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(54) CAMERA MODULE WITH MOVING PRISM

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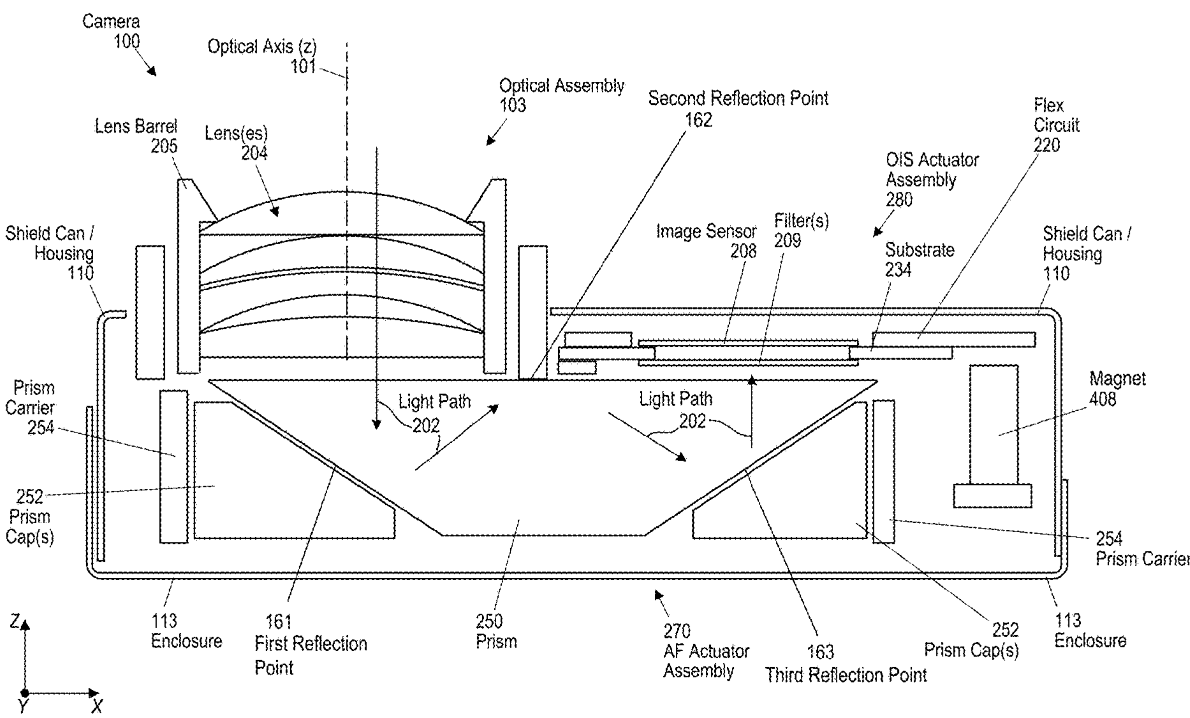
(57) **ABSTRACT**

A camera is provided. The camera includes an optical assembly having one or more lenses. The camera also includes an image sensor, a prism, and an actuator. The prism is configured to receive light that has passed through the one or more lenses, reflect the received light multiple times, and transmit the received light to the image sensor in a direction parallel to the optical axis. The image sensor is located at a same side of the prism as the one or more lenses. The actuator is configured to move the prism along an axis parallel to the optical axis for auto focus (AF).



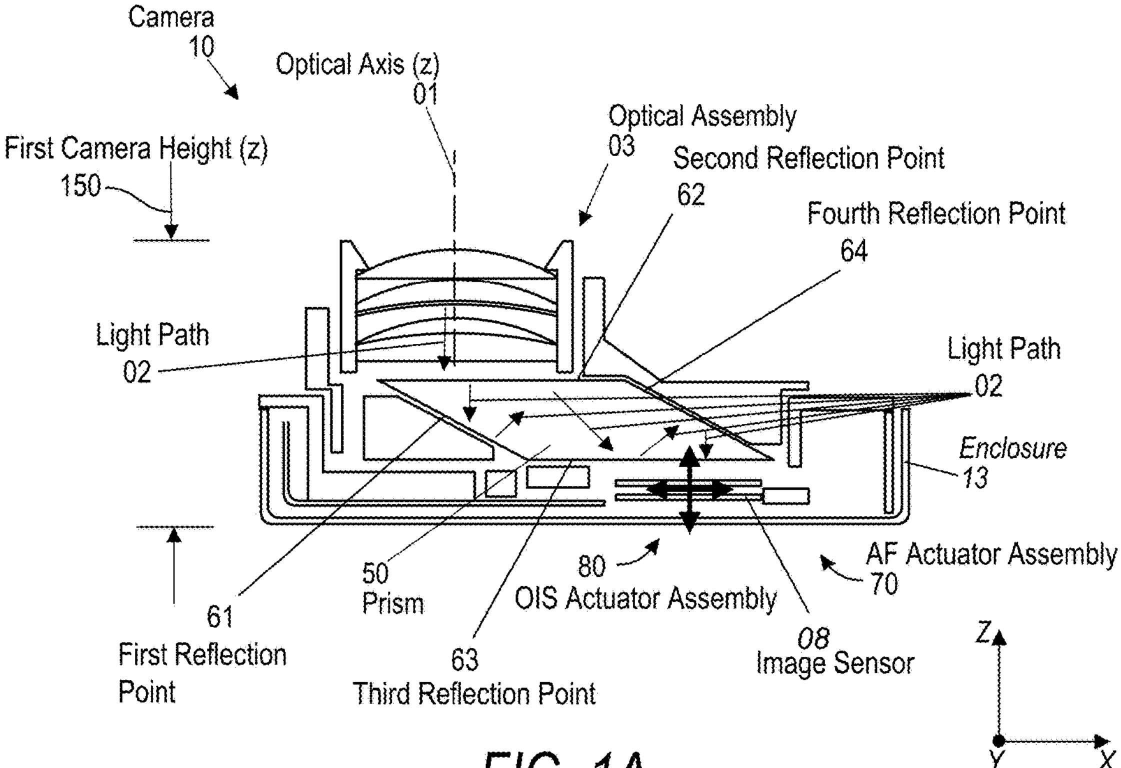

Camera
10
Optical Axis (z)
01
First Camera Height (z)
150
Optical Assembly
03
Second Reflection Point
62
Fourth Reflection Point
64
Light Path
02
Light Path
02
Enclosure
13
AF Actuator Assembly
70
80
OIS Actuator Assembly
50
Prism
61
First Reflection Point
63
Third Reflection Point
08
Image Sensor
Z
Y
X

FIG. 1A

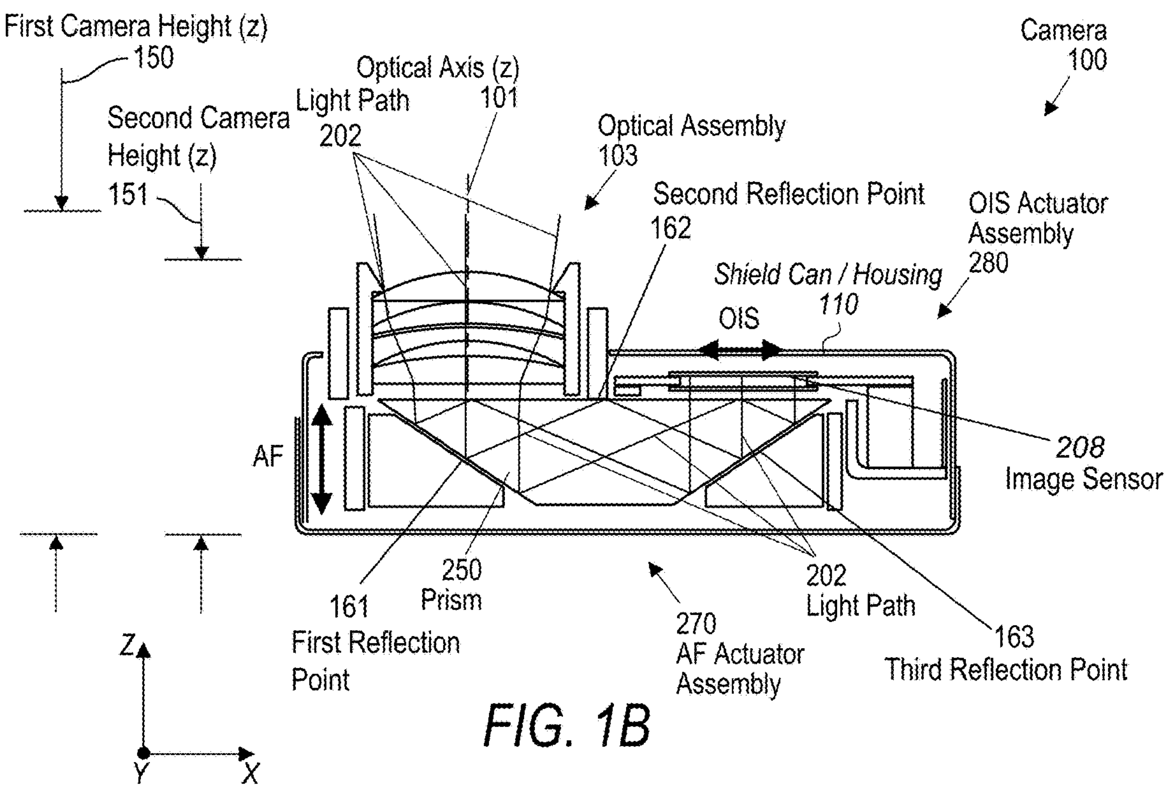

First Camera Height (z)
150
Camera
100
Optical Axis (z)
101
Light Path
202
Second Camera Height (z)
151
Optical Assembly
103
Second Reflection Point
162
OIS Actuator Assembly
280
Shield Can / Housing
110
OIS
AF
208
Image Sensor
250
Prism
161
First Reflection Point
270
AF Actuator Assembly
202
Light Path
163
Third Reflection Point
Z
Y
X

FIG. 1B

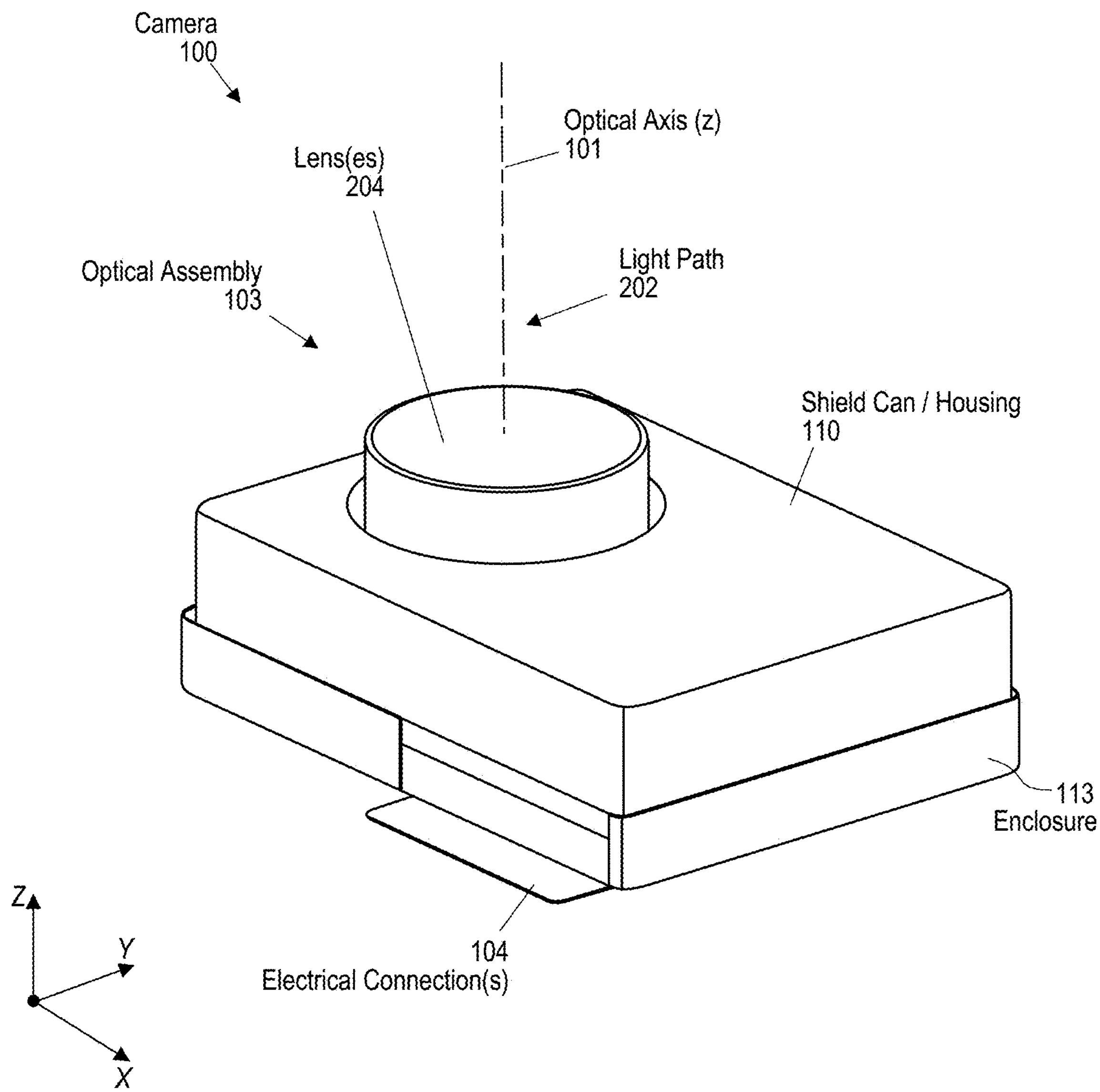
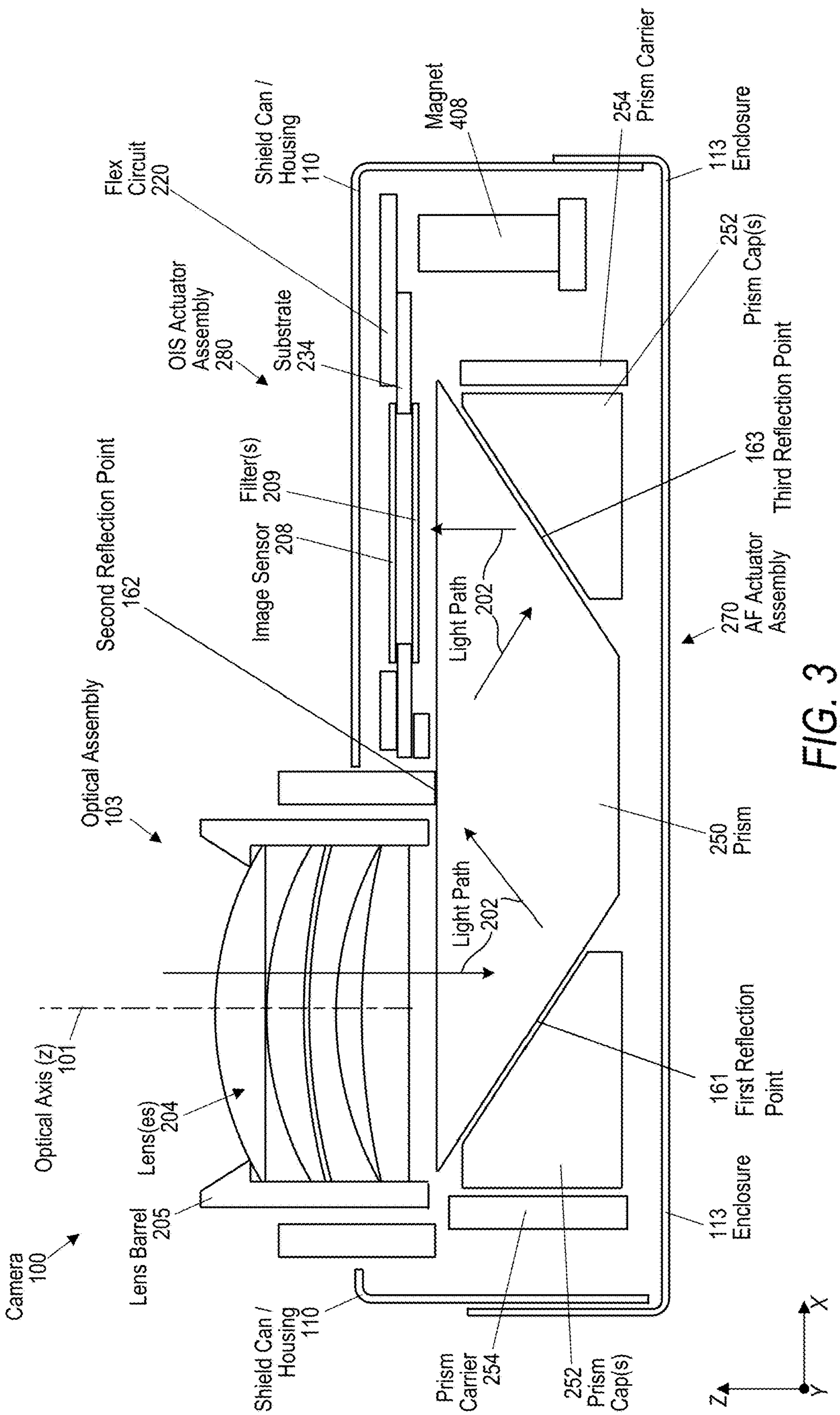

