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(54) **INTEGRATED SENSOR AND LENS ASSEMBLY WITH DIFFERENTIAL THREADS ADJUSTMENT**

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USPC 396/298, 533; 359/827, 829; 348/340
See application file for complete search history.

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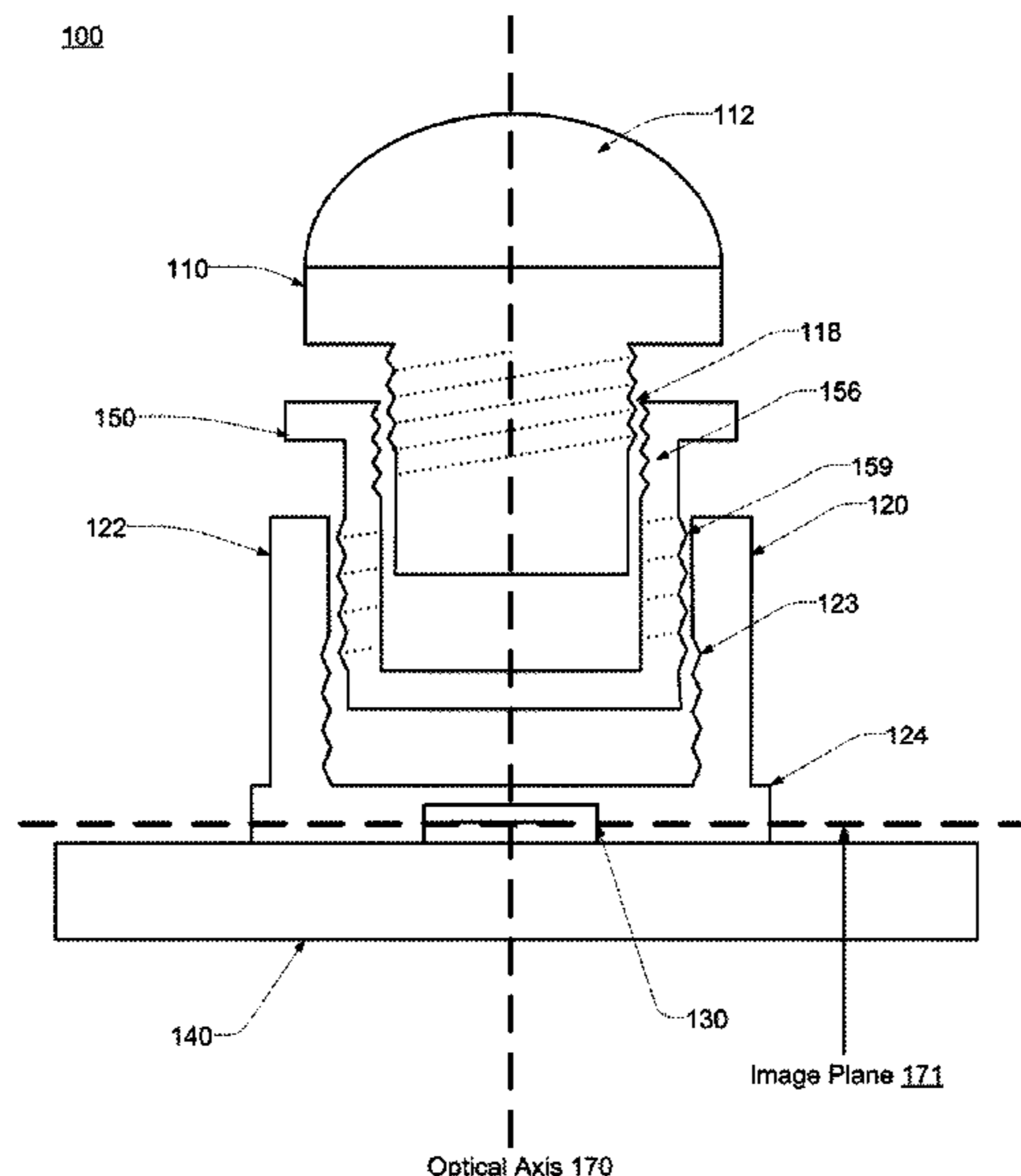
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(57) **ABSTRACT**

An integrated image sensor and lens assembly comprises a lens barrel, an adapter tube, and a lens mount. The lens mount includes a first thread having a first pitch and the tube adapter comprises a second thread reciprocal to the first thread. The first and second threads secure the tube adapter within the lens mount. The tube adapter further comprises a third thread having a second pitch different than the first pitch, and the lens barrel comprises a fourth thread reciprocal to the third thread. The third and fourth threads secure the lens barrel within the tube adapter. A rotation of the tube adapter with respect to the lens barrel and the lens mount causes linear movement of the lens barrel and the lens mount with respect to the tube adapter in a same direction along the optical axis.

20 Claims, 6 Drawing Sheets



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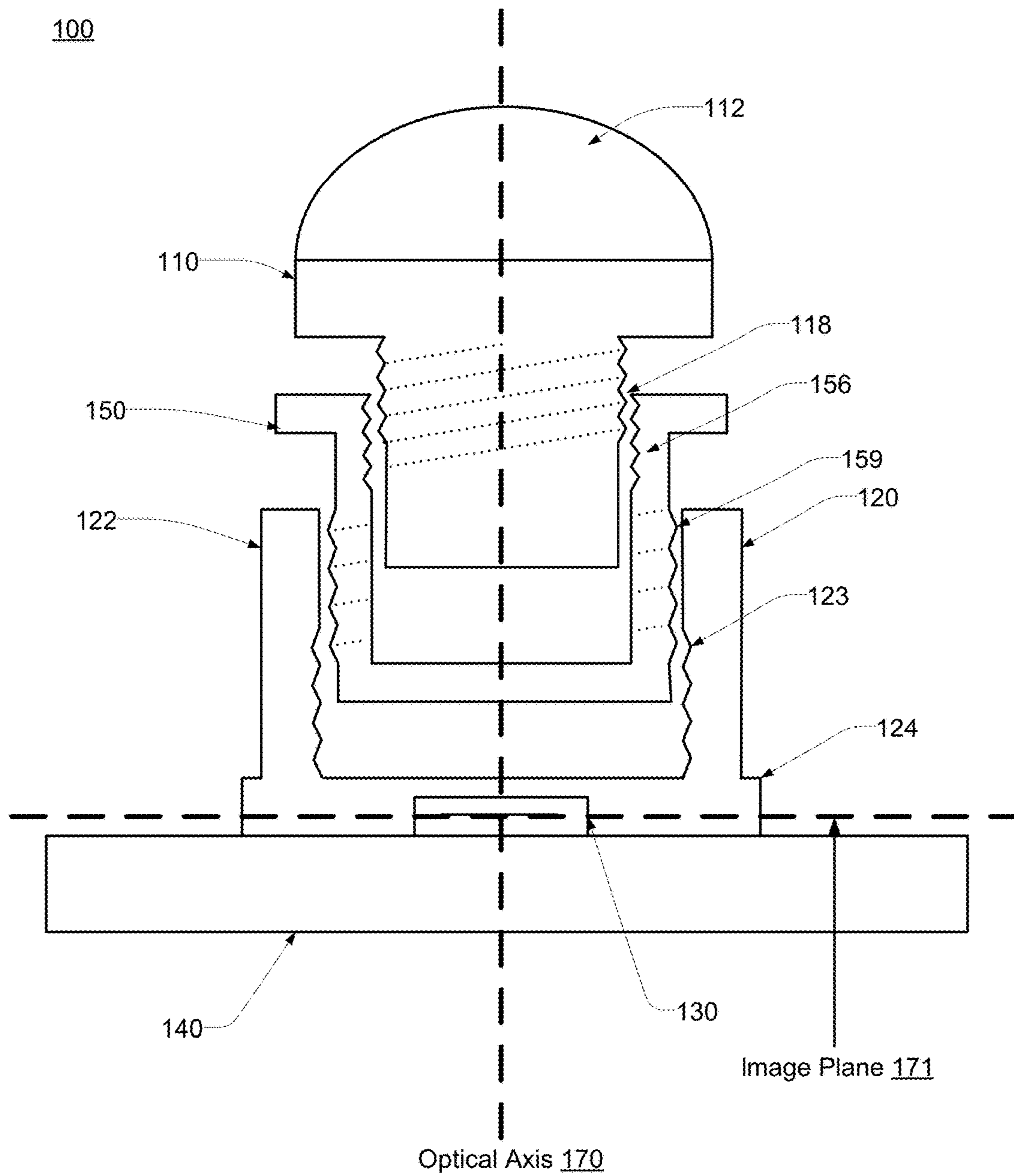


