

(19) **United States**

(12) **Patent Application Publication**
Hammond

(10) **Pub. No.: US 2019/0376764 A1**

(43) **Pub. Date: Dec. 12, 2019**

(54) **ANALOG-DIGITAL HYBRID FIREARM
SCOPE**

(52) **U.S. Cl.**
CPC *F41G 1/38* (2013.01); *F41A 19/59*
(2013.01); *F41G 1/345* (2013.01)

(71) Applicant: **TrackingPoint, inc.**, Pflugerville, TX
(US)

(72) Inventor: **Douglas Richard Hammond**,
Pflugerville, TX (US)

(73) Assignee: **TrackingPoint, inc.**, Pflugerville, TX
(US)

(21) Appl. No.: **16/006,531**

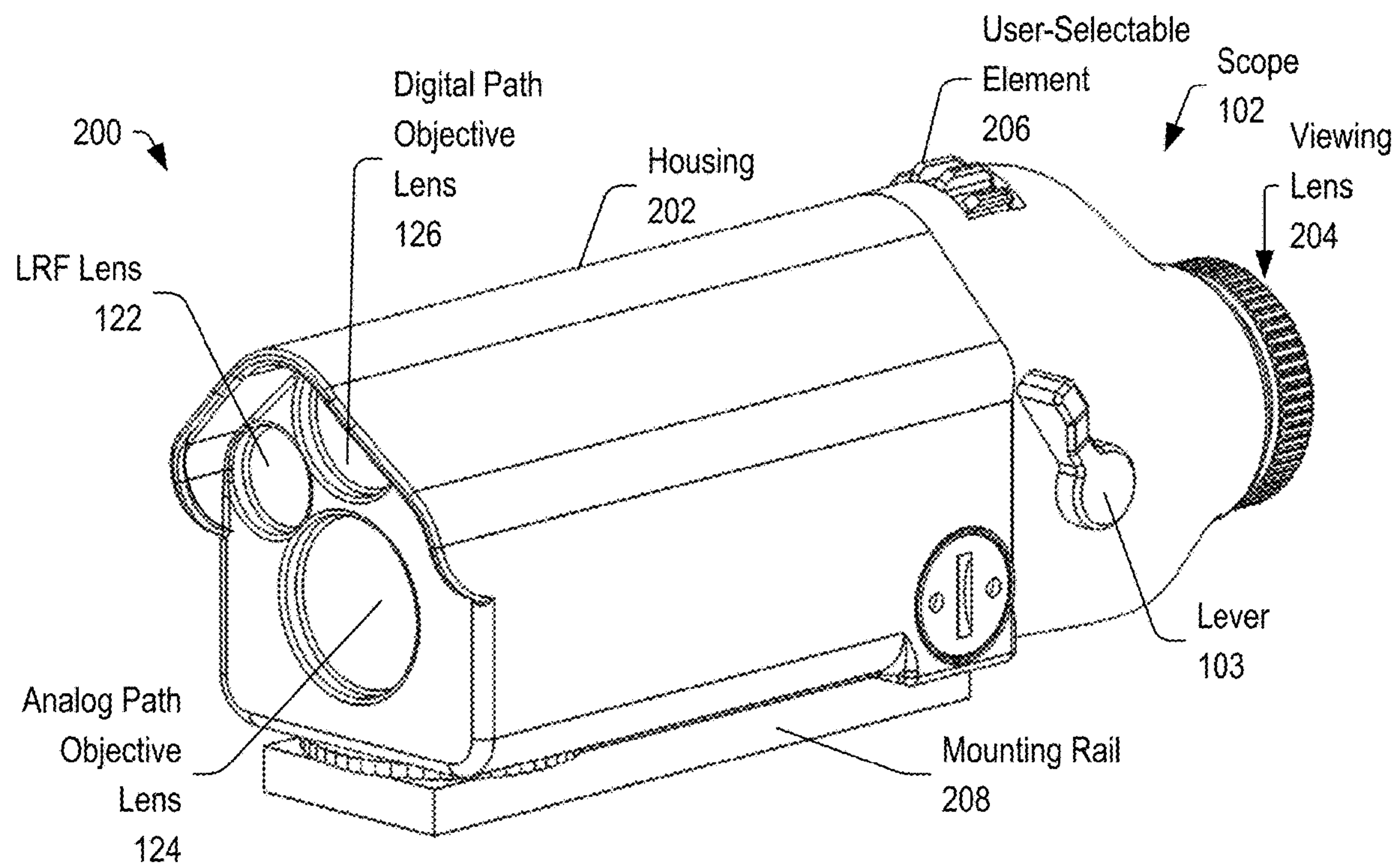
(22) Filed: **Jun. 12, 2018**

Publication Classification

(51) **Int. Cl.**
F41G 1/38 (2006.01)
F41G 1/34 (2006.01)
F41A 19/59 (2006.01)

(57) **ABSTRACT**

In some embodiments, a firearm system can include an optical scope. The optical scope may include a direct-view optics assembly and a switchable microdisplay element. The direct-view optics assembly can include an objective lens and a viewing lens, and may be configured to direct and focus light received by the objective lens toward the viewing lens. The switchable microdisplay element may be configured to selectively interrupt a light path between the objective lens and the viewing lens to present image data to the viewing lens.