Camera
100
Optical Axis (z)
101
Lens(es)
204
Light Path
202
Optical Assembly
103
Shield Can / Housing
110
113
Enclosure
104
Electrical Connection(s)
Z
Y
X

FIG. 2



Camera 100
Lens Barrel 205
Lens(es) 204
Optical Axis (z) 101
Optical Assembly 103
Second Reflection Point 162
Image Sensor 208
Filter(s) 209
OIS Actuator Assembly 280
Substrate 234
Flex Circuit 220
Shield Can / Housing 110
Magnet 408
254 Prism Carrier
113 Enclosure
252 Prism Cap(s)
163 Third Reflection Point
270 AF Actuator Assembly
Light Path 202
Light Path 202
250 Prism
161 First Reflection Point
113 Enclosure
Shield Can / Housing 110
Prism Carrier 254
252 Prism Cap(s)
Z
X
Y

FIG. 3

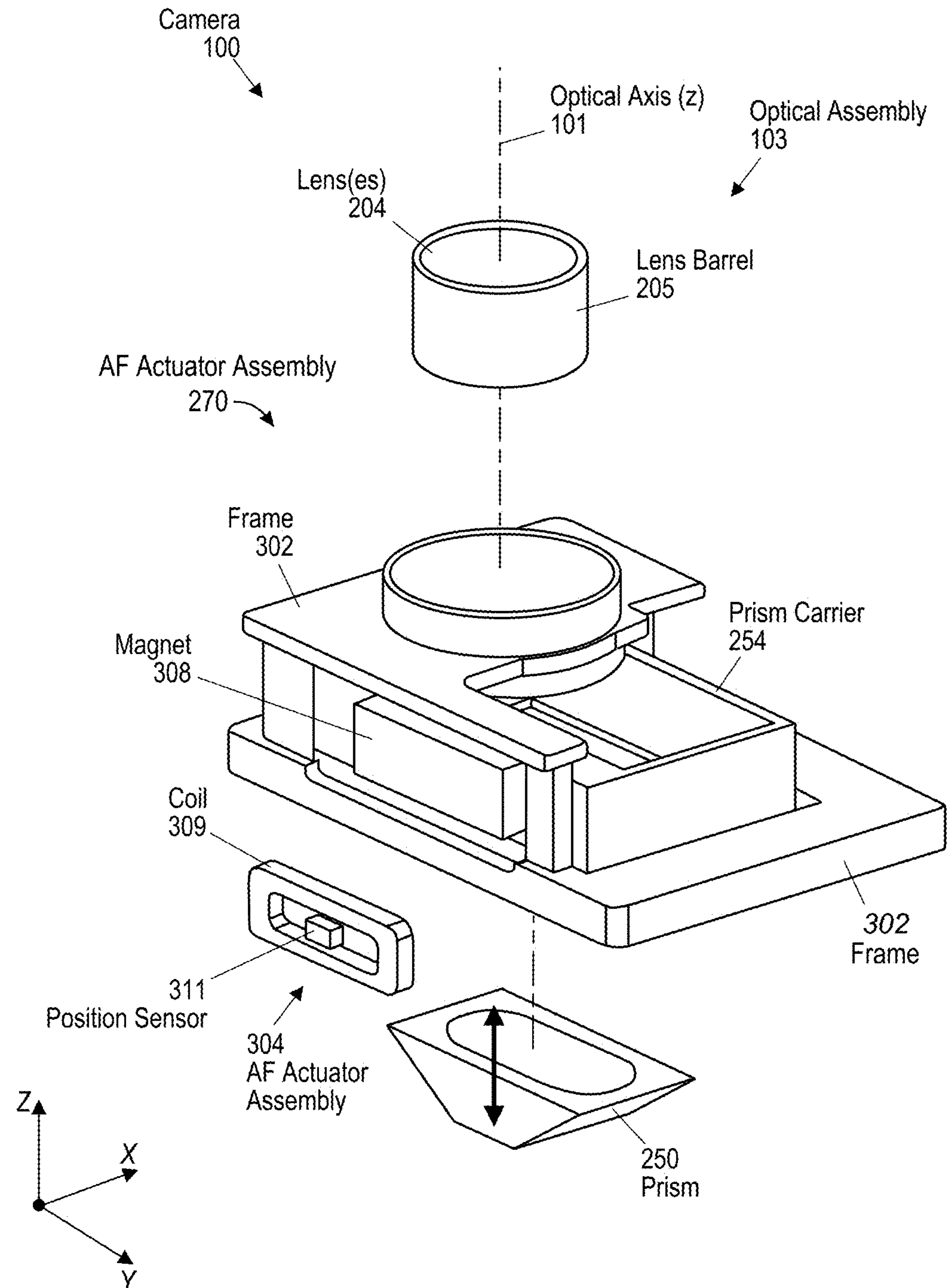

Camera
100
Optical Axis (z)
101
Optical Assembly
103
Lens(es)
204
Lens Barrel
205
AF Actuator Assembly
270
Frame
302
Prism Carrier
254
Magnet
308
Coil
309
302
Frame
311
Position Sensor
304
AF Actuator
Assembly
250
Prism
Z
X
Y

FIG. 4

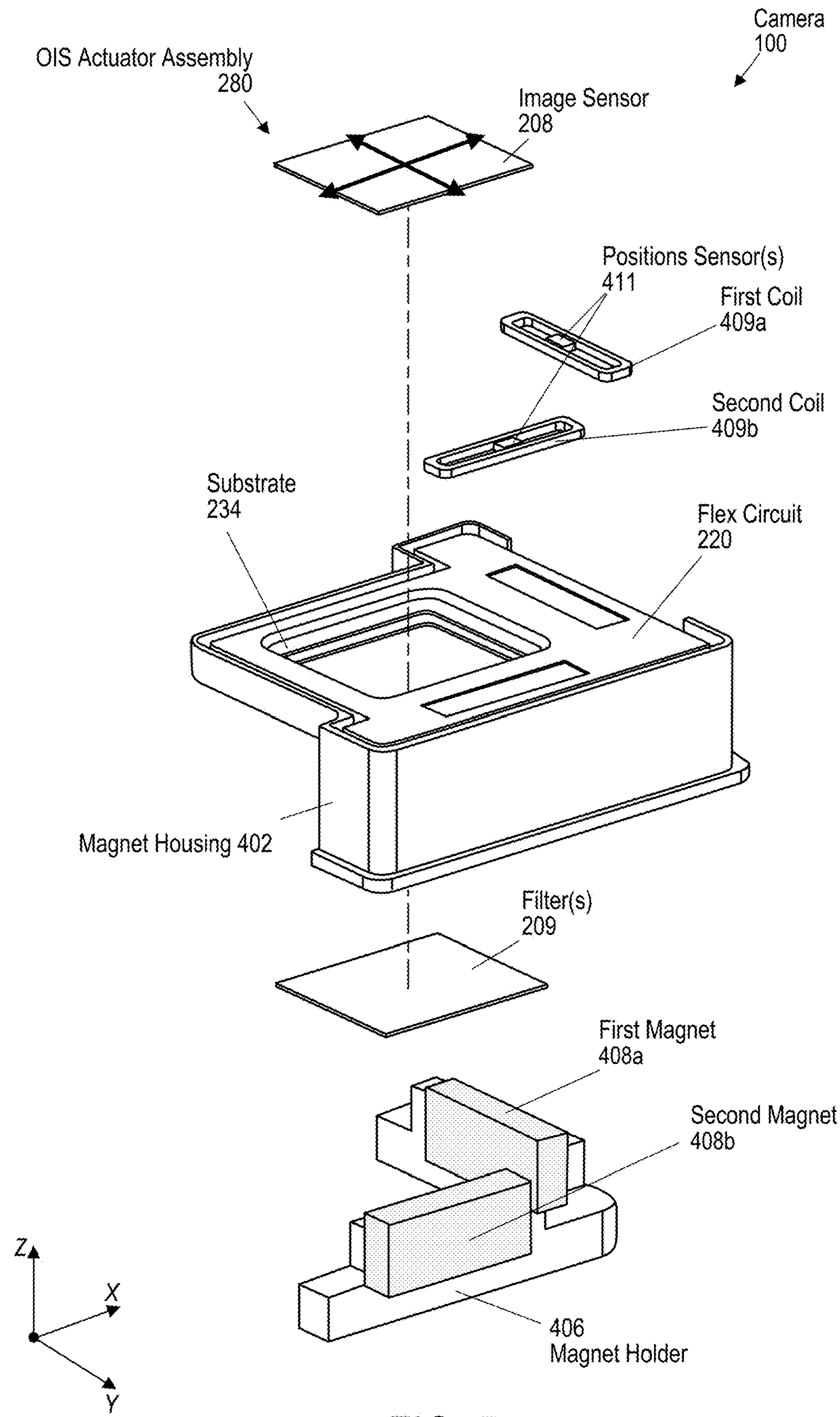

Camera
100
OIS Actuator Assembly
280
Image Sensor
208
Positions Sensor(s)
411
First Coil
409a
Second Coil
409b
Substrate
234
Flex Circuit
220
Magnet Housing 402
Filter(s)
209
First Magnet
408a
Second Magnet
408b
406
Magnet Holder
Z
X
Y

FIG. 5

Method 600

701 Rotate the prism carrier upside-down and position the prism within the prism carrier

703 Dispense glue on lateral sides of the prism for adhesion between the prism carrier and the prism

705 Dispense glue on the prism caps and position the prism caps on the prism so that the dispensed glue adheres the prism caps to the prism and the prism carrier

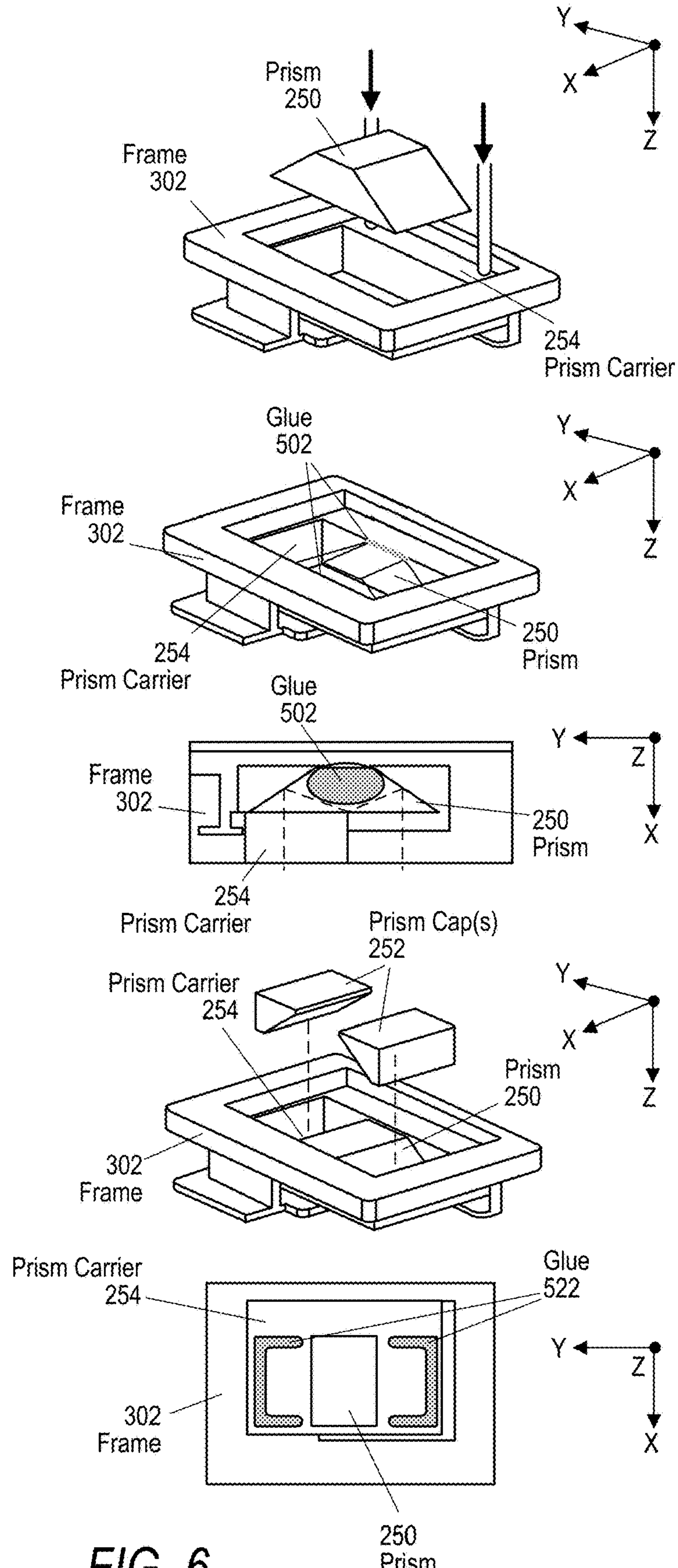
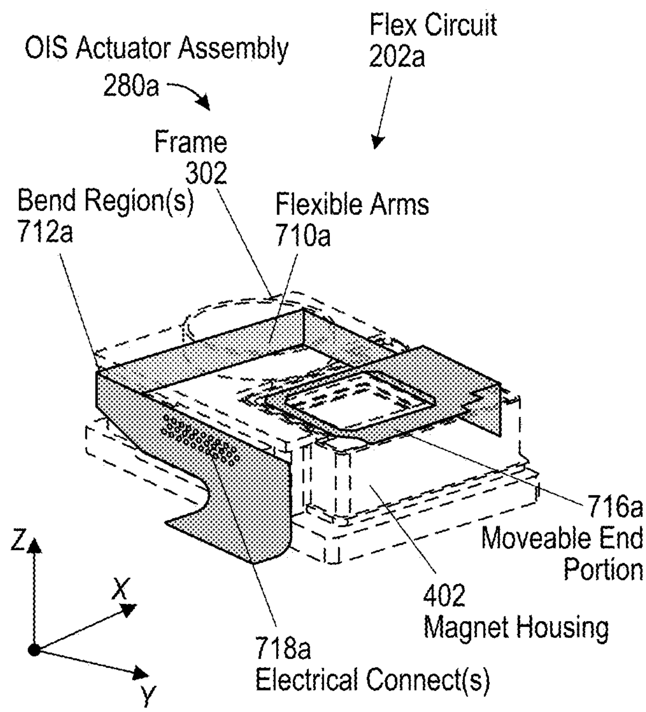