FIG. 1

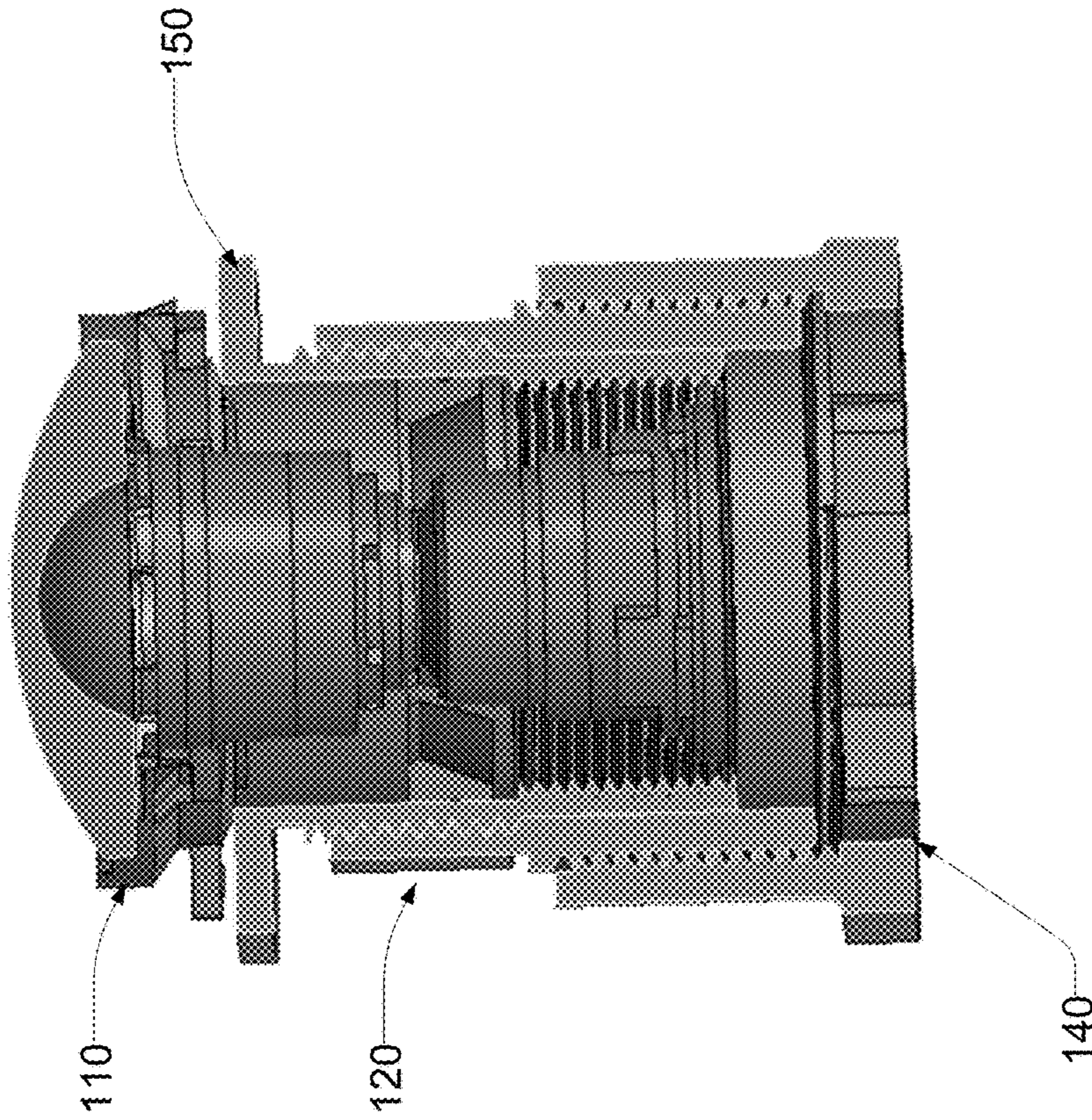


FIG. 2B

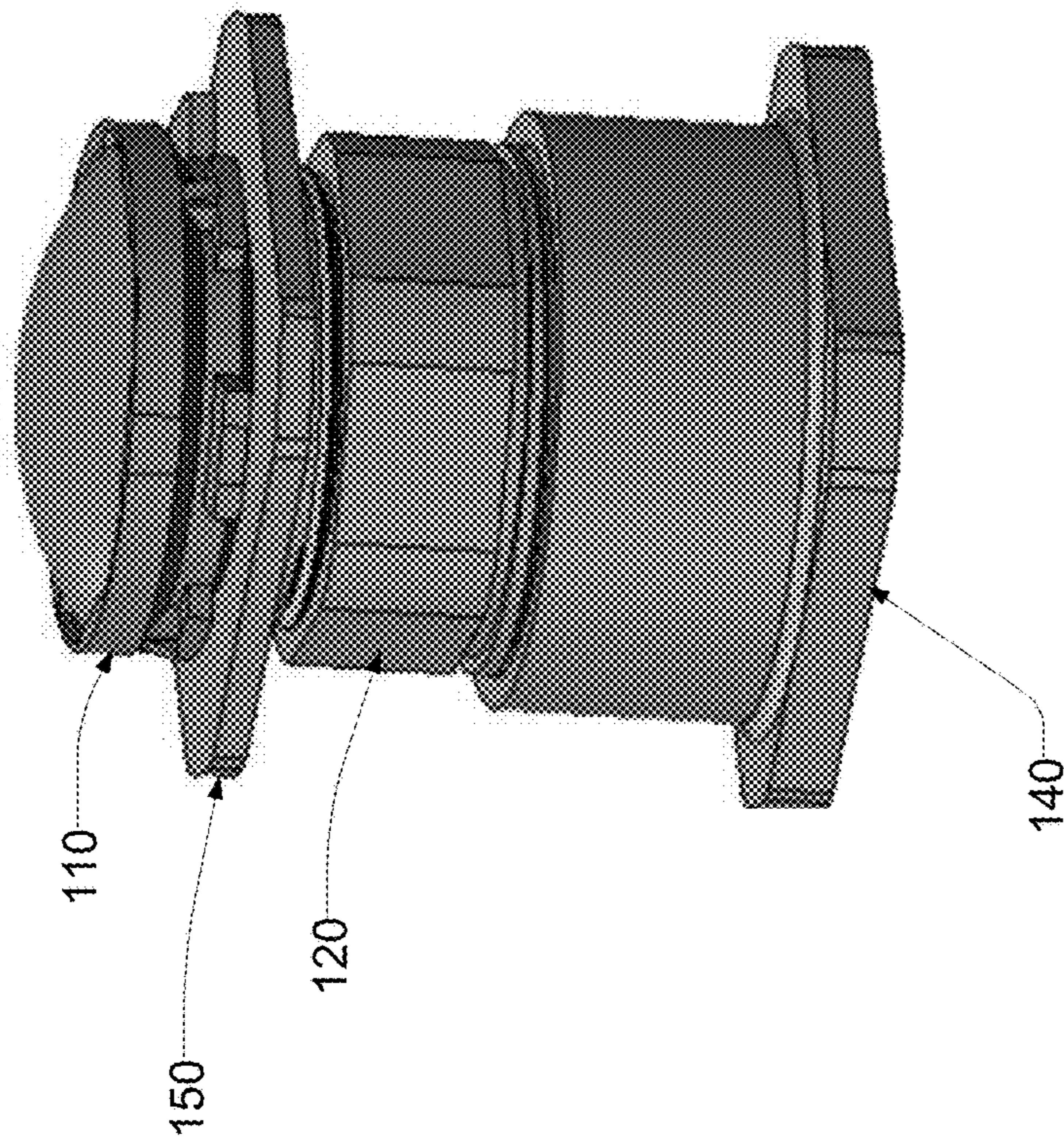


FIG. 2A

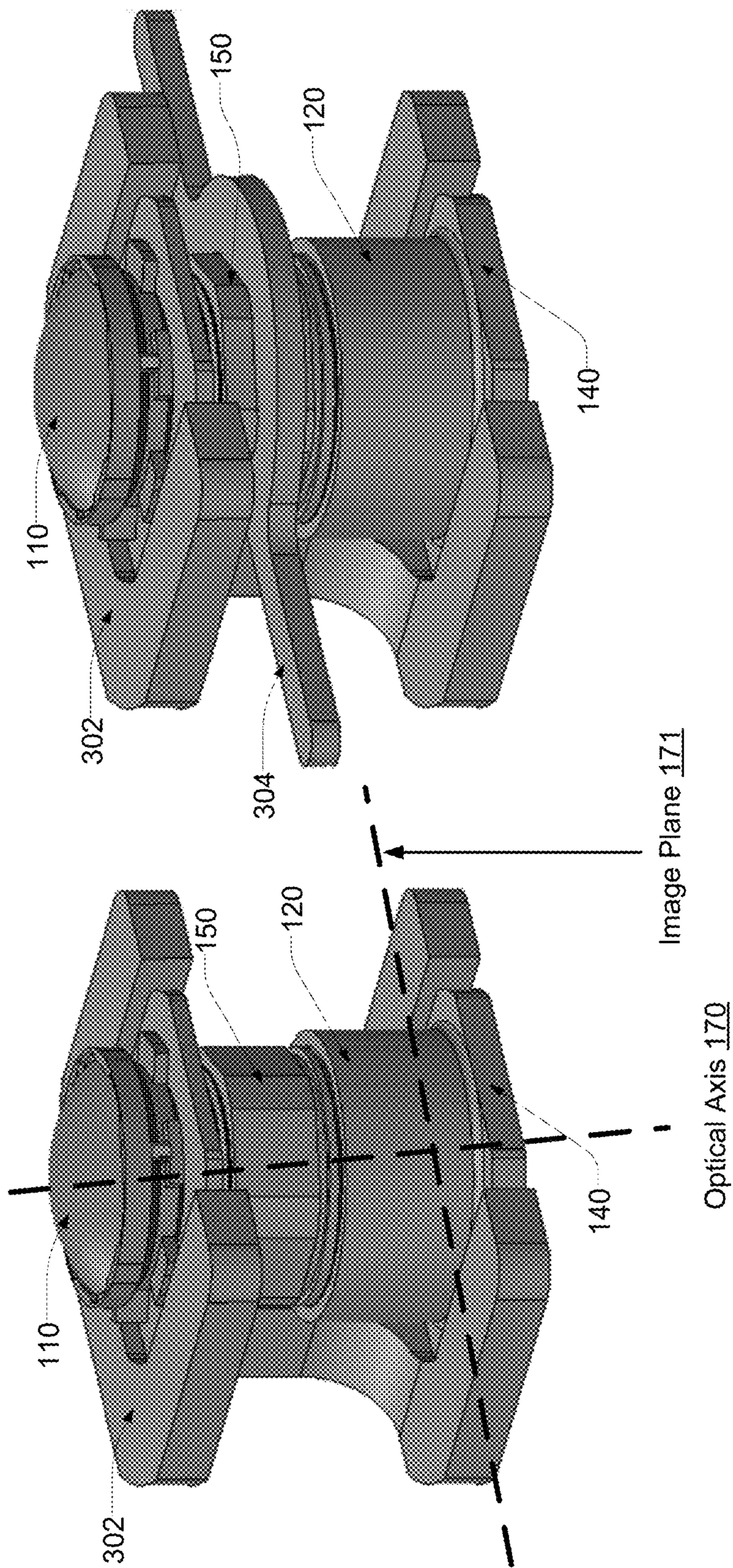


FIG. 3B

FIG. 3A

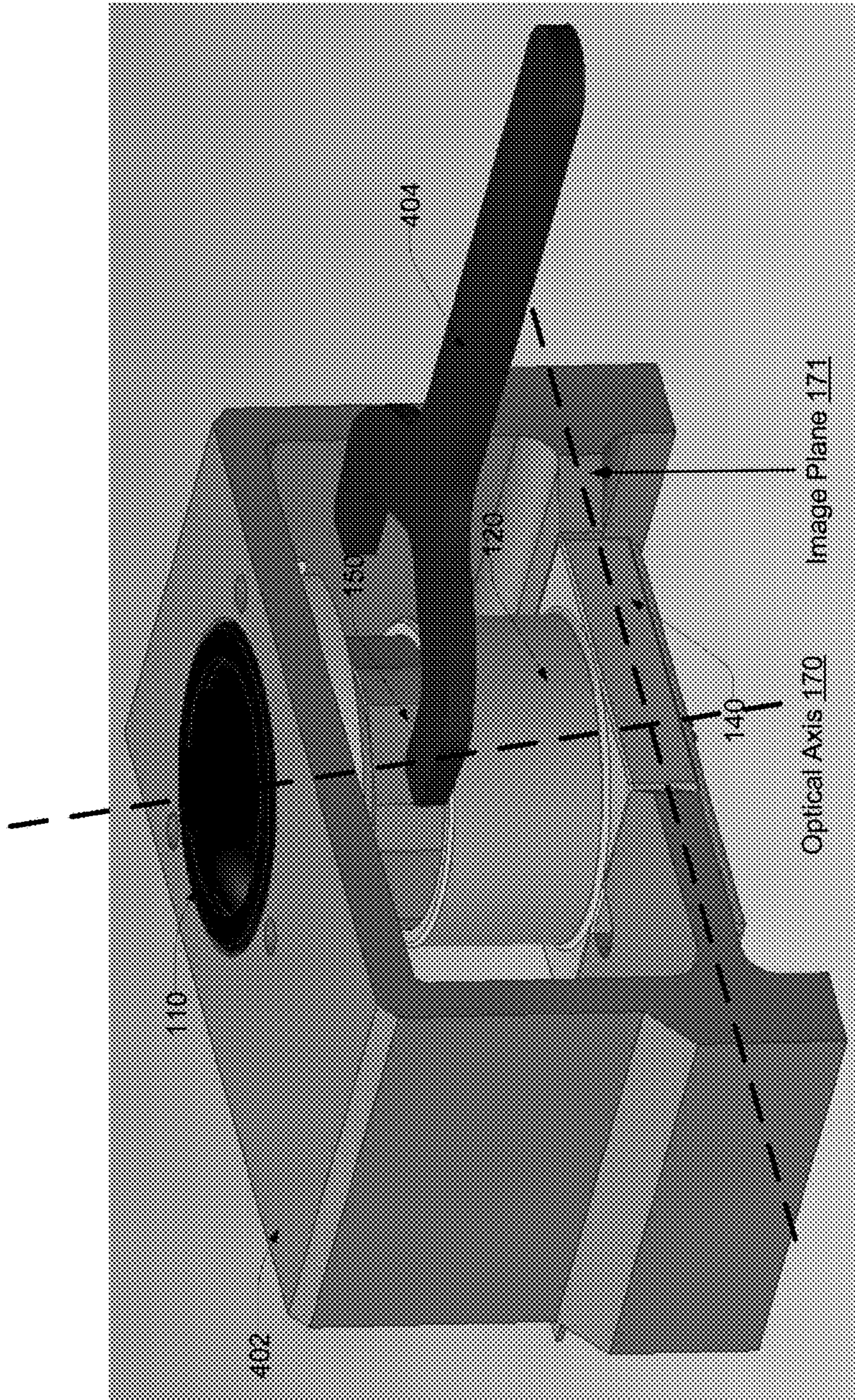


FIG. 4A

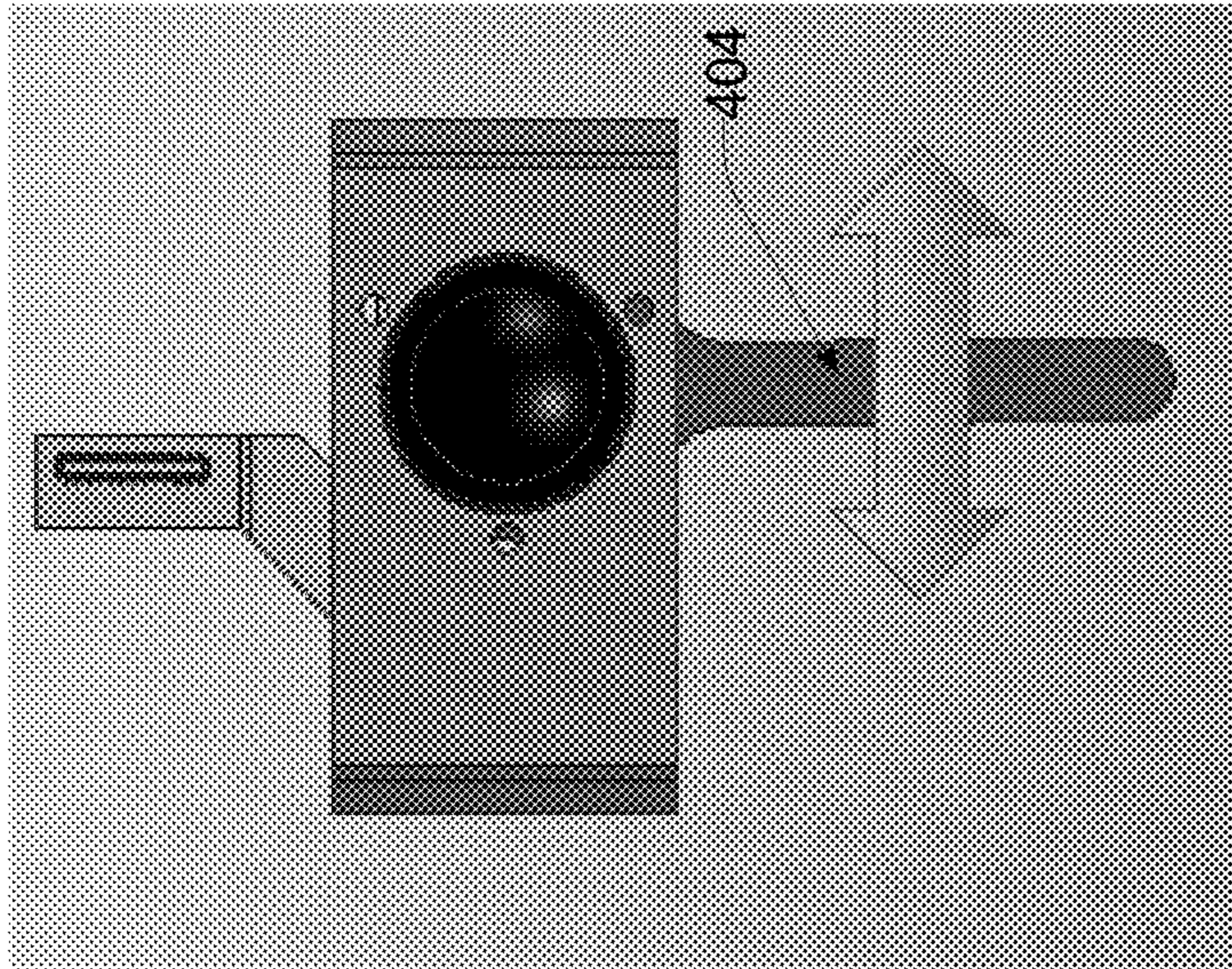


FIG. 4B

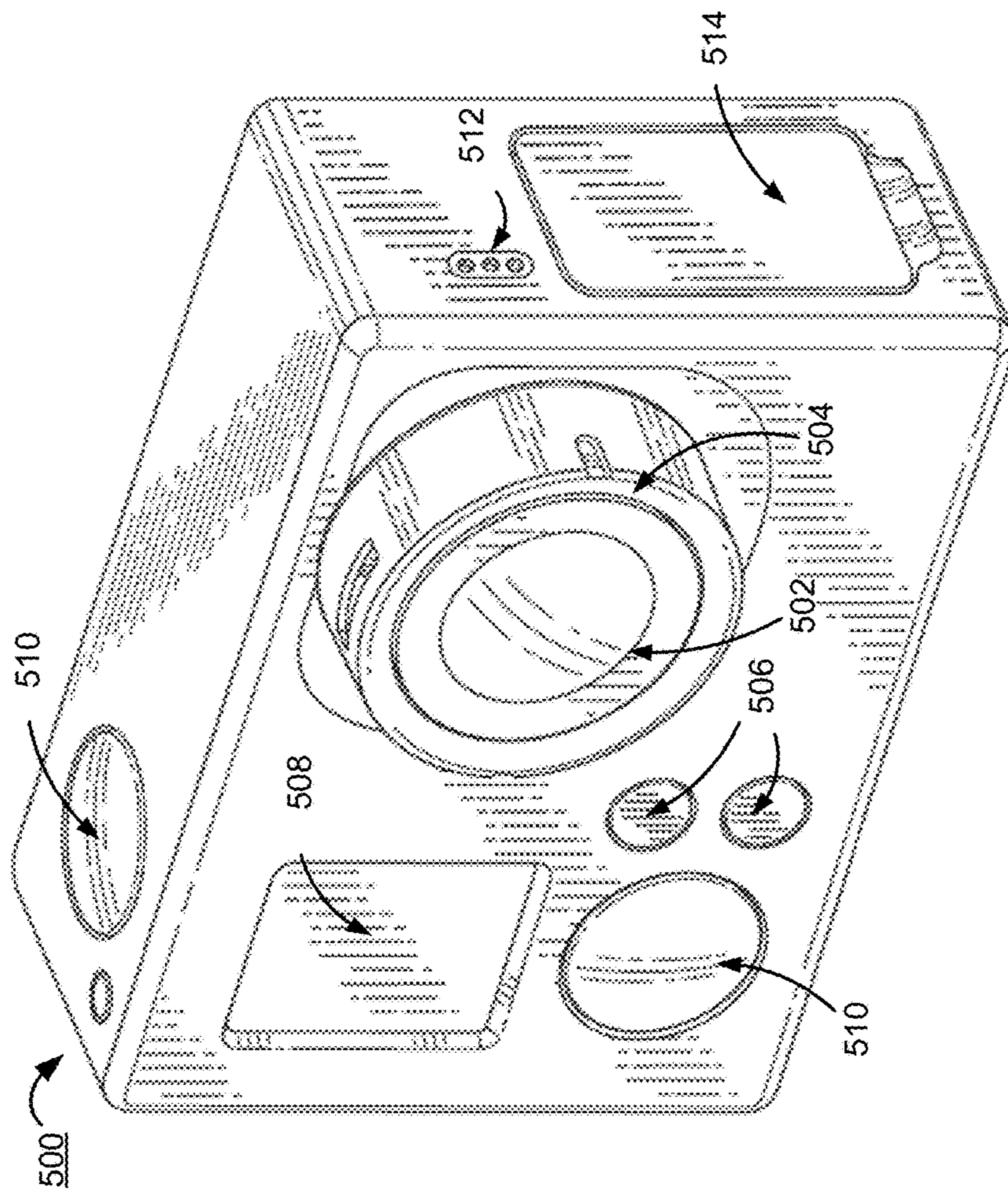


FIG. 5

**INTEGRATED SENSOR AND LENS
ASSEMBLY WITH DIFFERENTIAL
THREADS ADJUSTMENT**

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

*CROSS-REFERENCE TO RELATED
APPLICATIONS*

This application is a reissue of U.S. application Ser. No. 14/938,725, filed on Nov. 11, 2015, now U.S. Pat. No. 10,116,853, issued on Oct. 30, 2018, the entire disclosure of which is hereby incorporated by reference.

BACKGROUND

Manufacturing of lens assemblies for high-resolution cameras typically require a high degree of precision in positioning components of the lens assembly to ensure that the lens will achieve proper focus. As a result, a challenge exists in achieving a fast, automated, and high-yielding assembly process for high-resolution cameras.

In a conventional manufacturing process, a lens barrel housing the camera lens is placed within a housing assembly affixed to an image sensor. The position of the lens barrel is adjusted relative to the image sensor such that the focal plane of the lens aligns with the image plane of the image sensor. Upon tuning the lens barrel's position and alignment for optical focal length and axial tilt, dimensional shifts of the lens barrel may be introduced such as by post curing and cycling tests or by thermal changes following alignment. The lens may shift along the optical axis and the optical axis may tilt as a result of the lens barrel shifting, which alters the distance between the lens and the image sensor. This affects focus of the lenses and compromises performance and yield.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a cross-sectional view of an embodiment of an integrated image sensor and lens assembly.