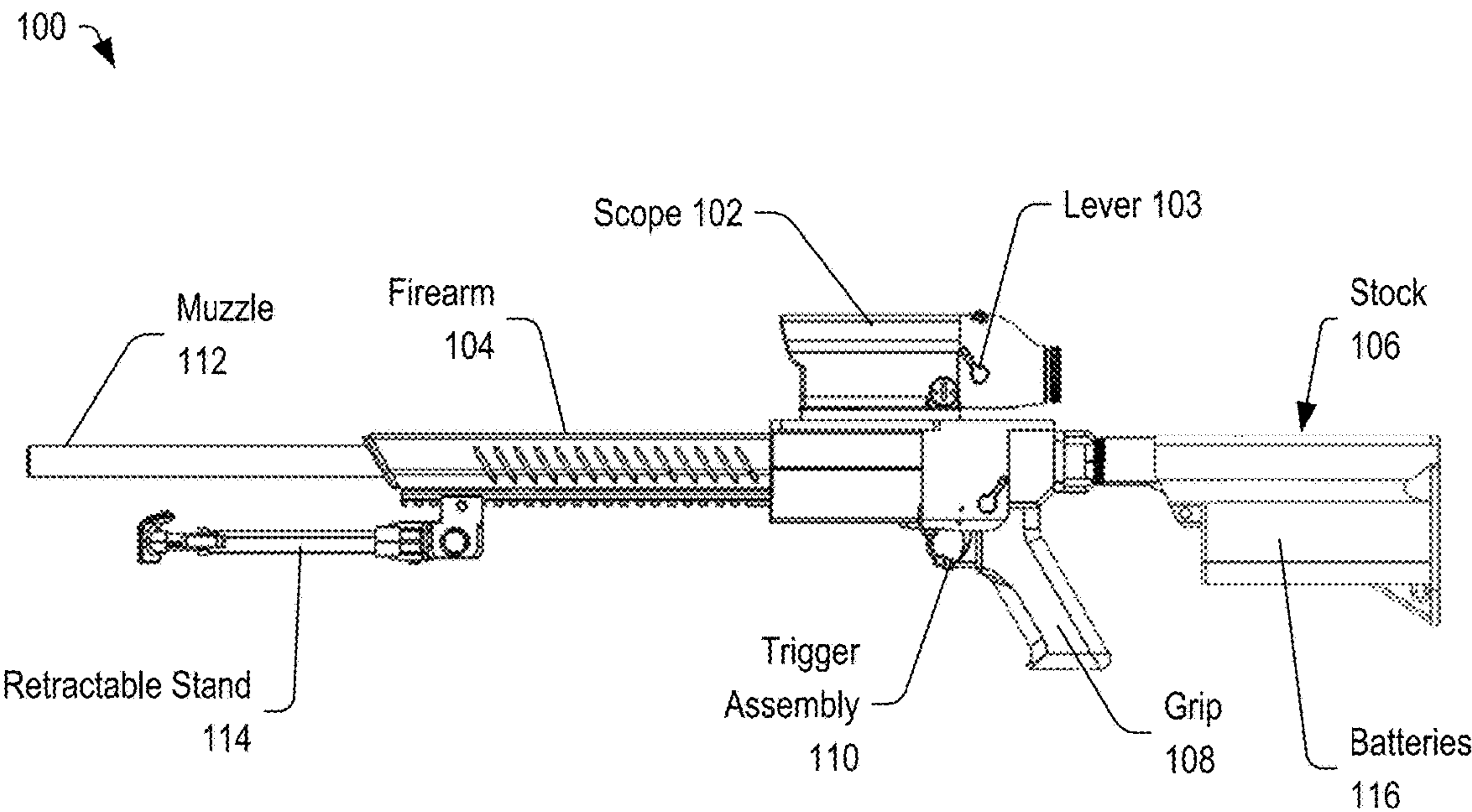


FIG. 1A

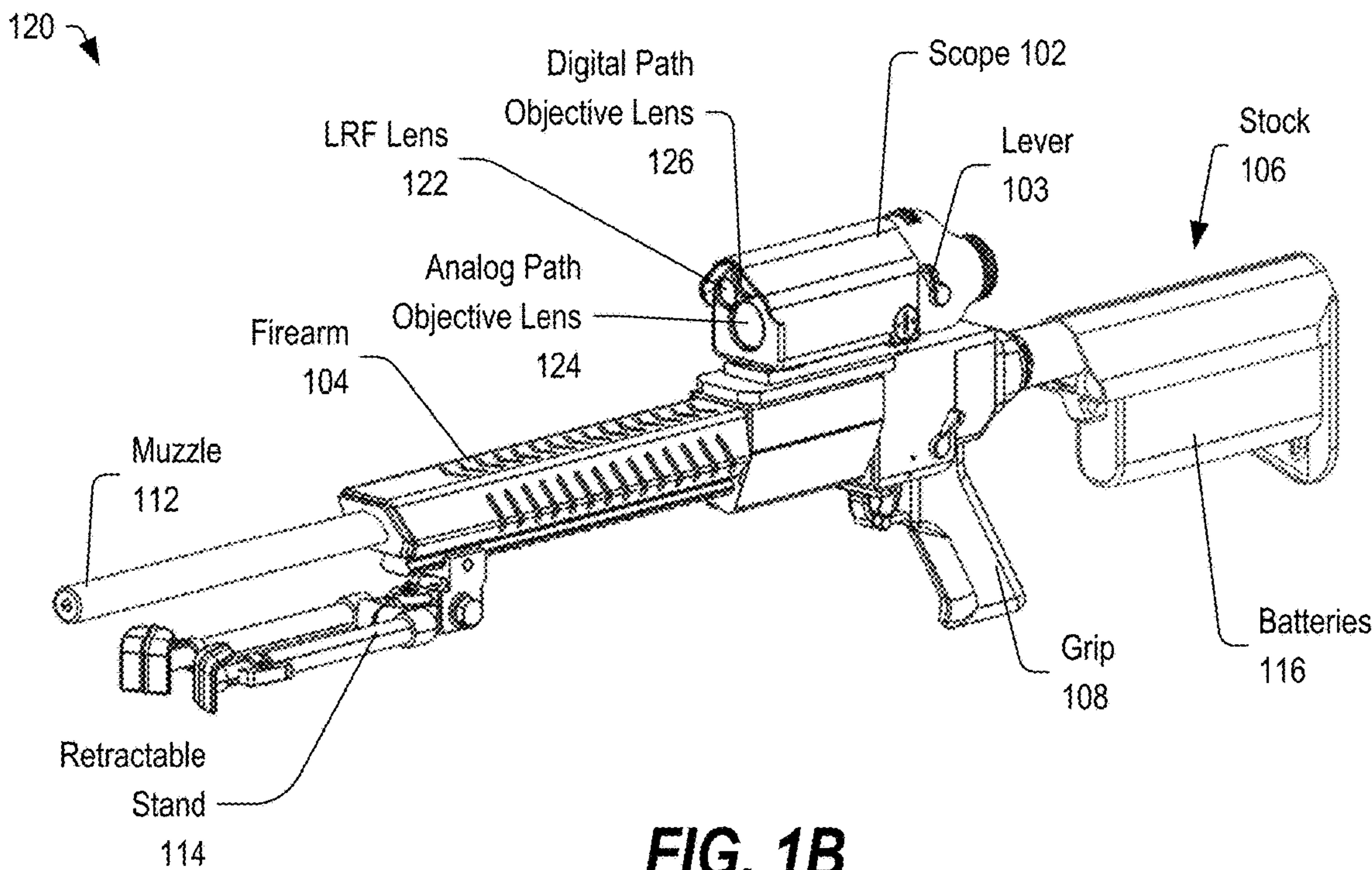


FIG. 1B

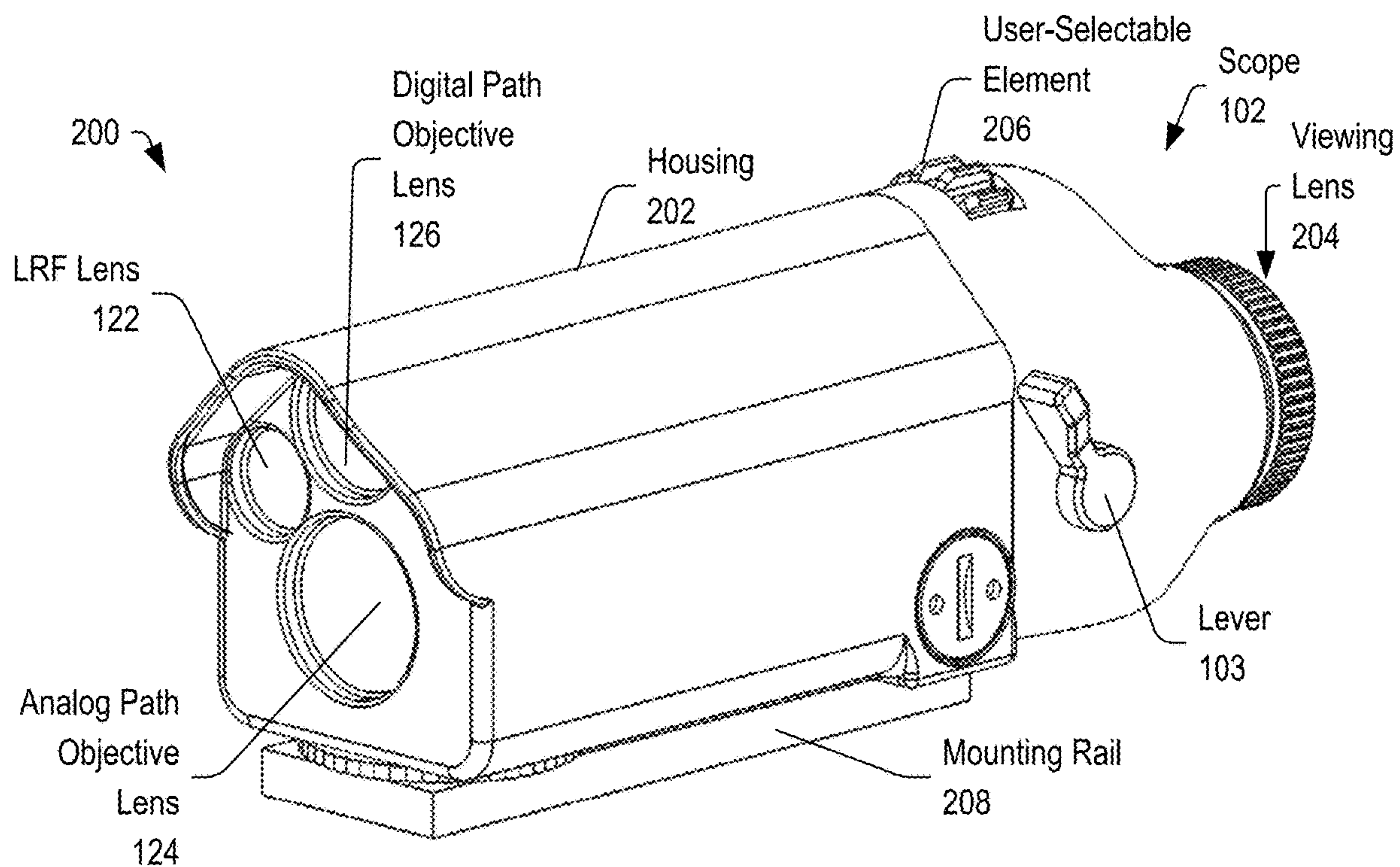


FIG. 2A

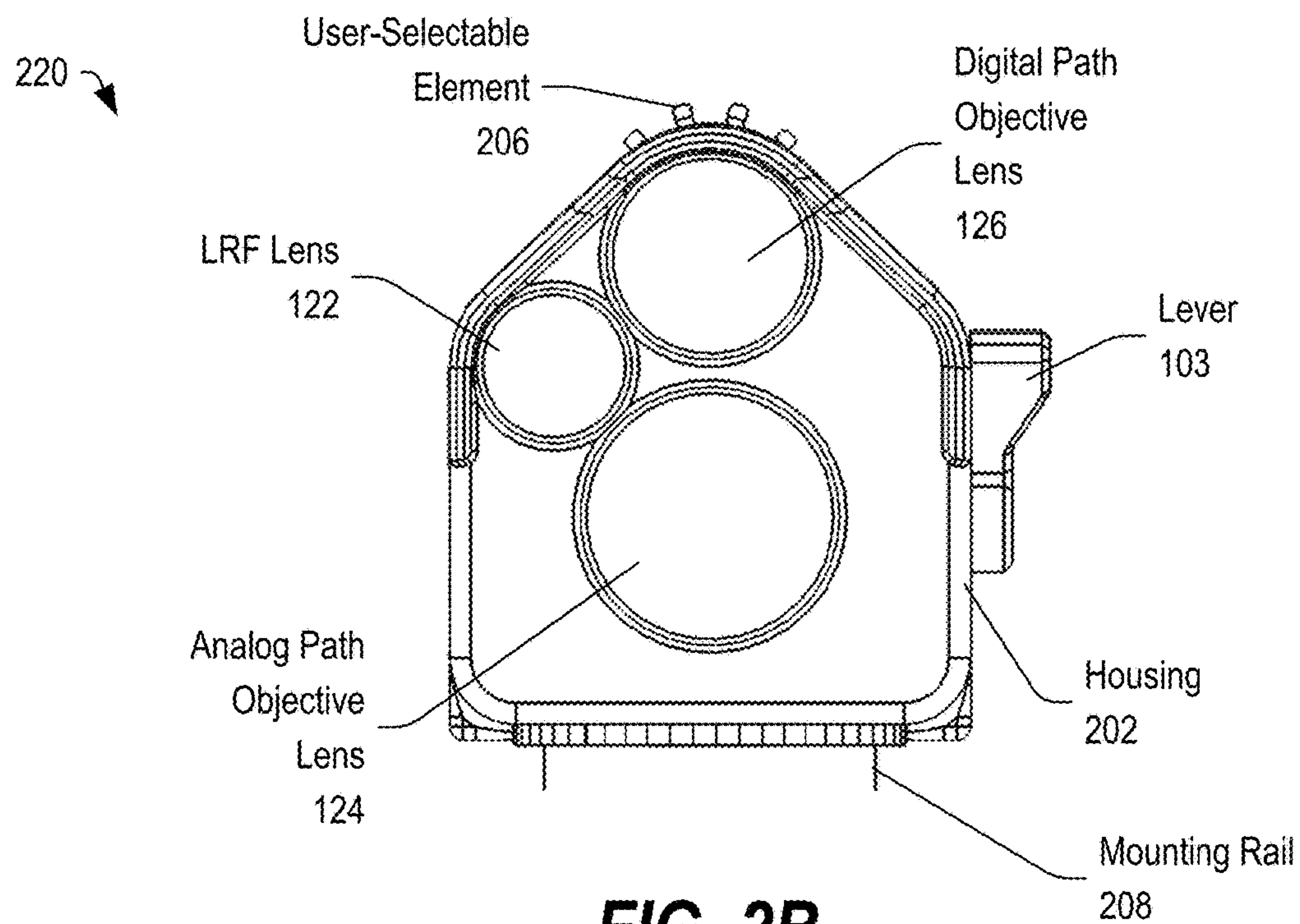


FIG. 2B

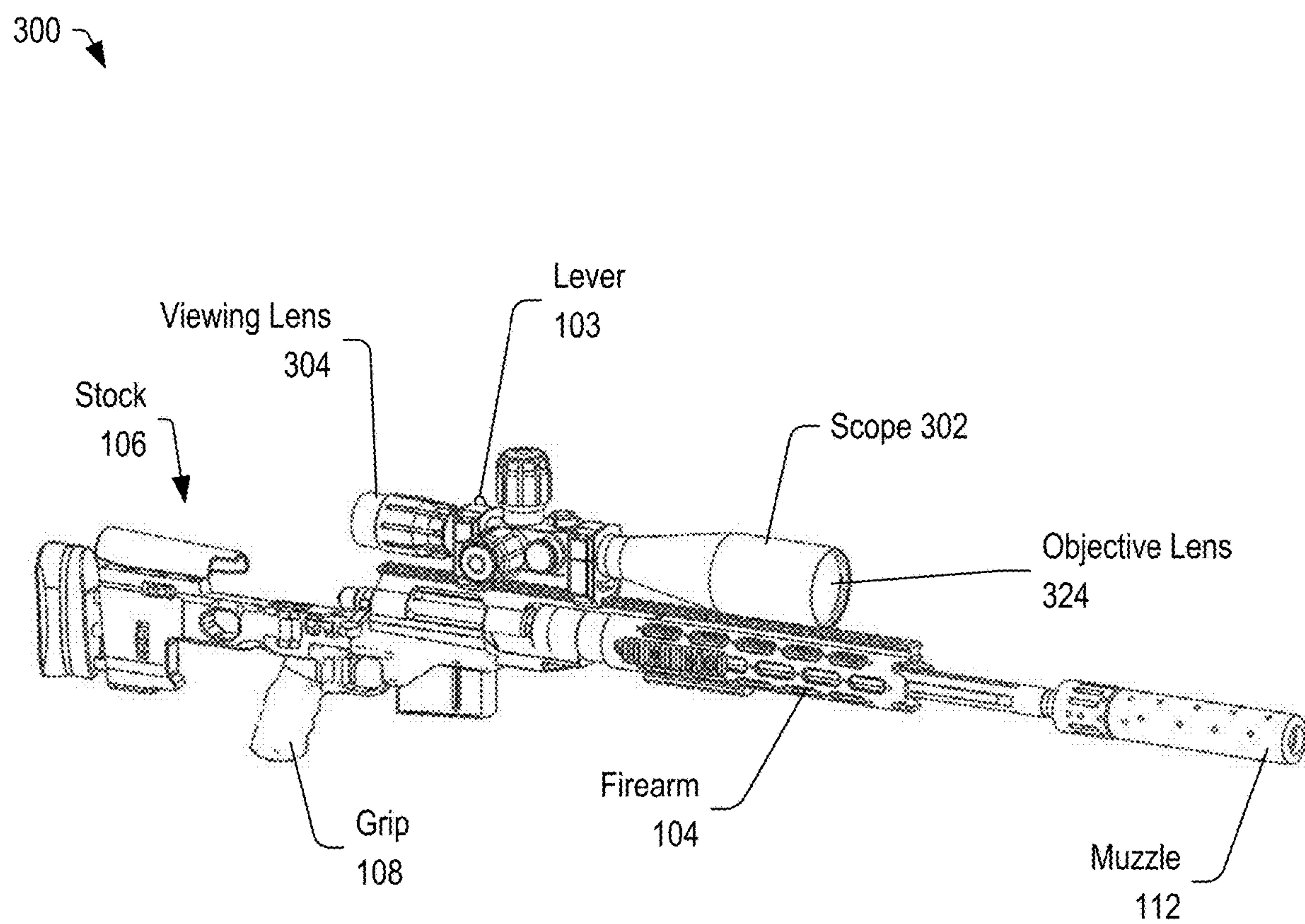


FIG. 3

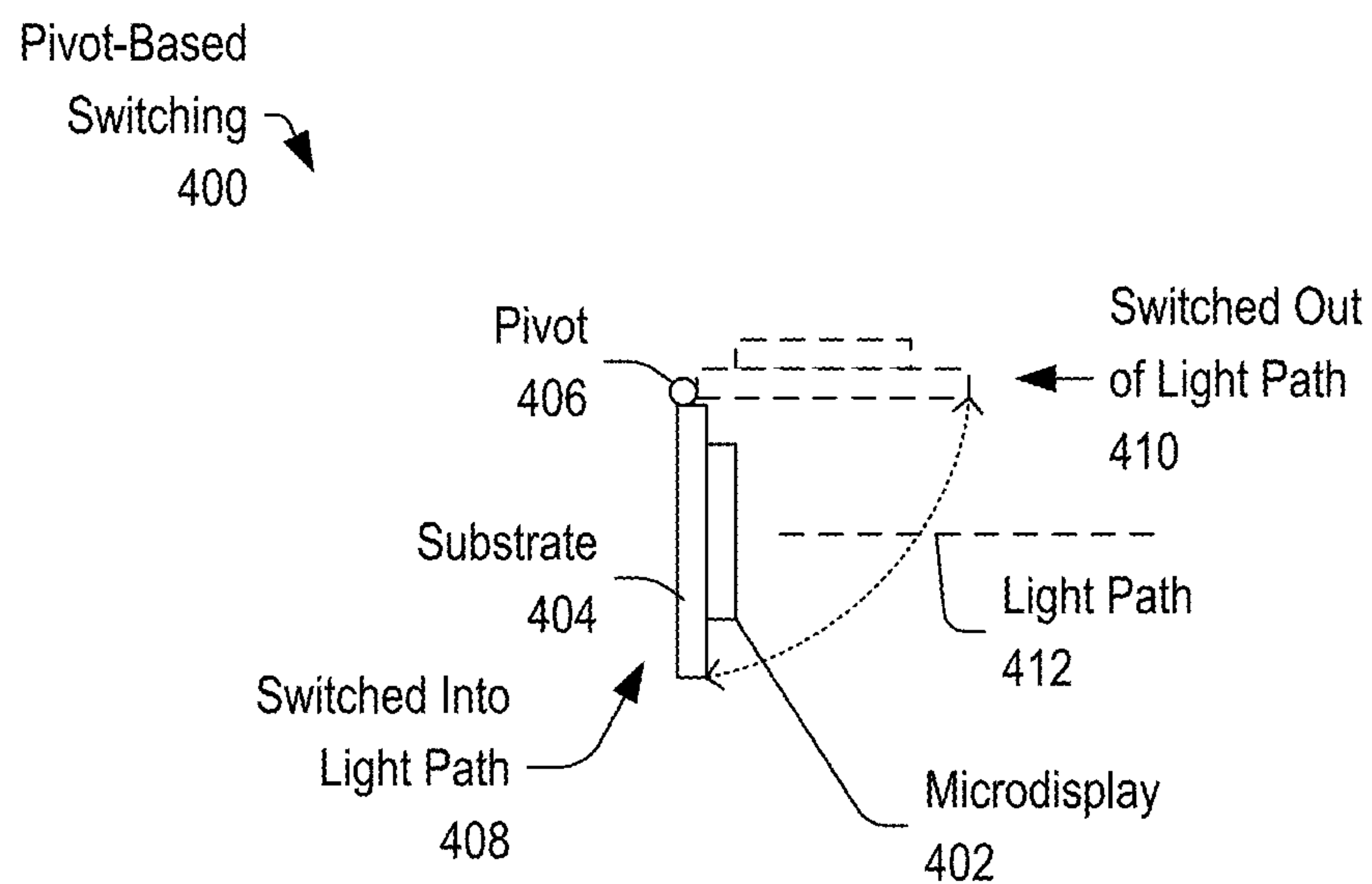


FIG. 4A