FIG. 6


OIS Actuator Assembly
280a
Flex Circuit
202a
Frame
302
Bend Region(s)
712a
Flexible Arms
710a
716a
Moveable End
Portion
402
Magnet Housing
718a
Electrical Connect(s)
Z
X
Y

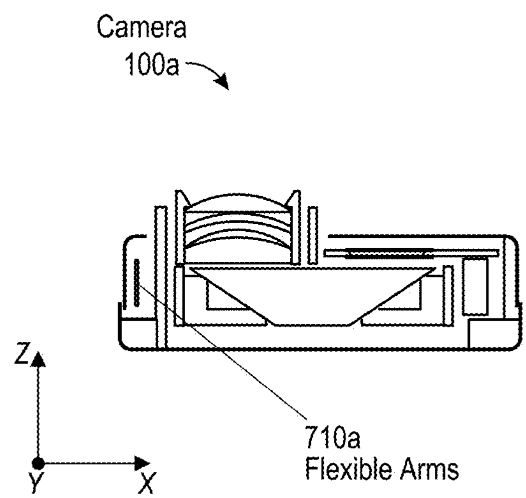

Camera
100a
Z
Y
X
710a
Flexible Arms

FIG. 7A

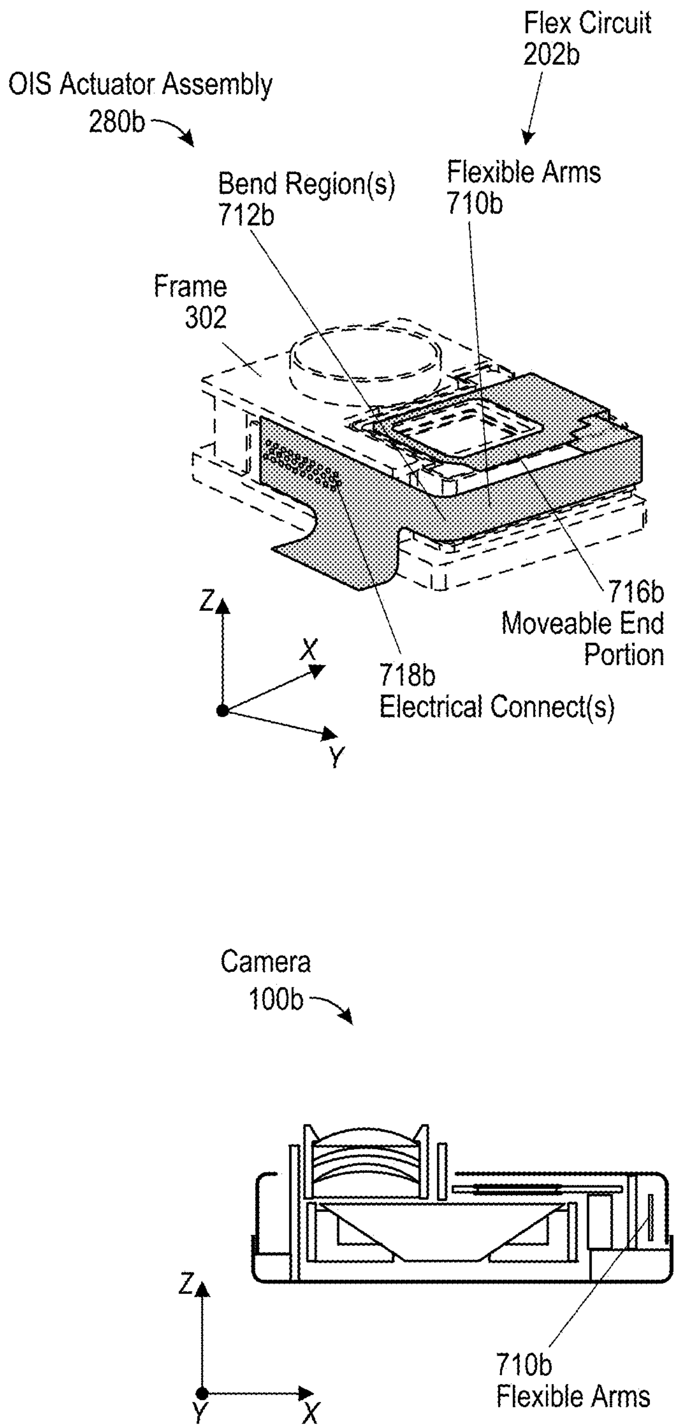

Flex Circuit
202b
OIS Actuator Assembly
280b
Bend Region(s)
712b
Flexible Arms
710b
Frame
302
716b
Moveable End
Portion
718b
Electrical Connect(s)
Z
X
Y
Camera
100b
Z
Y
X
710b
Flexible Arms

FIG. 7B

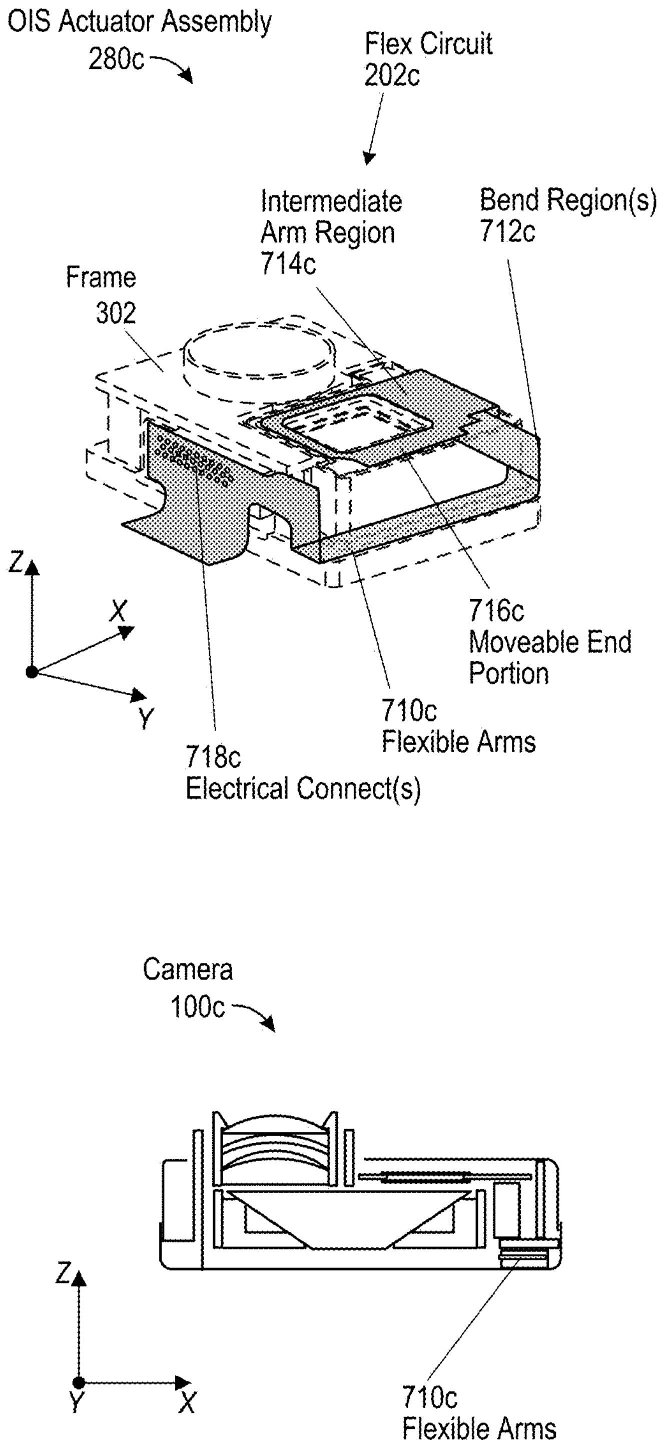
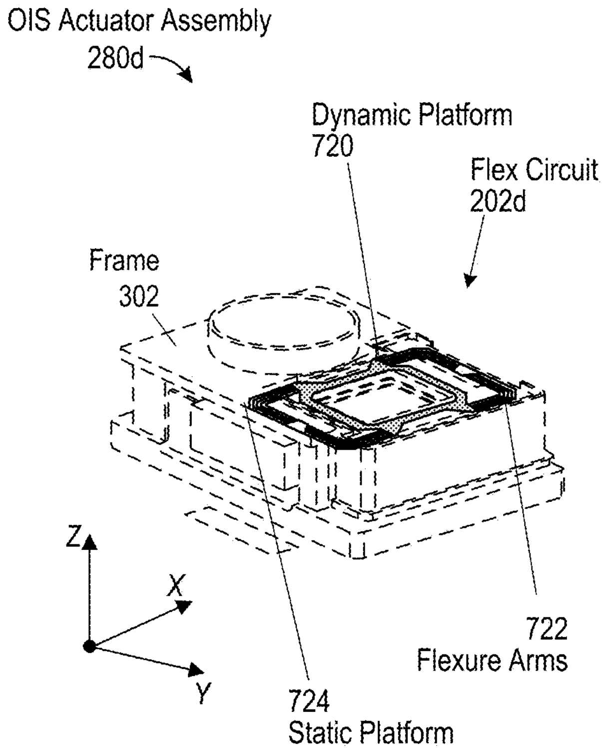

OIS Actuator Assembly
280c
Flex Circuit
202c
Intermediate
Arm Region
714c
Bend Region(s)
712c
Frame
302
Z
X
Y
716c
Moveable End
Portion
710c
Flexible Arms
718c
Electrical Connect(s)
Camera
100c
Z
Y
X
710c
Flexible Arms

FIG. 8A


OIS Actuator Assembly
280d
Dynamic Platform
720
Flex Circuit
202d
Frame
302
Z
X
Y
722
Flexure Arms
724
Static Platform

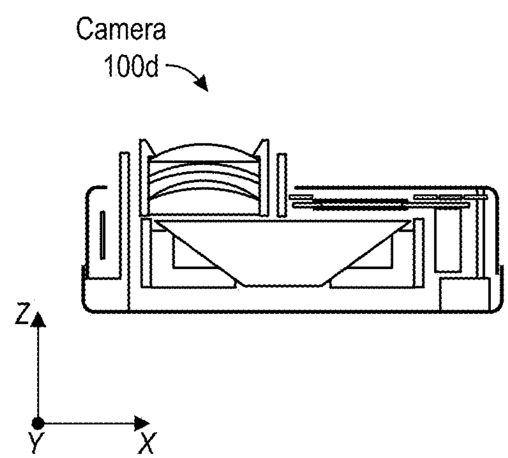

Camera
100d
Z
Y
X

FIG. 8B

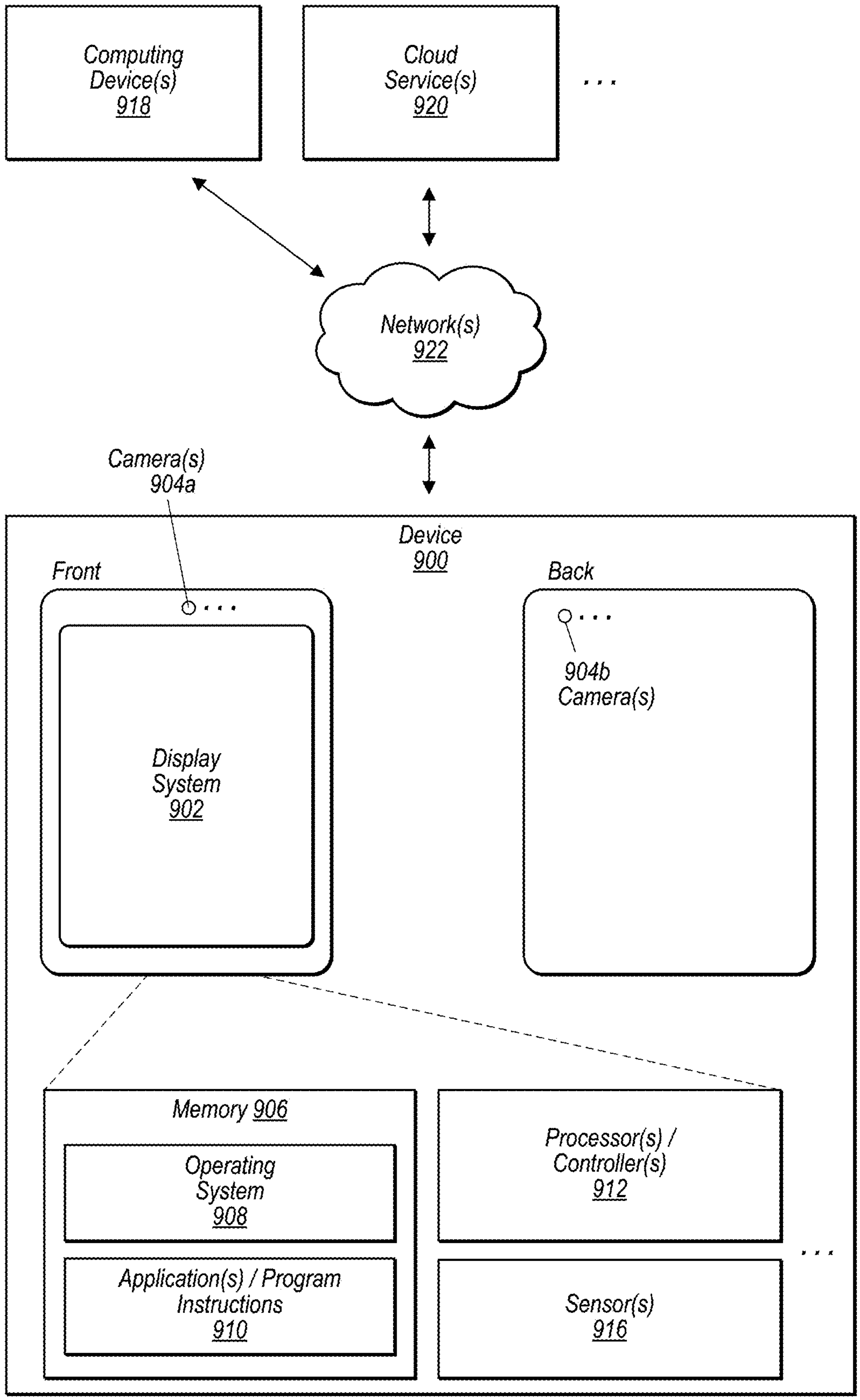

Computing Device(s) 918
Cloud Service(s) 920
...
Network(s) 922
Camera(s) 904a
Device 900
Front
Back
...
...
904b Camera(s)
Display System 902
Memory 906
Operating System 908
Application(s) / Program Instructions 910
Processor(s) / Controller(s) 912
Sensor(s) 916
...

