified. After the lens is hydrated at station 70, lens blank 10 settles by gravity against concave surface 52 of second lens carrier 46. Compressed air may then be introduced through bore 62 to transfer the lens back to convex surface 26 of first carrier element 18. The posterior surface of lens blank 10 will attach itself to convex surface 26 by surface tension. First carrier frame 16 is then transferred to a location above inspection carrier 74. Compressed air or other fluid, for example, deionized water is introduced through bores 38 of first carrier elements 18 to deposit lens blank 10 in recesses 78 of inspection carrier 74. The surrounding wall 22 of first carrier elements 18 does not permit lens carrier 18 to be submerged in recesses 78 of inspection carrier 74, requiring lens blank 10 to be forced off convex surface 26. Although this alternative process is satisfactory, I prefer to use the process described above for stations 80, 90 and 100 where third carrier elements 64 are used.

At station 110, third carrier frame 63 is removed and inspection carrier 74 is moved to an inspection station 120 where it may be inspected manually or by automated optical machinery.

At station 130, the deionized water is removed from recesses 78 of inspection carrier 74 and replaced at station 140 with a saline solution which has a pH and osmolality compatible to that of the tears of the human eye. Alternately, an aliquot of concentrated brine solution may be added to the deionized water such that the final solution has the same pH and osmolality mentioned above. Saline solution is used so that when the user removes the lens from the package ready to insert on to ones cornea, the pH and osmolality of the lens will be balanced with that of the eye so that the lens will not irritate the eye when inserted.

If the material from which lens blank 10 is made has an ionic characteristic, the salts in the saline solution will neutralize that ionic species. However, that neutralization can be done in the final package on the shelf outside the remainder of the manufacturing process.

At station 150, inspection carrier 74 is packaged, for example, hermetic seal with a material that does not permit liquid to transfer through the package materiel.

It will be noted that the shape of the recess 78, in which the lens is deposited at station 100, is important to keep the lens properly positioned for inspection. Thus, it can be seen from Fig. 6 that recess 78 is generally spherical in shape with a radius of curvature larger than the radius of curvature of the convex surface of lens blank 10, permitting lens blank 10 to center itself on surface 52 by gravity. Surface 52 provides a low friction for wet lens blanks to let the lens stay on center as inspection carrier 74 is moved from station to station through the inspection process. It will also be noted that the size of recess 78 is small enough to confine the lens after it is sealed into its package so that it may not roll over or invert during storage or shipment. This assures that the lens is always in the proper orientation when the package is opened so that the user will always be assured that the lens is in the same position ready for placement on the cornea of the eye.

It can be seen that the present process substantially reduces the amount of water, chemicals and time needed to hydrate the lens and do the diluent exchange. The use of deionized water is a particularly useful step in that it postpones the neutralization of the ionic species in the polymer from which the lens is made.

The present process also provides control of the positioning of the lens throughout the process so that it is always oriented properly and can be placed in the package in a consistent manner all the time so that when one removes the lens from the package one knows that it is properly oriented for placement on the eye. The present process also substantially reduces handling of the delicate lens.

The time reductions accomplished in the present process are significant. The release step is accomplished in less than ten (10) minutes normally less than five (5) minutes. The hydration/washing/extraction process is accomplished in less than a half hour at room temperature. The equilibration or acid neutralization process and final dimensional stabilization of the lens is accomplished in less than two hours at room temperature after lens blank 10 has been placed and sealed in its final package.

The present invention has been described in conjunction with preferred embodiments. Those skilled in the art will appreciate that many modifications and changes may be made to the preferred embodiments without departing from the scope of the present invention. It is, therefore, not intended to limit the present invention except to set forth in the appended claims.

Claims

1. A process for hydrating and/or washing a hydrophilic polymer contact lens blank (10), said lens blank having an anterior surface and a posterior surface, said process characterised by:

   confining said lens blank (10) in a cavity (55) to maintain the orientation of said lens blank without permitting said lens blank to invert or roll over;

   providing means (38) for the flow of a fluid into said cavity and about said anterior surface of said lens;

   providing means (62) for the flow of a fluid into said cavity and about said posterior surface of said lens; and

   providing means (24) for flow of said fluid out of said cavity.

2. A process according to claim 1 for hydrating a hydrophilic polymer contact lens blank to form a hydrogel contact lens, wherein said fluid is water.

3. A process according to claim 2 wherein said water used in said process is deionized water.

4. A process according to claim 2 or claim 3, wherein said hydrating steps result in approximately forty percent water content for the lens.

5. A process according to any preceding claim, wherein said cavity (55) is defined by cooperating first and second carrier elements (18, 46), one surface of said lens blank (10) being oriented toward a first surface of said first carrier element, and the other surface of said lens blank being oriented toward a first surface of said second carrier element.

6. A process according to claim 5, which comprises providing a flow of said fluid into said cavity (55) through said first carrier element (18) and through said second carrier element (46).

7. A process according to claim 5, wherein said flow about said lens blank (10) is introduced near the center of said cavity (55) from both the first and second carrier elements (18, 46) and flows radially along said lens blank and out of the cavity near the periphery thereof.

8. A process according to any of claims 5 to 7, wherein said first carrier element (18) includes a recess (32) defined by a base and a surrounding side wall (22), said base including said first carrier element first surface.

9. A process according to any of claims 5 to 8, wherein said second carrier element (46) includes a recess (54) defined by a base and a surrounding side wall (48), said base including said second carrier element first surface.

10. A process according to any of claims 5 to 9 wherein said lens blank (10) is formed in a two-part mold including a concave mold part for molding the anterior surface of said lens blank and a convex mold part for molding the posterior surface of said lens blank and said lens blank is placed in said first carrier element (18) by;

    opening said two-part mold leaving said lens blank in either said concave or convex mold parts;

    covering said mold part in which said lens blank is left with said first carrier element so that an optical surface of said lens blank is oriented toward said first surface of said first carrier element;

retaining said first carrier element first surface so oriented with respect to said lens blank;

releasing said lens blank from the mold part in which it was left;

attaching said lens blank to said first surface of said first carrier element;

holding said lens blank on said first carrier element first surface;

disengaging said mold part from said first carrier element.

11. A process according to claim 10, wherein said release step includes submerging said mold part in which the lens blank (10) is left and said first carrier element (18) together in water so as initially to hydrate the lens blank and cause it to separate from the mold part in which said lens blank was left;

said mold part and said first carrier element submerged at an angle to the horizontal so that said lens blank moves under the force of gravity from said mold part to said first carrier element without trapping air between the lens blank and said first carrier element first surface and without permitting said lens blank to invert or roll over.

12. A process according to claim 10 or claim 11, wherein said holding step includes holding said lens blank (10) on said first carrier element first surface by surface tension.

13. A process according to any of claims 5 to 12, further including additional steps following said hydrating and/or washing steps comprising:

at least deposition by gravity of said lens blank into one of said first or second carrier elements (18, 46);

separating said first and second elements;

depositing said lens from said first or second carrier element to which it is attached into an inspection carrier (74).

14. A process according to claim 13 wherein said depositing of said lens blank (10) into said inspection carrier (74) is done by compressed air.

15. A process according to claim 13 wherein said depositing of said lens blank (10) into said inspection carrier (74) is done by a flow of water.

16. A process according to claim 13 wherein said deposition step includes placing a quantity of water in said inspection carrier (74), lowering said first or second carrier element (18, 46) below the surface of the water in said inspection carrier to permit the lens to float off said first or second carrier element and deposit in said inspection carrier.

