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Intraocular lens injector

Abstract

Apparatuses, systems, and methods for implanting an intraocular lens into an eye are described. For example, an intraocular lens injector may include a passage formed in a distal end portion of the intraocular lens injector. The passage may define an interior surface, and a ramp may be formed on the interior surface so as to cause a leading haptic of an intraocular lens (IOL) being advanced through the passage to lift above a surface of an optic of the IOL to ensure proper folding of the IOL.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of U.S. application Ser. No. 16/750,140, filed Jan. 23, 2020, now issued as U.S. Pat. No. 11,571,294, which is a continuation of U.S. application Ser. No. 15/838,946, filed Dec. 12, 2017, now issued as U.S. Pat. No. 10,568,735, and claims the benefit of U.S. Provisional Application No. 62/446,194, filed Jan. 13, 2017, and claims the benefit U.S. Provisional Application No. 62/469,682, filed Mar. 10, 2017, the entire contents of each being incorporated herein by reference.

TECHNICAL FIELD
(1) The present disclosure relates to systems, apparatuses, and methods for intraocular lens injectors. Particularly, the present disclosure relates to systems, apparatuses, and methods for intraocular lens injectors including features for lifting a leading haptic of an intraocular lens for improved intraocular lens folding performance.
BACKGROUND

(2) The human eye in its simplest terms functions to provide vision by transmitting and refracting light through a clear outer portion called the cornea, and further focusing the image by way of the lens onto the retina at the back of the eye. The quality of the focused image depends on many factors including the size, shape and length of the eye, and the shape and transparency of the cornea and lens. When trauma, age or disease cause the lens to become less transparent, vision deteriorates because of the diminished light which can be transmitted to the retina. This deficiency in the lens of the eye is medically known as a cataract. The treatment for this condition is surgical removal of the lens and implantation of an artificial intraocular lens ("IOL").
(3) Many cataractous lenses are removed by a surgical technique called phacoemulsification. During this procedure, an opening is made in the anterior capsule and a thin phacoemulsification cutting tip is inserted into the diseased lens and vibrated ultrasonically. The vibrating cutting tip liquefies or emulsifies the lens so that the lens may be aspirated out of the eye. The diseased lens, once removed, is replaced by an artificial lens.
(4) The IOL is injected into the eye through the same small incision used to remove the diseased lens. An IOL injector is used to deliver an IOL into the eye.

SUMMARY

(5) According to one aspect, the disclosure describes an intraocular lens injector that may include an injector body and a plunger. The injector body may include a bore defined by an interior wall, a longitudinal axis extending centrally along the injector body, and a distal end portion. The distal end portion may include a first sidewall; a second sidewall disposed opposite the first sidewall; a third sidewall extending between the first sidewall and the second sidewall; and a fourth sidewall opposite the third sidewall, the first sidewall, second sidewall, third sidewall, and fourth sidewall joined to define passage forming a portion of the bore. The injector body may also include a first ramp formed on an interior surface of the passage along the first sidewall and laterally offset from the longitudinal axis. The first ramp may be disposed at a position within the passage to contact a leading haptic of an intraocular lens. The first ramp may include a first leading surface being sloped and inwardly extending from the interior surface into the passage and a first peak disposed at a distal end of the first ramp disposed at a distal end of the first leading surface. The intraocular lens injector may also include a plunger slideable within the bore defined by the interior wall.
(6) The aspects of the present disclosure may include one or more of the following features. The first leading surface may include a first plurality of steps therealong. Each of the first plurality of steps may include a rise and a run. The rise and run of each of the steps is uniform. At least one of the rise and run of at least one step of the first plurality of steps may be different from the rise and the run of another of the steps of the first plurality of steps. The injector body may also include a compartment configured to receive the intraocular lens. The compartment may adjoins and be in fluid communication with the passage. A threshold may be defined between the passage and the compartment. A proximal end of the first leading surface of first ramp may be located along at the threshold.
(7) One or more of the following features may also be included in the various aspects of the present disclosure. A second ramp may be formed on the interior surface of the passage along the second sidewall and adjacent to the first ramp. The first ramp and the second ramp may be integrally formed. The second ramp may include a second leading surface, and the second leading surface may be sloped and extend inwardly from the interior surface of the passage. The second ramp may also include a second peak disposed at a distal end of the second leading surface. The second leading surface may include a second plurality of steps. Each of the second plurality of steps may include a rise and a run. The rise and run of each of the steps may be uniform. At least one of the rise and run of at least one step of the second plurality of steps may be different from the rise and the run of another of the steps of the second plurality of steps. The first leading surface and the second leading surface may be integrally formed. The first ramp further may include a first trailing surface disposed distally of the first peak. The first trailing surface may have a positive slope. A

second ramp may be formed on the interior surface of the passage along the second sidewall and adjacent to the first ramp. The second ramp may include a second leading surface that is sloped and that extends inwardly from the interior surface of the passage, a second peak disposed at a distal end of the second leading surface, and a second trailing surface. The second trailing surface may have a positive slope. The first trailing surface and the first trailing surface may be integrally formed.
(8) It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory in nature and are intended to provide an understanding of the present disclosure without limiting the scope of the present disclosure. In that regard, additional aspects, features, and advantages of the present disclosure will be apparent to one skilled in the art from the following detailed description.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a perspective view of an example intraocular lens injector.
(2) FIG. **2** shows a longitudinal cross-sectional view of the intraocular lens injector of FIG. **1**.
(3) FIG. **3** is a perspective view of a distal portion of an example injector body of the intraocular lens injector of FIG. **1**.
(4) FIG. **4** is a cross-sectional view of the distal portion of the injector body shown in FIG. **3**.
(5) FIG. **5** is an example cross-sectional shape of a nozzle of an intraocular lens injector.
(6) FIG. **6** shows a cross-sectional view of an intraocular lens receiving compartment formed in an injector body.
(7) FIG. **7** shows a perspective view of an intraocular lens receiving compartment formed in an injector body.
(8) FIG. **8** is a cross-sectional view of a plunger.
(9) FIG. **9** is a bottom view of a plunger.
(10) FIG. **10** is a partial perspective view showing tabs and a plunger lock of an example intraocular lens injector.
(11) FIG. **11** is a detail view of an example plunger tip of plunger.
(12) FIG. **12** shows an example interior surface of a door enclosing a lens-receiving compartment of an intraocular lens injector.
(13) FIG. **13** is a detail view of the distal end portion of the IOL injector showing a demarcation designating a pause position of an IOL being advanced through the IOL injector.
(14) FIG. **14** is a view of a distal end portion of an IOL injector with an IOL located therein at a pause position.
(15) FIG. **15** is a detail view of an example IOL injector showing an opening at an interface between a compartment into which an IOL is received and an internal bore of an injector body, the detail view being transverse to a longitudinal axis of the IOL injector, and the detail view showing a flexible wall portion in contact with an injector rod.
(16) FIG. **16** is a partial cross-sectional view of an example IOL injector.
(17) FIG. **17** shows an example IOL.
(18) FIG. **18** is a perspective view of an example plunger tip.
(19) FIG. **19** is a side view of the example plunger tip of FIG. **18**.
(20) FIG. **20** is a top view of the example plunger tip of FIG. **18**.
(21) FIG. **21** is a side view of a distal end portion of an example IOL injector.
(22) FIG. **22** is a cross-sectional view taken along line A-A of FIG. **21**.
(23) FIG. **23** is a plan view of the distal end portion of the IOL injector of FIG. **21**.
(24) FIG. **24** is a cross-sectional view taken along line B-B of FIG. **23**.

(25) FIG. **25** is a detail view of a ramp formed in an interior passage of a distal end portion of an IOL injector.
(26) FIG. **26** is a cross-sectional view taken along line C-C of FIG. **23**.
(27) FIG. **27** is a detail view of a ramp formed in an interior passage of a distal end portion of an IOL injector.
(28) FIG. **28** shows an example lifting feature disposed within an interior passage of an IOL injector operable to lift a leading haptic of an IOL during advancement of the IOL.
(29) FIG. **29** shows another example lifting feature disposed within an interior passage of an IOL injector operable to lift a leading haptic of an IOL during advancement of the IOL.
(30) FIGS. **30-33** illustrate lifting of a leading haptic of an IOL by a ramp form on an interior surface of a distal end portion of an IOL injector as the IOL is advanced through an interior passage of the IOL injector.