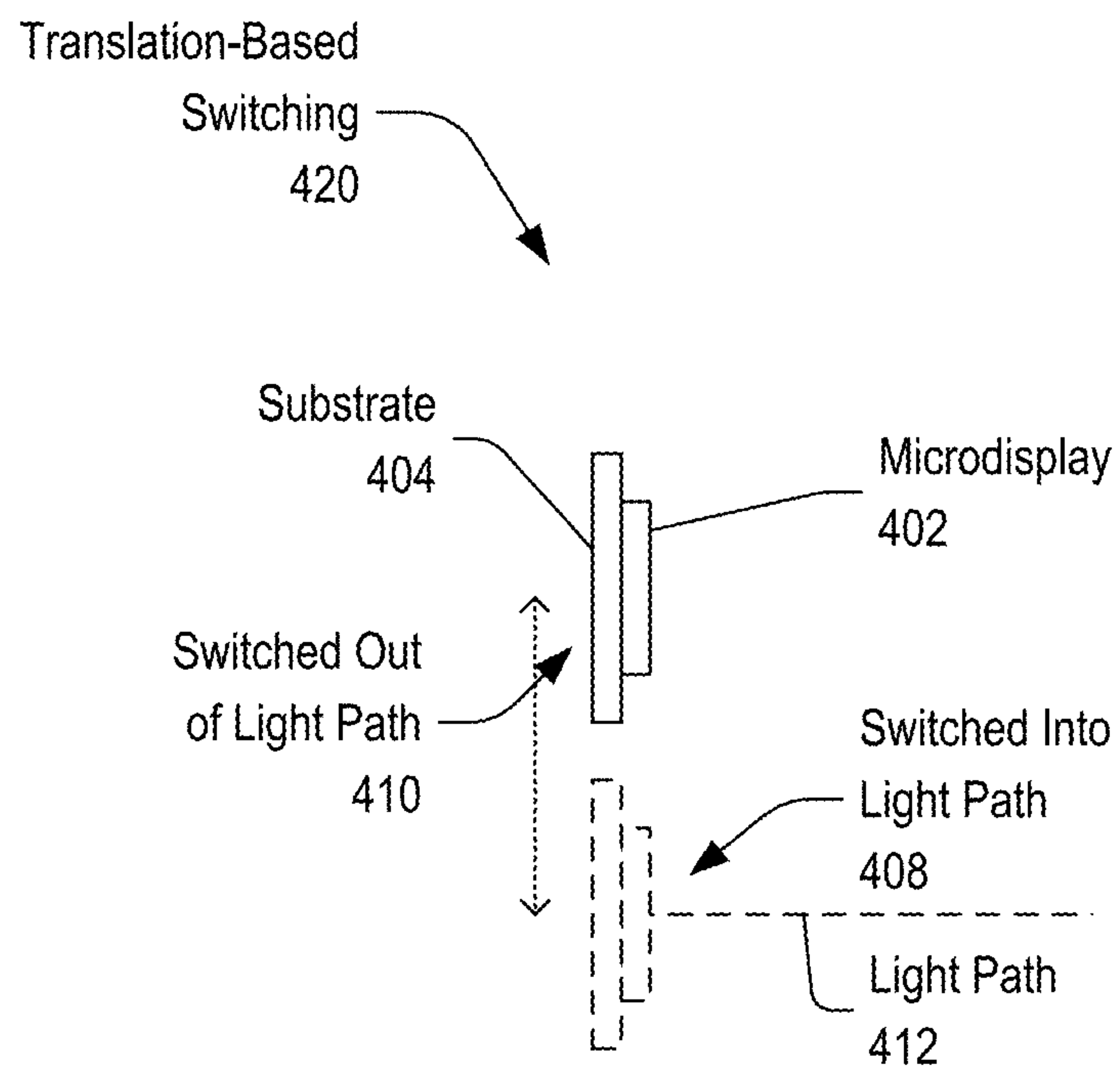


FIG. 4B

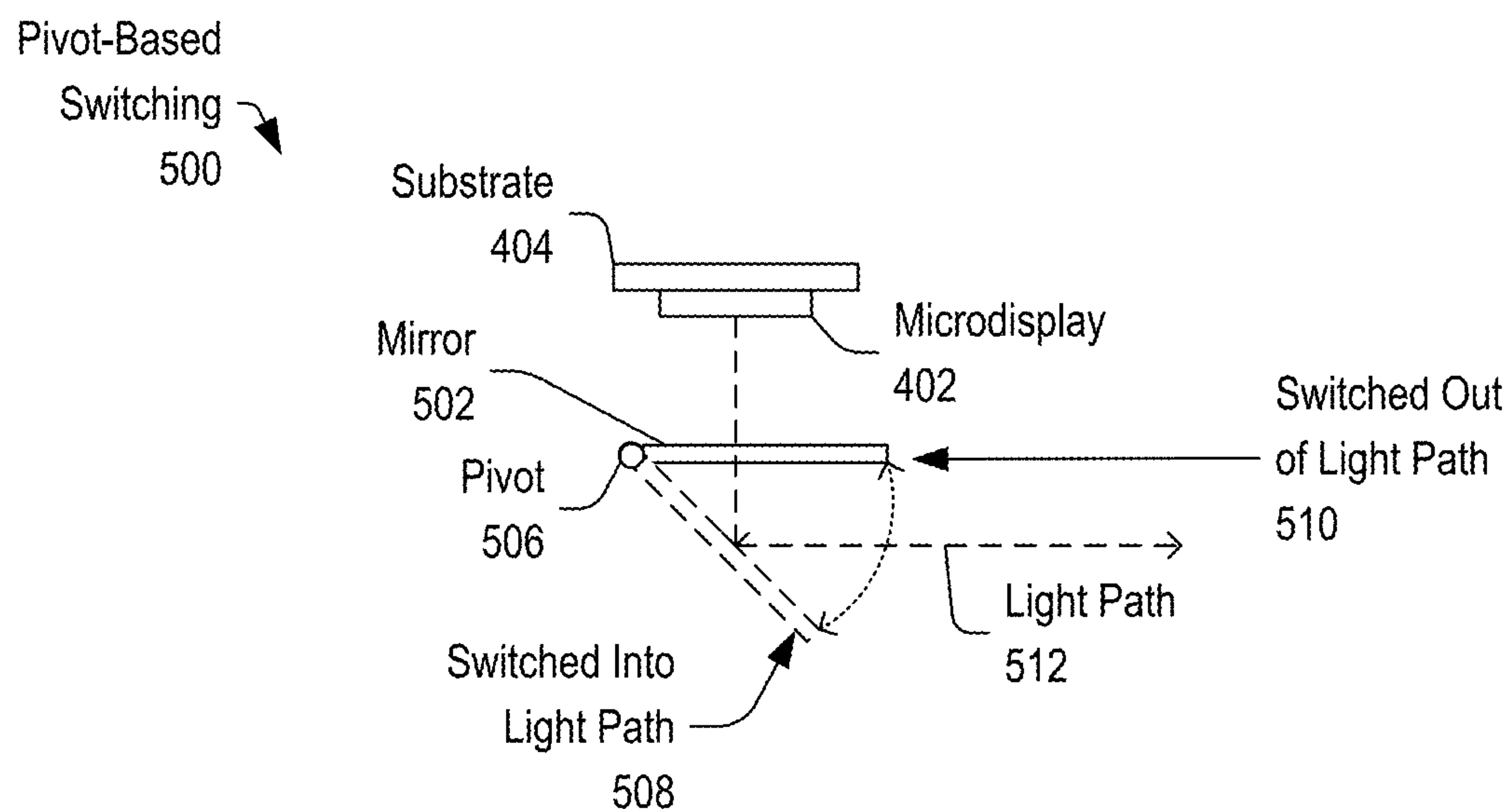


FIG. 5A

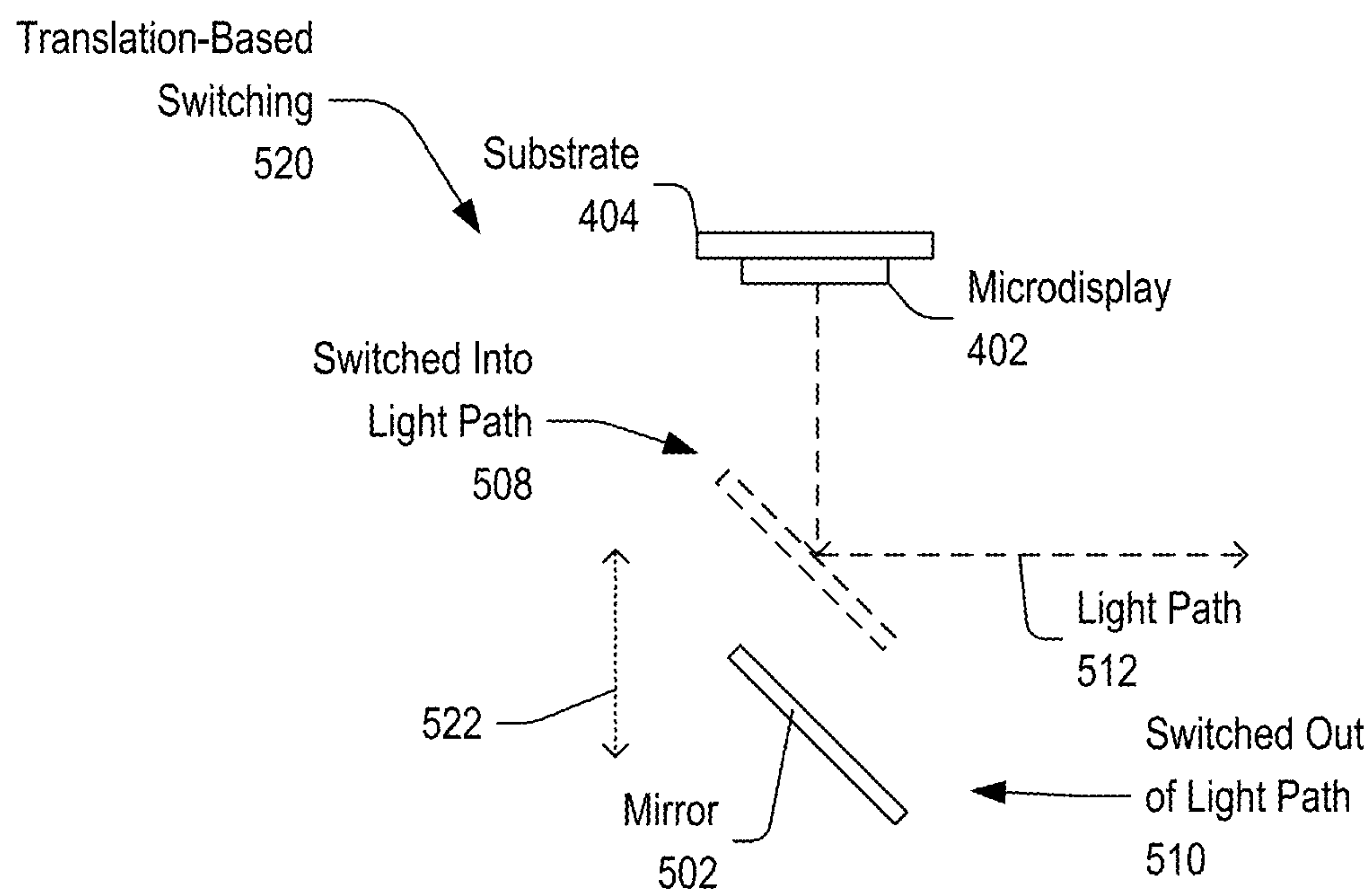


FIG. 5B

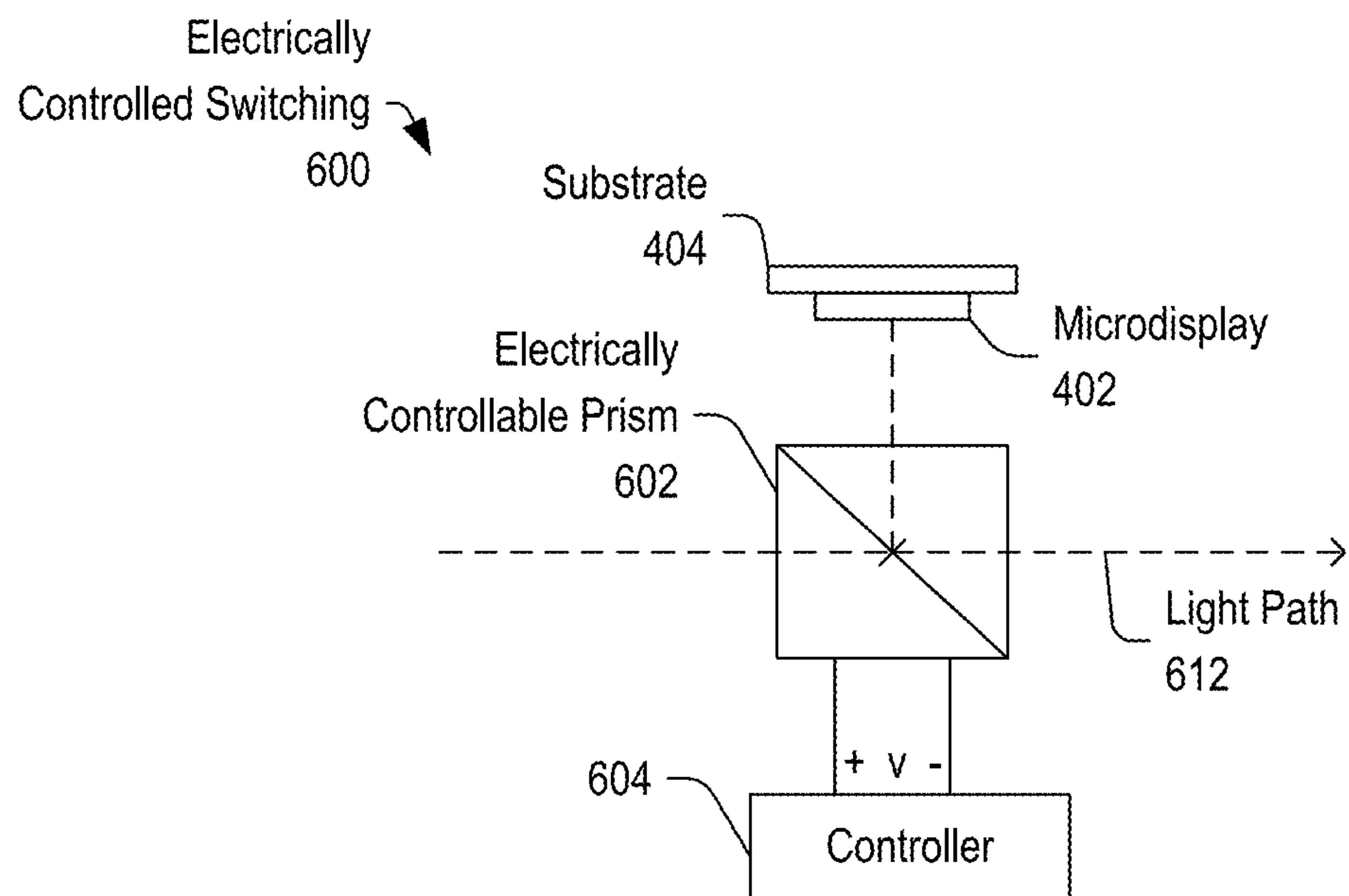


FIG. 6A

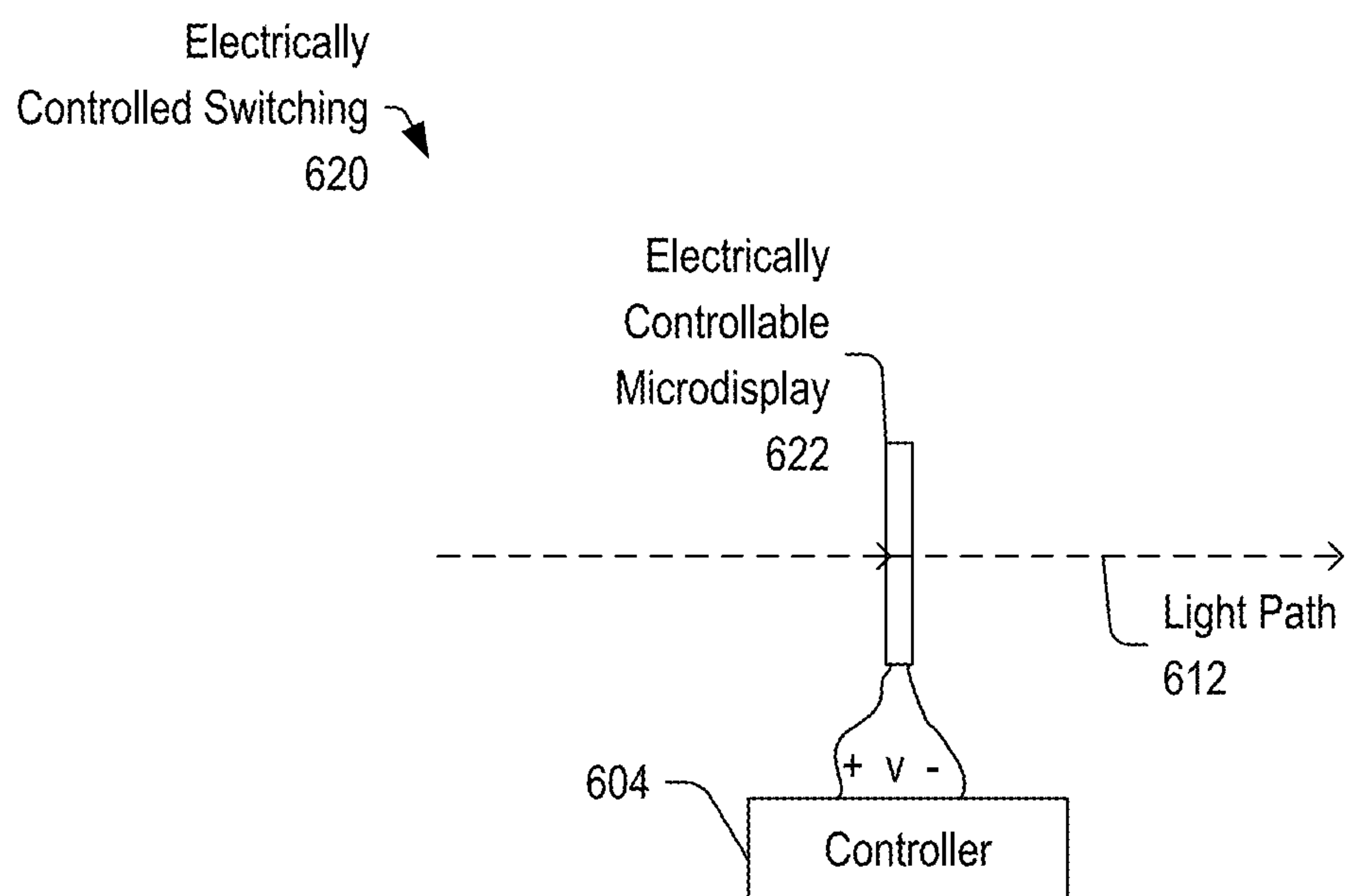


FIG. 6B

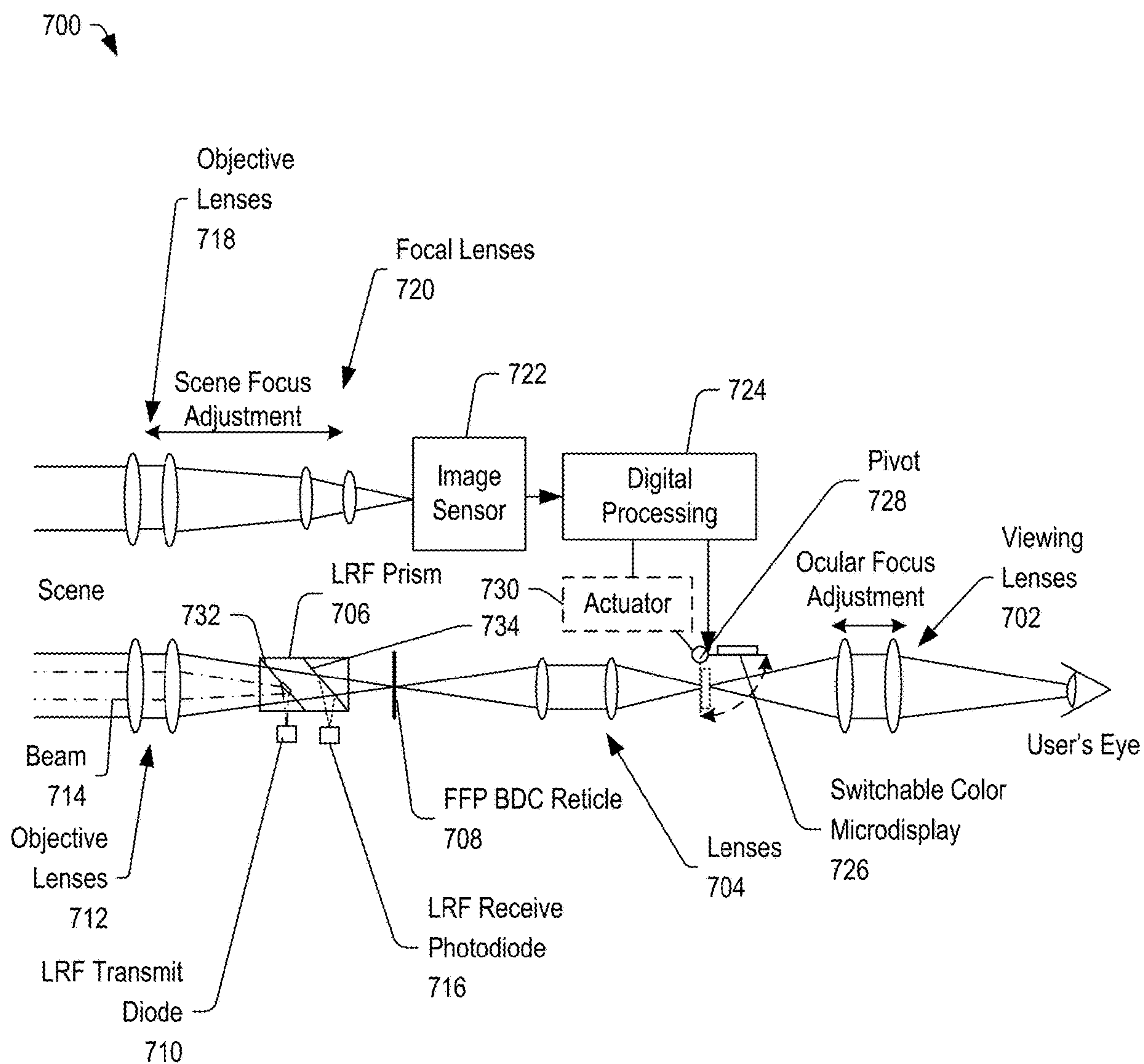


FIG. 7

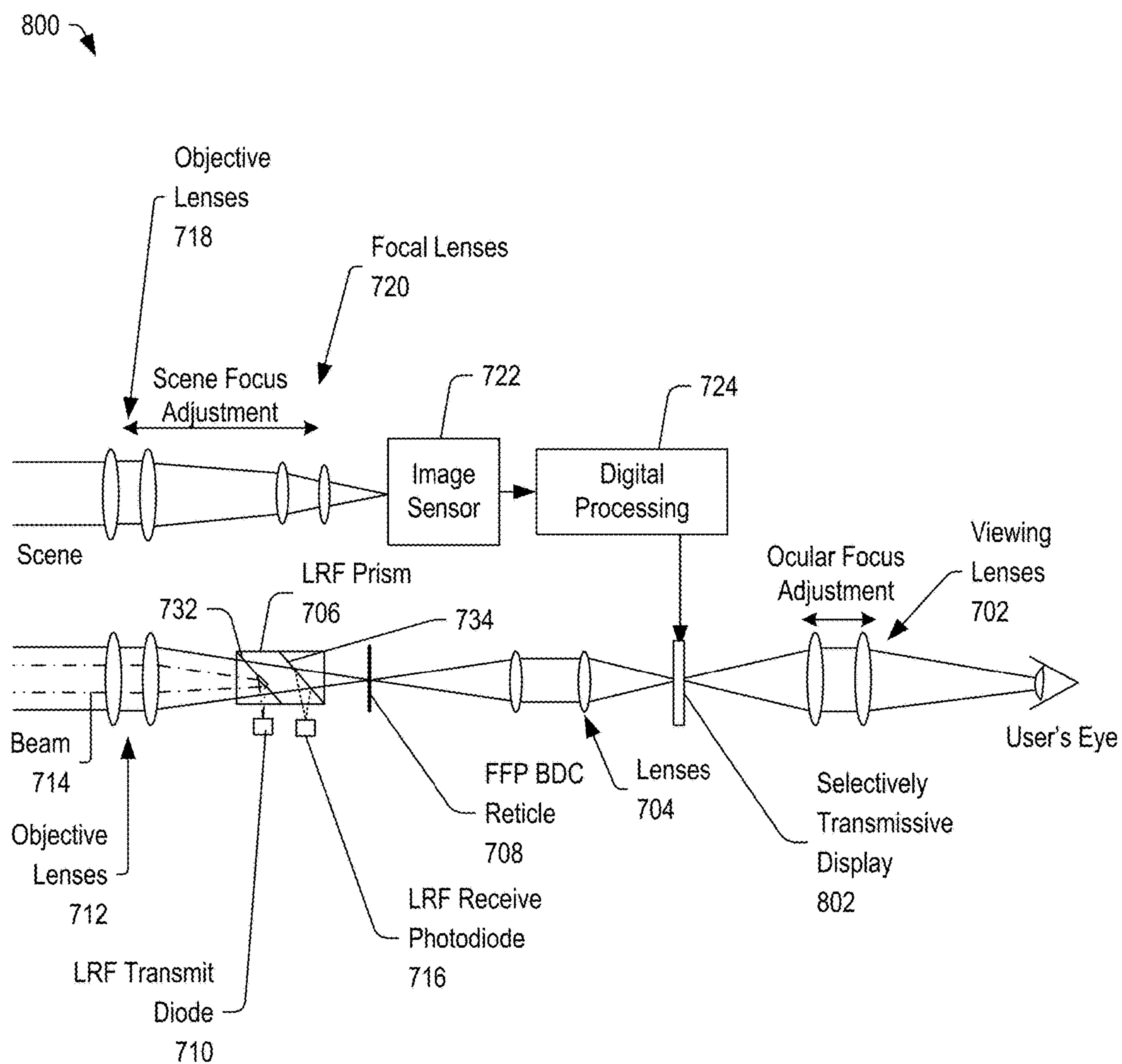