17. A process according to any of claims 5 to 12 further including additional steps following said step of separating said first and second carrier elements (18, 46), comprising:

covering the lens carrier element on which said lens (10) has been deposited with a third lens carrier element (64) having a first surface (66) disposed in confronting relationship to a surface of said lens blank;

said third lens carrier element and said first or second carrier elements cooperating to define a cavity to confine said lens blank without permitting said lens blank to invert or roll over;

transferring said lens blank from said one of said first or second carrier elements on which said lens was deposited to said third lens carrier element;

holding said lens on said third lens carrier by surface tension;

separating said first or second carrier element from said third lens carrier element; and,

depositing said lens from said third lens carrier element into a lens inspection carrier (74).

18. A process according to claim 17 wherein said transfer step includes injecting air into said first or second carrier element (18, 46) to drive said lens blank (10) to said third lens carrier element (64).

19. A process according to claim 17 wherein said step of depositing said lens (10 from said third carrier element (64) into said inspection carrier (74) includes the step of lowering said third carrier element into said inspection carrier and introducing a flow of water through said third lens carrier element behind the lens to break said surface tension thereby filling said inspection carrier with a volume of water sufficient to cover said lens.

20. A process according to claim 17 wherein said step of depositing said lens (10) from said third carrier element (64) into said inspection carrier (74) includes the step of placing a quantity of water into said inspection carrier and lowering said third carrier element into said water in said inspection carrier to submerge said lens and break said surface tension to permit said lens to float free into said inspection carrier.

21. A process according to any of claims 13 to 20, wherein said inspection carrier (74) includes a recess (78) defined by a base and a surrounding wall, said recess having a depth significantly less than the diameter of the lens (10) and said recess having transverse dimensions only slightly larger than the diameter of the lens so that the lens may not roll over or invert in the inspection carrier.

22. A process according to claim 21, wherein said inspection carrier recess base has a substantially

concave shape to cause the lens (10) to center itself on said concave recess base.

23. A process according to claim 22, wherein said concave recess base has a radius of curvature greater than the radius of curvature of the anterior surface of said lens blank (10) and said base includes a low friction surface so that said lens blank will tend to be self centering on said base.

24. A process according to any of claims 13 to 23, wherein said inspection carrier (74) is a part of the final package for the lens.

25. A process according to claim 24, further including the step of sealing said lens package.

26. A process according to any of claims 16 and 19 to 23, wherein said water is deionised water, said inspection carrier (74) is part of the final package for the lens, and said process further includes the step of removing said deionized water from said lens package, adding a quantity of buffered saline solution to said lens package and sealing said package, said saline solution having a pH value similar to that of human tears, and said saline solution in said package neutralizing any ionic species remaining in the hydrogel polymer of which the lens is made.

27. A process according to any of claims 5 to 12, further comprising:

separating said first and second carrier elements (18, 46) after said flow of fluid therethrough;

covering the one of said first and second carrier elements in which said lens blank (10) is deposited with a third carrier element (64);

transferring and attaching said lens blank to said third carrier element; and

depositing said lens blank from said third carrier element into a quantity of fluid in a lens inspection carrier (74), while maintaining the lens blank orientation without permitting the lens blank to invert or roll over, said inspection carrier having a volume and shape to maintain said lens blank so oriented during subsequent processing and inspection.

28. A process according to claim 27 wherein said lens inspection carrier (74) is part of the final package for the lens (10).

29. A process according to claim 27 or claim 28 wherein said transferring is done with compressed air and said attaching is done by surface tension.

30. A process according to any of claims 2 to 29, wherein said lens blank (10) includes a diluent in said hydrophilic polymer and said diluent is removed in said process.

31. A process according to claim 30 wherein said diluent includes a boric acid ester and said diluent is removed by hydrolyzing said ester and removing glycerol and boric acid products of hydrolysis from said lens blank (10).

32. A process according to claim 30 or claim 31 wherein said lens blank (10) is hydrated in a plurality of discrete steps wherein a quantity of said fluid is introduced into said cavity (55) and permitted to stay in said cavity for a predetermined period of time and is then removed from said cavity and replaced by another quantity of fluid;

said introduction and removal of fluid carried out a sufficient number of times to reduce said diluent to a desired level and to permit hydration of the lens to a desired level.

33. A process according to claim 32 wherein said introduction and removal of fluid is carried out six times and said fluid is permitted to stay in said cavity (55) for about two minutes during each of said six hydration steps.

34. A process according to any preceding claim, wherein said flow of fluid into said cavity (55) and about the anterior surface of said lens blank (10) is initiated at a different time from the flow of fluid into said cavity and about the posterior surface of said lens blank.

Patentansprüche

1. Verfahren zum Hydratisieren und/oder Waschen eines Kontaktlinsenrohlings (10) aus einem hydrophilen Polymer, wobei der Linsenrohling eine Vorderseite und eine Rückseite hat und das Verfahren gekennzeichnet ist durch:

Einschließen des Linsenrohlings (10) in einem Hohlraum (55) zur Aufrechterhaltung der Ausrichtung des Linsenrohlings, ohne daS sich der Linsenrohling umdrehen oder überschlagen kann;

Bereithalten von Mitteln (38) für den Flüssigkeitsstrom in den Hohlraum und über die Vorderseite der Linse;

Bereithalten von Mitteln (62) für den Flüssigkeitsstrom in den Hohlraum und über die Rückseite der Linse; und

Bereithalten von Mitteln (24) zum Abfließen der Flüssigkeit aus dem Hohlraum.

2. Verfahren nach Anspruch 1 zum Hydratisieren eines Kontaktlinsenrohlings aus hydrophilem Polymer, um eine Hydrogel-Kontaktlinse zu formen, wobei die Flüssigkeit Wasser ist.

3. Verfahren nach Anspruch 2, wobei das in dem Verfahren verwendete Wasser ein entionisiertes Wasser ist.

4. Verfahren nach Anspruch 2 oder Anspruch 3, wobei die Hydratisierungsstufen einen Gehalt von annähernd 40 % Wasser für die Linse ergeben.

5. Verfahren nach einem der vorhergehenden Ansprüche, wobei der Hohlraum (55) durch das Zusammenwirken erster und zweiter Tragelemente (18, 46) definiert wird, wobei eine Seite des Linsenrohlings (10) zu einer ersten Fläche des ersten Tragelements hin ausgerichtet wird und die andere Seite des Linsenrohlings zu einer ersten Fläche des zweiten Tragelements ausgerichtet wird.

6. Verfahren nach Anspruch 5, welches die Bereitstellung eines Stromes der genannten Flüssigkeit in den genannten Hohlraum (55) durch das erste Tragelement (18) und durch das genannte zweite Tragelement (46) vorsieht.

7. Verfahren nach Anspruch 5, wobei der genannte Strom um den Linsenrohling (10) in der Nähe der Mitte des Hohlraums (55) sowohl von dem ersten als auch dem zweiten Tragelement (18, 46) eingeleitet wird und radial längs des Linsenrohlings und aus den Hohlraum in der Nähe von dessen Umfang herausfließt.

8. Verfahren nach einem der Ansprüche 5 bis 7, wobei das erste Tragelement (18) eine Ausnehmung (32) umfaßt, die durch einen Grundkörper und eine umgebende Seitenwand (22) definiert ist, wobei der Grundkörper die erste Fläche des ersten Tragelements umfaßt.