FIG. 9

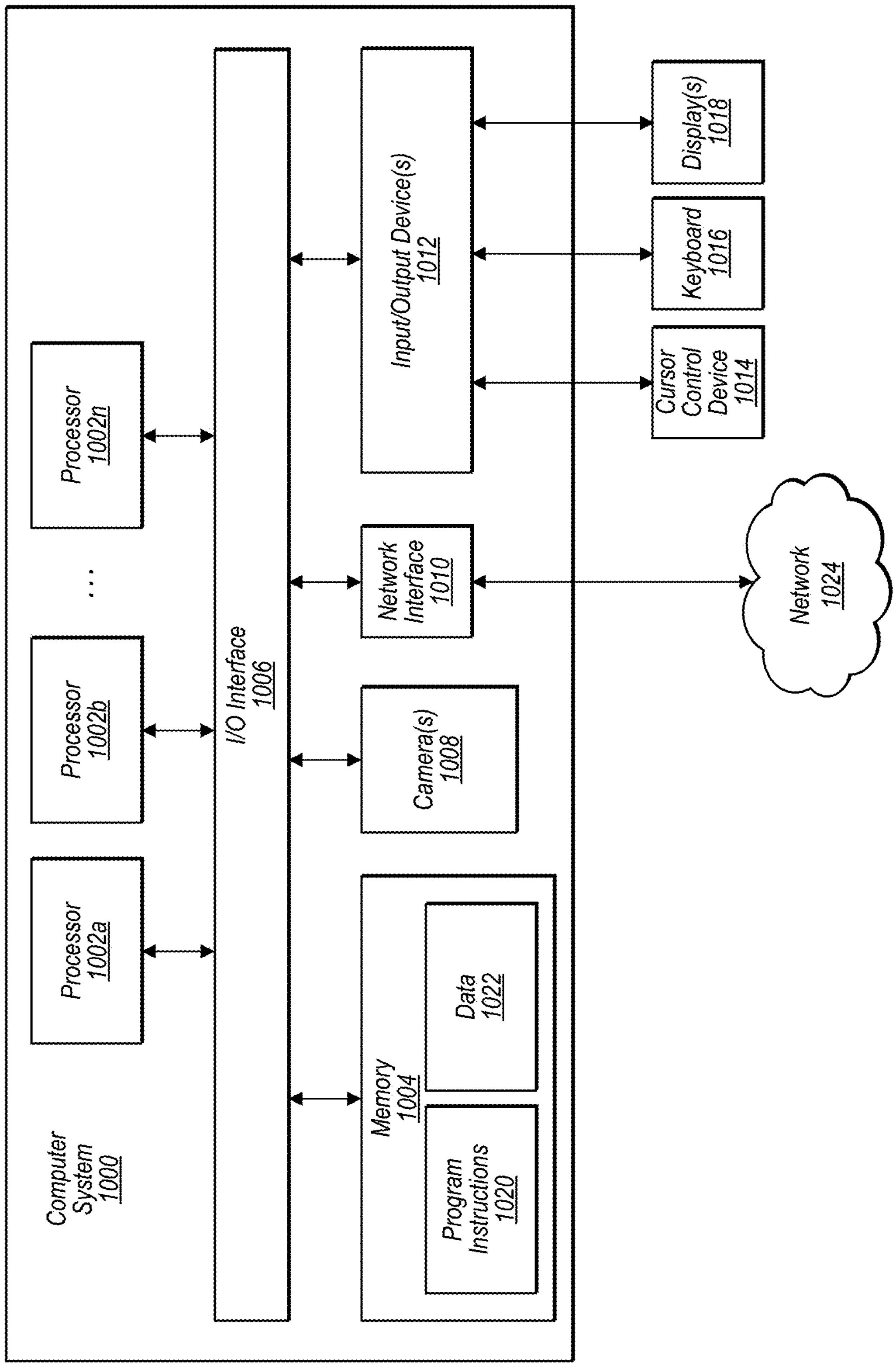

Computer System 1000
Processor 1002a
Processor 1002b
Processor 1002n
I/O Interface 1006
Memory 1004
Program Instructions 1020
Data 1022
Camera(s) 1008
Network Interface 1010
Input/Output Device(s) 1012
Cursor Control Device 1014
Keyboard 1016
Display(s) 1018
Network 1024

FIG. 10

CAMERA MODULE WITH MOVING PRISM

BACKGROUND

Priority Claim

[0001] This application claims benefit of priority to U.S. Provisional Application Ser. No. 63/554,826, entitled "Camera Module with Moving Prism," filed Feb. 16, 2024, and which is hereby incorporated herein by reference in its entirety.

Technical Field

[0002] This disclosure relates generally to a camera module and, particularly to a camera module with a moving prism for autofocus (AF).

Description of the Related Art

[0003] The advent of small, mobile multipurpose devices such as smartphones and tablet or pad devices has resulted in a need for high-resolution, small form factor cameras for integration in the devices. Some cameras may incorporate optical image stabilization (OIS) mechanisms that may sense and react to external excitation/disturbance by adjusting location of the optical lens on the X and/or Y axis in an attempt to compensate for unwanted motion of the lens. Furthermore, some cameras may incorporate an autofocus (AF) mechanism whereby the object focal distance can be adjusted to focus an object plane in front of the camera at an image plane to be captured by the image sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIGS. **1**A and **1**B illustrate components of two example cameras utilizing respective prisms positioned along light paths between respective optical assemblies and respective image sensor assemblies according to at least some embodiments. FIG. **1**A shows a cross-sectional view of a first example camera. FIG. **1**B shows a cross-sectional view of a second example camera.

[0005] FIG. **2** illustrates components of an example camera having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIG. **2** shows a perspective view of the exterior of the camera.

[0006] FIG. **3** illustrates components of an example camera having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIG. **3** shows a cross-sectional view of the camera.

[0007] FIG. **4** illustrates an example autofocus (AF) actuator assembly for a camera and including a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIG. **4** shows a perspective exploded view of the AF actuator assembly.

[0008] FIG. **5** illustrates an example optical image stabilization (IOS) actuator assembly for a camera having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIG. **5** shows a perspective exploded view of the OIS actuator assembly.

[0009] FIG. **6** illustrates an example method of assembling an AF actuator assembly for a camera having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments.

[0010] FIGS. **7**A and **7**B illustrates example flexures for a camera having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIGS. **7**A and **7**B show perspective views and cross-sectional views of the respective flexures.

[0011] FIGS. **8**A and **8**B illustrates example flexures for a camera having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIGS. **8**A and **8**B show perspective views and cross-sectional views of the respective flexures.

[0012] FIG. **9** illustrates a schematic representation of an example device that may include a camera, in accordance with some embodiments.

[0013] FIG. **10** illustrates a schematic block diagram of an example computing device, referred to as computer system, that may include or host embodiments of a camera, in accordance with some embodiments.

[0014] This specification includes references to "one embodiment" or "an embodiment." The appearances of the phrases "in one embodiment" or "in an embodiment" do not necessarily refer to the same embodiment. Particular features, structures, or characteristics may be combined in any suitable manner consistent with this disclosure.

[0015] "Comprising." This term is open-ended. As used in the appended claims, this term does not foreclose additional structure or steps. Consider a claim that recites: "An apparatus comprising one or more processor units . . . " Such a claim does not foreclose the apparatus from including additional components (e.g., a network interface unit, graphics circuitry, etc.).

[0016] "Configured To." Various units, circuits, or other components may be described or claimed as "configured to" perform a task or tasks. In such contexts, "configured to" is used to connote structure by indicating that the units/circuits/components include structure (e.g., circuitry) that performs those task or tasks during operation. As such, the unit/circuit/component can be said to be configured to perform the task even when the specified unit/circuit/component is not currently operational (e.g., is not on). The units/circuits/components used with the "configured to" language include hardware—for example, circuits, memory storing program instructions executable to implement the operation, etc. Reciting that a unit/circuit/component is "configured to" perform one or more tasks is expressly intended not to invoke 35 U.S.C. § 112, sixth paragraph, for that unit/circuit/component. Additionally, "configured to" can include generic structure (e.g., generic circuitry) that is manipulated by software and/or firmware (e.g., an FPGA or a general-purpose processor executing software) to operate in manner that is capable of performing the task(s) at issue. "Configure to" may also include adapting a manufacturing process (e.g., a semiconductor fabrication facility) to fabricate devices (e.g., integrated circuits) that are adapted to implement or perform one or more tasks.

[0017] "First," "Second," etc. As used herein, these terms are used as labels for nouns that they precede, and do not imply any type of ordering (e.g., spatial, temporal, logical, etc.). For example, a buffer circuit may be described herein as performing write operations for "first" and "second" values. The terms "first" and "second" do not necessarily imply that the first value must be written before the second value.

[0018] "Based On." As used herein, this term is used to describe one or more factors that affect a determination. This term does not foreclose additional factors that may affect a determination. That is, a determination may be solely based on those factors or based, at least in part, on those factors. Consider the phrase "determine a based on B." While in this case, b is a factor that affects the determination of A, such a phrase does not foreclose the determination of a from also being based on C. In other instances, a may be determined based solely on B.

[0019] It will also be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first contact could be termed a second contact, and, similarly, a second contact could be termed a first contact, without departing from the intended scope. The first contact and the second contact are both contacts, but they are not the same contact.

[0020] The terminology used in the description herein is for the purpose of describing particular embodiments only and is not intended to be limiting. As used in the description and the appended claims, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will also be understood that the term "and/or" as used herein refers to and encompasses any and all possible combinations of one or more of the associated listed items. It will be further understood that the terms "includes," "including," "comprises," and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0021] As used herein, the term "if" may be construed to mean "when" or "upon" or "in response to determining" or "in response to detecting," depending on the context. Similarly, the phrase "if it is determined" or "if [a stated condition or event] is detected" may be construed to mean "upon determining" or "in response to determining" or "upon detecting [the stated condition or event]" or "in response to detecting [the stated condition or event]," depending on the context.

DETAILED DESCRIPTION

[0022] Various embodiments described herein relate to a camera (e.g., a camera module) having a moving prism positioned between an optical assembly and an image sensor. The camera may include autofocus (AF). For example, the camera may include an AF actuator assembly to move the prism towards (e.g., the +z direction) both the optical assembly and the image sensor to change (e.g., decrease) the focal length of the camera and move away (e.g., the −z direction) from both the optical assembly and the image sensor to change (e.g., increase) the focal length of the camera. The prism (e.g., a trapezoidal prism) may include an odd number of reflection points (e.g., three (3) reflection points) so that light received by the prism from a first direction (e.g., from the optical assembly) is received at a first point (e.g., aligned with the optical assembly) within a plane that is orthogonal to the first direction and is outputted toward the first direction (e.g., towards the image sensor that is adjacent the optical assembly) at a second point (e.g., a different location from the first point, aligned with the image sensor) within the plane that is orthogonal to the first direction. In some aspects, at least one of the optical assembly or the image sensor also moves along the first direction to additionally change the focal length of the camera. In some aspects, the optical assembly and the image does not move along the first direction and thus do not change the focal length of the camera. As such, only movement of the prism along the first direction changes the focal length of the camera. In some aspects, the camera may include optical image stabilization (OIS). For example, the camera may include an OIS actuator assembly to move the image sensor in direction(s) (e.g., the x direction, the y direction) orthogonal to the first direction.

[0023] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings. In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present disclosure. However, it will be apparent to one of ordinary skill in the art that some embodiments may be practiced without these specific details. In other instances, well-known methods, procedures, components, circuits, and networks have not been described in detail so as not to unnecessarily obscure aspects of the embodiments.

[0024] FIGS. **1**A and **1**B illustrates components of two example cameras utilizing respective prisms positioned along light paths between respective optical assemblies and respective image sensor assemblies according to at least some embodiments. FIG. **1**A shows a cross-sectional view of a first example camera **10**. FIG. **1**B shows a cross-sectional view of a second example camera **100**. The camera **10** and the camera **100** of FIG. **1** may include one or more same or similar features as the features described with respect to or illustrated in FIGS. **2**, **3**, **4**, **5**, **6**, **7**A, **7**B, **8**A, **8**B, **9**, and **10**. The example X-Y-Z coordinate system(s) shown in FIGS. **1**A and **1**B may be used to discuss aspects of components and/or systems, and may apply to embodiments described throughout this disclosure.

[0025] As shown in FIG. **1**A, the camera **10** may include an optical assembly **03**, a prism **50**, and an image sensor **08**. The optical assembly **03**, the prism **50**, and the image sensor **08** may be positioned at different heights (e.g., in the z-direction) relative to each other. For example, the optical assembly **03** may be positioned at a higher position compared to the prism **50**, and the image sensor **08**. The prism **50** may be positioned at a lower height compared to the optical assembly **03** and a greater (e.g., a higher) height than the image sensor **08**. The image sensor **08** may be positioned at a lower position compared to the optical assembly **03**, and the prism **50**. The prism **50** may receive light along a light path **02** parallel to the optical axis **01** and passing through the optical assembly **03**. The prism **50**, upon receiving the light, may shift the light (e.g., in the x direction) and output the light in a direction parallel to the optical axis **01**, away from the optical assembly **03**, and towards the image sensor **08**. The prism **50** may shift the light by reflecting the light off an even number of reflection points (e.g., reflection surfaces) before outputting the light towards the image sensor **08**.

[0026] As shown in FIG. **1**A, the prism **50** may shift the light by receiving the light along the light path **02** from the optical assembly **03**. The light received by the prism **50** may continue along the light path **02** and may be reflected off the first reflection point **61** (e.g., a first reflection surface) within the prism **50**, may continue along the light path **02** and may reflect off the second reflection point **62** (e.g., a second reflection surface) within the prism **50**, may continue along the light path **02** and may reflect off the third reflection point **63** (e.g., a third reflection surface) within the prism **50**, and may continue along the light path **02** and may reflect off a fourth reflection point **64** (e.g., a fourth reflection surface) within the prism **50** before being outputted by the prism **50** along the light path **02** and in a direction parallel to the optical axis **01**, in a direction away from the optical assembly **03**, and towards the image sensor **08** for reception by the image sensor **08**.

[0027] Due to the configuration of the prism **50** (e.g., having an even number of reflection points), the position of the optical assembly **03** may be above (e.g., in the z direction) the prism **50** to enable the prism **50** to receive light from the optical assembly **03** along the light path **02** and the position of the image sensor **08** may be below (e.g., in the z direction) the prism **50** to enable the prism to output the received light along the light path **02** to the image sensor **08**. As such moving the prism **50** in the vertical direction (e.g., the z direction) does not change the focal length of the camera **10**. Accordingly, in addition to OIS movement of the image sensor **08** (e.g. in the x direction, in the y direction) using the OIS actuator assembly **80**, the camera **10** may rely on movement of the image sensor **08** in the z direction using the AF actuator assembly **70** for AF movement to change the focal length of the camera **10**.