DETAILED DESCRIPTION

(31) For the purposes of promoting an understanding of the principles of the present disclosure, reference will now be made to the implementations illustrated in the drawings, and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the disclosure is intended. Any alterations and further modifications to the described devices, instruments, methods, and any further application of the principles of the present disclosure are fully contemplated as would normally occur to one skilled in the art to which the disclosure relates. In particular, it is fully contemplated that the features, components, and/or steps described with respect to one implementation may be combined with the features, components, and/or steps described with respect to other implementations of the present disclosure.
(32) The present disclosure relates to systems, apparatuses, and methods for delivering an IOL into an eye. Particularly, the present disclosure relates to systems, apparatuses, and methods for intraocular lens injectors having features to improve leading haptic lift during intraocular lens folding. FIGS. **1** and **2** show an example IOL injector **10** that includes an injector body **20** and a plunger **30**. The injector body **20** defines a bore **40** extending from a proximal end **50** of the injector body **20** to a distal end portion **60** of the injector body **20**. The plunger **30** is slideable within the bore **40**. Particularly, the plunger **30** is slideable within bore **40** in order to advance an IOL, such as IOL **70**, within the injector body **20**. The IOL injector **10** also includes a longitudinal axis **75** disposed centrally through the body **20**. The longitudinal axis **75** may extend along the plunger **30** and define a longitudinal axis of the plunger **30**.
(33) The injector body **20** includes a compartment **80** operable to house an IOL prior to insertion into an eye. In some instances, a door **90** may be included to provide access to the compartment **80**. The door **90** may include a hinge **100** such that the door **90** may be pivoted about the hinge **100** to open the compartment **80**. The injector body **20** may also include tabs **110** formed at the proximal end **50** of the injector body **20**. The tabs **110** may be manipulated by fingers of a user, such as an ophthalmologist or other medical professional, to advance the plunger **30** through the bore **40**.
(34) FIGS. **3-5** illustrate details of the distal end portion **60** of the injector body **20**. In some instances, the distal end portion **60** has a tapered exterior surface. Further, the distal end portion **60** includes a passage **64** that tapers towards a distal opening **125**. The injector body **20** also includes a nozzle **120** at the distal end portion **60**. The nozzle **120** is adapted for insertion into an eye so that an IOL may be implanted. An IOL is expelled from distal opening **125** formed in the nozzle **120**. As shown in FIG. **5**, the nozzle **120** may have an elliptical cross section. Additionally, the nozzle **120** may include a beveled tip **130**. The compartment **80**, passage **64**, and opening **125** may define a delivery passage **127**. A size of the delivery passage **127** may vary along its length. That is, in some instances, a height H1 of the passage may change along a length of the delivery passage **127**. The variation in size of the delivery passage **127** may contribute to the folding of the IOL as it is advanced therealong.
(35) In some instances, the injector body **20** may include an insertion depth guard **140**. The

insertion depth guard **140** may form a flanged surface **150** that is adapted to abut an exterior eye surface. The insertion depth guard **140** abuts an eye surface and, thereby, limits an amount by which the nozzle **120** is permitted to extend into an eye. In some implementations, the flanged surface **150** may have a curvature that conforms to the outer surface of an eye. For example, the flanged surface **150** may have a curvature that conforms to a scleral surface of the eye. In other instances, the flanged surface **150** may have a curvature that corresponds to a corneal surface of the eye. In still other instances, the flanged surface **150** may have a curvature, part of which corresponds to a scleral surface and another part that corresponds to a corneal surface. Thus, the flanged surface **150** may be concave. In other instances, the flanged surface **150** may be flat. In still other instances, the flanged surface **150** may be convex. Further, the flanged surface **150** may have any desired contour. For example, the flanged surface **150** may be a curved surface having radii of curvature that vary along different radial directions from a center of the flanged surface **150**. In still other instances, the flanged surface **150** may define a surface that has varying curvature along different radial directions as well as curvature that varies along one or more particular radial directions.

(36) In FIG. **3**, the insertion depth guard **140** is shown as a continuous feature that forms a continuous flanged surface **150**. In some implementations, the insertion depth guard **140** may be segmented into a plurality of features or protrusions forming a plurality of eye-contacting surfaces. These eye-contacting surfaces may work in concert to control the depth to which the nozzle **120** may penetrate an eye. In other implementations, the insertion depth guard **140** may be omitted.

(37) FIG. **6** shows a cross-sectional detail view of the compartment **80** and a portion of bore **40** of the example injector body **20** shown in FIG. **2**. The bore **40** is defined by an interior wall **298**. The interior wall **298** includes a tapered portion that includes a first tapered wall **301** and a second tapered wall **303**. The tapered portion of the interior wall **298** defines an opening **170** at an interface **172** between the bore **40** and the compartment **80**. The opening **170** includes a height H2. A distal end portion **211** of the plunger rod **210** has a height of H3. In some instances, height H2 may be larger than height H3, such that, initially, there is no interference between the plunger rod **210** and the interior wall **298** at the opening **170**. In other instances, height H2 may be equal to or larger than height H3, such that the plunger rod **210** and the opening **170** initially have an interference fit. In some implementations, the first tapered wall **301** includes a flexible wall portion. In the example shown, the flexible wall portion **162** is an obliquely-extending, flexible portion of the interior wall **298** and, particularly, of the first tapered wall **301**. As shown in FIG. **7**, in some instances, portions of the first tapered wall **301** are removed, forming voids **163** that flank the flexible wall portion **162**. Thus, in some instances, the flexible wall portion **162** may extend in a cantilevered manner.

(38) Referring again to FIG. **6**, in some instances, the flexible wall portion **162** may be sloped toward the distal end portion **60** of the injector body **20**. In some instances, an angle B defined by the flexible wall portion **162** and the longitudinal axis **75** may be in the range of 20° to 60°. For example, in some instances, the angle B may be 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, or 60°. Further, the angle B may be greater or smaller than the defined range or anywhere within the recited range. Moreover, the scope of the disclosure is not so limited. Thus, the angle B may be any desired angle.

(39) The injector body **20** may also include a contoured ramp **180** formed along an interior receiving surface **190** of the compartment **80**. Generally, the interior receiving surface **190** is the surface on which an IOL, such as IOL **70**, is placed when loaded into the IOL injector **10**. FIG. **7** is a perspective view of a portion of the example injector body **20** shown in FIG. **2**. The door **90** is not shown. In some instances, a vertical distance C between a tip of the flexible wall portion **162** and the top of the contoured ramp **180** may correspond with a height H3 of a distal end portion **211** of the plunger rod **210**. In other instances, the distance C may be greater or less than the height H3 of the distal end portion **211** of the plunger rod **210**. The flexible wall portion **162** and contoured ramp

180 are discussed in more detail below. In some implementations, the flexible wall portion **162** may be omitted. For example, in some implementations, the flexible wall portion may be unnecessary, as the plunger **30** and the associated plunger rod **210** maintain are configured such that a plunger tip, e.g., plunger tip **220** discussed in more detail below, remains in contact with the contoured ramp **180** during advancement of the plunger **30**.

(40) As also shown in FIG. **7**, the injector body **20** may include a contoured surface **192** that is offset from the receiving surface **190**. A wall **194** is formed adjacent to the contoured surface **192**. A freely extending end **452** of a haptic **450**, shown in FIG. **17**, contacts the contoured surface **192** when IOL **70** is received into the compartment **80**.

(41) Referring to FIGS. **1** and **8-9**, the plunger **30** may include a body portion **200**, a plunger rod **210** extending distally from the body portion **200**, and a plunger tip **220** formed at a distal end **230** of the plunger rod **210**. The plunger **30** may also include a flange **240** formed at a proximal end **250** of the body portion **200**. A biasing element **260** may be disposed on the plunger **30**. In some instances, the biasing element **260** may be a spring. In some implementations, the biasing element **260** may be disposed adjacent to the flange **240**. A proximal end **262** may be fixedly attached at the body portion adjacent to the flange **240**. In other instances, the biasing element **260** may be disposed at another location along the body portion **200**. In still other implementations, the biasing element **260** may be formed or otherwise disposed on the injector body **20** and adapted to engage the plunger **30** at a selected location during advancement of the plunger **30** through bore **40**. Still further, in other implementations, the biasing element **260** may be omitted.

(42) The flange **240** may be used in concert with the tabs **110** to advance the plunger **30** through the injector housing **20**. For example, a user may apply pressure to tabs **110** with two fingers while applying opposing pressure to the flange **240** with the user's thumb. A surface of the flange **240** may be textured in order to provide positive gripping by a user. In some instances, the texture may be in the form of a plurality of grooves. However, any desired texture may be utilized.

(43) The body portion **200** may include a plurality of transversely arranged ribs **270**. In some instances, the ribs **270** may be formed on both a first surface **280** and a second surface **290** of the body portion **200**, shown in FIG. **1**. In other instances, the ribs **270** may be formed on only one of the first surface **280** and second surface **290**. A longitudinally extending rib **300** may also be formed on one or both of the first and second surfaces **280**, **290**.

(44) In some instances, the body portion **200** may also include one or more protrusions **202**, as shown in FIG. **9**. The protrusions **202** may extend longitudinally along a length of the body portion **200**. The protrusions **202** may be received grooves **204** formed in the injector body **20**, as shown in FIG. **1**. The protrusions **202** and grooves **204** interact to align the plunger **30** within the bore **40** of the injector body **20**.

(45) The body portion **220** may also include cantilevered members **292**. The cantilevered members **292** may extend from a distal end **294** of the body portion **200** towards the proximal end **250**. The cantilevered members **292** may include flared portions **296**. The cantilevered members **292** may also include substantially horizontal portions **297**. The flared portions **296** are configured to engage the interior wall **298** of the injector body **20** that defines the bore **40**, as shown in FIG. **2**. Engagement between the cantilevered members **292** and the interior wall **298** generates a force resistive to advancement of the plunger **30** and provides a tactile feedback to the user during advancement of the plunger **30**. For example, in some implementations, the resistive force generated by contact between the cantilevered members **292** and the interior wall **298** may provide a baseline resistance that resists advancement of the plunger **30**.