9. Verfahren nach einem der Ansprüche 5 bis 8, wobei das zweite Tragelement (46) eine Ausnehmung (54) umfaßt, die von einem Grundkörper und einer umgebenden Seitenwand (48) definiert ist, wobei der Grundkörper die erste Fläche des zweiten Tragelements umfaßt.

10. Verfahren nach einem der Ansprüche 5 bis 9, wobei der Linsenrohling (10) in einer zweiteiligen Form geformt wird, welche einen konkaven Formteil zum Formen der Vorderseite des Linsenrohlings und einen konvexen Formteil zum Formen der Rückseite des Linsenrohlings umfaßt, und der Linsenrohling in dem ersten Tragelement (18) plaziert wird durch:

Öffnen der zweiteiligen Form, wobei der Linsenrohling entweder in dem konkaven oder in dem konvexen Formteil zurückgelassen wird;

Abdecken desjenigen Formteils, in dem der Linsenrohling mit dem ersten Tragelement zurückgelassen wird, so daß eine optische Oberfläche des Linsenrohlings in Richtung der ersten Oberfläche des ersten Tragelements ausgerichtet wird;

Festhalten der ersten Oberfläche des ersten Tragelements, so daß sie in bezug auf den Linsenrohling ausgerichtet ist;

Freigeben des Linsenrohlings von dem Formteil, in dem er zurückgelassen wurde;

Anbringen des Linsenrohlings an der ersten Oberfläche des ersten Tragelements;

Halten des Linsenrohlings auf der ersten Oberfläche des ersten Tragelements;

Lösen des Formteils von dem ersten Tragelement.

11. Verfahren nach Anspruch 10, wobei der Freigabeschritt das Eintauchen in Wasser desjenigen Formteils, in dem der Linsenrohling (10) zurückgelassen wird, zusammen mit dem ersten Tragelement (18) umfaßt, derart, daß anfänglich der Linsenrohling hydratisiert und von demjenigen Formteil getrennt wird, in dem der Linsenrohling zurückgelassen wurde;

der Formteil und das erste Tragelement in einem Winkel zur Horizontalen eingetaucht werden, so daß der Linsenrohling sich unter der Schwerkraft von dem Formteil zu dem ersten Tragelement ohne Lufteinschluß zwischen dem Linsenrohling und der ersten Oberfläche des ersten Tragelements sowie ohne daß der Linsenrohling sich umdrehen oder überschlagen kann, bewegt.

12. Verfahren nach Anspruch 10 oder Anspruch 11, wobei der Halteschritt das Halten des Linsenrohlings (10) auf der ersten Oberfläche des ersten Tragelements durch Oberflächenspannung umfaßt.

13. Verfahren nach einem der Ansprüche 5 bis 12, ferner umfassend zusätzliche Schritte nach den Hydratisier- und/oder Waschschritten, umfassend:

zumindest eine Ablage des Linsenrohlings in eines der ersten oder zweiten Tragelemente (18, 46) mittels Schwerkraft;

Trennen der ersten und zweiten Elemente;

Ablegen der Linse aus dem ersten oder zweiten Tragelement, in das sie eingesetzt wurde, in einen Inspektionsträger (74).

14. Verfahren nach Anspruch 13, wobei die Ablage des Linsenrohlings (10) in den Inspektionsträger (74) durch Druckluft vorgenommen wird.

15. Verfahren nach Anspruch 13, wobei die Ablage des Linsenrohlings (10) in den Inspektionsträger (74) durch einen Wasserstrom vorgenommen wird.

16. Verfahren nach Anspruch 13, wobei der Ablegeschritt die Plazierung einer Wassermenge in dem Inspektionsträger (74), das Absenken des ersten und zweiten Tragelementes (18, 46) unter die Wasseroberfläche in dem Inspektionsträger umfaßt, damit die Linse von dem ersten oder zweiten Tragelement weggeschwemmt und in dem Inspektionsträger abgelegt werden kann.

17. Verfahren nach einem der Ansprüche 5 bis 12, ferner umfassend zusätzliche Schritte nach dem Schritt des Trennens des ersten und zweiten Tragelementes (18, 46) umfassend:

Abdecken des Linsentragelementes, auf dem die Linse (10) abgelegt worden ist, mit einem dritten Linsentragelement (64), das eine erste Seite (66) hat, die einer Seite des Linsenrohlings gegenüberliegend angeordnet ist;

das dritte Linsen-Tragelement und das erste oder zweite Tragelement wirken zur Bildung eines Hohlraums zusammen, um den Linsenrohling einzuschließen, ohne daß der Linsenrohling sich umdrehen oder überschlagen kann;

Überführen des Linsenrohlings von einem der ersten oder zweiten Tragelemente, auf dem die Linse abgelegt wurde, zu dem dritten Linsentragelement;

Halten der Linse auf dem dritten Linsenträger durch Oberflächenspannung;

Trennen des ersten oder zweiten Tragelementes von dem dritten Linsentragelement; und

Ablegen der Linse von dem dritten Linsentragelement in einem Linseninspektionsträger (74).

18. Verfahren nach Anspruch 17, wobei der Überführungsschritt das Einblasen von Luft in das erste oder zweite Tragelement (18, 46) umfaßt, um den Linsenrohling (10) zu dem dritten Linsentragelement (64) zu treiben.

19. Verfahren nach Anspruch 17, wobei der Schritt des Ablegens der Linse (10) von dem dritten Tragelement (64) in dem Inspektionsträger (74) den Schritt des Absenkens des dritten Tragelements in den Inspektionsträger und das Einleiten eines Wasserstromes durch das dritte Linsentragelement hinter der Linse umfaßt, um die Oberflächenspannung aufzubrechen, wodurch der Inspektionsträger mit einem Wasservolumen gefüllt wird, das ausreicht, um die Linse zu bedecken.

20. Verfahren nach Anspruch 17, wobei der Schritt des Ablegens der Linse (10) von dem ersten Tragelement (64) in dem Inspektionsträger (74) den Schritt der Plazierung einer Wassermenge in dem Inspektionsträger und das Absenken des dritten Tragelements in das Wasser in dem Inspektionsträger umfaßt, um die Linse unterzutauchen und die oberflächenspannung aufzuheben, damit die Linse frei in den Inspektionsträger geschwemmt werden kann.

21. Verfahren nach einem der Ansprüche 13 bis 20, wobei der Inspektionsträger (74) eine Ausnehmung (78) umfaßt, die durch einen Grundkörper und eine umgebende Wand gebildet ist, wobei die Ausnehmung eine Tiefe hat, die merklich geringer als der Durchmesser der Linse (10) ist und die Ausnehmung Querabmessungen hat, die nur geringfügig größer als der Durchmesser der Linse sind, so daß die Linse in dem Inspektionsträger sich nicht überschlagen oder umkehren kann.

22. Verfahren nach Anspruch 21, wobei die Ausnehmung in dem Grundkörper des Inspektionsträgers eine im wesentlichen konkave Form hat, damit die Linse (10) sich selbst auf der konkaven Ausnehmung des Grundkörpers zentrieren kann.

23. Verfahren nach Anspruch 22, wobei die konkave Ausnehmung des Grundkörpers einen Krümmungsradius hat, der größer als der Krümmungsradius der Vorderseite des Linsenrohlings (10) ist, und der Grundkörper eine Oberfläche geringer Reibung umfaßt, so daß der Linsenrohling dazu neigt, sich selbst auf dem Grundkörper zu zentrieren.