FIG. 8

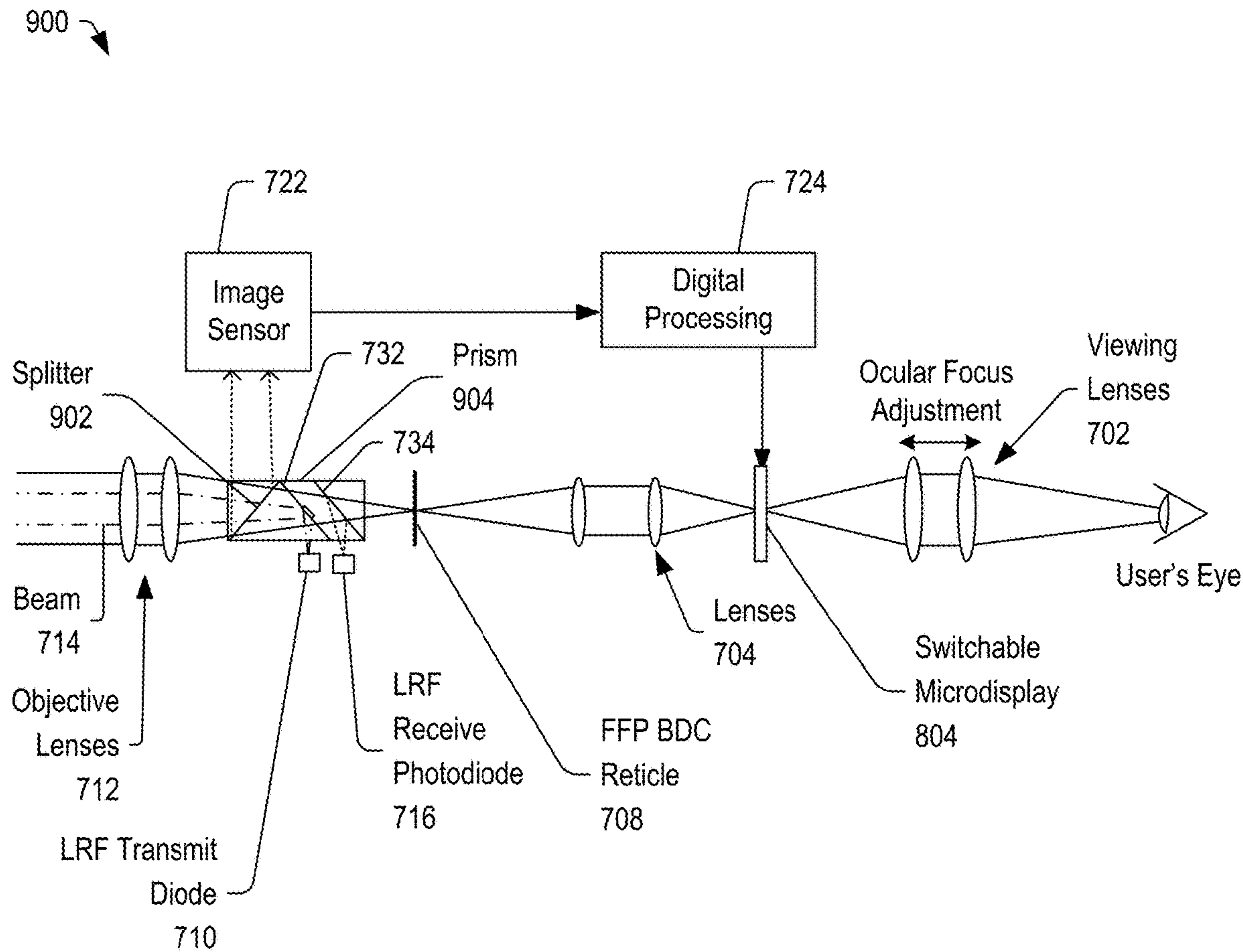


FIG. 9

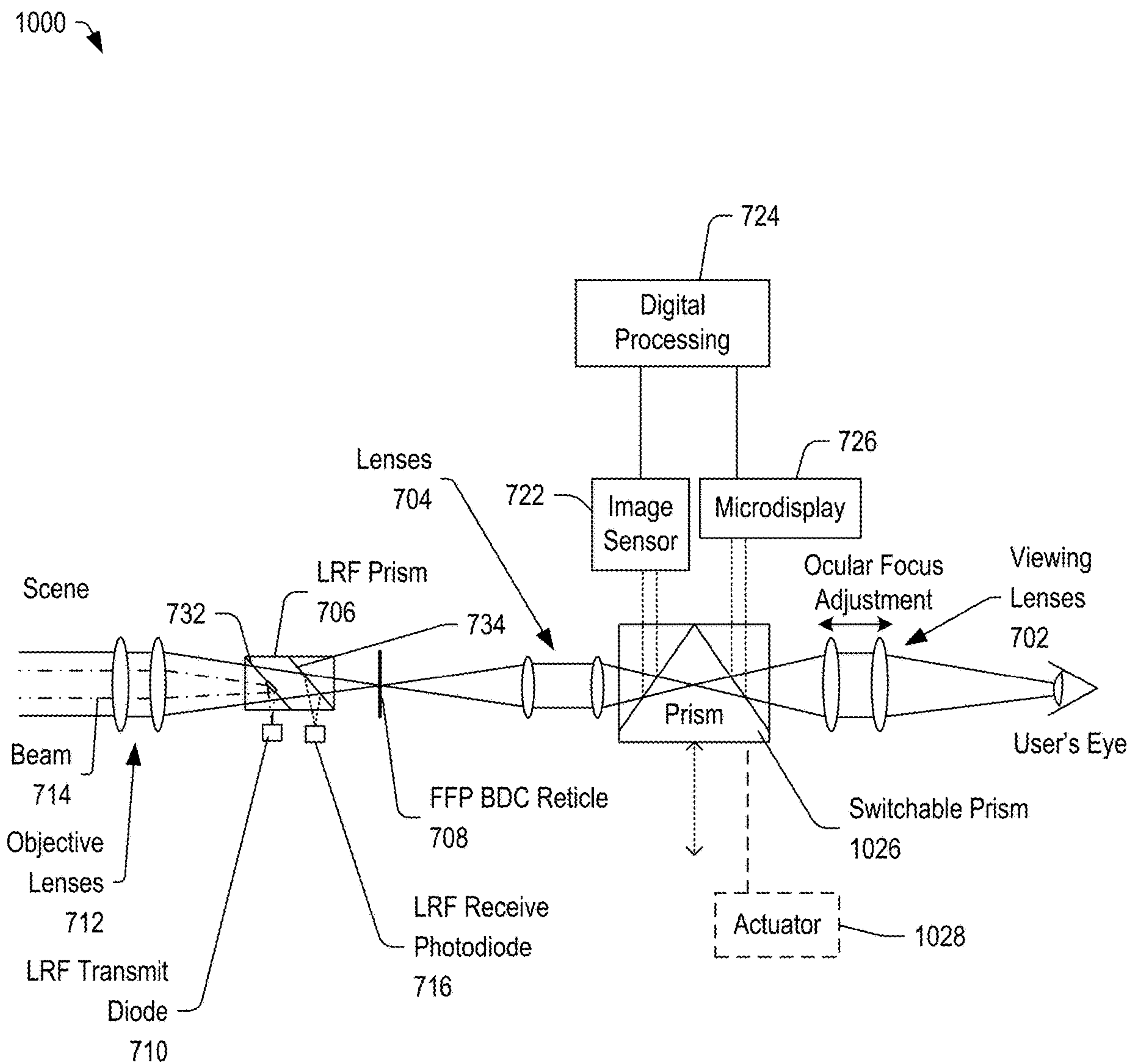


FIG. 10

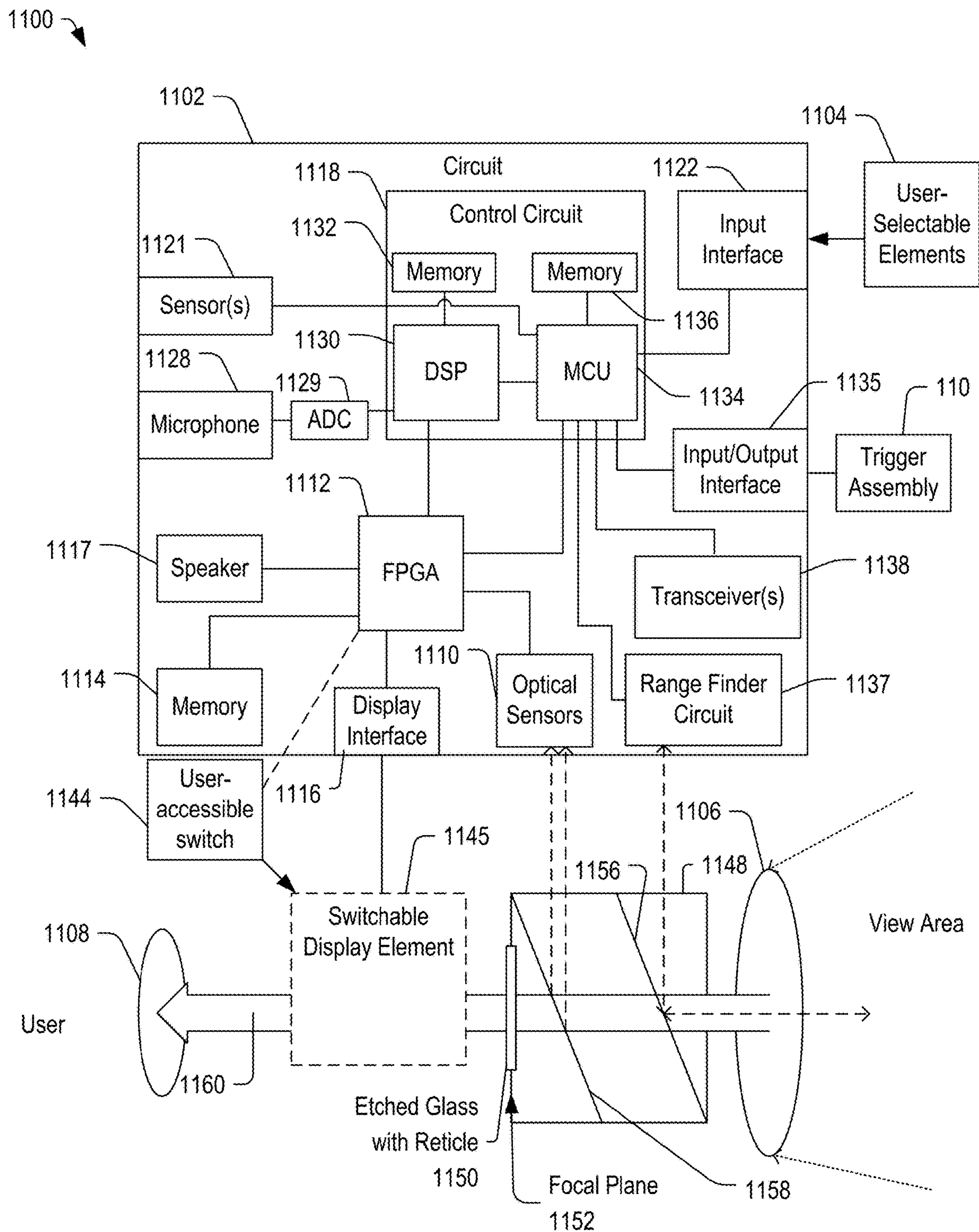


FIG. 11

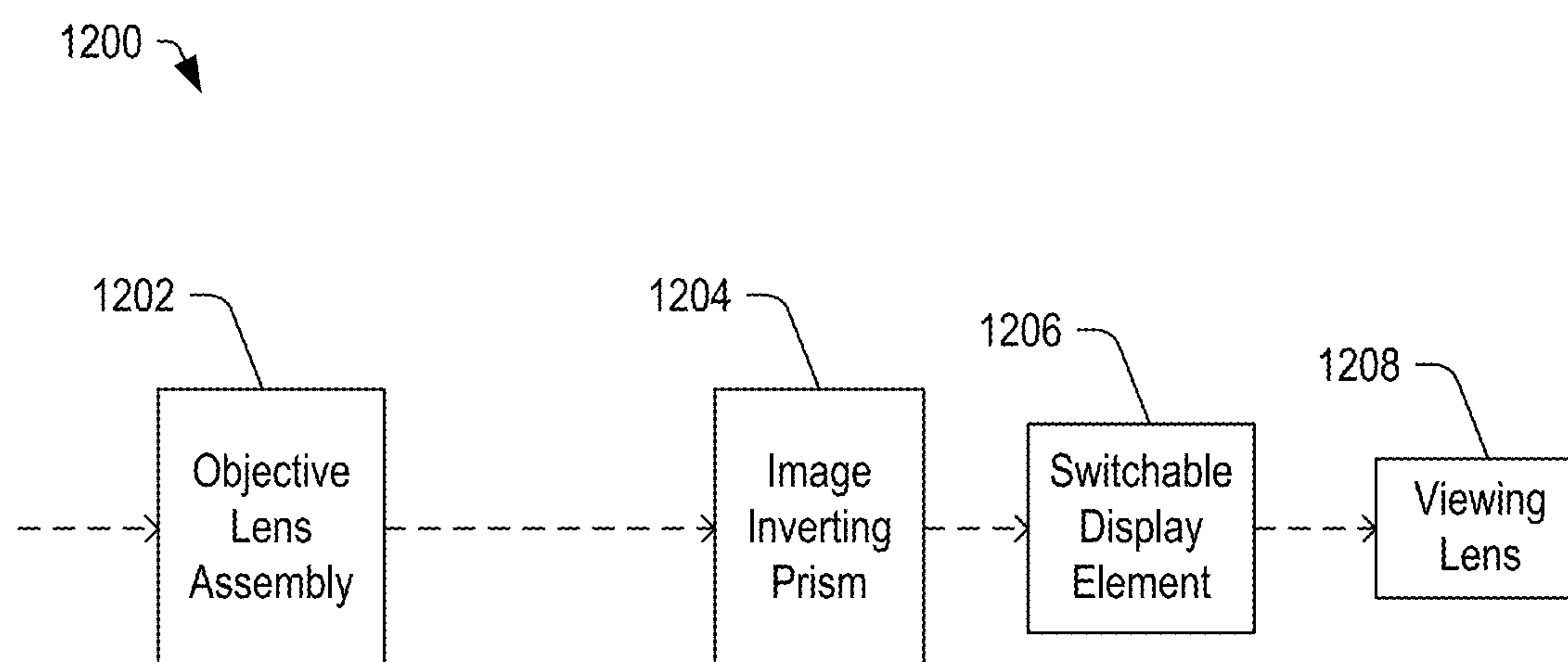


FIG. 12

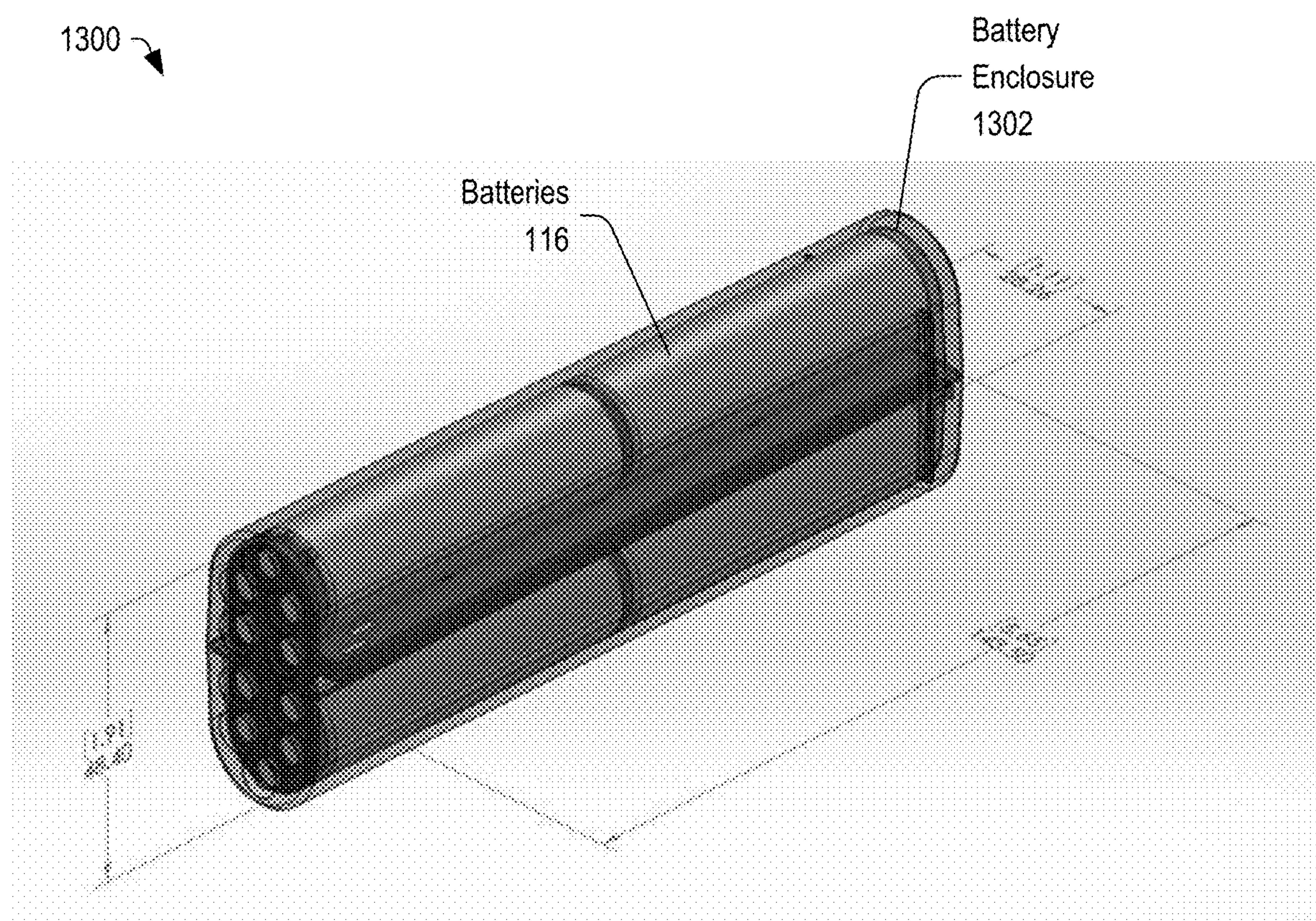


FIG. 13

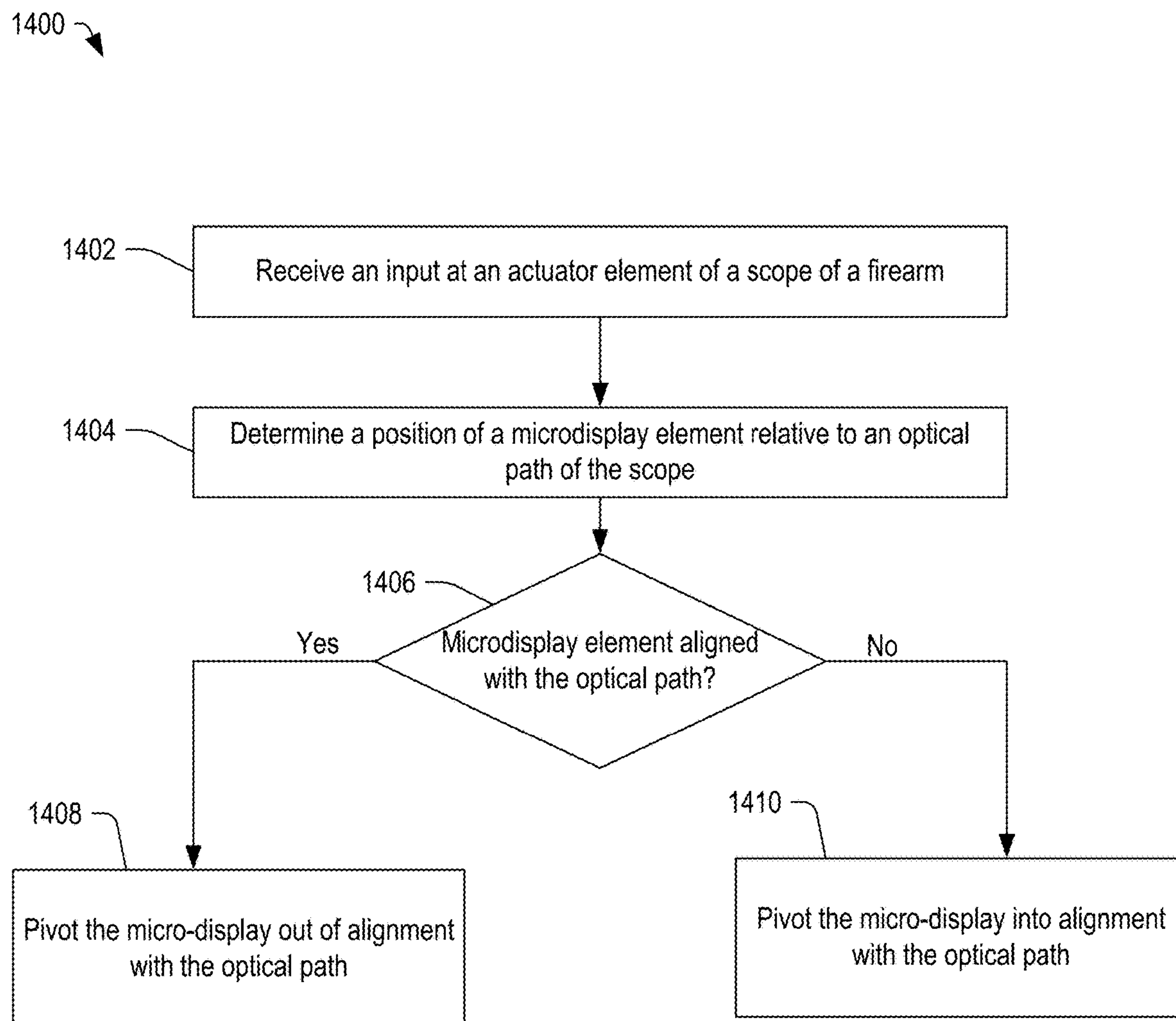