(46) In some instances, the plunger rod **210** may include an angled portion **212**. The distal end portion **211** may form part of the angled portion **212**. The angled portion **212** may define an angle, A, within the range of 1° to 5° with the longitudinal axis **75**. In some instances, the angle A maybe 2°. In some instances, the angle A may be 2.5°. In still other instances, the angle A may be 3°, 3.5°, 4°, 4.5°, or 5°. Further, while the above values of A are provided as examples, the angle A may be

greater or less than the indicated range or any value in between. Thus, the angle A may be any desired angle.
(47) The angled portion **212** ensures that the plunger tip **220** contacts and follows the receiving surface **190** as the plunger **30** is advanced through the bore **40**. Particularly, the angle A defined by the angled portion **212** exceeds what is needed to cause the plunger tip **220** to contact the interior wall **298** of the bore **40**. That is, when the plunger **30** is disposed within the bore **40**, engagement between the plunger tip **220** and the interior wall **298** causes the angled portion **212** to bend inwardly due to the angle A. Consequently, the angled portion **212** ensures that the plunger tip **220** properly engages the haptics and optic of an IOL being inserted from the IOL injector **10**. This is described in greater detail below. Although the angled portion **212** is shown as being a substantially straight portion bent at an angle relative to the remainder of the plunger rod **210**, the scope is not so limited. In some instances, a portion of plunger rod **210** may have a continuous curvature. In other instances, an entire length of the plunger rod **210** may be bent or have a curvature. Further, the amount of angular offset from the longitudinal axis **75** or amount of curvature may be selected in order to provide a desired amount of engagement between the plunger tip **220** and the interior surfaces of the injector body **20**.
(48) The biasing element **260** may be affixed to the body portion **200** adjacent to the flange **240**. In some instances, the biasing element **260** may form a hoop **310** extending distally along the body portion **200** that functions as a spring to resist advancement of the plunger **30** when the hoop **310** engages the injector body **20**. The biasing element **260** may also include a collar **261** that defines a channel **320** through which the body portion **200** extends. Thus, in operation, as the plunger **30** is advanced through the bore **40** of the injector body **20** (i.e., in the direction of arrow **330** shown in FIG. **2**), a distal end **265** of the biasing element **260** contacts the proximal end **50** of the injector body **20** at a selected location along the stroke of the plunger **30**. As the injector **30** is further advanced, the biasing element **260** is compressed and the channel **320** permits the distal end **265** of the biasing element **260** to move relative to the body portion **200**. Similarly, the channel **320** permits relative movement between the body portion **200** and the distal end **265** of the biasing element **260** during proximal movement of the plunger **30** (i.e., in the direction of arrow **340**, also shown in FIG. **2**).
(49) Referring to FIGS. **2**, **9**, and **10**, the IOL injector **10** may also include a plunger lock **350**. The plunger lock **350** is removably disposed in a groove **360** formed in one of the tabs **110**. The plunger lock **350** includes a protrusion **370** formed at one end thereof. The plunger lock **350** may include a single protrusion **370**, as shown in FIG. **2**. In other instances, the plunger lock **350** may include a plurality of protrusions **370**. For example, FIG. **10** illustrates an example plunger lock **350** having two protrusions **370**. In other instances, the plunger lock **350** may include additional protrusions **370**.
(50) When installed, the protrusion **370** extends through an aperture **375** formed in the injector body **20** and is received into a slot **380** formed in the plunger **30**. When the plunger lock **350** is installed, the protrusion **370** and slot **380** interlock to prevent the plunger **30** from moving within the bore **40**. That is, the installed plunger lock **350** prevents the plunger **30** from being advanced through or removed from the bore **40**. Upon removal of the plunger lock **350**, the plunger **30** may be freely advanced through the bore **40**. In some instances, the plunger lock **350** may include a plurality of raised ribs **390**. The ribs **390** provide a tactile resistance to aid in removal from and insertion into groove **360**.
(51) The plunger lock **350** may be U-shaped and define a channel **382**. The channel **382** receives a portion of the tab **110**. Further, when fitted onto the tab **110**, a proximal portion **384** of the plunger lock **350** may be outwardly flexed. Consequently, the plunger lock **350** may be frictionally retained on the tab **110**.
(52) Referring to FIGS. **2** and **8**, in some implementations, the body portion **20** may include shoulders **392** formed in bore **40**. The shoulders **392** may be formed at a location in the bore **40**

where the bore **40** narrows from an enlarged proximal portion **394** and a narrower distal portion **396**. In some instances, the shoulder **392** may be a curved surface. In other instances, the shoulder **392** may be defined a stepped change in the size of bore **40**.

(53) The cantilevered members **292** may engage the shoulder **392**. In some implementations, the flared portion **296** of the cantilevered members **292** may engage the shoulder **392**. In some instances, a location at which the cantilevered members **292** engage the shoulder **392** may be one in which the slot **380** aligns with the aperture **375**. Thus, in some implementations, engagement between the cantilevered members **292** and shoulder **392** may provide a convenient arrangement for insertion of the plunger lock **350** to lock the plunger **30** in place relative to the injector body **20**. In other implementations, the slot **380** and the aperture **375** may not align when the cantilevered members **292** engage the shoulder **392**.

(54) As the plunger **30** is advanced through the bore **40**, the flared portion **296** of the cantilevered members **292** may be inwardly displaced to comply with the narrowed distal portion **396** of the bore **40**. As a result of this deflection of the flared portion **296**, the cantilevered members **292** apply an increased normal force to the interior wall **298** of the bore **40**. This increased normal force generates a frictional force that resists advancement of the plunger **30** through bore **40**, thereby providing tactile feedback to the user.

(55) Referring to FIGS. **1** and **2**, the IOL injector may also include an IOL stop **400**. The IOL stop **400** is received into a recess **410** formed in an outer surface **420** the door **90**. The IOL stop **400** may include a protrusion **430** that extends through an opening **440** formed in the door. The protrusion **430** extends between a haptic and optic of an IOL loaded into the compartment **80**. As shown in FIGS. **1** and **17**, the IOL **70** includes haptics **450** and an optic **460**. The protrusion **430** is disposed between one of the haptics **450** and the optic **460**. The IOL stop **430** may also include a tab **435**. The tab **435** may be gripped by a user for removal of the IOL stop **430** from the injector body **20**.

(56) The IOL stop **400** may also include an aperture **470**. The aperture **470** aligns with another opening formed in the door **90**, for example opening **472** shown in FIG. **13**. The aperture **470** and second opening **472** in the door **90** form a passageway through which a material, such as a viscoelastic material, may be introduced into the compartment **80**.

(57) The IOL stop **400** is removable from the door **90**. When installed, the IOL stop **400** prevents advancement of the IOL, such as IOL **70**. Particularly, if advancement of the IOL **70** is attempted, the optic **460** contacts the protrusion **430**, thereby preventing advancement of the IOL **70**.

(58) FIG. **11** shows an example plunger tip **220**. The plunger tip **220** may include a first protrusion **480** and a second protrusion **490** extending from opposing sides. The first and second protrusions **480**, **490** define a first groove **500**. The first groove **500** defines a surface **502**. A second groove **510** is formed within the first groove **500**. The first groove **500**, particularly in combination with the first protrusion **480**, serves to capture and fold a trailing haptic of an IOL. The second groove **510** functions to capture and fold an optic of an IOL.

(59) A side wall **520** of the plunger tip **220** may be tapered. The tapered side wall **520** may provide a nesting space for a gusseted portion of the trailing haptic of an IOL. The gusseted portion of the haptic tends to remain proximal to the IOL optic. Thus, the tapered side wall **520** may provide a nesting space that promotes proper folding of the IOL during delivery into an eye.

(60) FIGS. **18-20** show another example plunger tip **220**. This plunger tip **220** includes a first protrusion **600**, a second protrusion **602**, and a groove **604**. The first protrusion extends at an oblique angle θ from longitudinal axis **606**. In some instances, the angle θ may be between 25° to 60°. In other instances, the angle θ may be lower than 25° or larger than 60°. In other instances, the angle θ may be between 0° to 60°. In still other implementations, the angle θ may be between 0° and 70°; 0° and 80°; or 0° and 90°. Generally, the angle θ may be selected to be any desired angle. For example, the angle θ may selected based on one or more of the following: (1) a size, such as a height, of passage **64** formed within the nozzle **60**; (2) the height of the compartment **80**; (3) how the height of the passage **64** and/or compartment varies along their respective lengths; and (3) the