24. Verfahren nach einem der Ansprüche 13 bis 23, wobei der Inspektionsträger (74) Teil der endgültigen Verpackung für die Linse ist.

25. Verfahren nach Anspruch 24, ferner umfassend den Schritt der Versiegelung der Linsenverpackung.

26. Verfahren nach einem der Ansprüche 16 und 19 bis 23, wobei das Wasser entionisiert wird, der Inspektionsträger (74) Teil der endgültigen Verpackung für die Linse ist und das Verfahren ferner den Schritt des Entfernens des entionisierten Wassers aus der Linsenverpackung, das Hinzufügen einer Menge gepufferter Salzlösung in die Linsenverpackung und das Versiegeln der Packung umfaßt, wobei die Salzlösung einen pH-Wert ähnlich demjenigen menschlicher Tränen hat und die Salzlösung in der Verpackung irgendwelche ionischen Spezies neutralisiert, die in dem Hydrogelpolymer verblieben sind, aus welchem die Linse hergestellt wird.

27. Verfahren nach einem der Ansprüche 5 bis 12, ferner umfassend:

Trennen der ersten und zweiten Tragelemente (18, 46), nachdem sie von dem Flüssigkeitsstrom durchströmt wurden;

Abdecken eines der ersten und zweiten Tragelemente, in dem der Linsenrohling (10) abgelegt wird, mit einem dritten Tragelement (64);

Überführen und Anbringen des Linsenrohlings auf dem dritten Tragelement; und

Ablegen des Linsenrohlings von dem ersten Tragelement in einer Flüssigkeitsmenge in einem Linseninspektionsträger (74), während die Ausrichtung des Linsenrohlings aufrechterhalten wird, ohne daß der Linsenrohling sich umkehren oder überschlagen kann, wobei der Inspektionsträger ein Volumen und eine Form hat, derart, daß der Linsenrohling während der nachfolgenden Behandlung und der Inspektion so ausgerichtet bleibt.

28. Verfahren nach Anspruch 27, wobei der Linseninspektionsträger (74) Teil der endgültigen Verpackung für die Linse (10) ist.

29. Verfahren nach Anspruch 27 oder Anspruch 28, wobei das Überführen mit Druckluft stattfindet und das Anbringen mittels Oberflächenspannung geschieht.

30. Verfahren nach einem der Ansprüche 2 bis 29, wobei der Linsenrohling (10) ein Abschwächungsmittel in dem hydrophilen Polymer umfaßt und das Abschwächungsmittel in dem Verfahren entfernt wird.

31. Verfahren nach Anspruch 30, wobei das Abschwächungsmittel einen Borsäureester umfaßt und das Abschwächungsmittel durch Hydrolysieren des Esters entfernt wird und Glyzerin- und Borsäureerzeugnisse der Hydrolyse von dem Linsenrohling (10) entfernt werden.

32. Verfahren nach Anspruch 30 oder 31, wobei der Linsenrohling (10) in einer Mehrzahl diskreter Schritte hydratisiert wird, wobei eine Menge der Flüssigkeit in den Hohlraum (55) eingeführt wird und in dem Hohlraum für eine vorbestimmte Zeitdauer belassen wird und anschließend aus dem Hohlraum entfernt und durch eine andere Flüssigkeitsmenge ersetzt wird;
das Einführen und Entfernen der Flüssigkeit ausreichend oft stattfindet, um das Abschwächungsmittel bis auf einen gewünschten Pegel zu reduzieren und die Hydratisierung der Linse bis auf einen gewünschten Pegel zu ermöglichen.

33. Verfahren nach Anspruch 32, wobei die Einführung und Entfernung von Flüssigkeit sechsmal durchgeführt wird und die Flüssigkeit für etwa zwei Minuten während jedes der sechs Hydratisierungsschritte in dem Hohlraum (55) belassen wird.

34. Verfahren nach einem der vorhergehenden Ansprüche, wobei der Flüssigkeitsstrom in den Hohlraum (55) und um die Vorderseite des Linsenrohlings (10) zu einem unterschiedlichen Zeitpunkt von dem Flüssigkeitsstrom in den Hohlraum und um die Rückseite des Linsenrohlings eingeleitet wird.

Revendications

1. Procédé pour hydrater et/ou laver une ébauche de lentille de contact polymère hydrophile (10), ladite ébauche de lentille ayant une surface antérieure et une surface postérieure, ledit procédé étant caractérisé par les étapes consistant:

   - a confiner ladite ébauche de lentille (10) dans une cavité (55) pour maintenir l'orientation de ladite ébauche de lentille sans permettre à ladite ébauche de lentille de se renverser ou de se retourner;
   - a fournir un moyen (38) pour l'écoulement d'un fluide dans ladite cavité et autour de ladite surface antérieure de ladite lentille;
   - a fournir un moyen (62) pour l'écoulement d'un fluide dans ladite cavité et autour de ladite surface postérieure de ladite lentille; et
   - à fournir un moyen (24) pour l'écoulement dudit fluide hors de ladite cavité.

2. Procédé selon la revendication 1 pour hydrater une ébauche de lentille de contact polymère hydrophile pour former une lentille de contact d'hydrogel, dans laquelle ledit fluide est l'eau.

3. Procédé selon la revendication 2, dans lequel ladite eau utilisée dans ledit procédé est de l'eau désionisée.

4. Procédé selon la revendication 2 ou 3, dans lequel lesdites étapes d'hydratation aboutissent à une teneur en eau d'approximativement quarante pourcent pour la lentille.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite cavité (55) est définie en faisant coopérer les premier et second éléments porteurs (18, 46), une surface de ladite ébauche de lentille (10) étant orientée vers une première surface dudit premier élément porteur, et l'autre surface de ladite ébauche de lentille étant orientée vers une première surface dudit deuxième élément porteur.

6. Procédé selon la revendication 5, qui consiste à fournir un écoulement dudit fluide dans ladite cavité (55) à travers ledit premier élément porteur (18) et à travers ledit deuxième élément porteur (46).

7. Procédé selon la revendication 5, dans lequel ledit écoulement autour de ladite ébauche de lentille (10) est introduit près du centre de ladite cavité (55) provenant à la fois des premier et deuxième éléments porteurs (18, 46) et s'écoule radialement le long de ladite ébauche de lentille et hors de la cavité près de sa périphérie.

8. Procédé selon l'une quelconque des revendications 5 à 7, dans lequel ledit premier élément porteur (18) inclut un évidement (32) défini par une base et une paroi latérale entourante (22), ladite base incluant ladite première surface du premier élément porteur.

9. Procédé selon l'une quelconque des revendications 5 à 8, dans lequel ledit deuxième élément porteur (46) inclut un évidement (54) défini par une base et une paroi latérale entourante (48), ladite base

incluant ladite première surface du deuxième élément porteur.