FIG. 2A illustrates a perspective view of an embodiment of a lens barrel, an adapter tube, a lens mount, and an image sensor substrate, as assembled.

FIG. 2B illustrates a cross-sectional view of an embodiment of a lens barrel, an adapter tube, a lens mount, and an image sensor substrate, as assembled.

FIG. 3A illustrates an embodiment of a stand and wrench for adjusting the focal length of an integrated image sensor and lens assembly.

FIG. 3B illustrates an embodiment of a stand and wrench for adjusting the focal length of an integrated image sensor and lens assembly.

FIG. 4A illustrates a perspective view of an embodiment of a stand and wrench for adjusting the focal length of an integrated image sensor and lens assembly.

FIG. 4B illustrates a top view of an embodiment of a stand and wrench for adjusting the focal length of an integrated image sensor and lens assembly.

FIG. 5 illustrates an embodiment of an example camera that includes the integrated image sensor and lens assembly.

DETAILED DESCRIPTION

The figures and the following description relate to preferred embodiments by way of illustration only. It should be

noted that from the following discussion, alternative embodiments of the structures and methods disclosed herein will be readily recognized as viable alternatives that may be employed without departing from the principles of what is claimed.

Reference will now be made in detail to several embodiments, examples of which are illustrated in the accompanying figures. It is noted that wherever practicable similar or like reference numbers may be used in the figures and may indicate similar or like functionality. The figures depict embodiments of the disclosed system (or method) for purposes of illustration only. One skilled in the art will readily recognize from the following description that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles described herein.

An integrated image sensor and lens assembly comprises a lens barrel, an adapter tube, and a lens mount. The lens barrel is coupled to the adapter tube which is coupled to the lens mount. The lens barrel houses a set of lenses for directing light to the image sensor. The lens mount is affixed to the image sensor substrate. The lens mount includes a tube portion and a base portion. The tube portion has a channel and extends from the base portion in a direction of an optical axis substantially perpendicular to a focal plane. The tube adapter includes a body extending into a channel of the tube portion of the lens mount, and the lens barrel includes a threaded portion extending into the body of the tube adapter. In some embodiments, the lens mount includes a first thread having a first pitch forming a spiral on an inner surface of the tube portion. The tube adapter comprises a second thread on an exterior surface of the tube adapter. The second thread is reciprocal to the first thread and has the first pitch. The first and second threads secure the tube adapter within the lens mount. The tube adapter further comprises a third thread having a second pitch different than the first pitch. The third thread forms a spiral on an interior surface of the tube adapter. The lens barrel comprises a fourth thread on an exterior surface of the lens barrel reciprocal to the third thread and has the second pitch. The third and fourth threads secure the lens barrel within the tube adapter. A rotation of the tube adapter with respect to the lens barrel and the lens mount causes linear movement of the lens barrel and the lens mount with respect to the tube adapter in a same direction along the optical axis.

A magnitude of a difference between the first pitch and the second pitch is smaller than the first pitch and the second pitch. A single rotation of the of the tube adapter with respect to the lens barrel and the lens mount causes a change in focal length less than the first pitch and less than the second pitch.

FIG. 1 illustrates a cross-sectional view of an embodiment of an integrated image sensor and lens assembly 100 that includes a camera lens barrel 110, a camera lens mount 120, an adapter tube 150, and an image sensor substrate 140. The example illustrated in FIG. 1 is an exploded view with parts separated for clarity of description. One of ordinary skill in the art would appreciate that the parts, as illustrated, may not be to scale relative to each other. The image sensor substrate 140 has an image sensor assembly 130 (e.g., a high-definition image sensor) for capturing images and/or videos. The image sensor substrate 140 comprises a printed circuit board for mounting the image sensor assembly 130 and may furthermore include various electronic components that operate with the image sensor assembly 130 or provide external connections to other components of the camera system. The image sensor assembly 130 houses an image sensor (e.g., a high-definition image sensor) for capturing

images and/or video and includes structural elements for physically coupling the image sensor assembly 130 to the image sensor substrate 140 and to the camera lens mount 120. The image sensor of the image sensor assembly 130 lies on an image plane 171 for optimal focus.

The camera lens mount 120 is physically affixed to the image sensor substrate 140 and secured to the adapter tube 150 via a first threaded securing mechanism. The adapter tube 150 is further secured to the camera lens barrel 110 via a second threaded securing mechanism. The lens barrel 110 includes a lens window 112 includes optical components to enable external light to enter the lens barrel 110 and be directed to the image sensor assembly 130. In an embodiment, the bottom of the adapter tube 150 is ring shaped and has an opening that allows rays of lights to pass through to the image sensor assembly 130.

The lens barrel 110 comprises one or more lenses (e.g., a compound lens) or other optical components to direct light to the image sensor assembly 130. The lens barrel 110 comprises a threaded or at least partially threaded portion that is substantially cylindrical and structured to at least partially extend into a substantially cylindrical opening of the adapter tube 150 and mate with a reciprocally threaded interior portion of the adapter tube 150. For example, in one embodiment, the lens barrel 110 includes threads 118 that form a spiral extending from the outer surface of the threaded portion of the lens barrel 110. In FIG. 1, the threads 118 are illustrated with dotted lines to indicate that they are on the outer surface of the lens barrel 110 and do not form part of the cross-sectional view. The adapter tube 150 includes threads 156 that form a spiral indentation on its inner surface. The threads 118, 156 of the lens barrel 110 and of the adapter tube 150 respectively are configured to mate with each other such that the lens barrel 110 may be fastened to the adapter tube 150 in a tunable arrangement with respect to each other to enable the vertical position of the lens barrel 110 within the adapter tube 150 to be vertically adjusted. For example, the lens barrel 110 can be rotated in a first direction to lower the lens barrel 110 with respect to a bottom edge of the adapter tube 150 and can be rotated in a second direction to raise the lens barrel 110 with respect to the bottom edge of the adapter tube 150. In an alternative embodiment, the threads 118 on the lens barrel 110 may be formed as an indentation on the outer surface of the threaded portion of the lens barrel 110 and the threads 156 may be formed extended from the inner surface of the adapter tube 150.

In the illustrated example, the threads 118 are on the upper subsection of the cylindrical portion of the lens barrel 110 and the threads 156 are on the upper subsection of the adapter tube 150. In other embodiments, the threads 118 may be throughout the entire cylindrical portion or a different portion 116 of the lens barrel 110 and the threads 156 may be throughout the entire inner surface or a different portion of the adapter tube 150.

The adapter tube 150 furthermore includes threads 159 forming a spiral extending from its outer surface. The threads 159 are illustrated with dotted lines to indicate that they are on the outer surface of the adapter tube 150 and not part of the cross-sectional view. The threads 159 are configured to mate with reciprocal threads 123 formed by an indentation on an inner surface of a tube portion 122 of the lens mount 120 so that the vertical positions of the adapter tube 150 and lens mount 120 are tunable with respect to each other. For example, the adapter tube 150 can be rotated in a first direction to lower the adapter tube 150 with respect to a base portion 124 of the lens mount 120 and can be rotated in a second direction to raise the adapter tube 150 with

respect to the base portion 124 of the lens mount 120. In an alternative embodiment, the threads 159 of the adapter tube 150 may be formed as an indentation on the outer surface of the adapter tube 150 and the threads 123 may be formed extended from the inner surface of the tube portion 122 of the lens mount 120.

In the illustrated example, the threads 159 are on the lower subsection of the adapter tube 150 and the threads 123 are on the lower subsection of the tube portion 122 of the lens mount 120. In other embodiments, the threads 159 may be throughout the entire outer surface or a different portion of the adapter tube 150 and the threads 123 may be throughout the entire tube portion 122 or a different portion of the lens mount 120. In a further embodiment, the threads 159 are on the upper subsection of the tube adapter 150 and the threads 123 are on the upper subsection of the tube portion 122 of the lens mount 120.