FIG. 14

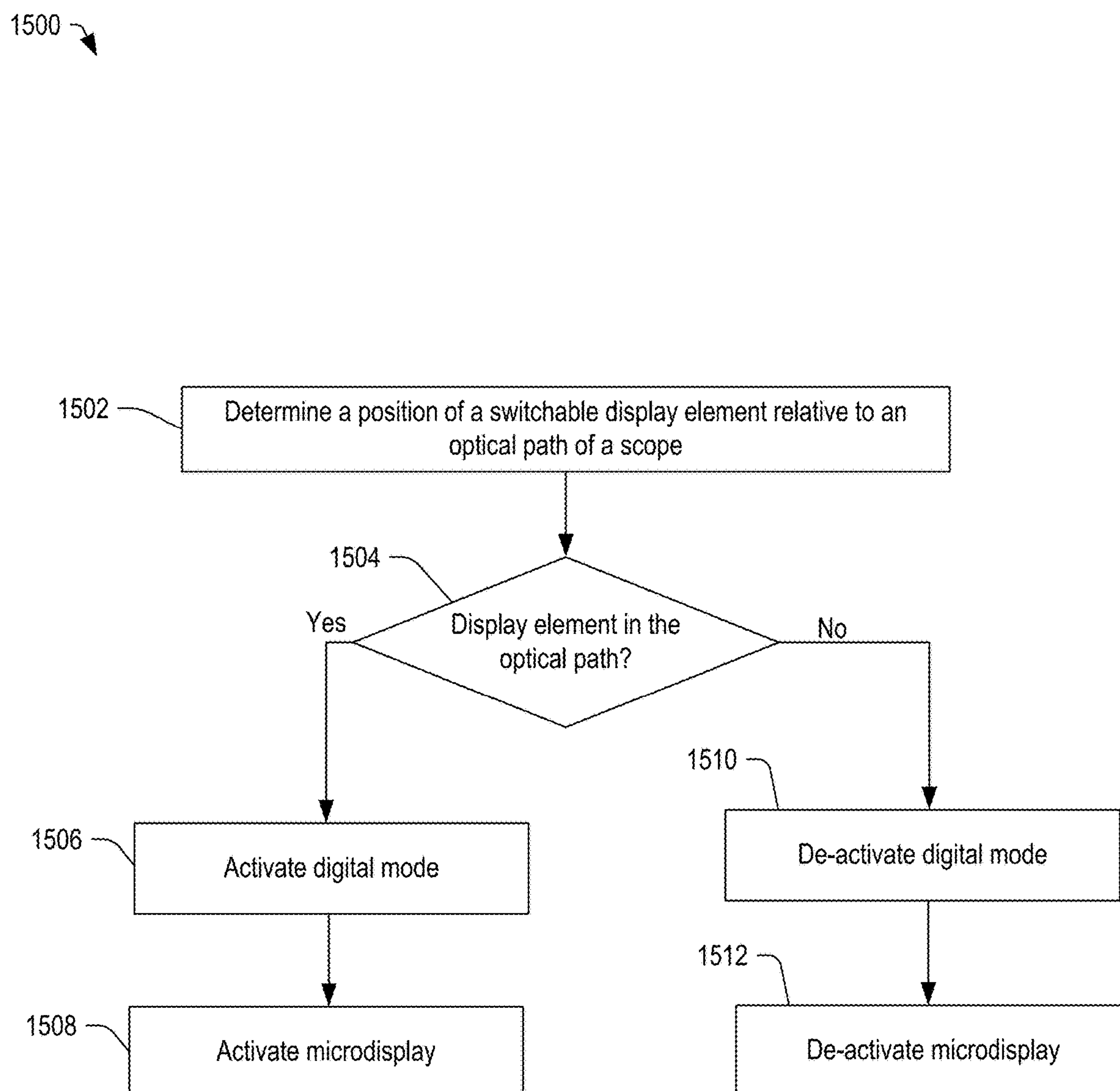


FIG. 15

ANALOG-DIGITAL HYBRID FIREARM SCOPE

FIELD

[0001] The present disclosure is generally related to a firearm scope including a switchable element, and more particularly to a firearm scope that includes a selectable, switchable digital display element.