[0028] However, the configuration of the camera **10** has several drawbacks. For instance, because the optical assembly **03**, the prism **50**, and the image sensor **08** are positioned along the z direction in a stacked or off-set but vertically stacked configuration, the height **150** of the camera **10** is at least the sum of the height of the optical assembly **03**, the prism **50**, and the image sensor **08** (e.g., and associated components of the image sensor **08** including those components for AF and OIS). Also, the space between the image sensor **08** and an enclosure **13** should be great or high enough to accommodate AF movement of the image sensor **08**. As described further herein, the additional space or gap allotted between the image sensor **08** and the enclosure **13** (e.g., any outer wall of the camera) to accommodate AF movement of the image sensor **08** may retain a greater amount of heat and thus not dissipate as much heat out of the camera **10** compared to a smaller space or gap that would be used for an image sensor that does not move for AF and instead moves only for OIS. As such, the image sensor **08** may not function as efficiently and/or effectively (e.g., limiting a length 4 k video sessions) due to the greater retention and poorer dissipation of the surrounding heat. Further, the camera **10** may be a component of the handset or mobile communication device (hereafter "handset") having a display screen. For example, the handset may be the same as or similar to the device **900** illustrated in FIG. **9** or the computer system **1000** illustrated in FIG. **10**. As another example, the display screen may be the same as or similar to the display system **902** in FIG. **9** or the display **1018** in FIG. **10**. As another example, camera **10** may be the same as or similar to the camera **904***b* in FIG. **9** or the camera **1008** in FIG. **10**. The display screen may be positioned on a surface of the handset opposite the optical assembly **03**. Accordingly, due to the stacked configuration of the optical assembly **03**, the prism **50**, and the image sensor **08**, the image sensor **08** may have to dissipate heat through the display screen of the handset. This could further reduce the camera's **10** ability to dissipate heat from the image sensor **08** and/or degrade the functionality and/or the life of the display screen. Also, because the optical assembly **03**, the prism **50**, and the image sensor **08** are positioned along the z direction in a stacked or off-set but vertically stacked configuration, relying on movement of the prism **50** for AF movement is not possible because moving the prism **50** towards to the optical assembly **03** or towards the image sensor **08** does not increase the length of the light path **02**. Additionally, relying on movement of the optical assembly **03** for AF rather than movement of the image sensor **08** further increases the height **150** (e.g., the z direction) of the camera **10**. Also, because of the configuration of the optical assembly **03**, the prism **50**, and the image sensor **08**, the change in focal length of the camera **10** may be limited by and/or to the distance that the image sensor **08** is able to move vertically (e.g., in the z direction) for AF.

[0029] As shown in FIG. **1**B, the camera **100** may include an optical assembly **103**, a prism **250**, and an image sensor **208**. Unlike the optical assembly **03**, the prism **50**, and the image sensor **08** of the camera **10**, both the optical assembly **103** and the image sensor **208** (e.g., and associated components of the image sensor **208** including those components for OIS) may be positioned adjacent each other and at a same height (e.g., a same position along the z direction) as each other. The prism **250** may be positioned below (e.g., along the z direction) both the optical assembly **103** and the image sensor **208**. The prism **250** may receive light along a light path **202** parallel to the optical axis **101** and passing through the optical assembly **103**. The prism **250**, upon receiving the light, may shift the light (e.g., in the x direction) and output the light in a direction parallel to the optical axis **101**, in a z direction towards the optical assembly **103**, and for reception by the adjacent image sensor **208**. The prism **250** may shift the light by reflecting the light off an odd number of reflection points (e.g., reflection surfaces) before outputting the light towards the image sensor **208**.

[0030] As shown in FIG. **1**B, the prism **250** may shift the light by receiving the light along the light path **202** from the optical assembly **103**. The light received by the prism **250** may continue along the light path **202** and may be reflected off the first reflection point **161** (e.g., a first reflection surface) within the prism **250**, may continue along the light path **202** and may reflect off the second reflection point **162** (e.g., a second reflection surface) within the prism **50**, and may continue along the light path **202** and may reflect off a third reflection point **163** (e.g., a third reflection surface) within the prism **250** before being outputted by the prism **250** along the light path **202** and in a direction parallel to the optical axis **101**, in the z direction towards the optical assembly **103**, and directly towards the image sensor **208** adjacent the optical assembly **103** for reception by the image sensor **208**.

[0031] Due to the configuration of the prism **250** (e.g., having an odd number of reflection points), the position of the optical assembly **103** may be above (e.g., in the z direction) the prism **250** to enable the prism **250** to receive light from the optical assembly **103** along the light path **202** and the position of the image sensor **208** may be adjacent the optical assembly **103** and above (e.g., in the z direction) the prism **250** to enable the prism **250** to output the received light along the light path **202** to the image sensor **208**. As such moving the prism **250** in the vertical direction (e.g., in the z direction) may change the focal length of the camera **100**. Accordingly, the camera **100** may rely on movement of the prism **250** in the z direction using the AF actuator assembly **270** for AF movement to change the focal length of the camera **100**. The image sensor **208** may still be moved for OIS (e.g., movement in the x direction, movement in the y direction) using the OIS actuator assembly **280**.

[0032] Compared to the camera **10** and other similar cameras, the configuration of the camera **100** has several advantages. For instance, because the optical assembly **03** and the image sensor **08** are adjacent each other, positioned at a same height (e.g., in the z direction) as each other, and positioned over the prism **250**, the height **151** of the camera **100** is less than the height **150** of the camera **10** and is the sum of the height of the optical assembly **03**, the prism **50**, and a distance between the prism **250** and the enclosure **113** for AF movement of the prism **250** (e.g., and associated components of the prism **250** including those components for AF). Because the image sensor **208** (e.g., and associated components of the image sensor **208** including those component for OIS movement of the image sensor **208**) are adjacent the optical assembly **103** and the height of the optical assembly **103** is greater than the height of the image sensor **208** (and associated components), the height **151** of the camera **100** is less than the height **150** of the camera **10** by at least the height of the image sensor **208** and the associated components. Also, the space or gap between the image sensor **208** and the shield can **110** (e.g., any adjacent outer wall of the camera) does not need to accommodate AF movement, because the prism **250**, rather than the image sensor **208** moves in the z direction for AF. As such, the space or gap between the shield can **110** and the image sensor **208** is smaller than the space or gap between the enclosure **13** and the image sensor **08** of the camera **10**.

[0033] As described further herein, the reduced space or gap allotted between the image sensor **208** and the shield can **110** (e.g., any adjacent outer wall of the camera) to accommodate the size and shape of the components associated with and including the image sensor **208** (e.g., and no AF movement of the image sensor **208**) may retain a lesser amount of heat compared to the space or gap between the image sensor **08** and the enclosure **13** of the camera **10** and thus dissipate more heat out of the camera **100** compared to the camera **10**. As such, the image sensor **208** may function more efficiently and/or effectively (e.g., enabling an increase in length of 4 k video sessions) due to the lesser retention and faster dissipation of the surrounding heat. Further, the camera **100** may be a component of a handset having a display screen. For example, the handset may be the same as or similar to the device **900** illustrated in FIG. **9** or the computer system **1000** illustrated in FIG. **10**. As another example, the display screen may be the same as or similar to the display system **902** in FIG. **9** or the display **1018** in FIG. **10**. As another example, camera **100** may be the same as or similar to the camera **904***b* in FIG. **9** or the camera **1008** in FIG. **10**. The display screen may be positioned on a surface of the handset opposite the optical assembly **103** and the image sensor **208**. Accordingly, due to the positioning of the image sensor **208** adjacent (e.g., the x direction, the y direction), the image sensor **08** may dissipate heat through the surface of the handset opposite the display screen. This could further increase the camera's **100** ability to dissipate heat from the image sensor **208** and/or enhance the functionality and/or the life of the display screen.

[0034] Also, because the optical assembly **103** and the image sensor **208** are positioned adjacent each other and higher than or above the prism **250** in the z direction, the prism **250** may be moved using an AF actuator assembly **280** to change the length of the light path **202** (and thus change the focal length of the camera **100**). For instance, moving the prism **250** away from both the optical assembly **103** and the image sensor **208** may increase the length of the light path **202** and thus increase the focal length of the camera **100** and moving the prism **250** towards both the optical assembly **103** and the image sensor **208** may decrease the length of the light path **202** and thus decrease the length of the focal length of the camera **100**. Also, because of the configuration of the optical assembly **103**, the prism **250**, and the image sensor **208**, the change in focal length of the camera **100** may be greater than the distance that the prism **250** is able to move vertically (e.g., in the z direction) for AF. For instance, because the prism **250** moves for AF towards both the optical assembly **103** and the image sensor **208** to reduce the length of the light path **202** and reduce the focal length of the camera **100**, the length of the light path **202** and the focal length of the camera **100** may be reduce by a multiple of two compared to the distance that the prism **250** moves towards both the optical assembly **103** and the image sensor **208**. Similarly, because the prism **250** moves for AF away from both the optical assembly **103** and the image sensor **208** to increase the length of the light path **202** and increase the focal length of the camera **100**, the length of the light path **202** and the focal length of the camera **100** may be increased by a multiple of two compared to the distance that the prism **250** moves away from both the optical assembly **103** and the image sensor **208**. Accordingly, the camera **100** may have a greater focal length (e.g., longer optical zoom) than the focal length of the camera **10**. Also, the camera **100** may have a greater AF stroke range (e.g., greater than 1 millimeter (mm)) (e.g., to achieve minimum or shorter focusing distance) compared to the camera **10**.

[0035] FIGS. **2** and **3** illustrate components of an example camera **100** having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIG. **2** shows a perspective view of the exterior of the camera **100**. FIG. **3** shows a cross-sectional view of the camera **100**. The camera **100** of FIGS. **2** and **3** may include one or more same or similar features as the features described with respect to or illustrated in FIGS. **1**A, **1**B, **4**, **5**, **6**, **7**A, **7**B, **8**A, **8**B, **9**, and **10**. The example X-Y-Z coordinate system(s) shown in FIGS. **2** and **3** may be used to discuss aspects of components and/or systems, and may apply to embodiments described throughout this disclosure.

[0036] In various embodiments, the camera **100** may include an optical assembly **103** having one or more lenses **204** defining an optical axis (z) **101** and a lens barrel **205**, a shield can or housing **110**, an enclosure or base **113**, and electrical connection(s) **104**. The shield can **110** may form an outer wall of a top portion (and in some cases side portions) of the camera **100** and form one or more camera shoulders. The enclosure **113** may form an outer wall of a bottom portion (and in some cases side portion(s)) of the camera **100**. The electrical connection(s) **104** may extend from the enclosure **113** (and/or the shield can **110**) and may electrically connect the camera **100** to an external device. For example, the camera **100** may be the same or similar camera as the camera **904***b* illustrated in FIG. **9** or the camera **1008** illustrated in FIG. **10**. As such, the electrical connection(s) **104** may extend from the enclosure **113** and may electrically connected the camera **100** to the device **900** illustrated in FIG. **9** or the computer system **1000** illustrated in FIG. **10**, respectively. In some aspects, the camera **100** may include autofocus (AF) (e.g., movement of the prism **250** in a single direction (e.g., a single dimension, the z direction) (e.g., illustrated in FIG. **3**) and/or may include optical image stabilization (OIS) (e.g., movement of the image sensor **208** in one or more directions (e.g., the x direction, the y direction). The optical assembly **103** may be positioned within the frame **302** of the camera **100**.

[0037] As described herein, the camera **100** may also include an AF actuator assembly **270**, the prism **250**, prism cap(s) **252**, and a prism carrier **254**. The prism **250** may move (e.g., via the AF actuator assembly **270**) in the z direction for AF. As shown in FIG. **3**, both the optical assembly **103** and the image sensor **208** (e.g., and associated components of the image sensor **208** including those components for OIS) may be positioned adjacent each other and at a same height (e.g., a same position along the z direction) as each other. In some aspects, the optical assembly **103** and the image sensor **208** may not move in the z direction for AF. The prism **250** may be positioned below (e.g., along the z direction) both the optical assembly **103** and the image sensor **208**. The prism **250** may receive light along a light path **202** parallel to the optical axis **101** and passing through the optical assembly **103**. The prism **250**, upon receiving the light, may shift the light (e.g., in the x direction) and output the light in a direction parallel to the optical axis **101**, in a z direction towards the optical assembly **103**, and for reception by the adjacent image sensor **208**. The prism **250** may shift the light by reflecting the light off an odd number (e.g., three (3)) of reflection points (e.g., reflection surfaces) before outputting the light towards the image sensor **208**. In some aspects, the prism **250** may be a trapezoidal prism, but may additionally or alternatively be any prism that reflects received light off of an odd number of reflection points or reflection surfaces within the prism **250**. In some aspects, the prism **250** may be any prism that receives light from a direction at a first point in a plane and outputs the light towards the same direction but at a second point, different from the first point, in the same plane.

[0038] For example, the prism **250** may shift the light by receiving the light along the light path **202** from the optical assembly **103**. The light received by the prism **250** may continue along the light path **202** and may be reflected off the first reflection point **161** (e.g., a first reflection surface) within the prism **250**, may continue along the light path **202** and may reflect off the second reflection point **162** (e.g., a second reflection surface) within the prism **50**, and may continue along the light path **202** and may reflect off a third reflection point **163** (e.g., a third reflection surface) within the prism **250** before being outputted by the prism **250** along the light path **202** and in a direction parallel to the optical axis **101**, in the z direction towards the optical assembly **103**, and directly towards the image sensor **208** adjacent the optical assembly **103** for reception by the image sensor **208**. It should be understood that the surface of the second reflection point **162** may be a transmissive surface of the prism **250** that permits light to pass therethrough. However, due to the angle that the first reflection point **160** folds the light path **202** towards the second reflection point **162**, the total internal reflectance (TIR) may be great enough so that the transmissive surface may become a reflective surface (an internal reflective surface) at the second reflection point **162** rather than a transmissive surface.

[0039] Due to the configuration of the prism **250**, the position of the optical assembly **103** may be above (e.g., in the z direction) the prism **250** to enable the prism **250** to receive light from the optical assembly **103** along the light path **202** and the position of the image sensor **08** may be adjacent the optical assembly **103** and above (e.g., in the z direction) the prism **250** to enable the prism **250** to output the received light along the light path **202** to the image sensor **208**. As such, moving the prism **250** in the vertical direction (e.g., in the z direction) may change the focal length of the camera **100**. Accordingly, the camera **100** may rely on movement of the prism **250** in the z direction using the AF actuator assembly **270** for AF movement to change the focal length of the camera **100**. The image sensor **208** may still be moved for OIS (e.g., movement in the x direction, movement in the y direction) using the OIS actuator assembly **280**.

[0040] As described herein, the AF actuator assembly **270** may move the prism **250** in the z direction to change the focal length of the camera **100**. For example, the camera **100** may include the prism **250** retained by a prism carrier **254** and capped at a surface of the prism **250** opposite the optical assembly **103** and the image sensor **208** with prism cap(s) **252**. As described further herein, the AF actuator assembly **270** may including a magnet fixedly attached to the prism **250** and/or the prism carrier **254** so that the magnet moves with the prism **250** and a coil positioned adjacent the magnet and fixedly attached to a static portion of the camera **100**. The magnet and the coil may together be a voice coil motor (VCM). A magnetic field from the magnet may interact with current flowing through the coil creating Lorentz forces to move the prism **250** towards the optical assembly **103** and the image sensor **208** (e.g., in the +z direction) to decrease the light path **202** and decrease the focal length of the camera **100**. Similarly, the magnetic field from the magnet may interact with current flowing through the coil creating Lorentz forces to move the prism **250** away from the optical assembly **103** and the image sensor **208** (e.g., in the −z direction) to increase the light path **202** and increase the focal length of the camera **100**. In some aspects, the optical assembly **103** may be static so that it does not move for AF.