10. Procédé selon l'une quelconque des revendications 5 à 9, dans lequel ladite ébauche de lentille (10) est formée dans un moule en deux parties incluant une partie du moule concave pour mouler la surface antérieure de ladite ébauche de lentille et une partie du moule convexe pour mouler la surface postérieure de ladite ébauche de lentille et ladite ébauche de lentille est placée dans ledit premier élément porteur (18):

- en ouvrant ledit moule en deux parties en laissant ladite ébauche de lentille dans l'une desdites parties du moule soit concave soit convexe;
- en recouvrant ladite partie du moule dans laquelle ladite ébauche de lentille est laissée avec ledit premier élément porteur de sorte qu'une surface optique de ladite ébauche de lentille est orientée vers ladite première surface dudit premier élément porteur;
- en conservant ladite première surface du premier élément porteur ainsi orienté par rapport à ladite ébauche de lentille;
- en libérant ladite ébauche de lentille de la partie du moule dans laquelle on l'a laissée;
- en fixant ladite ébauche de lentille à ladite première surface dudit premier élément porteur;
- en maintenant ladite ébauche de lentille sur ladite première surface du premier élément porteur;
- en dégageant ladite partie du moule dudit premier élément porteur.

11. Procédé selon la revendication 10, dans lequel ladite étape de démoulage inclut l'immersion conjointe de ladite partie du moule, dans laquelle est laissée l'ébauche de lentille (10), et dudit premier élément porteur (18) dans de l'eau de façon à hydrater initialement l'ébauche de lentille et à la séparer de la partie du moule dans laquelle était laissée ladite ébauche de lentille; ladite partie du moule et ledit premier élément porteur sont immergés sous un angle par rapport à l'horizontale de sorte que ladite ébauche de lentille se déplace sous la force de la gravité à partir de ladite partie du moule vers ledit premier élément porteur sans piéger l'air entre l'ébauche de lentille et ladite première surface du premier élément porteur et sans permettre à ladite ébauche de lentille de se renverser ou de se retourner.

12. Procédé selon la revendication 10 ou 11, dans lequel ladite étape de maintien inclut le maintien de ladite ébauche de lentille (10) sur ladite première surface du premier élément porteur grâce à la tension superficielle.

13. Procédé selon l'une quelconque des revendications 5 à 12, incluant de plus des étapes supplémentaires suivant lesdites étapes d'hydratation et/ou de lavage consistant:

- au moins à déposer par gravité ladite ébauche de lentille dans l'un desdits premier ou second éléments porteurs (18, 46);
- à séparer lesdits premier et second éléments;
- à déposer ladite lentille provenant dudit premier ou second élément porteur auquel elle est fixée dans un portoir de contrôle (74).

14. Procédé selon la revendication 13, dans lequel ledit dépôt de ladite ébauche de lentille (10) dans ledit portoir de contrôle (74) est effectué par air comprime.

15. Procédé selon la revendication 13, dans lequel ledit dépôt de ladite ébauche de lentille (10) dans ledit portoir de contrôle (74) est effectué à l'aide d'un écoulement d'eau.

16. Procédé selon la revendication 13, dans lequel ladite étape de dépôt consiste à placer une quantité d'eau dans ledit portoir de contrôle (74), à abaisser ledit premier ou deuxième élément porteur (18, 46) au-dessous de la surface de l'eau dans ledit portoir de contrôle pour permettre à la lentille d'être enlever par l'eau dudit premier ou deuxième élément porteur et de se déposer dans ledit portoir de contrôle.

17. Procédé selon l'une quelconque des revendications 5 à 12, incluant de plus des étapes supplémentaires suivant ladite étape consistant à séparer lesdits premier et second éléments (18, 46), consistant:

- à recouvrir l'élément porteur de la lentille sur lequel ladite lentille (10) a été déposée avec un troisième élément porteur de lentille (64) ayant une première surface (66) disposée en relation frontale par rapport à une surface de ladite ébauche de lentille;
- ledit troisième élément porteur de lentille et lesdits premier ou second éléments porteurs coopérant pour définir une cavité afin de confiner ladite ébauche de lentille sans permettre à ladite ébauche de lentille de se renverser ou de se retourner;
- a transférer ladite ébauche de lentille provenant d'un desdits premier ou second éléments sur lequel ladite lentille a été déposée vers ledit troisième élément porteur de lentille;
- à maintenir ladite lentille sur ledit troisième porteur de lentille par tension superficielle;
- à séparer ledit premier ou second élément porteur dudit troisième élément porteur de lentille; et

- à déposer ladite lentille provenant dudit troisième élément porteur de lentille dans un portoir de contrôle de lentille (74).

18. Procédé selon la revendication 17, dans lequel ladite étape de transfert inclut l'injection d'air dans ledit premier ou second élément porteur (18, 46) pour conduire ladite ébauche de lentille (10) vers ledit troisième élément porteur de lentille (64).

19. Procédé selon la revendication 17, dans lequel ladite étape consistant à déposer ladite lentille (10) provenant dudit troisième élément porteur (64) dans ledit portoir de contrôle (74) inclut l'étape consistant à abaisser ledit troisième élément porteur dans ledit portoir de contrôle et à introduire un écoulement d'eau à travers ledit troisième élément porteur de lentille derrière la lentille pour briser ladite tension superficielle, remplissant ainsi le portoir de contrôle avec un volume d'eau suffisant pour recouvrir ladite lentille.

20. Procédé selon la revendication 17, dans lequel ladite étape consistant à déposer ladite lentille (10) provenant dudit troisième élément porteur (64) dans ledit portoir de contrôle (74) inclut l'étape consistant à placer une quantité d'eau dans ledit portoir de contrôle et à abaisser ledit troisième élément porteur dans ladite eau dans ledit portoir de contrôle pour immerger ladite lentille et briser ladite tension superficielle pour permettre à la lentille de flotter librement dans ledit portoir de contrôle.

21. Procédé selon l'une quelconque des revendications 13 à 20, dans lequel ledit portoir de contrôle (74) inclut un évidement (78) défini par une base et une paroi entourante, ledit évidement ayant une profondeur significativement inférieure au diamètre de la lentille (10) et ledit évidement n'ayant des dimensions transversales que légèrement supérieures au diamètre de la lentille de sorte que la lentille ne peut pas se retourner ou se renverser dans le portoir de contrôle.

22. Procédé selon la revendication 21, dans lequel ladite base de l'évidement du portoir de contrôle possède une forme sensiblement concave pour obliger la lentille (10) à se centrer sur ladite base de l'évidement concave.

23. Procédé selon la revendication 22, dans lequel ladite base de l'évidement concave possède un rayon de courbure supérieur au rayon de courbure de la surface antérieure de ladite ébauche de lentille (10) et ladite base inclut une surface de faible friction de sorte que ladite ébauche de lentille tendra à se centrer d'elle-même sur ladite base.

24. Procédé selon l'une quelconque des revendications 13 à 23, dans lequel ledit portoir de contrôle (74) est une partie de l'emballage final pour la lentille.

25. Procédé selon la revendication 24, incluant de plus l'étape consistant à sceller ledit emballage de lentille.

26. Procédé selon l'une quelconque des revendications 16 et 19 à 23, dans lequel ladite eau est de l'eau désionisée, ledit portoir de contrôle (74) est une partie de l'emballage final pour la lentille, et ledit procédé inclut de plus l'étape consistant à retirer ladite eau désionisée dudit emballage de lentille, à ajouter une quantité de solution saline tamponnée audit emballage de lentille et à sceller ledit emballage, ladite solution saline ayant une valeur de pH similaire à celle des larmes humaines, et ladite solution saline dans ledit emballage neutralisant toute espèce ionique restant dans le polymère hydrogel dont la lentille est constituée.