BACKGROUND

[0002] Analog firearm scopes have been used for many years. Some analog firearm scopes provide adjustable zoom and optionally user-selectable features that allow the user to manually adjust the reticle alignment for range and wind.

[0003] Digital firearm scope solutions exist that can automate some adjustments related to a ballistic solution for a particular target and offer additional advanced features. Such solutions may rely on a battery based power supply.

SUMMARY

[0004] Embodiments of an optical firearm scope are described below that can provide an analog direct-view path with an etched glass or wire reticle for use in all conditions, including battery power loss. The scope may include a separate digital imaging path configured to direct light to a high-resolution color complementary metal-oxide semiconductor (CMOS) sensor to capture light associated with a view area. The scope may further include a switchable, color microdisplay element that can be selectively actuated into the analog direct-view path to switch between a direct-view and a digital functionality.

[0005] In some embodiments, an optical firearm scope may include a first light path including an etched glass reticle and configured to receive light associated with a view area. The optical firearm scope may further include a second light path including at least one optical sensor configured to capture image data associated with a view area. The optical firearm scope can include a microdisplay configured to display image data, and that can be selectively actuated into the first light path to provide a digital display. In a first mode, the optical sensors and the microdisplay may be in a low-power or power off mode with the microdisplay outside of the first light path, and in a second mode, the optical sensors and the microdisplay may be in an operating power mode with the microdisplay in the first light path.

[0006] In some embodiments, an optical scope may include a direct-view optics assembly and a switchable display element. The direct-view optics assembly can include an objective lens and a viewing lens. The direct-view optics assembly may be configured to direct and focus light from a view area received by the objective lens toward the viewing lens. The switchable display element may be configured to selectively interrupt a light path between the objective lens and the viewing lens to present image data to the viewing lens.

[0007] In other embodiments, a method can include, in a first mode, providing light received at an objective lens of an optical scope through a first focal plane including a reticle to a viewing lens of the optical scope. The method may further include receiving an input corresponding to a change of position of a lever of the optical scope and, in a second mode, coupling a switchable display element into the optical path to provide image data viewable from the viewing lens.

[0008] In still other embodiments, an optical scope may include control circuitry, a direct-view optics assembly, and a switchable display element. The direct-view optics assembly may include an objective lens and a viewing lens, and may be configured to direct and focus light received by the objective lens toward the viewing lens. The switchable display element may be coupled to the control circuitry and configured to selectively interrupt a light path between the objective lens and the viewing lens to present image data to the viewing lens.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1A depicts a side view of a firearm system including a scope with a switchable display element, in accordance with certain embodiments of the present disclosure.

[0010] FIG. 1B depicts an isometric view of the firearm system of FIG. 1A.

[0011] FIG. 2A depicts an isometric view of the scope of FIGS. 1A-1B.

[0012] FIG. 2B depicts a front view of the scope of FIGS. 1A-2A.

[0013] FIG. 3 depicts an isometric view of a firearm system including second embodiment of a scope including a switchable display element, in accordance with certain embodiments of the present disclosure.

[0014] FIG. 4A depicts a switchable display element including a pivot configured to enable pivot-based switching, in accordance with certain embodiments of the present disclosure.

[0015] FIG. 4B depicts a switchable display element configured to provide a translation-based switching, in accordance with certain embodiments of the present disclosure.

[0016] FIG. 5A depicts a switchable display element including a stationary display and a movable mirror element configured to provide pivot-based switching, in accordance with certain embodiments of the present disclosure.

[0017] FIG. 5B depicts a switchable display element including a stationary display and a movable mirror element configured to provide translation-based switching, in accordance with certain embodiments of the present disclosure.

[0018] FIGS. 6A and 6B depict switchable display elements configured to provide electrically controlled switching, in accordance with certain embodiments of the present disclosure.

[0019] FIG. 7 depicts a diagram of components of a scope of FIGS. 1A-2B including a microdisplay that can be selectively switched into an optical path, in accordance with certain embodiments of the present disclosure.

[0020] FIG. 8 depicts a diagram of components of a scope of FIGS. 1A-2B including a selectively transmissive microdisplay, in accordance with certain embodiments of the present disclosure.

[0021] FIG. 9 depicts a diagram of components of a scope of FIG. 3 including a splitter configured to direct light from the optical path toward a sensor circuit, in accordance with certain embodiments of the present disclosure.

[0022] FIG. 10 depicts a diagram of components of a scope of FIGS. 1A-3 including a switchable display element including a switchable prism, in accordance with certain embodiments of the present disclosure.

[0023] FIG. 11 depicts a block diagram of a scope of any of FIGS. 1A-10 including circuitry configured to control

operation of the switchable microdisplay, in accordance with certain embodiments of the present disclosure.

[0024] FIG. 12 depicts a block diagram of components of a scope including an image rotating prism and a switchable display element in accordance with certain embodiments of the present disclosure.

[0025] FIG. 13 depicts an isometric view of a battery pack that can be incorporated within the firearm of FIGS. 1A-3, within the scope of FIGS. 3-12, or any combination thereof.

[0026] FIG. 14 depicts a flow diagram of a method of selectively actuating a display into alignment with a light path, in accordance with certain embodiments of the present disclosure.

[0027] FIG. 15 depicts a flow diagram of a method of selectively controlling a display, in accordance with certain embodiments of the present disclosure.

[0028] In the following discussion, the same reference numbers are used in the various embodiments to indicate the same or similar elements.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0029] Embodiments of a firearm system, scopes, apparatuses, and devices are described below that include direct-view optics configured to focus light from a view area toward a viewing lens. Further, the firearm system, scopes, apparatuses, and devices include a switchable display that can be selectively enabled to provide a digital image to the viewing lens.

[0030] In some embodiments, the firearm system, scopes, apparatuses, and devices described below may include a fire control system including a control circuit within the scope that is coupled to a trigger assembly of the firearm. The fire control system may be configured to selectively control timing of discharge of the firearm to ensure that the ballistic strikes its intended target. In some embodiments, the fire control system may be enabled independently of the display, allowing the use of the fire control functionality in conjunction with the direct-view optics. In other embodiments, the fire control system may be enabled in conjunction with activation of the switchable display. In other embodiments, the fire control system may be disabled and the switchable display may be enabled, such that the trigger assembly functions as a traditional firearm with a digital optical display. In still other embodiments, the display and the fire control system may be deactivated and powered off or transitioned to a low-power mode and the user may utilize the direct-view optics. Other embodiments are also possible.

[0031] In some embodiments, a goal of the fire control system is to improve the probability of a hit when the weapon system is discharged by aiding and augmenting the shooter's capabilities.

[0032] In some embodiments, the firearm system may include a scope including a direct-view path with an etched glass reticle for use in all conditions, including battery power loss. Additionally, the scope may include a digital image processing pipeline, integrated laser rangefinder (LRF), environmental sensors (temperature, barometric pressure, humidity, and other environmental sensors), an Inertial Measurement Unit (IMU) including accelerometers and directional sensors (elevation angle, cant angle, cardinal direction), other sensors, or any combination thereof. These sensor measurements may be combined with pre-configured ballistics inputs for the ammunition and firearm parameters

to determine a ballistic firing solution corresponding to a predicted impact point of a discharged ballistic. The sensors may be sampled and the firing solution may be recalculated at the sampling rate of the sensors.

[0033] FIG. 1A depicts a side view of a firearm system 100 including a scope 102 with a switchable display element, in accordance with certain embodiments of the present disclosure. The firearm system 100 may include a firearm 104 coupled to the scope 102. The firearm 104 may include a stock 106, a grip 108, a trigger assembly 110, and a muzzle 112. In some embodiments, the firearm 104 may include a retractable stand 114. Further, in some embodiments, the stock 106 may define a housing sized to secure a power supply, such as batteries 116.

[0034] In the illustrated example, the scope 102 may include a direct-view optic (DVO) with the added capabilities of a digital optic. The scope 102 may include a direct-view path with a traditional etched glass reticle for use in all conditions, including battery power loss. Additionally, the scope 102 may include a digital imaging pipeline, integrated laser rangefinder (LRF), environmental sensors (temperature, barometric pressure, humidity, and other environmental sensors), and an Inertial Measurement Unit (IMU) including accelerometers and directional sensors (elevation angle, cant angle, cardinal direction), imaging sensors (such as a complementary metal oxide semiconductor (CMOS) image sensor), other sensors, or any combination thereof. The scope 102 may include a lever 103, which may be accessed by the user to transition the operating mode of the scope between the direct-view path mode in which focused light from the view area is provided to the viewing lens of the scope 102 and the digital imaging pipeline mode in which digital images of the view area are presented by the display to the viewing lens of the scope 102. The lever 103 may cause the display, a mirror, a prism, or another object to move into or out of the light path to switch between a digital display mode and a direct-view mode. In some embodiments, the lever 103 may cause a control circuit to provide an electrical signal to one of a mirror, a prism, and a display device to alter the reflectivity of a surface in order to selectively switch the display element into the light path.

[0035] In some operating modes, the sensor measurements may be combined by a processor of the scope 102 with pre-configured ballistics inputs for the ammunition and firearm parameters to determine a ballistic firing solution. In a particular embodiment, the sensors can be sampled and the firing solution recalculated at the sampling rate of the sensors.

[0036] FIG. 1B depicts an isometric view 120 of the firearm system 100 of FIG. 1A. In the illustrated example, a front portion of the scope 102 is visible, showing three lenses. In this example, the scope 102 may include a laser rangefinder (LRF) lens 122 through which a laser rangefinder circuit may emit a pulsed collimated beam and receive reflected light that can be used to determine a range to a target. The scope 102 may also include an objective lens 124 associated with an analog path. Further, the scope 102 may include an objective lens 126 associated with a digital path with an associated optical sensor. The scope 102 includes the lever 103, which may be accessed by a user to switch between a direct-view mode and a digital display mode. In an alternative embodiment, the lever 103 may be

replaced with a switch, a button, or another user-selectable element accessible by the user to switch between operating modes.

[0037] FIG. 2A depicts an isometric view **200** of the scope **102** of FIGS. 1A-1B. The scope **102** may include a housing **202** defining an enclosure sized to secure an optics assembly including a plurality of lenses configured to focus and optionally magnify light from a view area. The housing **202** may be coupled to a mounting rail **208**, which may be configured to couple to a firearm **104**.

[0038] The scope **102** may include a viewing lens **204** through which a user may view focused light from the view area, which may be presented by the DVO assembly, by a switchable display element, or both. The scope **102** may further include user-selectable elements including a wheel **206**, which can be turned to adjust focus and optionally magnification or zoom settings of the DVO assembly. The scope **102** may also include a user-selectable locking lever or switch **103** that can be accessed by a user to switch between operating modes of the scope **102** and optionally the firearm **104**.

[0039] In some embodiments, the scope **102** may include a direct-view mode in which circuitry, including a switchable display element within the scope **102**, is powered off or configured in a low-power state while light from the view area of the scope **102** is provided to the viewing lens **204** through the DVO assembly. The scope **102** may also include a digital optical mode in which the circuitry and the display element of the scope **102** are powered on and the display element is switched into the visual optical path of the viewing lens **204** to provide a digital display including optical data associated with the view area. The scope **102** may also include a fire-control mode in which timing of the discharge of the firearm **104** may be controlled via electrical signals from the scope **102** to the trigger assembly **110**. In an example, in the fire-control mode, the scope **102** may process sensor data, including motion and orientation data, to determine a current aim point of a firearm **104** relative to a ballistic solution for a selected target. The ballistic solution may represent a calculation of the expected flight of a ballistic if fired from the weapon and may include the measured distance to the target from the laser rangefinder (LRF), measured environmental data (temperature, humidity, barometric pressure), measured directional data from the IMU sensors, and measured or manual external wind input. In the fire-control mode, the scope **102** may control timing of the discharge of the firearm **104**, in response to a trigger pull, to prevent discharge until the aim point of the firearm **104** is aligned with the selected target according the ballistic solution (within a selected threshold).

[0040] In some embodiments, the scope **102** may include a digital display mode with fire-control in which the digital display is active and in line with the viewing lens **204**. The scope **102** may further include a digital display mode without fire-control in which the digital display is active and in line with the viewing lens **204** and in which the trigger assembly **110** is not controlled by the scope **102** and is responsive to a trigger pull. The scope **102** may also include a direct-view hybrid mode in which the digital display is inactive, but the fire-control is active while the light from the view area is provided to the viewing lens **204** via the DVO assembly. Other embodiments are also possible.

[0041] FIG. 2B depicts a front view **220** of the scope **102** of FIGS. 1A-2A. In this example, the scope **102** may include

an LRF lens **122**, through which a pulsed collimated beam may be emitted by a LRF circuit toward the view area and through which reflected light may be received by LRF sensors. The LRF circuit may be configured to determine a range to a target within the view area.

[0042] The scope **102** may further include an objective lens **124** associated with an analog path. The objective lens **124** may be aligned with a DVO assembly including a plurality of lenses, which may be configured to focus light from the view area toward the viewing lens **204**. The scope **102** may also include a second objective lens **126** associated with the circuitry of the scope **102** and configured to direct light from the view area toward one or more optical sensors of the circuitry.

[0043] In some embodiments, the housing may be approximately 7 inches long, 2.75 inches tall, and 2.5 inches wide. In some embodiments, the scope **102** may weigh approximately 2.9 pounds. In other embodiments, composite materials or lightweight lenses can be used to reduce the weight.

[0044] In one possible embodiment, the scope **102** may include 30 mm direct-view aperture **124** and a 22 mm digital camera objective aperture **126**. The aperture **122** may be a 15 mm laser rangefinder transmit aperture, which may be separated from the direct-view path. In some embodiments, an additional objective, such as a thermal objective, can be added.

[0045] The scope **102** may include an adjustable ocular lens assembly (viewing lens **204**) to allow the shooter to focus the reticle and display element to their eye. The ocular adjustment would typically be +4 to -4 diopters. Further, a manual scene focus knob can be included to optimally focus the camera objective on the target. A base adjustment mechanism for zeroing the scope **102** may be included. The advantage of the base adjustment method is that the direct-view reticle, LRF transmit, LRF receive, and digital reticle can all be co-aligned on an optical alignment fixture at the time of manufacture and be permanently fixed into place. The co-aligned optics assembly can then be zeroed on the firearm **104** and no other adjustments are necessary. Other embodiments of adjusting and zeroing the direct-view and digital paths are also possible.

[0046] It should be appreciated that the embodiments of FIGS. 1A-2B represent one possible example of a scope **102**, which has three lenses. In other embodiments, one or two of the lenses may be eliminated, and the scope **102** may include a single lens through which the LRF beam may be transmitted, and the light from the view area as well as the reflected light from the LRF beam may be received. One possible example is described below with respect to FIG. 3.

[0047] FIG. 3 depicts an isometric view of a firearm system **300** including a second embodiment of a scope **302** including a switchable display element, in accordance with certain embodiments of the present disclosure. The firearm system **300** may include all of the elements of the firearm system **100** of FIG. 1, except that that the scope **102** may be replaced with the scope **302** having an objective lens **324** and including a viewing lens **304**. Other lenses shown with respect to FIGS. 1A-2B may be omitted.

[0048] In the illustrated example, the scope **302** may include a direct-view light path, circuitry including optical sensors and including a display element, a LRF circuit, and one or more light splitters configured to direct LRF frequencies toward the LRF circuit. A portion of the light captured

by the objective lens **324** maybe directed to the optical sensors of the circuitry, and the remainder of the light allowed pass through to the viewing lens **304**. The scope **302** may be configured to enable the various modes described above, including a direct-view mode, a hybrid direct-view mode with direct-view optics and fire control functionality, a digital display mode with fire control functionality, and a digital display mode without fire control functionality.