The base portion 124 of the lens mount includes a bottom surface in a plane substantially parallel to a surface of the image sensor substrate 140. In one embodiment, the base portion 124 may include a recess (not viewable in FIG. 1) to enable the bottom surface of the base portion 124 to lie flat against the image sensor substrate 140 while partially enclosing the image sensor assembly 130. The tube portion 122 of the lens mount 120 extends away from the image sensor assembly 130 along the optical axis 170 and includes a substantially cylindrical channel for receiving the lens adapter 150.

The first set of threads 118, 156 securing the lens barrel 110 to the adapter tube 150 and the second set of threads 159, 123 securing the adapter tube 150 to the camera lens mount 120 are configured to cause the lens barrel 110 and the lens mount 120 to move in the same direction along the optical axis 170 in response to a rotation of the adapter tube 150 with respect to both the lens barrel 110 and the lens mount 120. Thus, for example, a rotation of the adapter tube 150 about the optical axis 170 in a first direction with respect to the lens mount 120 and the lens barrel 110 (which may be prevented from rotating with respect to each other) causes the lens barrel 110 to be pushed away from the adapter tube 150 and causes the lens mount 120 to be pulled towards the adapter tube 150. Similarly, a rotation of the adapter tube 150 about the optical axis 170 in a second direction with respect to the lens mount 120 and the lens barrel 110 (which may be prevented from rotating with respect to each other) causes the lens barrel 110 to be pulled toward the adapter tube 150 and causes the lens mount 120 to be pushed away from the adapter tube 150. The overall change in focal length is determined by the difference between the distance the lens barrel 110 moves with respect to the adapter tube 150 and the distance the lens mount 120 moves with respect to the adapter tube 150. These distances are in turn dictated by the respective pitches of the first set of threads 118, 156 securing the lens barrel 110 to the adapter tube 150 and the second set of threads 159, 123 securing the adapter tube 150 to the camera lens mount 120.

Using the differential threading mechanism described above, very fine adjustments can be made to the focal length that is not limited by the pitch of the threads 118, 156, or the threads 123, 159. This beneficially enables the integrated sensor and lens assembly 100 to achieve similar or better levels of precision with coarser threads than assemblies having non-differential threading. Such coarser threading is desirable because very fine pitched threads can be very weak and easy to damage, especially for plastic material parts.

For example, in one embodiment, the threads 118 of the lens barrel 110 and the threads 156 of the tube adapter 150

have a first pitch of 0.53 mm such that the position of the lens barrel **110** along the optical axis **170** can be adjusted relative to the tube adapter **150** at a rate ± 0.53 mm per turn of the adapter tube **150** relative to the lens barrel **110**. The threads **159** on the outer surface of the adapter tube **150** and the threads **123** on the inner surface of the tube portion **122** of the lens mount **120** have a second pitch of 0.50 mm such that the position of the lens mount **120** along the optical axis can be adjusted relative to the tube adapter **150** at a rate of ± 0.50 mm per turn of the adapter tube **150** relative to the lens barrel **110**. The difference between the first pitch of the threads **118**, **156** and the second pitch of the threads **159**, **123** is 0.03 mm so that the position of the lens barrel **110** relative to the lens mount **120** can be adjusted at a rate of 0.03 mm per turn of the adapter tube **150** relative to the lens barrel **110** and lens mount **120**. This very fine adjustment can be achieved with pitches much coarser than that which would be traditionally used in a non-differential threading system, and therefore enable the use of threads that are substantially more durable than would be otherwise be used. In various embodiments, as tuning may result in particle generation, a viscous non-curing fluid can be applied to the threads **118**, **156**, **159**, and **123** in order to provide sealing and particle retention. In the case where a fluid is used, the lower portion **116** of the lens barrel **110** may be tapered and the body **158** of the adapter tube **150** may be configured to include an interior lip (not shown) to retain the fluid and preclude it from being deposited onto the sensor **140**.

FIGS. **2A** and **2B** illustrate, respectively, a perspective view of and a cross-sectional view of a lens barrel **110**, an adapter tube **150**, a lens mount **120**, and an image sensor substrate **140**, as assembled.

FIGS. **3A** and **3B** illustrate a first embodiment of a stand **302** and wrench **304** for adjusting the focal length of an integrated image sensor and lens assembly **100** described above. The stand **302** supports the integrated image sensor and lens assembly **100** and prevents the lens barrel **110** and the lens mount **120** from rotating about the optical axis **170** while allowing rotation of the tube adapter **150** about the optical axis **170** and allowing axial movement of the lens barrel **110** and lens mount **120** along the optical axis **170** relative to the tube adapter **150**. As illustrated in FIG. **3B**, the wrench **504** is structured to secure around the tube adapter **150** and includes torque arms to enable rotation of the tube adapter **150** relative to the lens barrel **110** and the lens mount **120**, thereby adjusting the focal plane of the assembly **100**. In addition to the wrench **304** as illustrated, stepper motors or other similar tools may be used to rotate the tube adapter **150** relative to the lens barrel **110** and the lens mount **120**.

FIG. **4A** and **4B** illustrate a second embodiment of a stand **402** and wrench **404** for adjusting the focal length of an integrated image sensor and lens assembly **100** described above including a perspective view and top view respectively. The stand **402** and wrench **404** of FIG. **4A** operate similarly to the stand **502** and wrench **504** of FIGS. **5A-B** but include some structural variations.

Example Camera System Configuration

FIG. **5** illustrates an embodiment of an example camera **500** that includes the integrated image sensor and lens assembly **100** described above. The camera **500** comprises a camera body having a camera lens structured on a front surface of the camera body, various indicators on the front of the surface of the camera body (such as LEDs, displays, and the like), various input mechanisms (such as buttons, switches, and touch-screen mechanisms), and electronics (e.g., imaging electronics, power electronics, etc.) internal to the camera body for capturing images via the camera lens

and/or performing other functions. The camera **500** is configured to capture images and video, and to store captured images and video for subsequent display or playback. As illustrated, the camera **500** includes a lens **502** configured to receive light incident upon the lens and to direct received light onto an image sensor internal to the lens. The lens **502** is enclosed by a lens ring **504**, which are both part of the integrated image sensor and lens assembly **100** discussed above.

The camera **500** can include various indicators, including the LED lights **506** and the LED display **508**. The camera **500** can also include buttons **510** configured to allow a user of the camera to interact with the camera, to turn the camera on, and to otherwise configure the operating mode of the camera. The camera **500** can also include a microphone **512** configured to receive and record audio signals in conjunction with recording video. The side of the camera **500** includes an I/O interface **514**.

Additional Configuration Considerations

Throughout this specification, some embodiments have used the expression “coupled” along with its derivatives. The term “coupled” as used herein is not necessarily limited to two or more elements being in direct physical or electrical contact. Rather, the term “coupled” may also encompass two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other, or are structured to provide a thermal conduction path between the elements.

Likewise, as used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus.

In addition, use of the “a” or “an” are employed to describe elements and components of the embodiments herein. This is done merely for convenience and to give a general sense of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

Finally, as used herein any reference to “one embodiment” or “an embodiment” means that a particular element, feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. The appearances of the phrase “in one embodiment” in various places in the specification are not necessarily all referring to the same embodiment.

Upon reading this disclosure, those of skill in the art will appreciate still additional alternative structural and functional designs for the embodiments as disclosed from the principles herein. Thus, while particular embodiments and applications have been illustrated and described, it is to be understood that the disclosed embodiments are not limited to the precise construction and components disclosed herein. Various modifications, changes and variations, which will be apparent to those skilled in the art, may be made in the arrangement, operation and details of the method and apparatus disclosed herein without departing from the scope defined in the appended claims.