thickness of the plunger tip **220**. The second protrusion **602** may include a tapered portion **608**. The tapered portion **608** is operable to engage an optic of an IOL, such as optic **460** shown in FIG. **17**. The optic may slide along the tapered surface so that the optic may be moved into the groove **604**. As a result, the second protrusion **602** is positioned adjacent to a surface of the optic.
(61) The example plunger tip **220** shown in FIGS. **18-20** also include a surface **610** that may be similar to the surface **502**. The surface **610** is adapted to contact and displace a trailing or proximally extending haptic, such as haptic **450** shown in FIG. **17**, so that the haptic folds. In some instance, the surface **610** may be a flat surface. In other instances, the surface **610** may be a curved or otherwise contoured surface. The example plunger tip **220** may also include a side wall **612** and support surface **613**. Similar to the side wall **520**, the side wall **612** may be tapered, as shown in FIG. **20**. In some instances, the side wall **612** may include a first curved portion **614**. The first curved portion **614** may receive a bent portion of the trailing haptic that remains proximal to the optic during folding. The trailing haptic is supported by support surface **613** during the folding process. The side wall **612** may also include a second curved surface **615**.
(62) The obliquely-extending first protrusion **600** effectively increases a height H4, as compared to the plunger tip **220** shown in FIG. **11**, for example. This increased height H4 improves the ability of the plunger tip **220** to capture the trailing haptic during advancement of the plunger **30**. In operation, as the plunger **30** is advanced distally, the distal end **618** engages an interior wall of the delivery passage **127** due to changes in the height H1 of the delivery passage **127**. As the height H1 decreases, the first protrusion **600** pivots about hinge **620**, effectively reducing the total height H4 of the plunger tip **220**. As the first protrusion **600** pivots about hinge **620** and rotated in a direction towards the second protrusion **602**, the first protrusion **600** captures the trailing haptic between the optic of the IOL and the first protrusion **600**. Therefore, with the first protrusion **600** pivotable about the hinge **620**, the size of the plunger tip **220** is able to adapt and conform to the changing height H1 of the delivery passage **127** as the IOL is advanced distally and folded.
(63) FIG. **12** shows an interior surface **530** of door **90**. The surface **510** may include a ridge **530**. The ridge **530** may include a curved portion **540**. In the example illustrated, the curved portion **540** extends proximally and inwardly towards the longitudinal axis **75**. The curved portion **540** is configured to overlay a portion of a trailing haptic of an IOL, which promotes proper folding of the IOL when the plunger **30** is advanced through the injector body **20**.
(64) In operation, the plunger lock **350** may be inserted into the groove **360** to lock the plunger **30** in position relative to the injector body **20**. An IOL, such as IOL **70**, may be loaded into the compartment **80**. For example, the door **90** may be opened by a user and a desired IOL inserted into the compartment **80**. The door **90** may be closed upon insertion of the IOL into the compartment **80**. In some instances, an IOL may be preloaded during manufacturing.
(65) The IOL stop **400** may be inserted into the recess **410** formed in the door **90**. Viscoelastic material may be introduced into the compartment **80** via the aligned aperture **470** and corresponding opening formed in the door **90**. The viscoelastic material functions as a lubricant to promote advancement and folding of the IOL during advancement and delivery of the IOL into an eye. In some instances, the viscoelastic material may be introduced into the compartment **80** at the time of manufacturing.
(66) The IOL stop **400** may be removed from the recess **410** formed in the door **90**, and the plunger lock **350** may be removed from the groove **360**. The plunger **30** may be advance through the bore **40**. Sliding engagement between the cantilevered members **292** and the interior wall **298** of the injector body **20** generates a resistive force that resists advancement of plunger **30**. In some instances, the plunger **30** may be advanced through the bore **40** until the plunger tip **220** extends into the compartment **80**. For example, the plunger **30** may be advanced until the plunger tip **220** is adjacent to or in contact with the IOL. In other instances, the plunger **30** may be advanced through the bore **40** such that the IOL is partially or fully folded. Further, the plunger **30** may advance the IOL to a position within the nozzle just short of being ejected from the distal opening **125**. For

example, in some instances, advancement of the plunger **30**, prior to insertion of the nozzle **120** into a wound formed in the eye, may be stopped at the point where the distal end **265** of the biasing element **260** contacts the proximal end **50** of the injector body **20**.

(67) FIG. **21** shows the distal end portion **60** of the IOL injector **10**. FIG. **22** is a cross-sectional view of the distal end portion **60** of the IOL injector **10** taken along line A-A. Longitudinal axis **75** is shown in FIG. **22** and extends centrally along the passage **64** such that the longitudinal axis **75** divides the distal end portion **60** symmetrically in FIG. **22**. Referring to FIGS. **21** and **22**, the distal end portion **60** includes a first sidewall **700**, a second sidewall **702** opposite the first sidewall **700**, a third sidewall **704** disposed between the first and second sidewalls **700** and **702**, and a fourth sidewall **706** opposite the third sidewall **704** and also disposed between the first and second sidewalls **700** and **702**. The sidewalls **700**, **702**, **704**, and **706** define the passage **64**.

(68) In order to provide improved folding of an IOL, such as IOL **70**, a ramp **708** is formed on an interior surface **710** of the first sidewall **700**. Referring to FIGS. **22**, **23**, and **28**, the ramp **708** includes a peak **709**, a leading surface **712** disposed proximally the peak **709**, and a trailing surface **713** disposed distally of the peak **709**. The peak **709** extends along a width of the ramp **708** and separates the leading surface **712** from the trailing surface **713**. The peak **709** represent a portion of the ramp **708** with the largest separation from plane C, shown in FIG. **24** and discussed in more detail below. As is readily apparent, the leading surface **712** of the ramp **708** increases the lift, i.e., displacement in the direction of arrow **709**, of a leading haptic of an IOL (e.g., leading haptic **450** of IOL **70**, shown in FIG. **10**) at a much faster rate as the IOL is advance through the passage **64** than would otherwise be provided by the surface **710** if the ramp **708** were omitted. The ramp **708** operates to mitigate or eliminate improper folding of the leading haptic during folding of the IOL within the IOL injector **10**. For example, the ramp **708** may avoid improper folding in which the leading haptic remains distal to an in contact with a leading edge **728** (shown in FIG. **24**) of the optic **460** during folding of the IOL **70**. Thus, the ramp **708** is operable to lift the leading haptic **450** above the optic **460** such that the haptic **450** is able to be folded over the optic **460** as the IOL **70** is folded prior to being expelled from the IOL injector **10** and into an eye for implantation.

(69) As shown in FIG. **22**, the ramp **708** is laterally offset from the longitudinal axis **75**, which forms a centerline along the IOL injector **10**, towards the third sidewall **704**. The location of the ramp **708** is such that a freely extending end of a leading haptic of an IOL, such as freely extending end **452** of haptic **450** of IOL **70** extending digitally from the optic **460**, encounters the ramp **708** as the IOL is advance along the delivery passage **127** by the plunger **30**.

(70) FIG. **23** is a plan view of the distal end portion **60** of the IOL injector **10** showing the second sidewall **702**. FIG. **24** is a cross-sectional view of the distal end portion **60** taken along line B-B shown in FIG. **22**. The line B-B represents a plane passing through a portion of the ramp **708** having the largest distance between a point along the peak **709** and the plane C, shown in FIG. **24**. H5 represents the maximum dimension between the ramp **708** and the plane C. The ramp **708** is positioned within the passage **64** to contact and engage the freely extending end of the leading haptic. In the illustrated example, the ramp **708** is disposed distally of the threshold **65** between the compartment **80** and the passage **64**. The ramp **708** begins at a proximal end indicated by point **705**. In some instances, a longitudinal distance G between the point **705** and the peak **709** (which, in some instances, may be coincident with point **707**, described in more detail below) may be within the range of 0.5 mm to 1.5 mm. Thus, in some implementations, the distance G may be 0.5 mm, 0.6 mm, 0.7 mm, 0.8 mm, 0.9 mm, 1.0 mm, 1.1 mm, 1.2 mm, 1.3 mm, 1.4 mm, or 1.5 mm. However, the distance G may be selected to be any value within the indicated range or a value larger or smaller than the indicated range. Line **710** corresponds to an interior surface of the first sidewall **700** defining the passage **64** away from and not forming part of the ramp **708**. A length L of the ramp **708** along the cross-section shown in FIG. **24** may be within the range of 8 mm to 10 mm. In other implementations, the length L of the ramp **708** may be greater than 10 mm or less than 8 mm.

(71) Referring to FIGS. **30-33** illustrates the operation of the ramp **708** in lifting the leading haptic **450** above optic **460** as the IOL **70** is advanced within the IOL injector **10**. In operation, as the plunger rod **210** advances the IOL **70** along the delivery passage **127**, the freely extending end **452** of the leading haptic **450** contacts and rides along a leading surface **712** of the ramp **708**. As the IOL **70** is continued to be advanced, the leading haptic **450** is lifted as it rides along the leading surface **712**. Lifting of the leading haptic **450** continues until the leading haptic **450** has obtained a sufficient height above the optic **460** of the IOL. For example, a height obtained by the leading haptic **450** as a result of riding along the leading surface **712** of the ramp **708** may be selected to ensure that leading haptic avoids being trapped forward or distal of a leading edge **714** of the optic **460**. Further, a position of the leading surface **712** of the ramp **708** longitudinally along the distal end portion **60** and a slope of the leading surface **712** may be selected such that the leading haptic **450** achieves a desired height above the optic **460** before or simultaneous with curling of the lateral edges **453** (shown in FIG. **14**) of the optic **460** as the optic **460** begins to fold. A ramp **708** configured in such a way ensures that the freely extending end **452** of the leading haptic **450** is tucked proximal to the leading edge **714** of the optic and between the folded lateral sides **453** thereof. An illustration of this folding arrangement of the leading haptic relative to the optic is shown in FIG. **19**.

(72) In the example shown in FIG. **24**, the leading surface **712** is a smooth surface. That is, in some implementations, the leading surface **712** may be free of discontinuities or rapid changes in curvature. However, the scope of the disclosure is not so limited. In some implementations, the leading surface **712** of the ramp **708** may have stepped surface. FIG. **25** shows a detail cross-sectional view of an example leading surface **712** of the ramp **708** in which the leading surface **712** includes a plurality of steps **716**. In some instances, the leading surface **712** may be formed entirely of steps **716**. In other instances, the leading surface **720** may have a plurality of steps along only a portion of its length. In other implementations, the sizes of one or more steps **716** may vary from the sizes of one or more other steps **716** of the leading surface **712**.