27. Procédé selon l'une quelconque des revendications 5 à 12, comprenant de plus les étapes consistant:

- à séparer lesdits premier et second éléments (18, 46) après ledit écoulement de fluide à travers eux;
- à recouvrir l'un desdits premier et second éléments porteurs dans lesquels ladite ébauche de lentille (10) est déposée avec un troisième élément porteur (64);
- à transférer et à fixer ladite ébauche de lentille audit troisième élément porteur; et
- à déposer ladite ébauche de lentille provenant dudit troisième élément porteur à l'intérieur d'une quantité de fluide dans un portoir de contrôle de lentille (74), tout en maintenant l'orientation de l'ébauche de lentille sans permettre à l'ébauche de lentille de se renverser ou de se retourner, ledit portoir de contrôle ayant un volume et une forme pour maintenir ladite ébauche de lentille ainsi orientée pendant le traitement ultérieur et le contrôle.

28. Procédé selon la revendication 27, dans lequel ledit portoir de contrôle de lentille (74) est une partie de l'emballage final pour la lentille (10).

29. Procédé selon la revendication 27 ou 28, dans lequel ledit transfert est effectué avec de l'air comprimé et ladite fixation est effectuée par tension superficielle.

30. Procédé selon l'une quelconque des revendications 2 à 29, dans lequel ladite ébauche de lentille (10) inclut un diluant dans ledit polymère hydrophile et ledit diluant est éliminé dans ledit procédé.

31. Procédé selon la revendication 30, dans lequel ledit diluant inclut un ester d'acide borique et ledit diluant est éliminé en hydrolysant ledit ester et en éliminant, de ladite ébauche de lentille (10), les produits d'hydrolyse, le glycérol et l'acide borique.

32. Procédé selon la revendication 30 ou 31, dans lequel ladite ébauche de lentille (10) est hydratée au cours d'une pluralité d'étapes discrètes, dans lesquelles une quantité dudit fluide est introduite dans ladite cavité (55) et reste dans ladite cavité pendant une durée prédéterminée et est ensuite éliminée de ladite cavité et remplacée par une autre quantité de fluide; ladite introduction et ladite élimination du fluide effectuées à raison d'un nombre suffisant de fois pour réduire la teneur en ledit diluant à une valeur souhaitée et pour permettre l'hydratation de la lentille à un degré souhaité.

33. Procédé selon la revendication 32, dans lequel ladite introduction et ladite élimination de fluide sont effectuées six fois et ledit fluide reste dans ladite cavité (55) pendant environ deux minutes au cours de chacune desdites six étapes d'hydratation.

34. Procédé selon l'une quelconque des revendications précédentes, dans lequel ledit écoulement de fluide dans ladite cavité (55) et autour de la surface antérieure de ladite ébauche de lentille (10) est démarré à un moment différent de l'écoulement du fluide dans ladite cavité et autour de la surface postérieure de ladite ébauche de lentille.

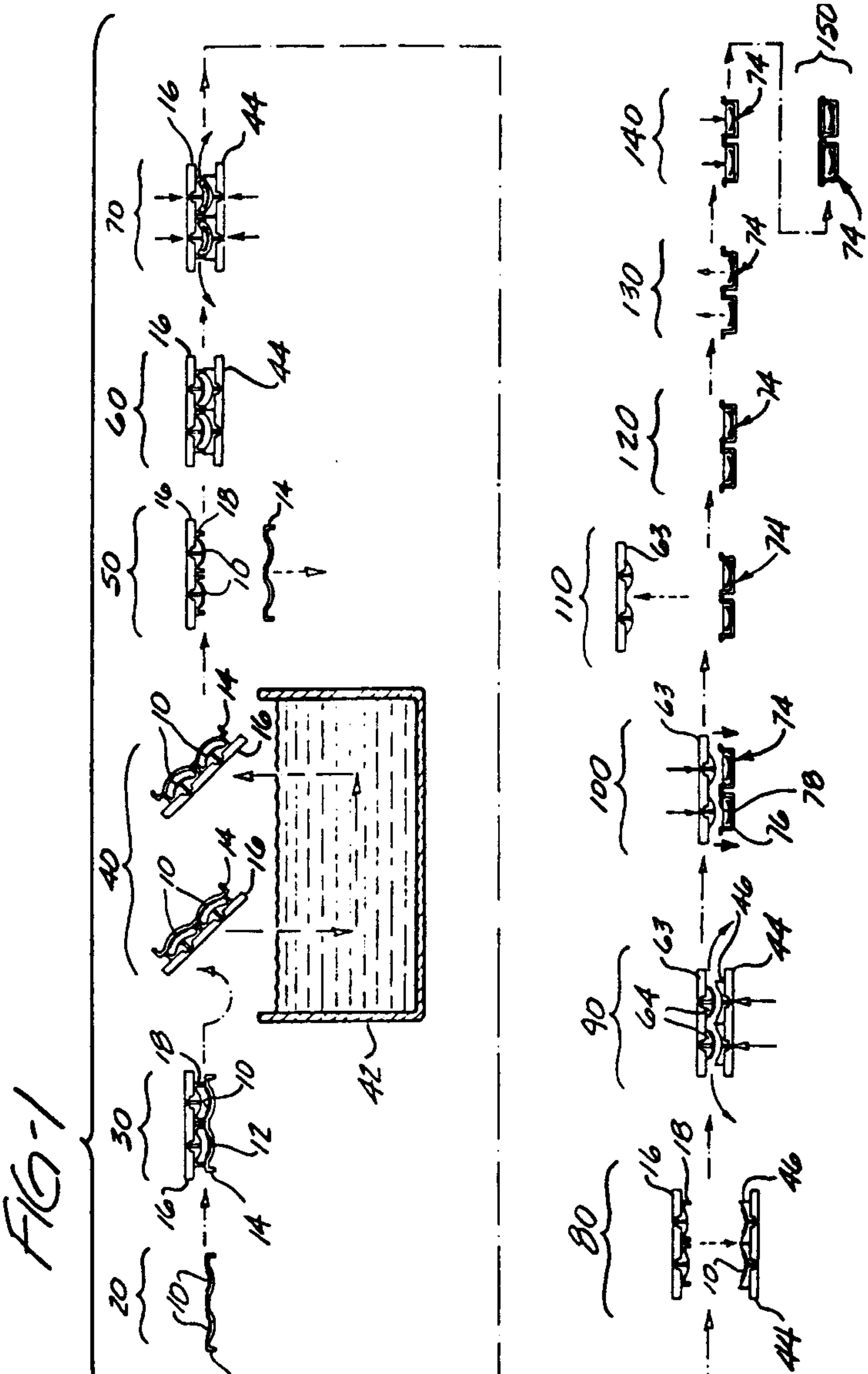
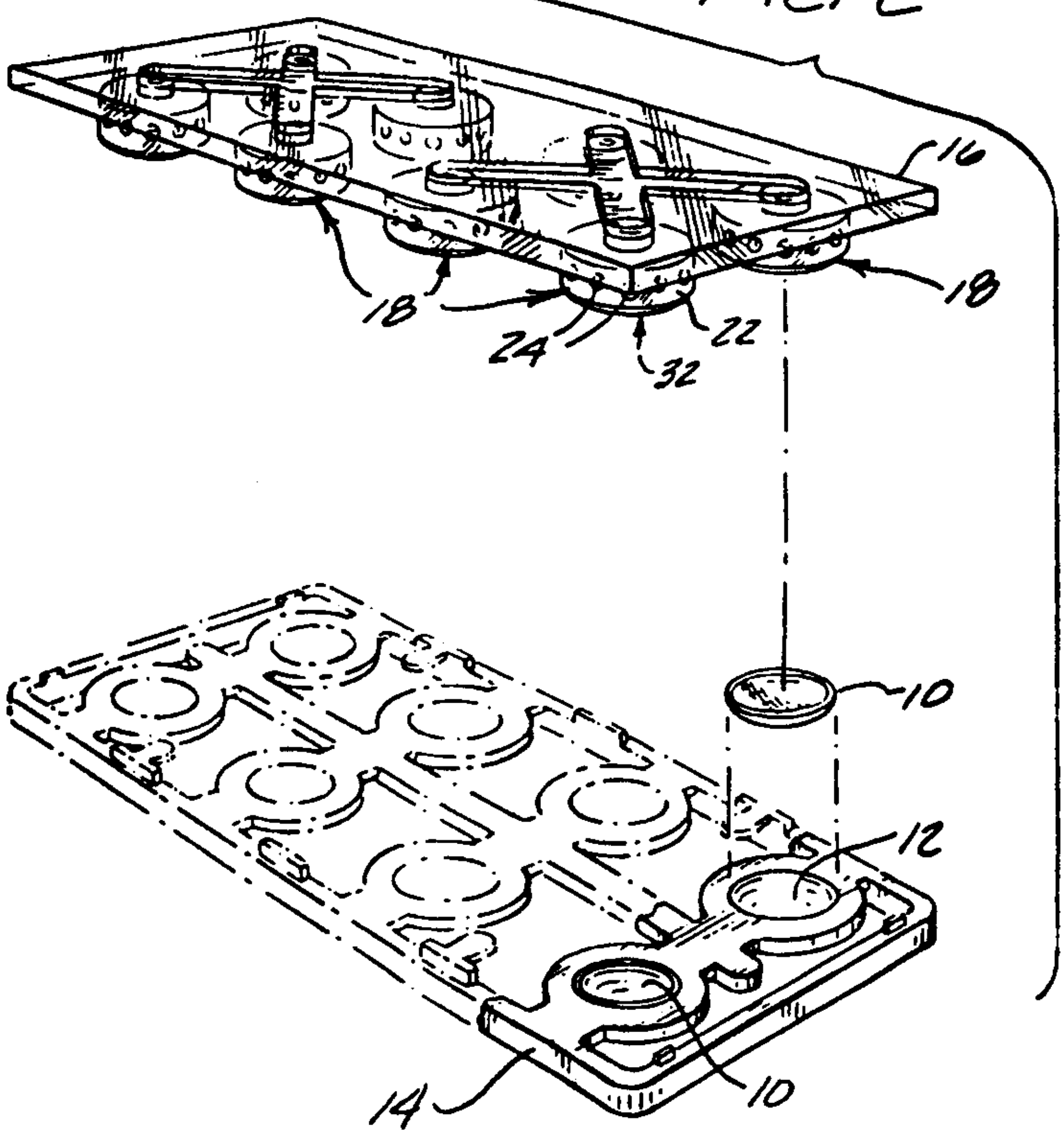