[0049] In the illustrated example, the scope **302** may include a lever **103** that can be accessed by a user to manually move the display element or a mirror element into the light path; to electrically activate an element to move a digital display, a mirror, or a prism into the light path; to electrically activate a mirror, a prism, or a display to interrupt the light path; or any combination thereof. Other embodiments are also possible.

[0050] FIG. 4A depicts a switchable display element including a pivot configured to enable pivot-based switching **400**, in accordance with certain embodiments of the present disclosure. The switchable display element may include a substrate **404** coupled to a pivot (or hinge) **406** and configured to move about the pivot **406** to move into and out of a light path **412**. A microdisplay **402** may be coupled to the substrate **404**, such that movement of the substrate **404** causes the microdisplay **402** to be moved.

[0051] In the illustrated example, the microdisplay **402** is switched into the light path at **408** and is switched out of the light path at **410**. When the microdisplay **402** is switched into the light path at **408**, the microdisplay **402** interrupts the light path and can present digital display information as a visible display to the viewing lens.

[0052] FIG. 4B depicts a switchable display element configured to provide a translation-based switching **420**, in accordance with certain embodiments of the present disclosure. In this example, instead of pivoting or moving about the pivot **406** (as in FIG. 4A), the substrate **404** may be configured to move along a plane or along a path into and out of the light path **412** (as indicated by the dashed arrow).

[0053] In the examples of FIGS. 4A and 4B, the switchable display element may be moved manually, such as based on a mechanical coupling with the lever **103**. Alternatively, the switchable display element may be moved using an electrically controlled actuator, which may be controlled electrically in response to user interactions with the lever **103**, a switch, another user-selectable element, or any combination thereof.

[0054] FIG. 5A depicts a switchable display element including a stationary display and a movable mirror element configured to provide pivot-based switching **500**, in accordance with certain embodiments of the present disclosure. In this example, a switchable display element may include a microdisplay **402** coupled to a substrate **404** that is fixed or stationary and configured to direct image or display information toward a movable mirror **502**, which may be configured to move about a pivot **506** into the light path **512** (as indicated at **508**) or out of the light path **512** (as indicated at **510**).

[0055] FIG. 5B depicts a switchable display element including a stationary display and a movable mirror element configured to provide translation-based switching **520**, in accordance with certain embodiments of the present disclosure. In this example, the microdisplay **402** and substrate **404** may again remain stationary, while the mirror **502** is

translated into the light path **512** (as indicated at **508**) and out from the light path **512** (as indicated at **510**) in the direction of arrow **522**.

[0056] In the examples of FIGS. 5A and 5B, the switchable display element may be moved manually, such as based on a mechanical coupling with the lever **103**. Alternatively, the switchable display element may be moved using an electrically controlled actuator, which may be controlled electrically in response to user interactions with the lever **103**, a switch, another user-selectable element, or any combination thereof.

[0057] FIGS. 6A and 6B depict switchable display elements configured to provide electrically controlled switching **600**, in accordance with certain embodiments of the present disclosure. In FIG. 6A, the microdisplay **402** and the substrate **404** may be stationary, and an electrically controllable prism **602** (or mirror) may be electrically activated by signals received from a controller **604** to reflect light from the microdisplay **402** into the light path **612**. In particular, the microdisplay **402** may provide image data from a view area, text, other graphics, and so on. In some embodiments, the controller **604** may include a processor, sensors, and other circuitry.

[0058] When the prism **602** is inactive, the prism **602** may allow light from the objective lens assembly to pass through toward the viewing lens along the light path. When the prism **602** is active, the prism **602** may reflect light from the microdisplay **402** into the light path **612** while blocking light from the objective lens. Other embodiments are also possible.

[0059] In FIG. 6B, the electrically controls switching **620** may be implemented using an electrically controllable microdisplay **622**. In some embodiments, the microdisplay **622** may be transparent when inactive to allow light from the object lens assembly to pass through toward the viewing lens along the light path **612**. When the controller **604** provides electrical signals to activate the microdisplay **622**, the microdisplay **622** may block light from the objective lens and display image data and other information received from a digital signal processing circuit, which may be part of the controller **604**. Other embodiments are also possible.

[0060] It should be understood that, in FIGS. 6A and 6B, the reflectivity of the surface of the electrically controllable prism **602** or the electrically controllable microdisplay **622** may be controlled by applied signals, such as a voltage. Other embodiments are also possible.

[0061] It should be appreciated that the examples provided in FIGS. 4A-6B represent different ways of switching the display element into the light path, either physically via manual or electrically controlled movement of a mirror (or prism) or a display, or via electrical signals that alter the reflectivity of a surface of a prism, a display, or any combination thereof.

[0062] FIG. 7 depicts a diagram **700** of components of a scope **102** or **302** of FIGS. 1A-3 including a display element that can be selectively switched into an optical path, in accordance with certain embodiments of the present disclosure. While the diagram **700** shows two different optical paths, it should be appreciated that the two different optical paths may be received through the objective lenses **124** and **126** or through a single objective lens **324** with a light splitter providing the light to the image sensor **722** of the digital optical path. In alternative embodiments, additional digital light paths may be included by adding lenses and by

including sensors responsive to other wavelength bands. In an example, one or more additional digital light paths may be included to provide, for example, a thermal path including associated thermal imaging sensors. Additional sensor possibilities could include long-wavelength infrared (LWIR) sensors, short-wavelength infrared (SWIR) sensors, medium wavelength infrared (MWIR) sensors, or visible-light digital sensors that are optimized for low-light imaging. These multiple digital paths could be used individually or fused and displayed to the user. Further, the paths could be used individually or fused for the purposed of display and optionally for target acquisition, selection, tracking, and fire control. Other embodiments are also possible.

[0063] The diagram **700** may include a viewing lens **702** through which a user may view light from the view area or images via a microdisplay **726**. The scope **102** or **302** may include erector lenses **704**, a reticle **708**, and objective lenses **712**. In operation, light from a scene or view area may be received by the objective lenses **712**, which may focus the light toward the reticle **708** which may be located at the first focal plane of the scope **102** or **302**. The light from the scene may be presented to erector lenses **704**, which direct the light through a second focal plane toward the viewing lenses **702**.

[0064] The pulsed LRF transmit beam **714** is directed to the objective lenses **712** by a partially mirrored prism surface **732** of the LRF prism **706**. The LRF prism **706** may direct received reflected light associated with the beam **714** from the scene toward an LRF receive photodiode **716** by using a dichroic coated prism surface **734**. The LRF circuitry may be configured to determine a range to an object based on the reflected light received by the LRF receive photodiode **716**.

[0065] The scope **102** may include objective lenses **718** and focal lenses **720** as part of a digital light path. In the embodiment of the scope **302**, the objective lenses **718** may be omitted and a beam splitter may be used to direct light from the objective lenses **712** either directly to an image sensor **722** or through focal lenses **720** to the image sensor **722**.

[0066] In the illustrated example, the image sensor **722** may be a color complementary metal-oxide semiconductor (CMOS) image sensor. The image sensor **722** may include an output coupled to digital processing circuitry **724**. The digital processing circuitry **724** may be configured to process image data from the image sensor **722** and to provide at least a portion of the image data to a switchable microdisplay **726**, which may be a color display. The digital processing circuitry **724** may also be coupled to an actuator **730** that can be configured to move the microdisplay **726** into the optical path or out of the optical path about a pivot **728** to selectively present the user visual information associated with the scene via either the DVO assembly (i.e., lenses **712** and **704**, and reticle **708**) or the microdisplay **726**.

[0067] The scope **102**, as represented in the diagram **300**, may provide a direct-view optical path (through lenses **712**, **704**, and **702**) with a reticle **708** located in the first focal plane. In some embodiments, the direct-view optical path may provide a fixed 4× magnification with an objective diameter of 30 mm and a first focal plane ballistics drop compensating reticle. The laser rangefinder (LRF) transmit diode **710** and LRF receive photodiode **716** can be integrated into this direct-view aperture as shown in FIG. 7.

[0068] In some embodiments, a small mirrored portion of the transmit splitter surface **732** can couple the pulsed laser light from the LRF transmit diode **710** into the optical path. The receive splitter **734** may be a simple dichroic splitter that reflects the infrared LRF laser light and transmits the visible light. Alternatively, the LRF transmit path can include a third small aperture (lens **122** in FIGS. 1A-2B) instead of including the transmit splitter **732** in the direct-view path. The inclusion of the extra LRF lens **122** may have the advantage of not needing the small obscuration in the optical path, which may slightly reduce the direct-view light transmission and the LRF receive signal. In some embodiments, both the LRF transmit and receive can be separated into different optical paths (i.e. one lens path for the transmit diode and lenses, one path for the receive diode and lenses, and one path for the direct-view optical path). In embodiments where one or more LRF optical paths are separated from the direct-view path, the optical paths should remain mechanically coupled to ensure that alignment of the LRF transmit, LRF receive, and direct-view reticle **708** is maintained. This can be accomplished using a base adjustment mechanism that moves the scope housing **202** all optical paths together with respect to the firearm mounting rail **208**. Other mechanical alignment and adjustment methods are also possible.

[0069] In the embodiments of FIGS. 1A-2B, a separate digital imaging light path may provide light to a high-resolution color CMOS image sensor **722**. In some embodiments, the digital light path may have a 90 mm effective focal length, an aperture F/4, and a telecentric objective with a base image magnification of approximately 4×. In some embodiments, the digital zoom provided by the digital processing circuit **724** may provide a 6X multiplier; effectively making the objective a 4-24X digital optic.

[0070] The switchable color microdisplay **726** may be selectively incorporated in the second focal plane. In some embodiments, the microdisplay **726** may be an organic light-emitting diode (OLED) display with a resolution of 800×600 pixels or higher. The microdisplay **726** can be actuated by a locking lever or switch **103** accessible on the exterior of the scope **102** or **302**, allowing the user to quickly switch between direct-view and digital-view mode. When the microdisplay **726** is switched out of the optical path, in a first mode, the digital image pipeline and other electronics may enter a low-power state or power-off state. This low-power state may allow for significant power savings while having a very short wake-up time when switched back into the optical path.

[0071] In some embodiments, the scope **102** or **302** may allow for both a direct-view and a digital day view. The digital image pipeline may also be configured to provide digital night vision, such as when using a near-infrared (NIR) illuminator and optionally thermal sensors. With the addition of an NIR illuminator, the scope **102** or **302** with a CMOS image sensor **722** may be configured to detect and identify in low-light or night-time conditions.

[0072] In some embodiments, a single aperture may be used for digital, direct-view, and LRF light. In other embodiments, one of the apertures **126** or **122** may be used or an additional aperture may be provided for a thermal camera objective, which can be added to the architecture for day and night thermal vision capabilities. The thermal objective may be schematically similar to the day digital optical path shown with a 640×512 pixel uncooled vanadium oxide

microbolometer (8-14 μm spectral range) and germanium lenses. Other embodiments are also possible.

[0073] FIG. 8 depicts a diagram 800 of components of a scope 102 of FIGS. 1A-2B including a selectively transmissive microdisplay 802, in accordance with certain embodiments of the present disclosure. In this example, the diagram 800 may include all of the elements of the scope 102 of FIG. 7, except that the pivot 728 and the actuator 730 may be omitted. Further, the switchable microdisplay 726 may be replaced with a selectively transmissive display 802 positioned at the second focal plane and responsive to electrical signals from the digital processing circuitry 724 to allow direct-view light to pass through to the viewing lenses 702 or to present digital image data to the viewing lenses 702. Other embodiments are also possible.

[0074] FIG. 9 depicts a diagram 900 of components of a scope 302 of FIG. 3 including a splitter 902 configured to direct light from the optical path toward a sensor circuit, in accordance with certain embodiments of the present disclosure. The scope 302 may include all of the elements of the scope 102 of FIG. 7 or 8, except that the lenses 718 and 720 may be omitted. Further, the LRF prism 406 may be replaced with a prism assembly 604 that includes splitters 732 and 734 and that further includes a splitter 902, which may direct a portion of the received light toward the image sensor 722.

[0075] In some embodiments, the splitter 902 may be configured to direct a portion of the light from the view area towards the image sensor 722 while also passing the remaining light from the view area to the viewing lens 702. In other embodiments, the splitter 902 may be configured to switch into and out of the light path to selectively divert at least a portion of the light toward the image sensor 722. In other embodiments, the splitter 902 may be electrically activated to selectively divert at least a portion of the light toward the image sensors 722. Other embodiments are also possible.

[0076] In this embodiment, the switchable microdisplay 804 may be implemented as a selectively transmissive display that can be electrically controlled to allow the direct-view light to be delivered to the viewing lenses 702 or to provide digital display data to the viewing lenses. Alternatively, the display may be actuated into and out of the second focal plane to provide the image data to the viewing lens. Other embodiments are also possible.

[0077] FIG. 10 depicts a diagram of components of a scope 1000 of FIGS. 1A-3 including a switchable display element including a switchable prism 1026, in accordance with certain embodiments of the present disclosure. The scope 1000 may include most of the elements of the scope 700 of FIG. 7, except that the separate digital light path may be omitted, and the switchable prism 1026 may be provided. The switchable prism 1026 may be moved into and out of the light path to selectively direct a portion of the light toward one or more image sensors 722, which may be coupled to the digital processing circuit 724. The digital processing circuit 724 may provide image data to the microdisplay 726, which may provide the image data to the prism 1026 to direct the digital data toward the viewing lenses 702. Other embodiments are also possible.

[0078] In the above discussion of FIGS. 7-10, embodiments have been disclosed that have included a first direct-view light path from the objective lens to the viewing lens and a second digital-view light path to allow light to the image sensor. Further, embodiments have been shown that

include a single light path from which a portion of the light can be diverted by a mirror or splitter to sensors for generating display data. It should be appreciated that the optical devices of FIGS. 1A-10 may be implemented with one or more light paths. In an example, in addition to the direct-view light path and the digital light path, the scope may include additional digital light paths by adding lenses and by including sensors responsive to other wavelength bands. In an example, one or more additional digital light paths may be included to provide, for example, a thermal path including associated thermal sensors. Additional sensor possibilities could include long-wavelength infrared (LWIR) sensors, short-wavelength infrared (SWIR) sensors, medium wavelength infrared (MWIR) sensors, or digital sensors that are optimized for low-light imaging. These multiple digital paths could be used individually or fused and displayed to the user. Further, the paths could be used individually or fused for the purposed of display and optionally for target acquisition, selection, tracking, and fire control. Other embodiments are also possible.

[0079] Alternatively, in some embodiments, splitters may be used that can include reflective surfaces that are reflective only within a particular frequency range, making it possible to divert light of different frequencies toward different sensors while allowing visible light to pass through to the viewing lenses. Other embodiments are also possible.

[0080] FIG. 11 depicts a block diagram of a scope 1100 of any of FIGS. 1A-10 including circuitry configured to control operation of the switchable microdisplay 426, in accordance with certain embodiments of the present disclosure. The scope 1100 includes a circuit 1102 coupled to one or more user-selectable elements 1104, such as buttons, levers, switches, rollers, other selectable elements, or any combination thereof. The circuit 1102 may also be coupled to a trigger assembly 110 of a firearm 104. Further, the circuit 1102 may be coupled to a user-accessible switch 1144, which may be coupled to a switchable display element 1145.

[0081] The scope 1100 may include one or more lenses including an objective lens 1106 configured to receive light from a view area including reflected light corresponding to a pulsed laser beam. The scope may further include a prism 1148 including a first splitter 1156 configured to direct reflected laser light toward a range finder circuit 1137. The prism 1148 may further include a second splitter 1158 configured to direct a portion of the received light toward one or more optical sensors 1110. The prism 1148 may further include etched glass with a reticle 1150 positioned at a first focal plane 1152. The scope 1100 may also include a switchable display element 1145 configured to selectively intersect a light path 1160 to a viewing lens 1108.

[0082] The circuit 1102 may include a field-programmable gate array (FPGA) 1112 including inputs coupled to the one or more optical sensors 1110, a memory 1114, a display interface 1116, and a speaker 1117. The FPGA 1112 may also be coupled to a control circuit 1118.