(73) In some implementations, each of the steps **716** includes a rise **718** and a run **720**. The run **720** extends in a direction parallel to a longitudinal axis **75** of the IOL injector **10**, while the rise **718** extends in a direction perpendicular to the longitudinal axis **75** of the IOL injector **10**. In some implementations, the rise **718** of one or more of the steps **716** may have a length in the range of 0.2 to 0.5 mm. Particularly, the length of the rise **718** may be 0.2 mm, 0.3 mm, 0.4 mm, or 0.5 mm. However, these dimensions are merely examples. In other implementations, the length of the rise **718** may be larger or smaller than the indicated range. That is, in some instances, the rise **718** may be larger than 0.5 mm or smaller than 0.2 mm.

(74) The run **720** of one or more of the steps **716** may have a length in the range of 0.2 to 0.5 mm. Particularly, the length of the run **720** may be 0.2 mm, 0.3 mm, 0.4 mm, or 0.5 mm. However, these dimensions are merely examples. In other implementations, the length of the run **720** may be larger or smaller than the indicated range. That is, in some instances, the run **720** may be larger than 0.5 mm or smaller than 0.2 mm.

(75) Although FIG. **25** shows an example leading surface **712** having a plurality of steps **716** that are uniform in size. Thus, in some implementations, with the leading surface **712** having a plurality of steps **716** with uniform sizes, the leading surface **712** defines a linear slope. However, the scope of the disclosure is not so limited. Rather, in other instances, one or more of the rise **718**, the run **720**, or both the rise **718** and run **720** of one or more of the steps **716** may be different than one or more other steps **716**. In some instance, the run **718** of the steps may decrease in the distal direction along the leading surface **712**. In other implementations, the run **718** of the steps may increase in the distal direction along the leading surface **712**. In some instances, the rise **718** of the steps may increase in the distal direction along the leading surface **712**. In other implementations, the rise **718** of the steps may decrease in the distal direction along the leading surface **712**. In instances where the rise **718** and run **720** of one or more of the steps **716** varies, the leading surface **712** may define

an overall curved surface or, more generally, a non-linear surface. In some implementations, the stepped leading surface **712** may be arranged to form an overall parabolic shape to the leading surface **712**. An overall parabolic shape of the leading surface **712** may alter an amount of lift imparted to the leading haptic **450** as a distance traveled by the leading haptic **450** in the distal direction changes. Particularly, the amount of lift imparted to the leading haptic **450** may increase per rate of movement of the leading haptic **450** in the distal direction along the longitudinal axis of the passage **64** of the distal end portion **60**. However, the overall shape defined by the leading surface **712** may be any desired shape. For example, the leading surface **712** may have an inclined undulating surface, an inclined flat surface, or any other desired surface.

(76) An overall slope of the ramp **708** is defined by a line **703** extending from a point **705**, a proximal end of the ramp **708**, to a point **707** wherein the line **705** tangentially touches the peak **709** of the ramp **708**. The slope line **703** is angularly offset from the plane C by an angle T. In some instances, the angle T may be between 17° and 27°. Particularly, in some instances, the angle T may be 17°, 18°, 19°, 20°, 21°, 22°, 23°, 24°, 25°, 26°, or 27°. However, the angle T may be selected to be any value within the indicated range or a value larger or smaller than the indicated range.

(77) Referring to FIGS. **22**, **24**, and **25**, the trailing surface **713** of the ramp **708** gradually recedes into the interior surface **710** of the first sidewall **700**. In the example shown in FIG. **24**, the trailing surface **713** has a positive slope as the trailing surface **713** extends distally. In some examples, the positive slope of the trailing surface **713** is provided for manufacturability of the IOL injector **10** and, particularly, for the distal end portion **60**. In the case of injection molding, for example, a positive slope of the trailing surface **713** provides a draft angle that facilitates manufacturing of the distal end portion **60**. However, the trailing surface **713** need not have a positive slope. In other implementations, the trailing surface **713** may have a neutral slope, i.e., a slope of zero, or a negative slope. In still other implementations, the trailing surface **713** of the ramp **708** may be omitted.

(78) In some implementations, the third sidewall **704** may also include ramp **722** formed on an interior surface thereof, as shown in FIG. **22**. In some instances, the ramp **722** may blend with the ramp **708**. For example, in some instances, the ramp **722** may be a continuation of the ramp **708** that continues from the inner surface of the first sidewall **700** onto the inner surface of the third sidewall **704**. In some implementations, the ramp **722** may be omitted.

(79) The ramp **722** includes a leading surface **723**, a trailing surface **725**, and a peak **727** disposed between the leading surface **723** and the trailing surface **725**. Similar to the peak **709**, the peak **727** extends along a width of the ramp **722** and separates the leading surface **723** from the trailing surface **725**. FIG. **26** is a cross-sectional view of the distal end portion **60** taken along line C-C shown in FIG. **23**. The line C-C represents a plane that passes through the peak **709** of the ramp **708** and the peak **727** of the ramp **722**. While peaks **709** and **727** are aligned in the example distal end portion **60** illustrated in FIG. **21-26**, the scope of the disclosure is not so limited. Rather, the peaks **709** and **727** may be offset. In some instances, the peak **709** may be disposed proximally of the peak **727**. In other instances, the peak **709** may be disposed distally of the peak **727**.

(80) As shown in FIG. **26**, the peak **723** of the ramp **722** is disposed at an angle relative to vertical axis **729**, whereas the peak **709** of the ramp **708** is parallel with the horizontal axis **731**. However, in other implementations, the peak **709** may be angled relative to the horizontal axis **731**. In some instances, the peak **723** may be parallel with the vertical axis **729**. Referring to FIG. **22**, a surface **724** corresponding to an inner surface of the passage **64** of a distal end portion **60** that omits the ramp **722** is illustrated. Consequently, the difference in topography experienced by a leading haptic, such as leading haptic **450**, in instances with the ramp **722** as opposed to those without the ramp **722** is apparent. As shown in FIG. **26**, the surface **710** joins with surface **724** to form a representation of a continuous surface that would otherwise exist in the passage **64** if the ramps **708** and **722** were omitted.

(81) The freely extending end **452** of the leading haptic **450** engages the ramp **722** as the IOL **70** is advance within the passage **64** and operates to restrict distal movement of the leading haptic **450** as the leading haptic **450** is being lifted by the ramp **708**. As the IOL **70** continues to advance, the leading haptic **450** engages the leading surface **723** of the ramp **722**. As a result, the distal movement of the leading haptic **450** is temporarily reduced or stopped such that the leading haptic **450** is folded over the surface **726** of the optic **460**. As advancement of the IOL **70** continues, a point is reached where the force applied to the leading haptic **450** in the distal direction as a result of advancement of the IOL **70** exceeds a resistive force applied to the leading haptic **450** by the ramp **722**. As a result, the leading haptic **450** is deflected and forced past the ramp **722** with the leading haptic **450** folded over the optic **460** and adjacent to the surface **726**. The point at which the leading haptic **450** is moved past the ramp **722** and folded over the surface **726** of the optic **460** occurs just prior to folding of the lateral sides **453** of the optic **460**. The folded lateral sides **453** of the optic **460** capture the leading haptic **450** therebetween and maintain the leading optic **450** in a folded configuration.
(82) As explained above, the ramp **708** and the ramp **722** may join into a single topographical feature present within the passage **64**. In other implementations, the ramp **708** and the ramp **722** may be separate features formed in the passage **64**. Further, the leading surface **723** of the ramp **722** may be a smooth surface, i.e., free discontinuities or rapid changes in curvature. However, like the leading surface **712** of the ramp **708**, the leading surface **723** of the ramp **722** may have a stepped surface. FIG. **27** shows a detail view the ramp **722** shown in FIG. **22**. The ramp **722** includes a stepped leading surface **723** having a plurality of steps **730**. In some instances, the leading surface **723** may be formed entirely of steps **730**. In other instances, the leading surface **723** may have a plurality of steps along only a portion of its length. In other implementations, the sizes of one or more steps **730** may vary from the sizes of one or more other steps **730** of the leading surface **723**.
(83) In the instances where the ramp **708** and the ramp **722** are joined, one of the leading surface **712** of the ramp **708** and the leading surface **723** of the ramp **722** may include one or more steps while the other of the leading surface **712** of the ramp **708** and the leading surface **723** of the ramp **722** may omit steps. In some instances, both the leading surface **712** and the leading surface **723** may include one or more steps. In still other implementations, both the leading surface **712** and the leading surface **723** may omit steps.
(84) In instances wherein the leading surface **712** of the ramp **708** and the leading surface **723** of the ramp **722** include a plurality of steps, the rise and run of the steps of each of the leading surfaces **712** and **723** may be the same or the rise and run of each of the leading surfaces **712**, **723** may vary from each other. Further, a slope of each of the leading surfaces **712** and **723** may be the same or different from one another. In some instances, the rise and run of the steps on each of the leading surfaces **712** and **723** may vary both between the leading surfaces **712** and **723** and on each of the leading surfaces **712** and **723**.
(85) Each of the steps **730** includes a rise **732** and a run **734**. The run **734** extends in a direction parallel to a longitudinal axis **75** of the IOL injector **10**, while the rise **732** extends in a direction perpendicular to the longitudinal axis **75** of the IOL injector **10**. In some implementations, the rise **732** of one or more of the steps **730** may have a length in the range of 0.2 to 0.5 mm. Particularly, the length of the rise **732** may be 0.2 mm, 0.3 mm, 0.4 mm, or 0.5 mm. However, these dimensions are merely examples. In other implementations, the length of the rise **732** may be larger or smaller than the indicated range. That is, in some instances, the rise **732** may be larger than 0.5 mm or smaller than 0.2 mm. In instances where the rise **718** and run **720** of one or more of the steps **716** varies, the leading surface **712** may define an overall curved surface or, more generally, a non-linear surface.
(86) The run **734** of one or more of the steps **730** may have a length in the range of 0.2 to 0.5 mm. Particularly, the length of the run **734** may be 0.2 mm, 0.3 mm, 0.4 mm, or 0.5 mm. However, these dimensions are merely examples. In other implementations, the length of the run **734** may be larger

or smaller than the indicated range. That is, in some instances, the run **734** may be larger than 0.5 mm or smaller than 0.2 mm.