FIG-1

FIG-2



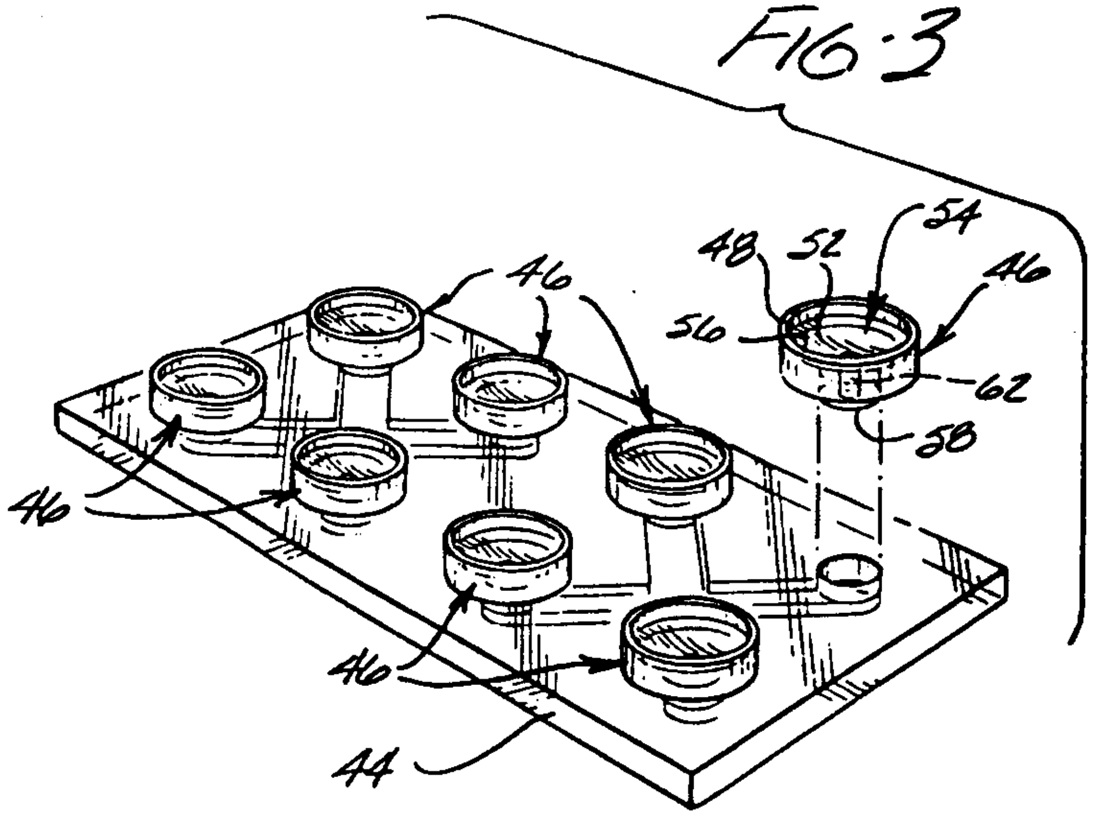


FIG-3
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FIG-4

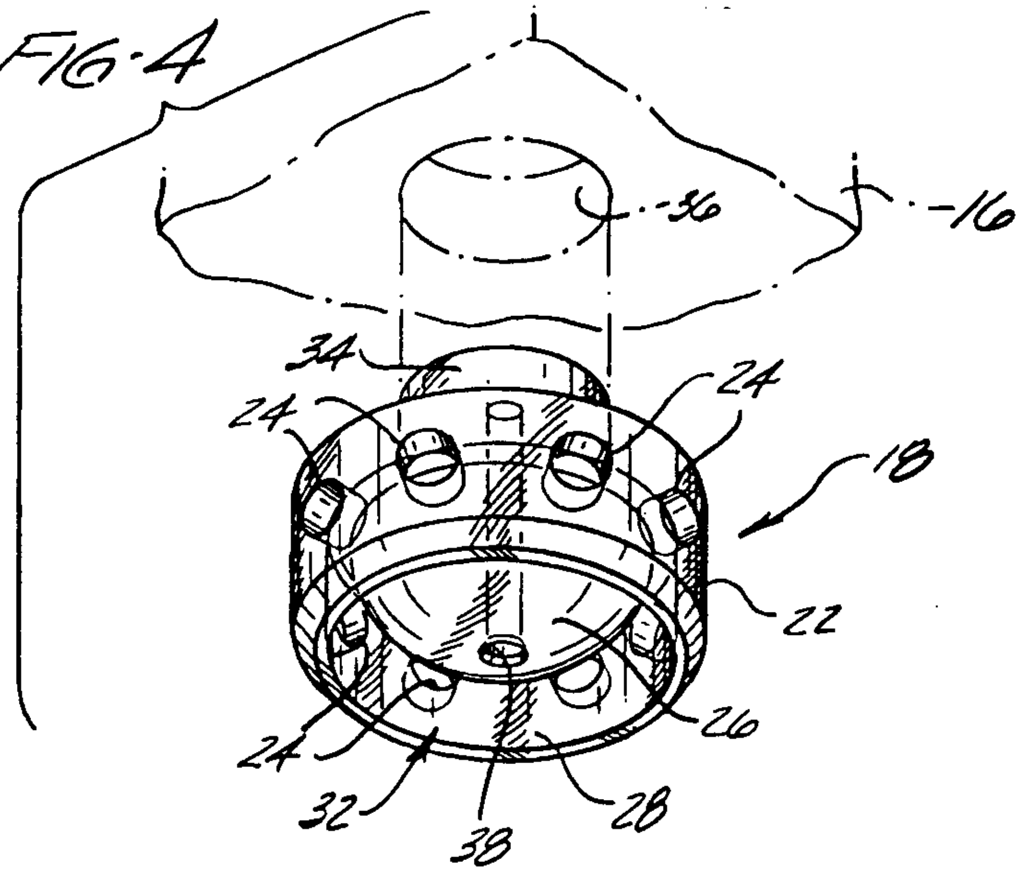
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FIG-5

