# LENS WITH MULTI-SEGMENTED LINEAR MENISCUS WALL

## RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application Serial No. 61/386629 which was filed on September 27, 2010 and entitled, "LENS WITH MULTI-SEGMENTED LINEAR MENISCUS WALL" , and as a Continuation in Part Application to Non-Provisional Patent Application U.S. Serial No. 13/095786 which was filed on April 27, 2011 and entitled "ARCUATE LIQUID MENISCUS LENS", as well as Non-Provisional Patent Application U.S. Serial No. 13/149105 which was filed on May 31, 2011 and entitled "LENS WITH CONICAL FRUSTUM MENISCUS WALL", as a Continuation in Part Application, the contents of each of which are relied upon and incorporated by reference.

## FIELD OF USE

The present invention relates generally to a liquid meniscus lens, more specifically, it includes an arcuate liquid meniscus lens with a meniscus wall including multiple conical frustum segments.

## BACKGROUND

Liquid meniscus lenses have been known in various industries. As discussed more fully below with reference to Figs. 1A and 1B, known liquid meniscus lenses were engineered in cylindrical shapes with a perimeter surface formed by points at a fixed distance from an axis which is a straight line. Known liquid meniscus lenses have been limited to designs with a first interior surface generally parallel to second interior surface and each perpendicular to a cylindrical axis. Known examples of the use of liquid meniscus lenses include devices such as electronic cameras and mobile phone devices.

Traditionally, an ophthalmic device, such as a contact lens and an intraocular lens included a biocompatible device with a corrective, cosmetic or therapeutic quality. A contact lens, for example, can provide one or more of: vision correcting functionality;

step meniscus wall such as 801A-1 from Fig. 8A, or a segment of a multi-gradient meniscus wall such as 801B-1 from Fig. 8B.

Fig. 6C combines Figs. 6A and 6B, showing the location of the liquid meniscus boundary in both an unpowered 604A state and a powered 604B state. According to the present invention, a liquid meniscus lens with a multi-step meniscus wall 601 placed at a given angle relative to an optical axis, as shown in Fig. 6C, provides more consistent and repeatable control over liquid meniscus movement resulting from the application of an electrical potential to a meniscus wall portion than a liquid meniscus lens with a linear meniscus wall placed at a similar angle relative to the optical axis. Examples of a lens including a linear meniscus wall are described in the U.S. Patent Application Serial Number 61,359,548, filed June 29, 2010 and entitled, "LENS WITH CONICAL FRUSTUM MENISCUS WALL", which is incorporated herein by reference.

In some preferred embodiments, a voltage is applied to a meniscus wall and a corresponding liquid meniscus boundary moves along the multi-step meniscus wall 601 toward the front curve lens 606. Steps 609 at the end of each linear segment 608 are functional to slow and stop liquid meniscus movement at designated zones to achieve specific add power changes or other desirable liquid meniscus boundary movement. As the liquid meniscus boundary travels along each linear segment 608, it is slowed and more easily stopped near each step 609 due to changes in liquid meniscus boundary contact angle at the junction between the linear segment 608 and the step 609.

Similarly, Fig. 7C combines Figs. 7A and 7B, showing the location of the liquid meniscus boundary in both an unpowered 704A state and a powered 704B state. According to the present invention, a liquid meniscus lens with a multi-gradient meniscus wall 701 placed at a given angle relative to an optical axis, as shown in Fig. 7C, provides more consistent and repeatable control over liquid meniscus movement resulting from the application of an electrical potential to a meniscus wall portion than a liquid meniscus lens with a linear meniscus wall placed at a similar angle relative to the optical axis. Examples of a lens including a linear meniscus wall are described in the U.S. Patent Application Serial Number 61,359,548, filed June 29, 2010 and entitled "LENS WITH CONICAL FRUSTUM MENISCUS WALL", which is incorporated herein by reference.

**CLAIMS**

1. An optical lens comprising:

a front lens comprising a front lens exterior surface and a front lens interior surface;

a back lens comprising a back lens interior surface and a back lens exterior surface, said back lens positioned proximate to said front lens such that said front lens interior surface and said back lens interior surface form a cavity therebetween;

a volume of saline solution and oil contained within the cavity formed between said front lens interior surface and said back lens interior surface, said volume of saline solution and oil comprising a meniscus therebetween; and

a meniscus wall formed on an area of the interior surface of the front lens, the meniscus wall comprising multiple portions each in the shape of a discrete frustum of a cone formed in the front lens and bordering the meniscus formed between the saline solution and oil.