The invention claimed is:

- [1]**. An integrated image sensor and lens assembly comprising:
 - an image sensor substrate comprising an image sensor;

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a lens mount affixed to the image sensor substrate and comprising a tube portion and a base portion, the tube portion having a channel and extending from the base portion in a direction of an optical axis substantially perpendicular to a focal plane, the lens mount comprising a first thread having a first pitch forming a first spiral on an inner surface of the tube portion;

a tube adapter extending into the channel of the tube portion, the tube adapter comprising a second thread on an exterior surface of the tube adapter, the second thread reciprocal to the first thread and having the first pitch, the first and second threads securing the tube adapter within the lens mount, the tube adapter further comprising a third thread having a second pitch different than the first pitch, the third thread forming a second spiral on an inner surface of the tube adapter; and

a lens barrel housing a set of lenses for directing light to the image sensor, the lens barrel having a threaded portion extending into the tube adapter, and the threaded portion comprising a fourth thread on an exterior surface of the lens barrel reciprocal to the third thread and having the second pitch, the third and fourth threads securing the lens barrel within the tube adapter, wherein the lens barrel is configured to rotate about the optical axis,

wherein rotation of the tube adapter with respect to the lens barrel and the lens mount causes linear movement of the lens barrel and the lens mount with respect to the tube adapter in a same direction along the optical axis, wherein a magnitude of a difference between the first pitch and the second pitch is smaller than the first pitch and the second pitch, and

wherein an upper subsection of the lens mount and a lower subsection of the lens barrel are unthreaded.]

[2. The integrated image sensor and lens assembly of claim 1, wherein the first thread is on a lower subsection of the lens mount and the second thread is on a lower subsection of the tube adapter, the third thread is on an upper subsection of the tube adapter and the fourth thread is on an upper subsection of the lens barrel.]

[3. The integrated image sensor and lens assembly of claim 1, wherein the threaded portion of the lens barrel is tapered and wherein the tube adapter is configured to retain a fluid and to prevent the fluid from being deposited onto the image sensor.]

[4. The integrated image sensor and lens assembly of claim 3, wherein the fluid is viscous non-curing fluid.]

[5. The integrated image sensor and lens assembly of claim 1, wherein a single rotation of the of the tube adapter with respect to the lens barrel and the lens mount causes a change in focal length less than the first pitch and less than the second pitch.]

[6. A camera comprising: one or more controls to operate the camera;

a storage medium to store images and video captured by the camera; an image sensor substrate comprising an image sensor;

a lens mount affixed to the image sensor substrate and comprising a tube portion and a base portion, the tube portion having a channel and extending from the base portion in a direction of an optical axis substantially perpendicular to a focal plane, the lens mount comprising a first thread having a first pitch forming a spiral on an inner surface of the tube portion;

a tube adapter extending into the channel of the tube portion, the tube adapter comprising a second thread on

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an exterior surface of the tube adapter, the second thread reciprocal to the first thread and having the first pitch, the first and second threads securing the tube adapter within the lens mount, the tube adapter further comprising a third thread having a second pitch different than the first pitch, the third thread forming a spiral on an inner surface of the tube adapter; and

a lens barrel housing a set of lenses for directing light to the image sensor, the lens barrel having a threaded portion extending into the tube adapter, and the threaded portion comprising a fourth thread on an exterior surface of the lens barrel reciprocal to the third thread and having the second pitch, the third and fourth threads securing the lens barrel within the tube adapter, wherein the lens barrel is configured to rotate about the optical axis,

wherein rotation of the tube adapter with respect to the lens barrel and the lens mount causes linear movement of the lens barrel and the lens mount with respect to the tube adapter in a same direction along the optical axis, wherein a magnitude of a difference between the first pitch and the second pitch is smaller than the first pitch and the second pitch, and

wherein an upper subsection of the lens mount and a lower subsection of the lens barrel are unthreaded.]

[7. The camera of claim 6, wherein the first thread is on a lower subsection of the lens mount and the second thread is on a lower subsection of the tube adapter, the third thread is on an upper subsection of the tube adapter and the fourth thread is on an upper subsection of the lens barrel.]

[8. The camera of claim 6, wherein the threaded portion of the lens barrel is tapered and wherein the tube adapter is configured to retain a fluid and to prevent the fluid from being deposited onto the image sensor.]

[9. The camera of claim 8, wherein the fluid is viscous non-curing fluid.]

[10. The camera of claim 6, wherein a single rotation of the of the tube adapter with respect to the lens barrel and the lens mount causes a change in focal length less than the first pitch and less than the second pitch.]

[11. An integrated lens assembly comprising:

a lens mount affixed to an image sensor substrate including an image sensor and comprising a tube portion and a base portion, the tube portion having a channel and extending from the base portion in a direction of an optical axis substantially perpendicular to a focal plane, the lens mount comprising a first thread having a first pitch forming a first spiral on an inner surface of the tube portion;

a tube adapter extending into the channel of the tube portion, the tube adapter comprising a second thread on an exterior surface of the tube adapter, the second thread reciprocal to the first thread and having the first pitch, the first and second threads securing the tube adapter within the lens mount, the tube adapter further comprising a third thread having a second pitch different than the first pitch, the third thread forming a second spiral on an inner surface of the tube adapter; and

a lens barrel housing a set of lenses for directing light to the image sensor, the lens barrel having a threaded portion extending into the tube adapter, and the threaded portion comprising a fourth thread on an exterior surface of the lens barrel reciprocal to the third thread and having the second pitch, the third and fourth threads securing the lens barrel within the tube adapter,

wherein the lens barrel is configured to rotate about the optical axis,
 wherein rotation of the tube adapter with respect to the lens barrel and the lens mount causes linear movement of the lens barrel and the lens mount with respect to the tube adapter in a same direction along the optical axis, wherein a magnitude of a difference between the first pitch and the second pitch is smaller than the first pitch and the second pitch, and

wherein an upper subsection of the lens mount and a lower subsection of the lens barrel are unthreaded.]

[12. The integrated lens assembly of claim 11, wherein the first thread is on a lower subsection of the lens mount and the second thread is on a lower subsection of the tube adapter, the third thread is on an upper subsection of the tube adapter and the fourth thread is on an upper subsection of the lens barrel.]

[13. The integrated lens assembly of claim 11, wherein a single rotation of the of the tube adapter with respect to the lens barrel and the lens mount causes a change in focal length less than the first pitch and less than the second pitch.]

[14. An integrated image sensor and lens assembly comprising:

an image sensor substrate comprising an image sensor;
 a lens mount affixed to the image sensor substrate and comprising a tube portion and a base portion, the tube portion having a channel and extending from the base portion in a direction of an optical axis substantially perpendicular to a focal plane, the lens mount comprising a first thread having a first pitch forming a first spiral on an inner surface of the tube portion;

a tube adapter extending into the channel of the tube portion, the tube adapter comprising a second thread on an exterior surface of the tube adapter, the second thread reciprocal to the first thread and having the first pitch, the first and second threads securing the tube adapter within the lens mount, the tube adapter further comprising a third thread having a second pitch different than the first pitch, the third thread forming a second spiral on an inner surface of the tube adapter; and

a lens barrel housing a set of lenses for directing light to the image sensor, the lens barrel having a threaded portion extending into the tube adapter, and the threaded portion comprising a fourth thread on an exterior surface of the lens barrel reciprocal to the third thread and having the second pitch, the third and fourth threads securing the lens barrel within the tube adapter,

wherein the lens barrel is configured to rotate about the optical axis,

wherein rotation of the tube adapter with respect to the lens barrel and the lens mount causes linear movement of the lens barrel and the lens mount with respect to the tube adapter in a same direction along the optical axis, wherein a single rotation of the of the tube adapter with respect to the lens barrel and the lens mount causes a change in focal length less than the first pitch and less than the second pitch, and

wherein an upper subsection of the lens mount and a lower subsection of the lens barrel are unthreaded.]

[15. The integrated image sensor and lens assembly of claim 14, wherein the first thread is on a lower subsection of the lens mount and the second thread is on a lower subsection of the tube adapter, the third thread is on an upper subsection of the tube adapter and the fourth thread is on an upper subsection of the lens barrel.]

[16. The integrated image sensor and lens assembly of claim 14, wherein the threaded portion of the lens barrel is tapered and wherein the tube adapter is configured to retain a fluid and to prevent the fluid from being deposited onto the image sensor.]