[0041] In some aspects, the AF actuator assembly **270** may also include one or more sets of ball bearings and one or more tracks formed in the prism carrier **254** and interior surfaces of the frame **302**. A pre-load plate positioned opposite the coil from the magnet may pull the prism carrier **254** towards the pre-load plate via the magnet thereby allowing the prism carrier **254** to move vertically using the one or more sets of ball bearings pressed against the one or more respective tracks. In addition, a position sensor located within the coil may be used to determine a position of the prism **250** along the z direction.

[0042] In various embodiments, the camera **100** may also include a flex circuit **220**, an OIS actuator assembly, a substrate **234** (e.g., an OIS FPC, printed circuit board, and/or the like), the image sensor **208**, and filter(s) **209** positioned below (e.g., in the z direction) the image sensor **208**. As described herein, the image sensor **208** may be positioned above (e.g., in the z direction) the prism **250** and adjacent (e.g., in the x direction) the optical assembly. The image sensor **208** may be attached to or otherwise integrated into the substrate **234**, such that the image sensor **208** is connected to the OIS frame or flex circuit **220** via the substrate **234**. For example, a dynamic platform of the flex circuit **220** may retain the substrate **234** for mounting one or more electronic components and/or the image sensor **208**. In some aspects, the substrate **234** may include an opening with a cross-section sized to permit light to pass therethrough while also receiving or retaining the filter(s) **209** and the image sensor **208**. The substrate **234** may retain the filter(s) **209** and the image sensor **208** around a perimeter of the opening. In some aspects, the image sensor **208** may be retained on the top surface of the substrate **234** while the filter(s) **209** may be positioned between the prism **250** and the image sensor **208**. These configuration may allow the substrate **234** to retain the image sensor **208** (and in some cases the filter(s) **209**) while also allowing light to pass from the lens(es) **204** of the optics assembly **103**, through the prism **250**, through the filter(s) **209**, and be received by the image sensor **208** for image capturing. In other embodiments, the substrate **234** and the image sensor **208** may be separately attached to the OIS frame or flex circuit **220**. For instance, a first set of one or more electrical traces may be routed between the substrate **234** and the OIS frame or flex circuit **220**. A second, different set of one or more electrical traces may be routed between the image sensor **208** and the OIS frame or flex circuit **221**.

[0043] The flexure circuit **220** may have a variety of different configurations. As described further herein at least with respect to FIG. **8**B, the flex circuit **220** may include a dynamic platform, a static platform, and a plurality of flexure arms. The flex circuit **220** may be connected to a static portion of the camera (e.g., an interior surface of the shield can **110** and/or the enclosure **113**) via a static platform. The flex circuit **220** may also retain the substrate **234**, the image sensor **208**, and the filter(s) **209** via the dynamic platform. The plurality of flexure arms may provide a flexible mechanical coupling and an electrical coupling between the static platform and the dynamic platform. For example, the flexure arms may allow the dynamic platform to move in one or more directions (e.g., the x direction, the y direction) relative to the static platform (e.g., and a remainder of the camera **100**) using components of the OIS actuator assembly **280**. The flexure arms (e.g., using one or more electrical traces on each of the flexure arms) may enable electrical signals and power communication between the image sensor **208** and other electrical components of the camera **100**. The relatively flat or two-dimensional configuration of the flex circuit having a dynamic platform, a static platform, and a plurality of flexure arms connecting the static platform to the dynamic platform simplifies manufacturing of the camera **100** due to the minimal amount of flexure **220** components that extend in the z direction.

[0044] Alternatively, and as described further herein at least with respect to FIGS. **7**A, **7**B, and **8**A, the flex circuit **220** may include various configurations having flexible arms, bend regions between flexible arms, and/or a moveable end portion. The moveable end portion may retain the substrate **234**, the image sensor **208**, and the filter(s) **209**. The flexible arms, bend regions between flexible arms, and/or the moveable end portion may provide a flexible mechanical coupling between the image sensor **208** and a static portion of the camera **100**. The flexible arms may permit movement in one or more directions (e.g., the x direction, the y direction) of the moveable end portion via the OIS actuator assembly **280**. The bend regions between the flexible arms may enable the flex circuit **220** to wrap around an internal perimeter of the camera **100** (e.g., a perimeter around the camera **100** but within the housing **110**). The flexible arms, bend regions between flexible arms, the intermediate arm region, and/or the moveable end portion may enable electrical signal and power communication between the image sensor **208** and a static portion of the camera **100**.

[0045] As described herein, the OIS actuator assembly **280** may move the image sensor **208** (e.g., including the flex circuit **220**, the substrate **234**, and the filter(s) **209**) for OIS (e.g., in the x direction, in the y direction). The OIS actuator assembly **280** may include at least two magnets and a coil for each of the respective magnets. For example, the OIS actuator assembly **280** may include a first magnet positioned below the flex circuit **220** in a fixed position so that first magnet extends long-ways in the y direction. A first coil may be positioned on the flex circuit **220** over the first magnet (e.g., in the z direction) so that the first coil extends long-ways in the y direction. The first coil may be attached to the flex circuit **22** and may move with movement of the image sensor **208**, the substrate **234**, and the flex circuit **220**. The first magnet and the first coil may together be a voice coil motor (VCM). A magnetic field from the first magnet may interact with current flowing through the first coil creating Lorentz forces to move the image sensor **208**, via the flex circuit **220**, in the y direction for OIS. Similarly, the OIS actuator assembly **280** may include a second magnet positioned below the flex circuit **220** in a fixed position so that second magnet extends long-ways in the x direction. A second coil may be positioned on the flex circuit **220** over the second magnet (e.g., in the z direction) so that the second coil extends long-ways in the x direction. The second coil may be attached to the flex circuit **220** and may move with movement of the image sensor **208**, the substrate **234**, and the flex circuit **220**. The second magnet and the second coil may together be a voice coil motor (VCM). A magnetic field from the second magnet may interact with current flowing through the second coil creating Lorentz forces to move the image sensor **208**, via the flex circuit **220**, in the x direction for OIS.

[0046] As described further herein, close proximity between magnet groups may cause unwanted magnetic attraction forces. For example, OIS magnets positioned in close proximity to speaker magnets and/or magnets of another camera of an electronic device (e.g., a mobile phone) may cause unwanted magnetic attraction between the OIS magnets and the speaker magnets and/or between the OIS magnets and the magnets of the other camera. In addition, moving magnets (e.g., magnets attached to the substrate **234** and/or the flex circuit **220** rather than magnets fixedly attached to a static portion of the camera **100**) may be more susceptible to unwanted magnetic attraction forces between the OIS magnets and other sets of magnets. These unwanted magnetic attraction forces may pull the sets of moving magnets off center or offset reducing their ability or capacity to interact with respective coils to produce Lorentz forces. As such, additional power may be needed to overcome the reduced ability or capacity of the off centered or offset magnets to provide adequate actuation and/or functionality. Conversely, fixed magnets, such as the first magnet and second magnet of the OIS actuator assembly **280** as described herein, are inherently more robust because they are largely undisturbed and/or unaffected by the unwanted magnetic attraction forces. Additionally, fixed magnets, such as the first magnet and second magnet of the OIS actuator assembly **280** as described herein, may allow for more efficient and/or tight packaging of the camera **100** which may enable more space for positioning components within the camera **100** such as larger speakers and/or larger batteries.

[0047] In some aspects, the image sensor **208** and the flex circuit **220** may be used for both AF and OIS. For example, AF may be implemented using the prism **250** and the image sensor **208** and flex circuit **220**. As another example, AF may be implemented using the optical assembly **103**, the prism **250**, and the image sensor **208** and flex circuit **220**. As such, an AF actuator assembly may be implemented with the image sensor **208**, substrate **234**, and flex circuit **220** to implement AF movement of the image sensor **208**. Further, a space or gap between the image sensor **208** and the shield can **110** (e.g., any adjacent outer wall of the camera) may need to be great (e.g., high or large) enough to accommodate AF movement. However, the large the space or gap is between the image sensor **208** and the shield can **110**, the greater the amount of heat is retained within the camera **100** and adjacent the image sensor **208** and the less or the slower the heat is able to dissipate from the camera **100**. As such, using the image sensor **208** and the flex circuit **220** for AF in addition to OIS may reduce or degrade the functionality and/or efficiencies of the image sensor **208** (e.g., causing a decrease in length of 4 k video session) due to the greater retention and slower dissipation of heat surrounding the image sensor **208**.

[0048] In some aspects, the image sensor **208** may only move for OIS and may not move for AF. In this case, as described herein, AF may be implemented by moving the prism **250**. Using the image sensor **208** for OIS but not for AF has some advantages over using the image sensor **208** for both OIS and AF. Without AF, a space or gap between the image sensor **208** and the shield can **110** (e.g., any adjacent outer wall of the camera) may be smaller (e.g., shorter, narrower, or lesser) compared to an image sensor that implements AF. With the smaller gap, a lesser amount of heat may be retained within the camera **100** and/or adjacent the image sensor **208** and the more heat from the image sensor **208** and the actuator assemblies (e.g., the OIS actuator assembly **208**) may be dissipated from the camera **100** and adjacent the image sensor **208** through the shield can **110**. As such, using the image sensor **208** and the flex circuit **220** for only OIS may increase or improve the functionality and/or efficiencies of the image sensor **208** (e.g., enabling an increase in length of 4 k video session) due to the lesser retention and faster dissipation of heat surrounding the image sensor **208**.

[0049] It should be noted that the camera **100** may be a component of a handset having a display screen. For example, the handset may be the same as or similar to the device **900** illustrated in FIG. **9** or the computer system **1000** illustrated in FIG. **10**. As another example, the display screen may be the same as or similar to the display system **902** in FIG. **9** or the display **1018** in FIG. **10**. The display screen may be positioned on a surface of the handset opposite the optical assembly **103** and the image sensor **208**. Accordingly, due to the positioning of the image sensor **208** adjacent (e.g., the x direction, the y direction), the image sensor **08** may dissipate heat through the surface of the handset opposite the display screen (e.g., the shield can **110** rather than the enclosure **113**). This could further increase the camera's **100** ability to dissipate heat from the image sensor **208** and/or enhance the functionality and/or the life of the display screen.

[0050] FIG. **4** illustrates an example autofocus (AF) actuator assembly **270** for a camera and including a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIG. **4** shows a perspective exploded view of the AF actuator assembly **270**. The AF actuator assembly **270** of FIG. **4** may include one or more same or similar features as the features described with respect to or illustrated in FIGS. **1**A, **1**B, **2**, **3**, **5**, **6**, **7**A, **7**B, **8**A, **8**B, **9**, and **10**. The example X-Y-Z coordinate system(s) shown in FIG. **4** may be used to discuss aspects of components and/or systems, and may apply to embodiments described throughout this disclosure.

[0051] As shown in FIG. **4**, the camera **100** may include the prism **250** and a prism carrier **254**. The camera **100** may also include a frame **302** retaining the prism carrier **254** and receiving the optical assembly **103** including the lens(es) **204**, and the lens barrel **205**. The frame **302** may include a space therein not only to receive the prism carrier **254** but also to allow the prism carrier **254** (e.g., retaining the prism **250**) move up and down in the z direction for AF. For example, the frame **302** may have a space therein to receive the prism carrier **254** holding the prism **250** and to allow the prism carrier **254** holding the prism **250** to move vertically in the z direction towards and away, via the AF actuator assembly **270**, from the lens(es) **204** and the image sensor **208**. As such, the frame **302** may allow the prism **250** may move (e.g., via the AF actuator assembly **270**) in the z direction for AF.

[0052] The frame **302** may also be configured to reside within the shield can **110** and the enclosure **113** and to retain the prism carrier **254** and the prism **250** residing within the prism carrier **254** so that light may be received by the prism **250** from the lens(es) **204** and provided by the prism **250** to the image sensor **208** (not shown) adjacent the lens **204**. For example, the prism **250** may be positioned below (e.g., along the z direction) both the optical assembly **103** and the image sensor **208** (not shown). The prism **250** may receive light along a light path parallel to the optical axis **101** and passing through the optical assembly **103**. The prism **250**, upon receiving the light, may shift the light (e.g., in the x direction) and output the light in a direction parallel to the optical axis **101**, in a z direction towards the optical assembly **103**, and for reception by the adjacent image sensor **208**. The prism **250** may shift the light by reflecting the light off an odd number (e.g., three (3)) of reflection points (e.g., reflection surfaces) before outputting the light towards the image sensor **208**. In some aspects, the prism **250** may be a trapezoidal prism, but may additionally or alternatively be any prism that reflects received light off of an odd number of reflection points or reflection surfaces within the prism **250**.

[0053] The prism **250** may shift the light by receiving the light along the light path **202** from the optical assembly **103**. The light received by the prism **250** may continue along the light path and may be reflected off a first reflection point (e.g., a first reflection surface) within the prism **250**, may continue along the light path and may reflect off a second reflection point (e.g., a second reflection surface) within the prism **250**, and may continue along the light path and may reflect off a third reflection point (e.g., a third reflection surface) within the prism **250** before being outputted by the prism **250** along the light path and in a direction parallel to the optical axis **101**, in the z direction towards the optical assembly **103**, and directly towards the image sensor **208** adjacent the optical assembly **103** for reception by the image sensor **208**.

[0054] Due to the configuration of the prism **250** (e.g., having an odd number of reflection points), the position of the optical assembly **103** may be above (e.g., in the z direction) the prism **250** retained by the prism carrier **254** to enable the prism **250** to receive light from the optical assembly **103** along the light path **202** and the position of the image sensor **208** may be adjacent the optical assembly **103** and above (e.g., in the z direction) the prism **250** to enable the prism **250** to output the received light along the light path **202** to the image sensor **208**. As such, moving the prism **250** in the vertical direction (e.g., in the z direction) may change the focal length of the camera **100**. Accordingly, the camera **100** may rely on movement of the prism **250** in the z direction using the AF actuator assembly **270** for AF movement to change the focal length of the camera **100**. The image sensor **208** may still be moved for OIS (e.g., movement in the x direction, movement in the y direction) using the OIS actuator assembly **280**.

[0055] As described herein, the AF actuator assembly **270** may move the prism **250** in the z direction to change the focal length of the camera **100**. For example, the camera **100** may include the prism **250** retained by a prism carrier **254** and capped at a surface of the prism **250** opposite the optical assembly **103** and the image sensor **208** with prism cap(s) **252**. The AF actuator assembly **270** may including a magnet **308** fixedly attached to the prism **250** and/or the prism carrier **254** so that the magnet **308** moves with the prism **250** and a coil **309** positioned adjacent the magnet and fixedly attached to a static portion of the camera **100**. The magnet **308** and the coil **309** may together be a voice coil motor (VCM). A magnetic field from the magnet **308** may interact with current flowing through the coil **309** creating Lorentz forces to move the prism **250** towards the optical assembly **103** and the image sensor **208** (e.g., in the +z direction) to decrease the light path **202** and decrease the focal length of the camera **100**. Similarly, the magnetic field from the magnet **308** may interact with current flowing through the coil **309** creating Lorentz forces to move the prism **250** away from the optical assembly **103** and the image sensor **208** (e.g., in the −z direction) to increase the light path **202** and increase the focal length of the camera **100**. In some aspects, the optical assembly **103** may be static so that it does not move for AF. Alternatively, the optical assembly **103** may use another AF actuator assembly for further change in the length of the light path and the focal length of the camera **100**.