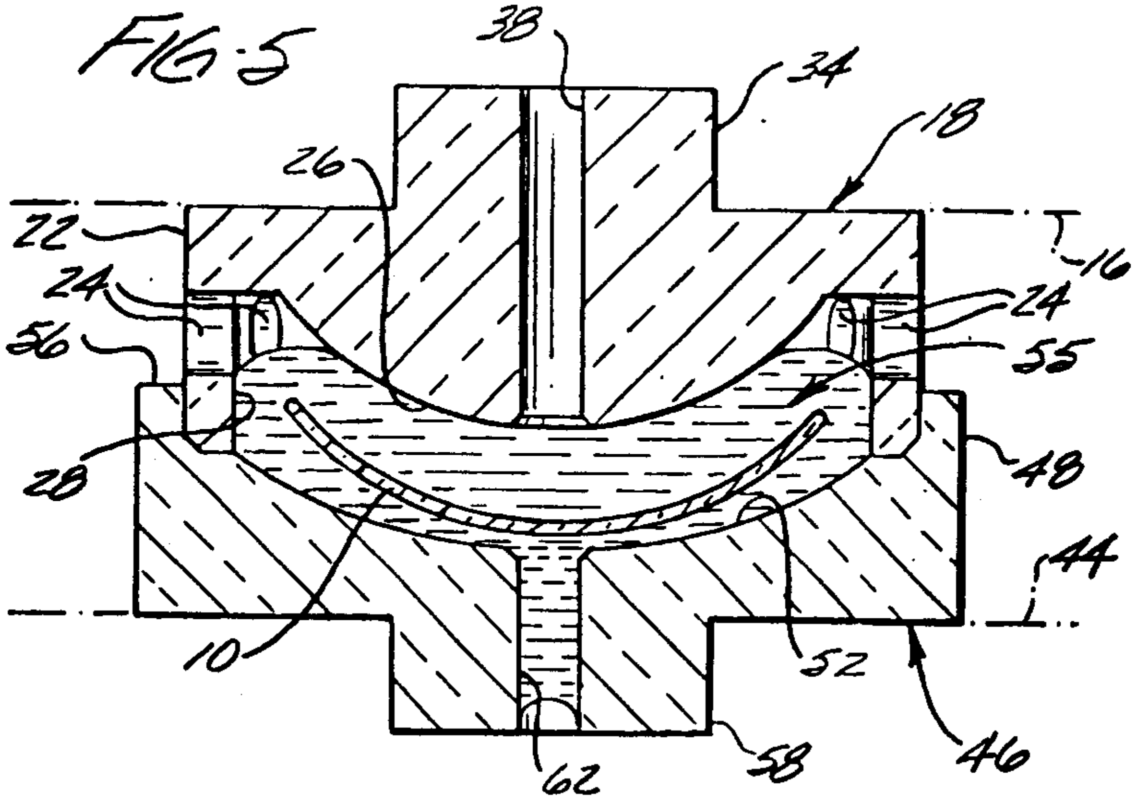
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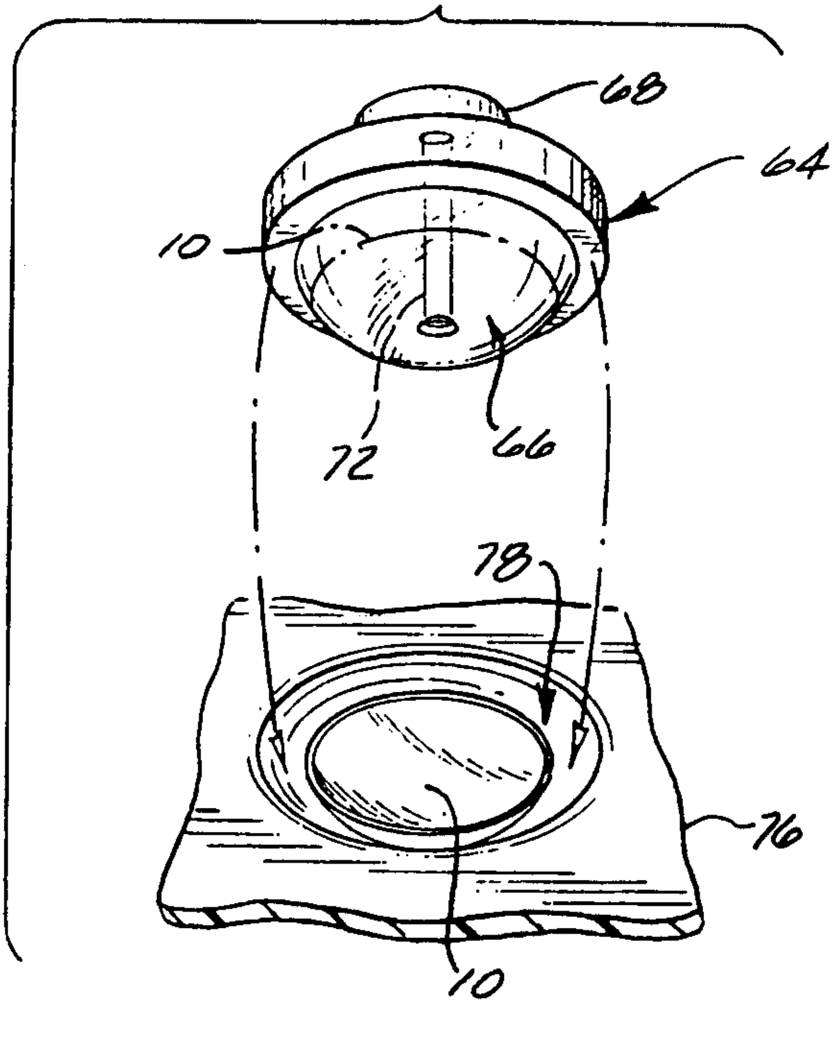
FIG-6



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