(87) Although FIG. **27** shows an example leading surface **723** having a plurality of steps **730** that are uniform in size. Thus, in some implementations, with the leading surface **723** having a plurality of steps **730** with uniform sizes, the leading surface **723** defines a linear slope. However, the scope of the disclosure is not so limited. Rather, in other instances, one or more of the rise **732**, the run **734**, or both the rise **732** and run **734** of one or more of the steps **730** may be different than one or more other steps **730**. In some instance, the run **734** of the steps may decrease in the distal direction along the leading surface **723**. In other implementations, the run **734** of the steps may increase in the distal direction along the leading surface **723**. In some instances, the rise **732** of the steps may increase in the distal direction along the leading surface **712**. In other implementations, the rise **732** of the steps **730** may decrease in the distal direction along the leading surface **723**. In instances where the rise **732** and run **734** of one or more of the steps **730** varies, the leading surface **723** may define an overall curved surface or, more generally, a non-linear surface. In some implementations, the stepped leading surface **723** may be arranged to form an overall parabolic shape to the leading surface **723**. However, the shape of the leading surface **723** may be any desired shape. For example, the leading surface **723** may have an inclined undulating surface, an inclined flat surface, or any other desired surface.

(88) FIG. **27** also shows a plane D that extends parallel to the longitudinal axis **75** of the IOL injector **10**. The plane D passes through a first point **731** defining a proximal end of the ramp **730**. An overall slope of the ramp **730** is defined by a line **733** extending from the point **71** to a point **735** wherein the line **733** tangentially touches the peak **727** of the ramp **730**. The slope line **733** is angularly offset from the plane D by an angle U. In some instances, the angle U may be between 63° and 73°. Particularly, in some instances, the angle U may be 63°, 64°, 65°, 66°, 67°, 68°, 69°, 70°, 71°, 72°, or 73°. However, the angle U may be selected to be any value within the indicated range or a value larger or smaller than the indicated range.

(89) In the illustrated example shown in FIG. **27**, the ramp **722** is disposed distally of the threshold **65** between the compartment **80** and the passage **64**. The ramp **708** begins at a proximal end indicated by point **731**. In some instances, a longitudinal distance H between the point **731** and the peak **709** (which, in some instances, may be coincident with point **735**) may be within the range of 0.4 mm to 1.4 mm. Thus, in some implementations, the distance H may be 0.4 mm, 0.5 mm, 0.6 mm, 0.7 mm, 0.8 mm, 0.9 mm, 1.0 mm, 1.1 mm, 1.2 mm, 1.3 mm, or 1.4 mm. However, the distance H may be selected to be any value within the indicated range or a value larger or smaller than the indicated range.

(90) Referring to FIGS. **22**, **26**, and **27**, the trailing surface **725** of the ramp **722** gradually recedes into the interior surface **724** of the third sidewall **704**. In the example shown in FIG. **24**, the trailing surface **725** has a positive slope as the trailing surface **725** extends distally. Similar to the trailing surface **713**, discussed above, in some examples, the positive slope of the trailing surface **725** is provided for manufacturability of the IOL injector **10** and, particularly, for the distal end portion **60**. In the case of injection molding, for example, a positive slope of the trailing surface **725** provides a draft angle that facilitates manufacturing of the distal end portion **60**. However, the trailing surface **725** need not have a positive slope. In other implementations, the trailing surface **725** may have a neutral slope, i.e., a slope of zero, or a negative slope. In still other implementations, the trailing surface **725** of the ramp **722** may be omitted.

(91) As shown in FIG. **26**, a height F of the passage **64** may be within the range of 2.4 mm to 2.6 mm. However, such dimensions are merely illustrative, and the height F of the passage may be greater than 2.6 mm or less than 2.4 mm. Further, a height E of the ramp **722** where the ramp **722** merges into the inner surface of the passage **64** (i.e., the inner surface of the passage **64** that is a continuation of the surface **724**) may be within the range of 1.5 mm to 1.8 mm. However, in some implementations, the height E may be greater than 1.8 mm or less than 1.5 mm. The height D of the

ramp **708** at the peak **709** may be within the range of 0.5 mm to 1.0 mm. As is apparent, the example dimensions provided are for the indicated features at the cross-section along line C-C (shown in FIG. **27**). Thus, in some implementations, the height E of the ramp **722** may be within the range of 57% to 75% of the height E of the passage **64**. Also, in some implementations, the height F of the ramp **708** may be within the range of 19% and 42% of the height E of the passage **64**. Again, though, the indicated ranges are illustrative only, and the heights D and E of the ramps **708** and **722**, respectively, relative to the height F of the passage **64** may be selected to be any desired amount.

(92) FIG. **28** shows another example lifting feature **800** disposed within the delivery passage **127** operable to lift the leading haptic **450** of IOL **70** over surface **726** of the optic **460**. In some implementations, the lifting feature **800** may be disposed in the passage **64** of the distal end portion **60**. For example, the lifting feature **800** may be attached to an upper surface (within the context of FIG. **29**). That is, in some instances, the lifting feature **800** may be attached to a surface of the passage **64** that is adjacent to the interior surface **530** of the door **90** (shown in FIG. **12**) and opposite the receiving surface **190** (shown in FIG. **6**). In the illustrated example, the lifting feature **800** is secured to an interior surface **802** of the passage **64**. The lifting feature **800** includes a base **804**, a pivoting portion **806**, and a hinge **808** connecting the pivoting portion **806** to the base **804**. Positions I through V shown in FIG. **28** illustrate folding of the leading haptic **450** as the IOL **70** is advanced through the passage **64** relative to the optic **460**.

(93) At position I, the pivoting portion **806** of the lifting feature **800** is shown in an initial, undisturbed configuration with the leading haptic **450** just beginning to engage the pivoting portion **806**. At position II, the leading haptic **450** is shown lifted in the direction of arrow **810** by an inclined surface **812** formed on the pivoting portion **806**. Additionally, the lifting feature **800** also causes displacement of the leading haptic **450** towards the optic **460**. In the context of advancement of the IOL **70**, movement of the leading haptic **450** towards the optic **460** means that the lifting feature **800** retards or slows advancement of the leading haptic **450** relative to the optic **460**, resulting in the relative movement of the leading haptic **450** towards the optic **460**.

(94) As a result of the engagement with the leading haptic **450**, the pivoting portion **806** is shown slightly deflected distally in a direction of arrow **814**. At position III, the leading haptic **450** is shown lifted to a maximum amount by the lifting feature **800** along with the pivoting portion **806** displaced to a greater extent distally. Position III also shows a leading edge **816** of the optic **460** positioned below the leading haptic **450** (in the context of the view shown in FIG. **28**). At position IV, the leading haptic **450** is shown folded over the surface **726** and the pivoting portion **806** is further folded distally. At position V, the leading haptic **450** is shown fully folded over the surface **726** of the optic **460**. The pivoting portion **806** is shown proximal of the leading haptic **450**. Consequently, as the IOL **70** is advanced, a point is reached where the pivoting portion **806** pivots about hinge **808** to permit the leading haptic **450** to distally pass the folding feature **800**. Thus, the folding feature **800** is operable to lift and fold the leading haptic **450** while also being operable to bend and permit the leading haptic **450** to distally move past the folding feature. As folding of the IOL **70** continues, the pivoting portion **806** remains bent about the hinge **808** to permit passage of the remainder of the IOL **70**.

(95) In some implementations, the inclined surface **812** may be a smooth surface. In other implementations, the inclined surface **812** may include a plurality of steps similar to the steps **716** shown in FIGS. **25** and **27**, for example.

(96) In some implementations, the folding feature **800** may be formed of a flexible material having a hardness less than a material forming the IOL **70**. Thus, the folding feature **800** is formed of a material that permits the IOL **70** to contact and slide against the folding feature **800** but prevent damage to the folding feature. However, in other implementations, the folding feature **800** may be formed of a material having a hardness that is greater that a material forming the IOL **70**. For example, the folding feature **800** may be designed so as to eliminate sharp edges to avoid damaging

the IOL **70** even though the material forming the folding feature **800** has a higher hardness than the material forming the IOL **70**.