[0056] In some aspects, the AF actuator assembly **270** may also include one or more sets of ball bearings and one or more tracks formed in the prism carrier **254** and interior surfaces of the shield can/housing **110** and/or the enclosure **113**. A pre-load plate positioned opposite the coil **309** from the magnet **308** may pull the prism carrier **254** towards the pre-load plate **254** via the magnet **308** thereby allowing the prism carrier **254** to move vertically using the one or more sets of ball bearings pressed against the one or more respective tracks. In addition, a position sensor **311** located within the coil **309** may be used to determine a position of the prism **250** along the z direction.

[0057] FIG. **5** illustrates an example optical image stabilization (OIS) actuator assembly **280** for the camera **100** having a moving prism **250** positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera **100** according to at least some embodiments. FIG. **5** shows a perspective exploded view of the OIS actuator assembly **280**. The OIS actuator assembly **280** of FIG. **5** may include one or more same or similar features as the features described with respect to or illustrated in FIGS. **1**A, **1**B, **2**, **3**, **4**, **6**, **7**A, **7**B, **8**A, **8**B, **9**, and **10**. The example X-Y-Z coordinate system(s) shown in FIG. **5** may be used to discuss aspects of components and/or systems, and may apply to embodiments described throughout this disclosure.

[0058] As shown in FIG. **5**, the camera **100** includes the image sensor **208**, the substrate **234**, the filter(s) **209**, and the OIS actuator assembly **280**. The OIS actuator assembly **280** may move the image sensor **208** (e.g., and the flex circuit **220**, the substrate **234**, and the filter(s) **209**) for OIS (e.g., in the x direction, in the y direction). The OIS actuator assembly **280** may include at least two magnets **408** retained by a magnet holder **406** (e.g., a static portion of the camera **100**) and a coil **409** for each of the respective magnets. For example, the OIS actuator assembly **280** may include a first magnet **408***a* positioned below the flex circuit **220** in a fixed position so that first magnet **408***a* extends long-ways in the y direction. A first coil **409***a* may be positioned on the flex circuit **220** over the first magnet **408***a* (e.g., in the z direction) so that the first coil **409***a* extends long-ways in the y direction. The first coil **409***a* may be attached to the flex circuit **220** and may move with movement of the image sensor **208**, the substrate **234**, and the flex circuit **220**. The first magnet **408***a* and the first coil **409***a* may together be a voice coil motor (VCM). A magnetic field from the first magnet **408***a* may interact with current flowing through the first coil **409***a* creating Lorentz forces to move the image sensor **208**, via the flex circuit **220** (e.g., retaining the substrate **234**) (not shown), in the y direction for OIS. Similarly, the OIS actuator assembly **280** may include a second magnet **408***b* positioned below the flex circuit **220** in a fixed position so that second magnet **408***b* extends long-ways in the x direction. A second coil **409***b* may be positioned on the flex circuit **220** over the second magnet **408***b* (e.g., in the z direction) so that the second coil **409***b* extends long-ways in the x direction. The second coil **409***b* may be attached to the flex circuit **220** and may move with movement of the image sensor **208**, the substrate **234**, and the flex circuit **220**. The second magnet **408***b* and the second coil **409***b* may together be a voice coil motor (VCM). A magnetic field from the second magnet **408***b* may interact with current flowing through the second coil **409***b* creating Lorentz forces to move the image sensor **208**, via the flex circuit **220**, in the x direction for OIS. The first magnet **408***a* and the second magnet **408***b* may be received and positioned within a magnet housing **402** to securely position the respective magnets below the respect coils. A suspension assembly may be used for movement of the flex circuit **220**, the substrate **234**, and the image sensor **208**. For example, the suspension assembly may use one or more of ball bearings, springs, or suspension wires for movement of the flex circuit **220**, the substrate **234**, and the image sensor **208**.

[0059] As described further herein, close proximity between magnet groups may cause unwanted magnetic attraction forces. For example, OIS magnets positioned in close proximity to speaker magnets of an electronic device (e.g., a mobile phone) may cause unwanted magnetic attraction between the OIS magnets and the speaker magnets. In addition, moving magnets (e.g., magnets attached to the substrate **234** and/or the flex circuit **220** rather than magnets fixedly attached to a static portion of the camera **100**) may be more susceptible to unwanted magnetic attraction forces between the OIS magnets and other sets of magnets. These unwanted magnetic attraction forces may pull the sets of moving magnets off center or offset reducing their ability or capacity to interact with respective coils to produce Lorentz forces. As such, additional power may be needed to overcome the reduced ability or capacity of the off centered or offset magnets to provide adequate actuation and/or functionality. Conversely, fixed magnets, such as the first magnet **408***a* and second magnet **408***b* of the OIS actuator assembly **280** as described herein, are inherently more robust because they are largely undisturbed and/or unaffected by the unwanted magnetic attraction forces. Additionally, fixed magnets, such as the first magnet **408***a* and second magnet **408***b* of the OIS actuator assembly **280** as described herein, may allow for more efficient and/or tight packaging of the camera **100** which may enable more space for positioning components within the camera **100** such as larger speakers and/or larger batteries.

[0060] FIG. **6** illustrates an example method **600** of assembling an AF actuator assembly for a camera having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. The method **600** of FIG. **6** may include one or more same or similar features as the features described with respect to or illustrated in FIGS. **1**A, **1**B, **2**, **3**, **4**, **5**, **7**A, **7**B, **8**A, **8**B, **9**, and **10**. The example X-Y-Z coordinate system(s) shown in FIG. **6** may be used to discuss aspects of components and/or systems, and may apply to embodiments described throughout this disclosure.

[0061] At step **701**, the method **600** may include that a prism carrier **254** may be rotated upside-down and a prism **250** may be positioned within the prism carrier **254**. For example, the prism carrier **254** may be positioned within a frame **302** that retains the prism carrier **254** and allow the prism carrier **254** to move in the vertical direction (e.g., the z direction). The frame **302** and the prism carrier **254** may be rotated upside-down so that the prism carrier **254** may receive the prism **250**. At step **703**, a glue **502** may be dispensed on lateral sides of the prism **250** between the prism **250** and the prism carrier **254** for adhesion between the prism **250** and the prism carrier **254**. For example, after the prism **250** is inserted or positioned into the prism carrier **254**, glue **502** may be dispensed on a first long side of the prism **250** between the prism **250** and the prism carrier **254**. Also, after the prism **250** is inserted or positioned into the prism carrier **254**, glue **502** may be dispensed on a second long side of the prism **250** opposite the first long side of the prism **254** between the prism **250** and the prism carrier **254**. Applying the glue **502** may securely fix the prism **250** to the prism carrier **254** for reliable AF movement as described herein. At step **705**, prism caps **252** may be provided and glue **522** may be dispensed between the prism caps **252** and the prism carrier **254** and on the prism caps **252** so that the prism caps **252** may be securely positioned on surfaces of the prism **250** and so that the prism **250** may be securely fastened to the prism carrier **254**. For example, after glue **502** is applied between the prism **250** and the prism carrier **254**, glue **522** may be dispensed on the prism caps **252** and the prism caps **252** may be positioned on surfaces of the prism **250**. The glue **522** may adhere the prism caps **252** to the prism **250**. The glue **522** may also be dispensed between the prism caps **252** and the prism carrier **254** securing both the prism **250** and the prism caps **252** to the prism carrier **254**. The prism caps **252** may provide the prism **250** with a more rectangular shape (rather than, for example, a trapezoidal shape of the prism **250** alone) so that the prism **252** may securely fit within the prism carrier **254** for reliable AF movement.

[0062] FIGS. **7**A, **7**B, **8**A, and **8**B illustrates example flexures for a camera having a moving prism positioned along a light path between an optical assembly and an image sensor assembly that may, for example, change the focal length of the camera according to at least some embodiments. FIGS. **7**A, **7**B, **8**A, and **8**B show perspective views and a cross-sectional views of the respective flexures. The example flexures of FIGS. **7**A, **7**B, **8**A, and **8**B may include one or more same or similar features as the features described with respect to or illustrated in FIGS. **1**A, **1**B, **2**, **3**, **4**, **5**, **6**, **9**, and **10**. The example X-Y-Z coordinate system(s) shown in FIGS. **7**A, **7**B, **8**A, and **8**B may be used to discuss aspects of components and/or systems, and may apply to embodiments described throughout this disclosure.

[0063] As shown in FIGS. **7**A, **7**B, **8**A, and **8**B, the camera **100** and/or the OIS actuator assembly **280** may also include a flex circuit **220** for retaining the substrate **234**, the image sensor **208**, and the filter(s) **209** and for permitting (e.g., by flexing) OIS movement of the image sensor **208**. The flexure circuit **220** may have a variety of different configurations. For example, as shown in FIG. **7**A, a camera **100***a* may have an OIS actuator assembly **280***a* that includes a flex circuit **220***a* having flexible arms **710***a*, bend regions **712***a* between flexible arms, a moveable end portion **716***a*, and/or electrical connections **718***a*. The moveable end portion **716***a* may retain the substrate **234**, the image sensor **208**, and the filter(s) **209** and include an opening therethrough to permit light to reach the image sensor **208** from the prism **250**. The electrical connection(s) **718***a* may connect the flex circuit **220***a* to the coil **309** of the AF actuator assembly **270** so that one or more drivers connected to the flex circuit **220***a* may control both AF movement of the prism **250** and OIS movement of the image sensor **208**. The flexible arms **710***a*, bend regions **712***a* between flexible arms, and/or the moveable end portion **716***a* may provide a flexible mechanical coupling between the image sensor **208** and a static portion of the camera. The flexible arms **710***a* may permit movement in one or more directions (e.g., the x direction, the y direction) of the moveable end portion **716***a* via the OIS actuator assembly **280**. The bend regions **712***a* between the flexible arms **710***a* may enable the flex circuit **220***a* to wrap around an internal perimeter and backside of the camera (e.g., a perimeter around the camera but within the housing **110**). The flexible arms **710***a*, bend regions **712***a* between flexible arms, and/or the moveable end portion **716***a* may enable electrical signals and power communication between the image sensor **208**, the coil **309** via the electrical connection(s) **718***a*, and a static portion of the camera **100**. As shown in FIG. 7A, the configuration of the flex circuit **220***a* include an extended shield can in the x direction and outward from an optical assembly side of the camera to accommodate the flex circuit **220***a* wrapped around a backside of the camera.

[0064] As another example, as shown in FIG. 7B, a camera **100***b* may have an OIS actuator assembly **280***b* that includes a flex circuit **220***b* having flexible arms **710***b*, bend regions **712***b* between flexible arms, a moveable end portion **716***b*, and/or electrical connections **718***b*. The moveable end portion **716***b* may retain the substrate **234**, the image sensor **208**, and the filter(s) **209** and include an opening therethrough to permit light to reach the image sensor **208** from the prism **250**. The electrical connection(s) **718***b* may connect the flex circuit **220***b* to the coil **309** of the AF actuator assembly **270** so that one or more drivers connected to the flex circuit **220***b* may control both AF movement of the prism **250** and OIS movement of the image sensor **208**. The flexible arms **710***b*, bend regions **712***b* between flexible arms, and/or the moveable end portion **716***b* may provide a flexible mechanical coupling between the image sensor **208** and a static portion of the camera. The flexible arms **710***b* may permit movement in one or more directions (e.g., the x direction, the y direction) of the moveable end portion **716***b* via the OIS actuator assembly **280**. The bend regions **712***b* between the flexible arms **710***b* may enable the flex circuit **220***b* to wrap around an internal perimeter and front side of the camera (e.g., a perimeter around the camera **100** but within the housing **110**). The flexible arms **710***b*, bend regions **712***b* between flexible arms, and/or the moveable end portion **716***b* may enable electrical signals and power communication between the image sensor **208**, the coil **309** via the electrical connection(s) **718***b*, and a static portion of the camera **100**. As shown in FIG. 7B, the configuration of the flex circuit **220***b* include an extended shield can in the x direction and outward from an image sensor side of the camera to accommodate the flex circuit **220***b* wrapped around a front side of the camera.

[0065] As yet another example, as shown in FIG. **8**A, a camera **100***c* may have an OIS actuator assembly **280***c* that includes a flex circuit **220***c* having flexible arms **710***c*, bend regions **712***c* between flexible arms, a moveable end portion **716***c*, and/or electrical connections **718***c*. The moveable end portion **716***c* may retain the substrate **234**, the image sensor **208**, and the filter(s) **209** and include an opening therethrough to permit light to reach the image sensor **208** from the prism **250**. The electrical connection(s) **718***c* may connect the flex circuit **220***c* to the coil **309** of the AF actuator assembly **270** so that one or more drivers connected to the flex circuit **220***c* may control both AF movement of the prism **250** and OIS movement of the image sensor **208**. The flexible arms **710***c*, bend regions **712***c* between flexible arms, and/or the moveable end portion **716***c* may provide a flexible mechanical coupling between the image sensor **208** and a static portion of the camera. The flexible arms **710***c* may permit movement in one or more directions (e.g., the x direction, the y direction) of the moveable end portion **716***c* via the OIS actuator assembly **280**. The bend regions **712***c* between the flexible arms **710***c* may enable the flex circuit **220***c* to wrap around an internal perimeter and bottom side of the camera (e.g., a perimeter around the camera but within the housing **110**). The flexible arms **710***c*, bend regions **712***c* between flexible arms, and/or the moveable end portion **716***c* may enable electrical signals and power communication between the image sensor **208**, the coil **309** via the electrical connection(s) **718***c*, and a static portion of the camera. As shown in FIG. **8**A, the configuration of the flex circuit **220***c* include an extended shield can in the x direction and outward from an image sensor side of the camera to accommodate the flex circuit **220***c* wrapped around a bottom side of the camera.

[0066] As yet another example, as shown in FIG. **8**B, a camera **100***d* may have an OIS actuator assembly **280***d* that includes flexure circuit **220***d* having a dynamic platform **720**, a static platform **724**, and a plurality of flexure arms **722**. The flex circuit **220***d* may be connected to an interior surface of the shield can **110** and/or the enclosure **113** via a static platform **724**. The flex circuit **220***d* may also retain the substrate **234**, the image sensor **208**, and the filter(s) **209** via the dynamic platform **720**. The plurality of flexure arms **722** may provide a flexible mechanical coupling and an electrical coupling between the static platform **724** and the dynamic platform **720** to allow for electrical power and signal communications between the image sensor **208**, the coils **409***a* and **409***b*, and the coil **309**, and one or more drivers and other electrical components internal and/or external to the camera. For example, the flexure arms **722** may allow the dynamic platform **720** to move in one or more directions (e.g., the x direction, the y direction) relative to the static platform **724** (e.g., and a remainder of the camera) using components of the OIS actuator assembly **280**. The flexure arms **722** (e.g., using one or more electrical traces on each of the flexure arms **722**) may enable electrical signals and power communication between the image sensor **208**, the coils **409***a* and **409***b*, and other electrical components of the camera. The relatively flat or two-dimensional configuration of the flex circuit **220***d* having a dynamic platform **720**, a static platform **724**, and a plurality of flexure arms **722** connecting the static platform **724** to the dynamic platform **720** simplifies manufacturing of the camera due to the minimal amount of flex circuit **220***d* components that extend in the z direction.