[0083] The control circuit 1118 may include a digital signal processor (DSP) 1130 coupled to a memory 1132 and configured to receive digital signals from a microphone 1128 via an analog-to-digital converter (ADC) 1129. The control circuit 1118 may also include a microcontroller unit 1134 coupled to a memory 1136 and to the DSP 1130. The MCU 1134 may also be coupled to one or more sensors 1121, an

input interface **1122**, an input/output interface **1135**, one or more transceivers **1138**, the range finder circuit **1137**, and the FPGA **1112**.

[0084] In some embodiments, the user-accessible switch **1144** may include a lever, a switch, or another feature accessible by the user to manually or mechanically switch the microdisplay into the light path **1160**. In some embodiments, the user-accessible switch **1144** may cause the circuit **1102** to control an actuator (such as actuator **730** in FIG. 7, which may be coupled to the control circuit **1102**) to move the switchable display element **1145** into the light path **1160**. The switchable display element **1145** may include pivotable displays, pivotable mirrors, translatable displays, translatable mirrors, movable prisms, electrically controllable displays, electrically controllable mirrors or prisms, or any combination thereof. Other embodiments are also possible.

[0085] The scope **1100** of FIG. 11 may be configured to enable a direct-view mode without fire control, a direct-view mode with fire control, a digital-view mode without fire control, a digital-view mode with fire control, or any combination thereof. In some embodiments, integration of the scope **102** (or **302**) including the fire control system with the trigger assembly of the firearm **104** (or **304**) may reduce the overall size and weight of the firearm system.

[0086] FIG. 12 depicts a block diagram of components of a scope **1200** including an image inverting prism **1204** and a switchable display element **1208** in accordance with certain embodiments of the present disclosure. The scope **1200** may include an objective lens assembly **1202** configured to capture light from a view area and focus the light toward an image inverting prism **1204**, which may be configured to rotate an image by 180 degrees. The image inverting prism **1204** may direct the rotated light toward a viewing lens **1208**. The image inverting prism **1204** may be one of many prism types designed to rotate the image 180 degrees and output the image in-line with the input. Some possible prism types include a Dove prism, Abbe prism, Pechan prism, and a Pechan-Schmidt prism. Other prism designs are possible.

[0087] The scope **1200** may include a switchable display element **1206**, which may include any of the above-described translatable or pivotable or electrically controllable microdisplays, mirrors, prisms, optical sensors, or any combination thereof. The switchable display element **1206** allows the user to selectively switch between a direct-view mode and a digital display mode.

[0088] The scope **1200** may be shorter and smaller than a conventional rifle scope because the scope **1200** may be implemented with a single focal plane. The image inverting prism **1204** can invert the captured light so that some of the lenses can be omitted, making it possible to produce a smaller, lighter optical device.

[0089] To keep the size of the optical device small, the battery power may be integrated into the stock **106** or **306** of the firearm **104** or **304**. By moving the batteries **116** to the stock **106** or **306**, the size and weight of the housing of the scope **102** or **302** may be reduced, and a portion of the overall weight can be distributed to the stock **106** (or **306**) for an improved center of gravity and improved balance. Further, moving the batteries **116** to the stock **106** may enable the inclusion of a powered data rail or connection system for the addition of other modular add-on units.

[0090] FIG. 13 depicts an isometric view of a battery pack **1300** that can be incorporated within the firearm **104** of

FIGS. 1A-3, within the scope of FIGS. 3-12, or any combination thereof. The battery pack **1300** may include a battery enclosure **1302** configured to encase or otherwise secure a plurality of batteries **116**. The battery pack **1300** may be installed in the stock **106** of the firearm **104** or **304**.

[0091] In some embodiments, the battery pack **1300** may be implemented as a smart battery pack that including four rechargeable lithium-ion cells with onboard protection circuits. Further, the battery pack **1300** can include a fuel gauge and one or more microcontrollers. It should be appreciated that the smart battery pack implementation with four rechargeable lithium-ion cells represents one possible option for a standardized system battery pack. Other embodiments are also possible.

[0092] In some embodiments, the battery pack **1300** may be approximately 5.65 inches long, 1.91 inches wide, and 1.11 inches tall, and may weigh approximately 0.60 pounds. In some embodiments, the battery capacity may be approximately 3,500 mAh that can provide up to 50 Watt-hours of energy. Other embodiments are also possible.

[0093] In some embodiments, the batteries **116** individually or the battery pack **1300** as a whole may have the capability to contain a crypto-key. In some embodiments, the circuit **1102** may be configured to operate only with a battery pack **1300** that has a valid crypto-key. In a particular embodiment, an electronic device may be configured to authenticate the battery chargers, the chargers may be configured to authenticate the batteries, and the batteries may be configured to authenticate the fire control system. Other embodiments are also possible.

[0094] The systems, apparatuses and methods described above with respect to FIGS. 1-13 may include a firearm system including a firearm and a scope coupled to the firearm. The scope may be mechanically coupled to the firearm and electrically coupled to a circuit of a trigger assembly to selectively control timing of discharge of the firearm.

[0095] In some embodiments, the firearm system may include an integrated fire control system. Precision fire control modes may utilize an electromechanical (EM) trigger mechanism that may include mechanical components, such as a trigger shoe and associated mechanical components as well as a trigger circuit, which may be controlled by a control circuit within the scope to selectively control timing of discharge of the firearm until the aim point of the firearm is aligned to a selected target.

[0096] In some embodiments, user-selectable elements or controls may be located in ergonomic locations on the firearm, such as on or adjacent to a trigger guard, on a housing of the scope, in other locations, or any combination thereof.

[0097] In some embodiments, the direct-view optical path can include a fixed 4× magnification objective and a ballistic drop compensating (BDC) reticle. Zeroing of the entire fire control system can be accomplished through windage and elevation adjustment mechanisms in the base of the scope. The direct-view path can be a primary optical path for general scouting or “glassing”. During this time, all the electronics can be operating in a low-power or “sleep” state.

[0098] User-interaction with a switch on the side of the scope (or on the firearm) may cause the scope to enter digital-view mode. In the digital-view mode, the scope may provide a number of functions, including laser rangefinder, ballistics calculation, and wireless networking functionality.

The wake-up time from a low-power state to the full-power digital mode may be configured to be less than 500 milliseconds.

[0099] In digital mode, the shooter will see a displayed reticle corresponding to the 100-yard zero of the firearm. To gather a firing solution for a target at any unknown range, the shooter may first range the target using a button, which may be located on the scope or on the trigger guard of the firearm. The shooter may align the reticle with the target and press and release the range button. Upon release of the button, the LRF of the optical scope may range objects corresponding to the aim point of the firearm. Within 250 milliseconds, the LRF circuit may determine the range and provide the range measurement data to the MCU, which may provide the range data to the FPGA for presentation with an adjusted reticle that is updated to the correct firing solution for that range. In addition to preconfigured ammunition and firearm parameters (projectile diameter, length, drag coefficient, barrel length, twist, muzzle velocity, height over bore, etc.), a ballistics calculator may also take into account the measurements from other sensors of the scope, including range to target, inclination angle, cant angle, shot direction, temperature, humidity, barometric pressure, and so on. In some embodiments, the user may provide a manual input corresponding to an estimate of the crosswind speed and direction, which may be input by interacting with a rocker button or pair of buttons on the scope. In other embodiments, laser scintillation-based wind measurement may be used to determine wind speed and direction. The ballistic solution may be determined based on a combination of parameters or factors, including bullet drop, spin drift, Magnus effect, Coriolis effect, aerodynamic jump, and so on.

[0100] In some embodiments, the reticle provided to the display may be updated in real-time, accounting for one or more parameters that may change between the time of ranging and the time that a shot is taken. The displayed reticle can persist through multiple shots, until the shooter ranges another target or cancels the current settings to return to the 100-yard zero reticle range. At all times, the scope may display the range that the reticle is currently set to and may display a secondary reticle to always indicate the 100-yard zero position. This allows for quick shots at point blank range without the need to do anything other than use the 100-yard reticle and squeeze the trigger.

[0101] In some embodiments, the scope can include a transceiver 1138 configured to transmit and receive data from external networks. In an example, the transceiver 1138 can live-stream the field of view of the scope, the heads-up display (HUD) with the reticle, and sensor information to a wireless network and optionally to other devices, directly or through the network. The other devices can include computers, phones, tablets, augmented reality glasses, other scopes, or any combination thereof. In a particular embodiment, the scope can operate as an 802.11G Wi-Fi hot spot and data as well as instructions can be sent and received via the transceiver 1138.

[0102] FIG. 14 depicts a flow diagram of a method 1400 of selectively actuating a display element into alignment with a light path, in accordance with certain embodiments of the present disclosure. The method 1400 may include receiving an input at an actuator element of a scope of a firearm, at 1402. The input may be received from a lever, a switch,

or another manual input, or may be received from a control circuit in response, for example, to a user's interactions with a switch or lever.

[0103] At 1404, the method 1400 can include determining a position of the switchable display element relative to the optical path of the scope. If, at 1406, the switchable display element is aligned with the optical path, the method 1400 may include pivoting the display element out of alignment with the optical path, at 1408. Otherwise, at 1406, if the display element is not aligned with the optical path, the method 1400 can include pivoting the display element into alignment with the optical path, at 1410.

[0104] FIG. 15 depicts a flow diagram of a method 1500 of selectively controlling a display, in accordance with certain embodiments of the present disclosure. At 1502, the method 1500 may include determining the position of a switchable display element relative to the optical path of the scope. The position may be determined by a magnetic or optical encoder or by mechanical, optical, or magnetic switches, or any combination thereof.

[0105] At 1504, if the display element position is in the optical path, the digital mode of the scope is activated, at 1506, and the microdisplay is activated, at 1508. Otherwise, at 1504, if the display element position is determined to be out of the optical path, the method 1500 may include deactivating digital mode, at 1510, and entering a low-power state including deactivation the microdisplay 1512.

[0106] It should be appreciated that the methods 1400 and 1500 of FIGS. 14 and 15 include determining a position of the microdisplay (904) or determining an operating mode (1004) of the scope. However, in other embodiments, rather than toggling from a current state to another state, the position may be established by moving the lever or the switch in one direction to position the display in the optical path and in the other direction to position the display out of the optical path.

[0107] In another embodiment, the user may interact with one or more user-selectable elements on the scope or on the firearm to adjust the operating mode of the scope between a first (direct-view) mode, a second (direct-view with fire control) mode, a third (digital-view with fire control) mode, and a fourth (digital-view without fire control) mode. Other operating modes are also possible.

[0108] In conjunction with the systems, apparatuses, and methods described above with respect to FIGS. 1A-15, a firearm system may include a firearm coupled to a scope that includes a direct-view mode in which a DVO assembly directs and focuses light from a view area toward a view lens of the scope. The scope may further include digital circuitry including a microdisplay element that can be configured to selectively interrupt the optical light path to provide image data to the viewing lens. The microdisplay element may selectively interrupt the second focal plane by pivoting into the second focal plane via user-selection of a lever or button or via a control signal provided to an actuator. Alternatively, the microdisplay element may selectively interrupt the second focal plane by transitioning from a fully transmissive (transparent) state to a digital-display state in which digital data is provided that is perceptible through the viewing lens of the scope. Other embodiments are also possible.

[0109] In some embodiments, the firearm may include a trigger assembly including mechanical components as well as electronic circuitry. The scope may include control circuitry coupled to the electronic circuitry of the trigger

assembly. In some embodiments, the scope may be configured to operate in a direct-view mode in which a direct view of a view area of the scope is presented to the viewing lens of the scope through a DVO assembly. In a digital-view mode, the scope may be configured to present a digital display to the viewing lens of the scope. In a fire control mode, whether in the digital-view mode or the direct-view mode, the scope may control timing of the discharge of the firearm to prevent discharge until the aim point corresponds to a ballistic solution of a selected target based on LRF data, sensor data, such as incline, direction, temperature, barometric pressure, other sensor data, or any combination thereof.

[0110] Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the scope of the invention.

1. An optical scope comprising:
 - a direct-view optics assembly including an objective lens and a viewing lens, the direct-view optics assembly configured to direct and focus light from a view area received by the objective lens toward the viewing lens; and
 - a switchable display element configured to selectively interrupt a light path between the objective lens and the viewing lens, the switchable display element to receive an electrical signal including image data and to present the image data to the viewing lens.
2. The optical scope of claim 1, further including a user-selectable element accessible by a user to cause the switchable display element to interrupt the light path.
3. The optical scope of claim 1, wherein the switchable display element is configured to pivot about a pivot point between a first position outside of the light path and a second position that interrupts the light path in response to one of an electrical signal and a mechanical movement of a user-selectable element on the scope.
4. The optical scope of claim 1, wherein the switchable display element is configured to translate between a first position outside of the light path and a second position that interrupts the light path in response to one of an electrical signal and a mechanical movement of a user-selectable element on the scope.
5. The optical scope of claim 1, wherein the optical scope further includes:
 - an actuator coupled to the switchable display element and configured to move the switchable display element between a first position outside of the light path and a second position that interrupts the light path; and
 - a control circuit coupled to the actuator and configured to provide signals to the actuator to control movement of the switchable display element.
6. The optical scope of claim 1, wherein the switchable display element is transmissive to light in a first mode and interrupts at least a portion of the light path in a second mode to display the image data.
7. The optical scope of claim 1, further comprising a firearm system coupled to the optical scope, the firearm system including:
 - a trigger assembly including mechanical components and an electronic circuit; and
 - wherein the scope includes a control circuit coupled to the electronic circuit of the trigger assembly.

8. The optical scope of claim 7, wherein the control circuit includes:

- an optical sensor circuit configured to capture image data associated with the view area; and
- a processing circuit coupled to the optical sensor circuit and to the switchable display element, the processing circuit configured to selectively provide the image data to the switchable display element.

9. The optical scope of claim 1, wherein the switchable display element comprises:

- a micro display that is stationary; and
- a movable mirror configured to move into and out of the light path.

10. The optical scope of claim 1, further comprising a plurality of sensors including at least one infrared sensor configured to capture infrared data associated with the view area.

11. A method comprising:

- in a first mode, providing light received at an objective lens of an optical scope through a first focal plane including a reticle to a viewing lens of the optical scope;

receiving an input corresponding to a change of position of a lever of the optical scope; and

- in a second mode, coupling a switchable display element into the optical path, the switchable display element to receive an electrical signal including image data and to provide the image data viewable from the viewing lens.

12. The method of claim 11, wherein coupling the switchable display element comprises selectively activating a microdisplay element within the optical path to transition from a transmissive state to an active state.

13. The method of claim 11, wherein coupling the switchable display element comprises moving one of a microdisplay and a mirror element into the optical path to direct the image data from the microdisplay toward the viewing lens.

14. The method of claim 13, wherein moving one of the microdisplay and the mirror element comprises moving the one of the microdisplay and the mirror element about a pivot.

15. The method of claim 13, wherein moving one of the microdisplay and the mirror element comprises translating the one of the microdisplay and the mirror element from a first position to a second position.

16. The method of claim 11, wherein coupling the switchable display element comprises applying an electrical signal to one of a mirror, a prism, and a display element to alter a reflectivity of a surface to interrupt the optical path.

17. An optical scope comprising:

- control circuitry;
- a direct-view optics assembly including an objective lens and a viewing lens, the direct-view optics assembly configured to direct and focus light received by the objective lens toward the viewing lens; and

- a switchable display element coupled to the control circuitry and configured to selectively interrupt a light path between the objective lens and the viewing lens, the switchable display element to receive an electrical signal including image data and to present image data to the viewing lens.

18. The optical scope of claim 17, further comprising a user-selectable element coupled to the optical scope and

accessible by a user to control the switchable display element to selectively interrupt the light path.

19. The optical scope of claim **17**, wherein the switchable display element comprises a microdisplay configured to move into and out of the light path.

20. The optical scope of claim **17**, wherein the switchable display element comprises:

a microdisplay that is fixed within the optical scope and outside of the light path; and

at least one of a mirror and a prism configured to move into and out of the light path.

21. The optical scope of claim **17**, wherein the switchable display element comprises at least one of a display, a mirror, and a prism that is responsive to electrical signals to selectively interrupt the light path.

* * * * *