(97) FIG. **29** illustrates another example lifting feature **900** disposed within the delivery passage **127** operable to lift the leading haptic **450** of IOL **70** over surface **726** of the optic **460**. In some implementations, the lifting feature **900** may be disposed in the passage **64** of the distal end portion **60**. For example, the lifting feature **900** may be attached to a lower surface (within the context of FIG. **29**). That is, in some instances, the lifting feature **900** may be attached to a surface of the passage **64** that is opposite to the interior surface **530** of the door **90** (shown in FIG. **12**) and adjacent the receiving surface **190** (shown in FIG. **6**). In the illustrated example, the lifting feature **900** is secured to an interior surface **902** of the passage **64**.

(98) The lifting feature **900** includes a base **904**, a pivoting portion **906**, and a hinge **908** connecting the pivoting portion **906** to the base **904**. The pivoting portion **906** has a "V" shape that defines a first inclined surface **910** and a second inclined surface **912**. The leading haptic **450** of the IOL **70** engages and slides along the first and second inclined surfaces **910** and **912** so as to lift the leading haptic **450** above (in the context of FIG. **32**) the surface **762** of the optic **460**.

(99) Positions I through III shown in FIG. **29** illustrate folding of the leading haptic **450** as the IOL **70** is advanced through the passage **64** relative to the optic **460**. At position I, the pivoting portion **906** of the lifting feature **900** is shown in an initial, undisturbed configuration with the leading haptic **450** just beginning to engage the pivoting portion **906**. At position II, the leading haptic **450** is partially folded and lifted in the direction of arrow **914** by the first and second inclined surfaces **910** and **912** formed on the pivoting portion **906**. As a result of the engagement with the leading haptic **450**, the pivoting portion **906** is shown deflected distally in a direction of arrow **916** relative to the base **904**, resulting in the inclined surface **912** forming a ramp that operates to further lift the leading haptic **450** above the top corner of the leading edge of the optic **760** (as viewed in the context of FIG. **29**). As is also illustrated at II, the lifting feature **900** also causes displacement of the leading haptic **450** towards the optic **460**. In the context of advancement of the IOL **70**, movement of the leading haptic **450** towards the optic **460** means that the lifting feature **900** retards or slows advancement of the leading haptic **450** relative to the optic **460**, resulting in the relative movement of the leading haptic **450** towards the optic **460**. At position III, the leading haptic **450** is shown lifted above and folded over the optic such that the leading haptic **450** is located adjacent to the surface **762** of the optic **460**. The folding feature **900** is shown on a side of the optic **460** opposite the leading haptic **450**.

(100) In some implementations, one or both of the inclined surfaces **910** and **912** may be a smooth surface. In other implementations, one or both of the inclined surfaces **910** and **912** may include a plurality of steps similar to the steps **716** shown in FIGS. **25** and **27**, for example.

(101) As the IOL **70** continues to advance along the passage **64**, the optic **460** presses against and slides over the folding feature **900** such that the pivoting portion **906** is further folded over. Similar to the folding feature **800**, the folding feature **900** may be formed of a flexible material having a hardness less than a material forming the IOL **70**. However, in other implementations, the folding feature **900** may be formed of a material having a hardness that is greater that a material forming the IOL **70**. Similar to the folding feature **800**, discussed above, in some instances, the folding feature **800** may be designed so as to eliminate sharp edges to avoid damaging the IOL **70** even though the material forming the folding feature **800** has a higher hardness than the material forming the IOL **70**. Thus, the folding feature **900** is formed of a material that permits the IOL **70** to contact and slide against the folding feature **900** but prevent damage to the folding feature.

(102) Advancement of the plunger **30** through the injector body **20** is discussed below with reference to FIGS. **1**, **6**, and **11**. In some instances, dimensional tolerances between the plunger **30** and the injector body **20** may permit relative movement between the plunger **30** and the injector body **20** such that the distal end portion **211** is able to move within bore **40** in the direction of arrows **471**, **472** (referred to hereinafter as "tolerance movement"). In instances, particularly those

in which the plunger **30** includes angled portion **212**, the plunger tip **220** normally remains in contact with the interior wall **298** even if the plunger **30** experiences tolerance movement as the plunger **30** advances through bore **40**. Thus, in some instances, notwithstanding any tolerance movement, the plunger tip **220** remains in contact with the interior wall **298**. Accordingly, the second tapered wall **303** directed and centers the plunger tip **220** into the opening **170**.

(103) If the plunger **30** experiences tolerance movement such that the plunger tip **220** no longer contacts the interior wall **298** of the bore **40**, the first tapered wall **301**, which includes the flexible wall portion **162**, directs and centers the plunger tip **220** into the opening **170** formed at the interface **172**, resulting in contact between the plunger tip **220** and the second tapered wall **303**. When the plunger **30** becomes fully engaged with the injector body **20**, the tolerance movement is substantially reduced or eliminated, ensuring that the plunger tip **220** remains engaged with the second tapered wall **303** and contoured ramp **180**. In some instances, full engagement between the plunger **30** and the injector body **20** occurs when the cantilevered members **292** are fully engaged with the interior wall **298** of the bore **40**. Consequently, in instances where tolerance movement may exist, upon full engagement between the plunger **30** and the injector body **20**, the flexible wall portion **162** no longer influences the position of the plunger **30**. In any case, once the plunger tip **220** advances through opening **170**, the flexible wall portion **162** no longer affects the directional path of plunger **30** nor any part thereof.

(104) As the plunger tip **220** is advanced through the compartment **80** in sliding contact with the receiving surface **190**, the first groove **500** of the plunger tip **220** is positioned to engage the trailing haptic of IOL, such as trailing haptic **450** of IOL **70**, as shown in FIG. **6**. As the plunger tip **220** is further advanced, the plunger tip **220** encounters the contoured ramp **180** and is forced vertically towards the door **90**. This vertical displacement of the plunger tip **220**, while remaining in contact with the receiving surface **190**, both folds the trailing haptic up over the optic of the IOL as well as align the second groove **510** of the plunger tip **220** with a trailing edge of the haptic. Particularly, the surface **502** of the plunger tip **220** contacts and displaces the haptic **450** as the plunger tip **220** is passed along the contoured surface **180**, thereby folding the trailing haptic **450**. As the trailing haptic **450** folds, the contoured surface **192** and wall **194** work in concert to both locate the freely extending end **452** of the trailing haptic **450** above and over the optic **460**. The profile of the contoured surface **192** operates to lift the trailing haptic **450** as the plunger tip **220** is displaced towards the distal end portion **60** of the injector body **20**. The wall **194** constrains lateral movement of the freely extending end **452** of the trailing haptic **450**, which cause the haptic to move distally relative to the optic **460**. Consequently, the trailing haptic **450** is both raised above and folded over the optic **460** as the plunger tip **220** contacts the trailing haptic **450** and follows along the contoured ramp **180**. As the plunger tip **220** is further advanced, the second groove **510** accepts the trailing edge of the optic **460**, and the plunger tip **220** is displaced vertically away from the door **90** due to a combination of influences from both the decreasing slope of the contoured ramp **180** and the angled portion **212** of the plunger rod **210**. Movement of the plunger tip **220** in the manner described provides for improved engagement and folding of the IOL **70**.

(105) FIG. **13** is a detail view of a portion of the distal end portion **60** of the injector body **20**. The distal end portion **60** includes a tapered portion **62** and the insertion depth guard **140**. The distal end **265** of the biasing element **260** may engage the proximal end **50** of the injector body **20** to define a pause location of the folded or partially folded IOL. The nozzle **120** may include a demarcation **1900** that provides a visual indication of the pause position. For example, in the example shown in FIG. **13**, the demarcation **1900** is a narrow ridge or line that encircles all or a portion of the distal end portion **60**. In some instances, the demarcation **1900** may be disposed between the tapered portion **62** and the insertion depth guard **140**. At least a portion of the injector body **20** may be formed form a transparent or semi-transparent material that permits a user to see an IOL within the injector body **20**. Particularly, the distal end portion **60** of the injector body **20** may be formed from a transparent material to permit observation of the IOL as it is moved therethrough by the plunger

30.

(106) FIG. **14** shows a view of the distal end portion **60** of the IOL injector **10** with IOL **70** located therein at a pause position. As shown in FIG. **14**, the pause position of the IOL may be defined as a location where the distal edge **462** of optic **460** of the IOL **70** substantially aligns with the demarcation **1900**. A haptic **450** or a portion thereof may extend beyond the demarcation **1900**. Again, the pause position may also correspond to the initial engagement of the distal end **265** of the biasing element **260** with the proximal end **50** of the injector body **20**. Therefore, the pause location may be jointly indicated by positioning of the IOL, or part thereof, relative to the demarcation **1900** and the initial contact between the distal end **265** of the biasing element **260**.

(107) In other instances, a location of the IOL relative to the distal opening **12** of the nozzle **120** when the distal end **265** of the biasing element **260** contacts the proximal end **50** of the injector body **20** may vary. In some instances, the IOL may be partially ejected from the distal opening **125** when the distal end **265** of the biasing element **260** contacts the proximal end **50** of the injector body **20**. For example, in some instances, approximately half of the IOL may be ejected from the distal opening **125** when the distal end **265** of the biasing element **260** contacts the proximal end **50** of the injector body **20**. In other instances, the IOL may be contained wholly within the IOL injector when the distal end **265** of the biasing element **260** contacts the proximal end **50** of the injector body **20**.