2. The optical lens of claim 1 wherein at least one of the front lens and the back lens is essentially flat.

3. The optical lens of claim 1 wherein the front lens and the back lens comprise an arcuate lens.

4. The optical lens of claim 3 additionally comprising a conductive coating on at least a portion of said meniscus wall.

5. The optical lens of claim 4 wherein the volume of oil is less than the volume of saline solution contained within the cavity.

6. The optical lens of claim 5 wherein the volume of oil comprises about 66% or more by volume as compared to an amount of saline solution.

7. The optical lens of claim 5 wherein the volume of oil comprises about 90% or less by volume as compared to an amount of saline solution.

8. The optical lens of claim 4 wherein the volume of oil comprises a density about equal to a density of the saline solution.

9. The optical lens of claim 4 wherein the volume of oil comprises density within about 10% of a density of the saline solution.

10. The optical lens of claim 4 wherein the volume of oil comprises density within about 5% of a density of the saline solution.

11. The optical lens of claim 4 wherein the conductive coating extends from an area interior to the cavity to an area external to the cavity.

12. The optical lens of claim 11, wherein the area of conductive coating external to the cavity forms an electrical terminal for providing an electrical charge to the liquid meniscus lens.

13. The optical lens of claim 11 wherein the saline solution and the oil form a meniscus and an application of an electrical potential to the area of conductive coating external to the cavity causes a change in position of contact of the meniscus along the meniscus wall.

14. The optical lens of claim 11 wherein the electrical potential comprises a direct current.

15. The optical lens of claim 11 wherein the electrical potential comprises between about 5.0 volts to 60.0 volts.

16. The optical lens of claim 15 wherein the electrical potential comprises about 20.0 volts.

17. The optical lens of claim 15 wherein the electrical potential comprises about 5.0 volts.

18. The optical lens of claim 11 wherein the electrical potential comprises between about 3.5 volts to about 7.5 volts.

19. The optical lens of claim 5 wherein the front curve lens exterior surface comprises an optical power other than about 0.

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21. The optical lens of claim 5 wherein the back curve lens exterior surface comprises an optical power other than about 0.

22. The optical lens of claim 5 wherein the back curve lens interior surface comprises an optical power other than about 0.

23. The optical lens of claim 5 additionally comprising a channel through one or both of the front curve lens and the back curve lens and a conductive material filling the channel.

24. The optical lens of claim 23 additionally comprising a terminal in electrical communication with the conductive material filling the channel.

25. The optical lens of claim 24 wherein application of an electrical potential to the terminal causes a change in the shape of the meniscus.

26. The optical lens of claim 5 additionally comprising an insulator coating along at least a portion of the interior surface of the front curve lens, wherein the insulator coating comprises an electrical insulator.

27. The optical lens of claim 26, wherein the insulator comprises one of Parylene C™ and Teflon AF.

28. The optical lens of claim 26 wherein the insulator comprises a boundary area to maintain separation between the conductive coating and a saline solution contained in the cavity between the front curve lens and the back curve lens.

29. The optical lens of claim 5 wherein an angle of the multiple conical frustums comprising the meniscus wall comprises between about 30° and 50°.

30. The optical lens of claim 29 additionally comprising a meniscus sharp adjacent to the meniscus wall, said sharp comprising a angular feature for containing the volume of saline solution and oil.

31. The optical lens of claim 29 wherein the sharp comprises a radial surface portion.

32. The optical lens of claim 31 wherein the radial surface portion comprises a radius in the range of 5 microns to 25 microns.

# LENS WITH MULTI-SEGMENTEDLINEAR MENISCUS WALL

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a volume of saline solution and oil contained within the cavity formed between said front lens interior surface and said back lens interior surface, said volume of saline solution and oil comprising a meniscus therebetween; and

a meniscus wall formed on an area of the interior surface of the front lens, the meniscus wall comprising multiple portions each in the shape of a discrete frustum of a cone formed in the front lens and bordering the meniscus formed between the saline solution and oil.

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