[0067] FIG. **9** illustrates a schematic representation of an example device **1100** that may include a camera (e.g., as described herein with respect FIGS. **1**A, **1**B, **2**, **3**, **4**, **5**, **6**, **7**A, **7**B, **8**A, **8**B, and **10**), in accordance with some embodiments. In some embodiments, the device **900** may be a mobile device and/or a multifunction device. In various embodiments, the device **900** may be any of various types of devices, including, but not limited to, a personal computer system, desktop computer, laptop, notebook, tablet, slate, pad, or netbook computer, mainframe computer system, handheld computer, workstation, network computer, a camera, a set top box, a mobile device, an augmented reality

(AR) and/or virtual reality (VR) headset, a consumer device, video game console, handheld video game device, application server, storage device, a television, a video recording device, a peripheral device such as a switch, modem, router, or in general any type of computing or electronic device.

[0068] In some embodiments, the device **900** may include a display system **902** (e.g., comprising a display and/or a touch-sensitive surface) and/or one or more cameras **904**. In some non-limiting embodiments, the display system **902** and/or one or more front-facing cameras **904***a* may be provided at a front side of the device **900**, e.g., as indicated in FIG. **9**. Additionally, or alternatively, one or more rear-facing cameras **904***b* may be provided at a rear side of the device **900**. In some embodiments comprising multiple cameras **904**, some or all of the cameras may be the same as, or similar to, each other. Additionally, or alternatively, some or all of the cameras may be different from each other. In various embodiments, the location(s) and/or arrangement(s) of the camera(s) **904** may be different than those indicated in FIG. **9**.

[0069] Among other things, the device **900** may include memory **906** (e.g., comprising an operating system **908** and/or application(s)/program instructions **910**), one or more processors and/or controllers **912** (e.g., comprising CPU(s), memory controller(s), display controller(s), and/or camera controller(s), etc.), and/or one or more sensors **916** (e.g., orientation sensor(s), proximity sensor(s), and/or position sensor(s), etc.). In some embodiments, the device **900** may communicate with one or more other devices and/or services, such as computing device(s) **918**, cloud service(s) **920**, etc., via one or more networks **922**. For example, the device **900** may include a network interface (e.g., network interface **910**) that enables the device **900** to transmit data to, and receive data from, the network(s) **922**. Additionally, or alternatively, the device **900** may be capable of communicating with other devices via wireless communication using any of a variety of communications standards, protocols, and/or technologies.

[0070] FIG. **10** illustrates a schematic block diagram of an example computing device, referred to as computer system **1000**, that may include or host embodiments of a camera (e.g., as described herein with respect to FIGS. **1**A, **1**B, **2**, **3**, **4**, **5**, **6**, **7**A, **7**B, **8**A, **8**B, and **9**). In addition, computer system **1000** may implement methods for controlling operations of the camera and/or for performing image processing images captured with the camera. In some embodiments, the device **1000** (described herein with reference to FIG. **10**) may additionally, or alternatively, include some or all of the functional components of the computer system **1000** described herein.

[0071] The computer system **1000** may be configured to execute any or all of the embodiments described above. In different embodiments, computer system **1000** may be any of various types of devices, including, but not limited to, a personal computer system, desktop computer, laptop, notebook, tablet, slate, pad, or netbook computer, mainframe computer system, handheld computer, workstation, network computer, a camera, a set top box, a mobile device, an augmented reality (AR) and/or virtual reality (VR) headset, a consumer device, video game console, handheld video game device, application server, storage device, a television, a video recording device, a peripheral device such as a switch, modem, router, or in general any type of computing or electronic device.

[0072] In the illustrated embodiment, computer system **1000** includes one or more processors **1002** coupled to a system memory **1004** via an input/output (I/O) interface **1006**. Computer system **1000** further includes one or more cameras **1008** coupled to the I/O interface **1006**. Computer system **1000** further includes a network interface **1010** coupled to I/O interface **1006**, and one or more input/output devices **1012**, such as cursor control device **1014**, keyboard **1016**, and display(s) **1018**. In some cases, it is contemplated that embodiments may be implemented using a single instance of computer system **1000**, while in other embodiments multiple such systems, or multiple nodes making up computer system **1000**, may be configured to host different portions or instances of embodiments. For example, in one embodiment some elements may be implemented via one or more nodes of computer system **1000** that are distinct from those nodes implementing other elements.

[0073] In various embodiments, computer system **1000** may be a uniprocessor system including one processor **1002**, or a multiprocessor system including several processors **1002** (e.g., two, four, eight, or another suitable number). Processors **1002** may be any suitable processor capable of executing instructions. For example, in various embodiments processors **1002** may be general-purpose or embedded processors implementing any of a variety of instruction set architectures (ISAs), such as the x86, PowerPC, SPARC, or MIPS ISAs, or any other suitable ISA. In multiprocessor systems, each of processors **1002** may commonly, but not necessarily, implement the same ISA.

[0074] System memory **1004** may be configured to store program instructions **1020** accessible by processor **1002**. In various embodiments, system memory **1004** may be implemented using any suitable memory technology, such as static random access memory (SRAM), synchronous dynamic RAM (SDRAM), nonvolatile/Flash-type memory, or any other type of memory. Additionally, existing camera control data **1022** of memory **1004** may include any of the information or data structures described above. In some embodiments, program instructions **1020** and/or data **1022** may be received, sent or stored upon different types of computer-accessible media or on similar media separate from system memory **1004** or computer system **1000**. In various embodiments, some or all of the functionality described herein may be implemented via such a computer system **1000**.

[0075] In one embodiment, I/O interface **1006** may be configured to coordinate I/O traffic between processor **1002**, system memory **1004**, and any peripheral devices in the device, including network interface **1010** or other peripheral interfaces, such as input/output devices **1012**. In some embodiments, I/O interface **1006** may perform any necessary protocol, timing or other data transformations to convert data signals from one component (e.g., system memory **1004**) into a format suitable for use by another component (e.g., processor **1002**). In some embodiments, I/O interface **1006** may include support for devices attached through various types of peripheral buses, such as a variant of the Peripheral Component Interconnect (PCI) bus standard or the Universal Serial Bus (USB) standard, for example. In some embodiments, the function of I/O interface **1006** may be split into two or more separate components, such as a north bridge and a south bridge, for example. Also, in some embodiments some or all of the functionality of I/O interface **1006**, such as an interface to system memory **1004**, may be incorporated directly into processor **1002**.

[0076] Network interface **1010** may be configured to allow data to be exchanged between computer system **1000** and other devices attached to a network **1024** (e.g., carrier or agent devices) or between nodes of computer system **1000**. Network **1024** may in various embodiments include one or more networks including but not limited to Local Area Networks (LANs) (e.g., an Ethernet or corporate network), Wide Area Networks (WANs) (e.g., the Internet), wireless data networks, some other electronic data network, or some combination thereof. In various embodiments, network interface **1010** may support communication via wired or wireless general data networks, such as any suitable type of Ethernet network, for example; via telecommunications/telephony networks such as analog voice networks or digital fiber communications networks; via storage area networks such as Fibre Channel SANs, or via any other suitable type of network and/or protocol.

[0077] Input/output devices **1012** may, in some embodiments, include one or more display terminals, keyboards, keypads, touchpads, scanning devices, voice or optical recognition devices, or any other devices suitable for entering or accessing data by one or more computer systems **1000**. Multiple input/output devices **1012** may be present in computer system **1000** or may be distributed on various nodes of computer system **1000**. In some embodiments, similar input/output devices may be separate from computer system **1000** and may interact with one or more nodes of computer system **1000** through a wired or wireless connection, such as over network interface **1010**.

[0078] Those skilled in the art will appreciate that computer system **1000** is merely illustrative and is not intended to limit the scope of embodiments. In particular, the computer system and devices may include any combination of hardware or software that can perform the indicated functions, including computers, network devices, Internet appliances, PDAs, wireless phones, pagers, etc. Computer system **1000** may also be connected to other devices that are not illustrated, or instead may operate as a stand-alone system. In addition, the functionality provided by the illustrated components may in some embodiments be combined in fewer components or distributed in additional components. Similarly, in some embodiments, the functionality of some of the illustrated components may not be provided and/or other additional functionality may be available.

[0079] Those skilled in the art will also appreciate that, while various items are illustrated as being stored in memory or on storage while being used, these items or portions of them may be transferred between memory and other storage devices for purposes of memory management and data integrity. Alternatively, in other embodiments some or all of the software components may execute in memory on another device and communicate with the illustrated computer system via inter-computer communication. Some or all of the system components or data structures may also be stored (e.g., as instructions or structured data) on a computer-accessible medium or a portable article to be read by an appropriate drive, various examples of which are described above. In some embodiments, instructions stored on a computer-accessible medium separate from computer system **1000** may be transmitted to computer system **1000** via transmission media or signals such as electrical, electromagnetic, or digital signals, conveyed via a communication medium such as a network and/or a wireless link. Various embodiments may further include receiving, sending or storing instructions and/or data implemented in accordance with the foregoing description upon a computer-accessible medium. Generally speaking, a computer-accessible medium may include a non-transitory, computer-readable storage medium or memory medium such as magnetic or optical media, e.g., disk or DVD/CD-ROM, volatile or non-volatile media such as RAM (e.g. SDRAM, DDR, RDRAM, SRAM, etc.), ROM, etc. In some embodiments, a computer-accessible medium may include transmission media or signals such as electrical, electromagnetic, or digital signals, conveyed via a communication medium such as network and/or a wireless link.

[0080] The methods described herein may be implemented in software, hardware, or a combination thereof, in different embodiments. In addition, the order of the blocks of the methods may be changed, and various elements may be added, reordered, combined, omitted, modified, etc. Various modifications and changes may be made as would be obvious to a person skilled in the art having the benefit of this disclosure. The various embodiments described herein are meant to be illustrative and not limiting. Many variations, modifications, additions, and improvements are possible. Accordingly, plural instances may be provided for components described herein as a single instance. Boundaries between various components, operations and data stores are somewhat arbitrary, and particular operations are illustrated in the context of specific illustrative configurations. Other allocations of functionality are envisioned and may fall within the scope of claims that follow. Finally, structures and functionality presented as discrete components in the example configurations may be implemented as a combined structure or component. These and other variations, modifications, additions, and improvements may fall within the scope of embodiments as defined in the claims that follow.

What is claimed is:

1. A camera, comprising:

an optical assembly comprising one or more lenses defining an optical axis;

an image sensor;

a prism configured to receive light that has passed through the one or more lenses, reflect the received light multiple times, and transmit the received light to the image sensor in a direction parallel to the optical axis, wherein the image sensor is located at a same side of the prism as the one or more lenses; and

an actuator configured to move the prism along an axis parallel to the optical axis for auto focus (AF).

2. The camera of claim **1**, wherein the actuator is configured to move the prism along the axis parallel to the optical axis for AF to change a distance between the prism and both the optical assembly and the image sensor so as to change a focal length of the camera by a factor of two relative to the distance in the one dimension by which the prism moves.

3. The camera of claim **1**, wherein the light received by the prism is reflected within the prism an odd number times.

4. The camera of claim **1**, wherein the actuator is configured to move the prism along the axis parallel to the optical axis for AF a distance away from both the image sensor and the optical assembly to increase the focal length of the camera.

5. The camera of claim **1**, wherein the actuator is configured to move the prism along the axis parallel to the optical axis for AF a distance towards both the image sensor and the optical assembly to decrease the focal length of the camera.

6. The camera of claim **1**, wherein the actuator comprises a voice coil motor (VCM) actuator having a magnet that moves with the prism and a coil attached to a component of the camera that does not move with movement of the prism.

7. The camera of claim **1**, wherein the actuator is a first actuator, the camera further comprising a second actuator and a flex circuit retaining the image sensor, and wherein the second actuator is configured to move the image sensor and the flex circuit along two different axes that are both orthogonal to the optical axis.

8. The camera of claim **7**, wherein the second actuator comprises:

a first coil that moves with movement of the image sensor and the flex circuit along a first axis of the two different axes;

a first magnet attached to a component of the camera that does not move with movement of the image sensor and flex circuit along the first axis of the two different axes;

a second coil that moves with movement of the image sensor and flex circuit along a second axis of the two different axes; and

a second magnet attached to a component of the camera that does not move with movement of the image sensor and flex circuit along the second axis of the two different axes.

9. An actuator assembly for a camera, comprising:

an autofocus (AF) actuator module comprising:

a prism configured to receive light through a surface, reflect the light multiple times within the prism, and output the light through the surface and towards an image sensor, and

an actuator configured to move the prism along an axis orthogonal to the surface of the prism for auto focus (AF); and

wherein the AF actuator module is configured to couple with an optical image stabilization (OIS) actuator module that is configured to move the image sensor for OIS.

10. The actuator assembly of claim **9**, further comprising:

the OIS actuator module comprising the image sensor and a flex circuit, wherein the OIS actuator module is configured to move the image sensor in one or more directions orthogonal to the axis for OIS.

11. The actuator assembly of claim **9**, wherein the light received by the prism is reflected within the prism an odd number times.

12. The actuator assembly of claim **9**, wherein the prism comprises a trapezoidal prism.

13. The actuator assembly of claim **9**, wherein the AF actuator module comprises a voice coil motor (VCM) actuator having a magnet that moves with the prism and a coil that is stationary with respect to the magnet and the prism.

14. A device, comprising:

a display;

a camera;

one or more processors; and

memory storing program instructions executable by the one or more processors to cause images captured by the camera to be displayed on the display; and

the camera comprising:

an optical assembly having one or more lenses,

an image sensor,

a prism configured to receive light that has passed through the one or more lenses, reflect the received light multiple times, and transmit the received light to the image sensor in a direction parallel to the optical axis, wherein the image sensor is located at a same side of the prism as the one or more lenses, and

an actuator configured to move the prism along an axis parallel to the optical axis for auto focus (AF).

15. The device of claim **14**, wherein the actuator is configured to move the prism along the axis parallel to the optical axis for AF to change a distance between the prism and both the optical assembly and the image sensor so as to change a focal length of the camera by a factor of two relative to the distance in the one dimension by which the prism moves.

16. The device of claim **14**, wherein the light received by the prism is reflected within the prism an odd number times.

17. The device of claim **14**, wherein the actuator is configured to move the prism along the axis parallel to the optical axis for AF a distance away from both the image sensor and the optical assembly to increase the focal length of the camera.

18. The device of claim **14**, wherein the actuator is configured to move the prism along the axis parallel to the optical axis for AF a distance towards both the image sensor and the optical assembly to decrease the focal length of the camera.

19. The device of claim **14**, wherein the actuator comprises a voice coil motor (VCM) actuator having a magnet that moves with the prism and a coil attached to a component of the camera that does not move with movement of the prism.

20. The device of claim **14**, wherein the optical assembly is positioned on a wall of a housing of the device that is opposite the display, and wherein the image sensor is positioned adjacent the optical assembly and adjacent the wall to dissipate heat from the image sensor through the wall.

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