[17. An integrated lens assembly comprising:

a lens mount affixed to the image sensor substrate including an image sensor and comprising a tube portion and a base portion, the tube portion having a channel and extending from the base portion in a direction of an optical axis substantially perpendicular to a focal plane, the lens mount comprising a first thread having a first pitch forming a first spiral on an inner surface of the tube portion;

a tube adapter extending into the channel of the tube portion, the tube adapter comprising a second thread on an exterior surface of the tube adapter, the second thread reciprocal to the first thread and having the first pitch, the first and second threads securing the tube adapter within the lens mount, the tube adapter further comprising a third thread having a second pitch different than the first pitch, the third thread forming a second spiral on an inner surface of the tube adapter; and

a lens barrel housing a set of lenses for directing light to the image sensor, the lens barrel having a threaded portion extending into the tube adapter, and the threaded portion comprising a fourth thread on an exterior surface of the lens barrel reciprocal to the third thread and having the second pitch, the third and fourth threads securing the lens barrel within the tube adapter, wherein the lens barrel is configured to rotate about the optical axis,

wherein rotation of the tube adapter with respect to the lens barrel and the lens mount causes linear movement of the lens barrel and the lens mount with respect to the tube adapter in a same direction along the optical axis, wherein a single rotation of the of the tube adapter with respect to the lens barrel and the lens mount causes a change in focal length less than the first pitch and less than the second pitch, and

wherein an upper subsection of the lens mount and a lower subsection of the lens barrel are unthreaded.]

[18. A camera comprising: one or more controls to operate the camera;

a storage medium to store images and video captured by the camera; an image sensor substrate comprising an image sensor;

a lens mount affixed to the image sensor substrate and comprising a tube portion and a base portion, the tube portion having a channel and extending from the base portion in a direction of an optical axis substantially perpendicular to a focal plane, the lens mount comprising a first thread having a first pitch forming a first spiral on an inner surface of the tube portion;

a tube adapter extending into the channel of the tube portion, the tube adapter comprising a second thread on an exterior surface of the tube adapter, the second thread reciprocal to the first thread and having the first pitch, the first and second threads securing the tube adapter within the lens mount, the tube adapter further comprising a third thread having a second pitch different than the first pitch, the third thread forming a second spiral on an inner surface of the tube adapter; and

a lens barrel housing a set of lenses for directing light to the image sensor, the lens barrel having a threaded

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portion extending into the tube adapter, and the threaded portion comprising a fourth thread on an exterior surface of the lens barrel reciprocal to the third thread and having the second pitch, the third and fourth threads securing the lens barrel within the tube adapter, wherein the lens barrel is configured to rotate about the optical axis,

wherein rotation of the tube adapter with respect to the lens barrel and the lens mount causes linear movement of the lens barrel and the lens mount with respect to the tube adapter in a same direction along the optical axis, wherein a single rotation of the of the tube adapter with respect to the lens barrel and the lens mount causes a change in focal length less than the first pitch and less than the second pitch, and

wherein an upper subsection of the lens mount and a lower subsection of the lens barrel are unthreaded.]

[19. The camera of claim 18, wherein the first thread is on a lower subsection of the lens mount and the second thread is on a lower subsection of the tube adapter, the third thread is on an upper subsection of the tube adapter and the fourth thread is on an upper subsection of the lens barrel.]

[20. The camera of claim 18, wherein the threaded portion of the lens barrel is tapered and wherein the tube adapter is configured to retain a fluid and to prevent the fluid from being deposited onto the image sensor.]

21. *An integrated image sensor and lens assembly comprising:*

an image sensor substrate supporting an image sensor defining an optical axis;

a lens mount coupled to the image sensor substrate;

a tube adapter received by the lens mount, the tube adapter including:

an upper threaded section;

a lower threaded section; and

an unthreaded section positioned axially between the upper threaded section and the lower threaded section; and

a lens barrel for directing light to the image sensor, the lens barrel having a threaded section engageable with the upper threaded section of the tube adapter, wherein an upper subsection of the lens mount and a lower subsection of the lens barrel are unthreaded.

22. *The integrated image sensor and lens assembly of claim 21, wherein the upper threaded section and the lower threaded section of the tube adapter each include an upper end and a lower end, the lower end of the upper threaded section spaced from the upper end of the lower threaded section along an axis generally parallel in relation to the optical axis.*

23. *The integrated image sensor and lens assembly of claim 21, wherein the lower threaded section of the tube adapter extends along an exterior surface thereof.*

24. *The integrated image sensor and lens assembly of claim 21, wherein the lens mount includes a threaded section engageable with the lower threaded section of the tube adapter.*

25. *The integrated image sensor and lens assembly of claim 24, wherein the lens mount further includes an unthreaded section adjacent to the threaded section thereof.*

26. *The integrated image sensor and lens assembly of claim 25, wherein the threaded section of the lens mount is spaced a first distance from the image sensor substrate and the unthreaded section of the lens mount is spaced a second distance from the image sensor substrate greater than the first distance.*

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27. *The integrated image sensor and lens assembly of claim 26, wherein the threaded section of the lens mount extends along an interior surface thereof.*

28. *The integrated image sensor and lens assembly of claim 21, wherein the tube adapter is rotatable about the optical axis relative to both the lens barrel and the lens mount.*

29. *The integrated image sensor and lens assembly of claim 28, wherein relative rotation between the tube adapter and the lens mount causes relative axial movement between the tube adapter and the lens mount along the optical axis.*

30. *The integrated image sensor and lens assembly of claim 29, wherein relative rotation between the tube adapter and the lens barrel causes relative axial movement between the tube adapter and the lens barrel along the optical axis.*

31. *An integrated image sensor and lens assembly comprising:*

an image sensor substrate supporting an image sensor defining an optical axis;

a lens mount supported by image sensor substrate;

a tube adapter received by the lens mount, the tube adapter including an upper threaded section and a lower threaded section positioned so as to eliminate any overlap therebetween along an axis generally parallel in relation to the optical axis; and

a lens barrel engageable with the upper threaded section of the tube adapter and configured to direct light to the image sensor, wherein an upper subsection of the lens mount and a lower subsection of the lens barrel are unthreaded.

32. *The integrated image sensor and lens assembly of claim 31, wherein the tube adapter includes an unthreaded section positioned axially between the upper threaded section and the lower threaded section.*

33. *The integrated image sensor and lens assembly of claim 32, wherein the unthreaded section of the tube adapter includes an upper end and a lower end, the upper end of the unthreaded section coterminous with a lower end of the upper threaded section and the lower end of the unthreaded section coterminous with an upper end of the lower threaded section.*

34. *The integrated image sensor and lens assembly of claim 31, wherein the lens mount includes a threaded section engageable with the lower threaded section of the tube adapter.*

35. *The integrated image sensor and lens assembly of claim 34, wherein the lens mount includes an unthreaded section adjacent to the threaded section thereof.*

36. *The integrated image sensor and lens assembly of claim 35, wherein the unthreaded section of the lens mount is positioned closer to the lens barrel than the threaded section of the lens mount.*

37. *The integrated image sensor and lens assembly of claim 31, wherein the lens mount, the tube adapter, and the lens barrel are configured to facilitate relative rotation between the tube adapter and the lens mount and relative rotation between the tube adapter and the lens barrel, wherein relative rotation between the tube adapter and the lens mount causes relative axial movement between the tube adapter and the lens mount along the optical axis and relative rotation between the tube adapter and the lens barrel causes relative axial movement between the tube adapter and the lens barrel along the optical axis.*

38. *An imaging device, comprising:*

one or more controls to operate the imaging device;

a storage medium to store images captured by the imaging device;

*an image sensor substrate supporting an image sensor
 defining an optical axis;
 a lens mount supported by the image sensor substrate;
 a tube adapter received by the lens mount, the tube
 adapter including: 5
 a first threaded section;
 an unthreaded section having a first end coterminous
 with the first threaded section and a second end
 opposite the first end; and
 a second threaded section coterminous with the second 10
 end of the unthreaded section; and
 a lens barrel for directing light to the image sensor, the
 lens barrel rotatably coupled to the tube adapter,
 wherein an upper subsection of the lens mount and a
 lower subsection of the lens barrel are unthreaded. 15*

*39. The imaging device of claim 38, wherein the first
 threaded section of the tube adapter is spaced from the
 second threaded section of the tube adapter along an axis
 generally parallel in relation to the optical axis.*

*40. The imaging device of claim 38, wherein the lens 20
 mount includes a threaded section spaced a first distance
 from the image sensor substrate and an unthreaded section
 spaced a second distance from the image sensor substrate
 greater than the first distance.*

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