(108) FIG. **15** shows a cross sectional view of the opening **170** formed at the interface **172**. In some instances, the opening **170** may define a “T” shape. The plunger tip **220** is shown disposed at the opening **170** with the flexible wall portion **162** contacting a surface **214** the plunger rod **210**. In some instances, the cross section of the plunger rod **210** increases towards the proximal end of the plunger rod **210**. Thus, as the plunger rod **210** is advanced through the opening **170**, the plunger rod **210** fills the opening as a result of the increasing cross section. Portions **173** and **175** of the opening **170** are filled by flanges **213**, **215** (shown in FIG. **9**).

(109) As the opening **170** is filled by the increasing cross section of the plunger rod **210** as the plunger rod **210** is advanced distally through the injector body **20**, the flexible wall portion **162** is flexed in the direction of arrow **471** to permit passage of the plunger rod **210**, as shown in FIG. **16**. Further, as a result of the angled portion **212** of the plunger rod **210**, the contoured ramp **180**, and the folding of IOL **70** as it is advanced through the IOL injector **10**, the plunger tip **220** is made to follow a defined path through the compartment **80**, the distal end portion **60**, and nozzle **120** uninfluenced by the flexible wall portion **162**.

(110) FIG. **16** shows the flexible wall portion **162** being flexed in the direction of **471** as the plunger rod **210** continues to advance distally through the IOL injector **10**. Further, FIG. **16** also shows the plunger tip **220** engaged with IOL **70** such that trailing haptic **450** is received into the first groove **500** at a location offset from the second groove **510**, and the proximal edge of the optic **460** is received into the second groove **510**.

(111) As the IOL **70** is advanced through the passage **64** of the distal end portion **60**, the IOL **70** is folded into a reduced size to permit passage of the IOL **70** through the nozzle **120** and into the eye. During folding of the IOL **70**, a resistive force on the plunger **30** is increased. Once the IOL **70** is fully folded **70**, the resistive force on the plunger **30** generally reduces.

(112) A wound may be formed in the eye. The wound may be sized to accommodate the nozzle **120** of the IOL injector **10**. The nozzle **120** may be inserted into the wound. The nozzle **120** may be advanced through the wound until the flanged surface **150** of the insertion depth guard **140** abuts the exterior surface of the eye. Contact between the insertion depth guard **140** and the exterior surface of the eye limits the depth to which the nozzle **120** may be inserted into the eye, preventing unnecessary stress on the edges of the wound as well as preventing enlargement of the wound due to over insertion of the IOL injector **10**. Consequently, the insertion depth guard **140** operates to reduce additional trauma to the eye and enlargement of the wound.

(113) With the nozzle properly positioned within the eye through the wound, the user may

complete delivery of the folded IOL into the eye. Referring to FIG. **2**, as advancement of the plunger **30** continues, the biasing element **260** is compressed. Compression of biasing element **260** increases a resistive force to advancement of the plunger **30**, also referred to as plunging force. This additional resistance to advancement of the plunger **30** diminishes changes to the plunging force associated with the folding of the IOL prior to insertion into the eye. Further, in some instances, the biasing element **260** may be made to contact the injector body **120** when, or proximate to when, the IOL **70** has fully folded so that the a reduction in resistive force that may result from the IOL **70** being fully folded may be offset by the compression of the biasing element **260**. This increase in resistive force provided by compression of the biasing element **260**, particularly in light of a reduction that may result due to the IOL **70** being fully folded, provides improved tactile feedback to a user, such as a medical profession, during delivery of the IOL **70** into an eye. This improved tactical feedback provides the user with improved control during delivery of the IOL **70**, which may prevent rapid expulsion of the IOL **70** into the eye.
(114) As a result, the user is able to provide a smooth application of force without experiencing any sudden or rapid changes in advancement of the plunger **30**. Such sudden or rapid changes may result in the IOL being rapidly expelled from an injector. Rapid expulsion of an IOL into an eye may cause damage, such as perforation of the capsular bag. Such damage may increase the time required to compete the surgical procedure and may increase the harm caused immediately and post operatively to the patient. Upon insertion of the IOL into the eye, the IOL injector **10** may be withdrawn from the eye.
(115) Although the disclosure provides numerous examples, the scope of the present disclosure is not so limited. Rather, a wide range of modification, change, and substitution is contemplated in the foregoing disclosure. It is understood that such variations may be made to the foregoing without departing from the scope of the present disclosure.

Claims

1. An intraocular lens (IOL) injector, comprising: an injector body, comprising: a bore defined by an interior wall, wherein the bore is configured to facilitate intraocular lens advancement through the injector body; a longitudinal axis extending centrally along the injector body; a plunger slideable within the injector body for pushing the IOL through the bore; and a lifting feature extending from the interior wall and configured to engage a leading haptic of the IOL, the lifting feature comprising: a base fixedly secured to the interior wall; a pivoting portion; and a hinge connecting the pivoting portion to the base, wherein the pivoting portion defines a first inclined surface and a second inclined surface for lifting the leading haptic of the IOL above an optic surface of the IOL as the IOL is advanced through the bore.
2. The IOL injector of claim 1, wherein the lifting feature is disposed in a distal end portion of the injector body.
3. The IOL injector of claim 1, wherein the lifting feature is configured such that the pivoting portion is deflected distally relative to the base upon engagement with the leading haptic of the IOL.
4. The IOL injector of claim 1, wherein one or both of the first and second inclined surfaces of the pivoting portion of the lifting feature comprises a plurality of steps.
5. The IOL injector of claim 1, wherein the lifting feature is formed of a flexible material having a hardness less than a material of the IOL.
6. The IOL injector of claim 1, wherein the lifting feature is formed of a material having a hardness greater than a material of the IOL.
7. The IOL injector of claim 1, wherein the plunger comprises a plunger tip configured to remain in contact with the interior wall of the injector body while being advanced through the injector body.
8. The IOL injector of claim 7, wherein the plunger tip comprises a first groove positioned to

engage a trailing haptic of the IOL as the plunger tip is advanced through the injector body.
9. The IOL injector of claim 8, wherein the plunger tip is further configured to fold the trailing haptic over the optic surface of the IOL as the plunger tip is advanced along the pivoting portion of the lifting feature.
10. An intraocular lens (IOL) injector, comprising: an injector body, comprising: a bore defined by an interior wall, wherein the bore is configured to facilitate intraocular lens advancement through the injector body; a longitudinal axis extending centrally along the injector body; a distal end portion comprising a plurality of sidewalls, the plurality of sidewalls defining a passage in fluid communication with the bore; a plunger slideable within the bore; and a lifting feature extending from at least one of the plurality of sidewalls of the distal end portion and configured to engage a leading haptic of the IOL, the lifting feature comprising: a base fixedly secured to the at least one of the plurality of sidewalls; a pivoting portion; and a hinge connecting the pivoting portion to the base, wherein the pivoting portion defines a first inclined surface and a second inclined surface for lifting the leading haptic of the IOL above an optic surface of the IOL as the IOL is advanced through the distal end portion.
11. The IOL injector of claim 10, wherein the lifting feature is configured such that the pivoting portion is deflected distally relative to the base upon engagement with the leading haptic of the IOL.
12. The IOL injector of claim 10, wherein one or both of the first and second inclined surfaces of the pivoting portion of the lifting feature comprises a plurality of steps.
13. The IOL injector of claim 10, wherein the lifting feature is formed of a flexible material having a hardness less than a material of the IOL.
14. The IOL injector of claim 10, wherein the lifting feature is formed of a material having a hardness greater than a material of the IOL.
15. The IOL injector of claim 10, wherein the plunger comprises a plunger tip configured to remain in contact with the interior wall of the injector body while being advanced through the injector body.
16. The IOL injector of claim 15, wherein the plunger tip comprises a first groove positioned to engage a trailing haptic of the IOL as the plunger tip is advanced through the injector body.
17. The IOL injector of claim 16, wherein the plunger tip is further configured to fold the trailing haptic over the optic surface of the IOL as the plunger tip is advanced along the pivoting portion of the lifting feature.
18. An intraocular lens (IOL) injector, comprising: an injector body, comprising: a bore defined by an interior wall; a distal end portion comprising a plurality of sidewalls, the plurality of sidewalls defining a passage in fluid communication with the bore; a plunger slideable within the bore, the plunger comprising a plunger tip configured to remain in contact with the interior wall of the injector body while being advanced through the injector body; and a lifting feature extending from the passage of the distal end portion and configured to engage a leading haptic of the IOL, the lifting feature comprising: a base fixedly secured to the passage; a pivoting portion; and a hinge connecting the pivoting portion to the base, wherein the pivoting portion defines a first inclined surface and a second inclined surface for lifting the leading haptic of the IOL above an optic surface of the IOL as the IOL is advanced through the distal end portion.
19. The IOL injector of claim 18, wherein the pivoting portion is deflected distally relative to the base upon engagement with the leading haptic of the IOL.
20. The IOL injector of claim 18, wherein one or both of the first and second inclined surfaces of the pivoting portion of the lifting feature include a plurality of steps.