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(54) **ACCESSORY DISPLAY FOR OPTICAL SIGHTING DEVICES**

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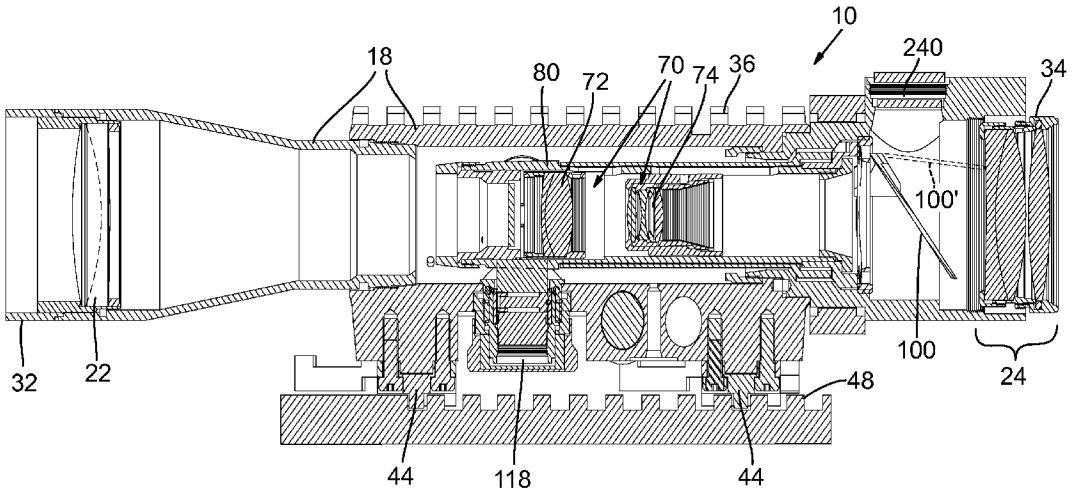
G02B 23/10	(2006.01)

(52) **U.S. Cl.**

CPC ***F41G 1/38*** (2013.01); ***G02B 23/10*** (2013.01); ***G02B 23/04*** (2013.01); ***G02B 26/0816*** (2013.01)

(57) **ABSTRACT**

Optical aiming systems having a primary direct view optical system and an accessory optical system are arranged to provide a user with distinct views of a primary image and accessory image display without head movement. The primary optical system may be a riflescope and the accessory optical system may include an electronic image display device that directs light through a side wall of the riflescope toward an optical combiner or mirror within a housing of the riflescope. The optical combiner or mirror reflects the accessory display light through an eyepiece of the riflescope to form an exit pupil that is distinct from an exit pupil of the riflescope. The optical path of the accessory optical system may be angularly displaced relative to the optical path of the riflescope so that the accessory image display does not occlude aiming points within the field of view of the riflescope.



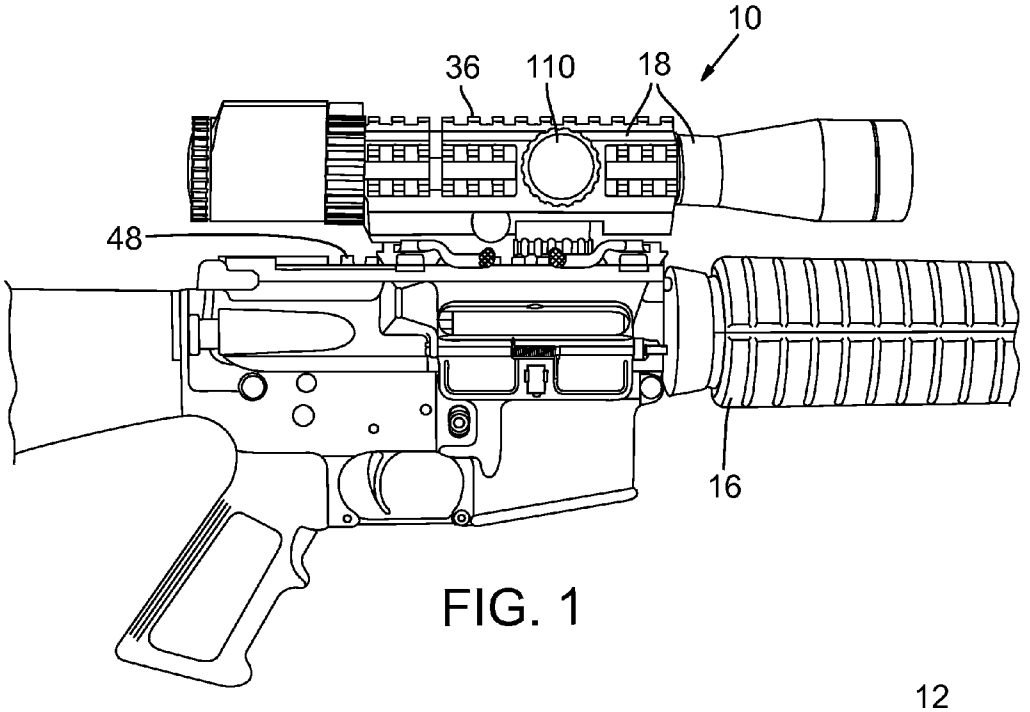


FIG. 1

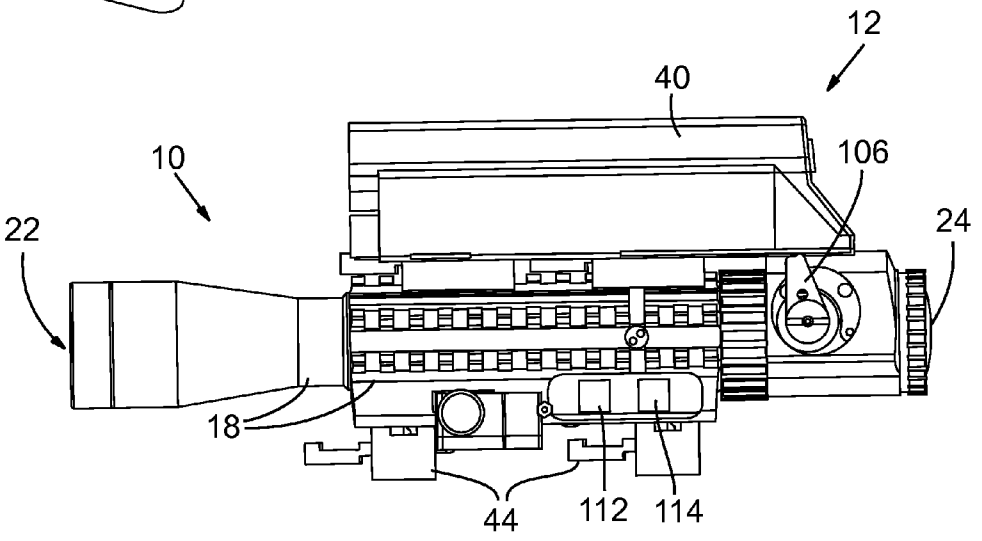


FIG. 2

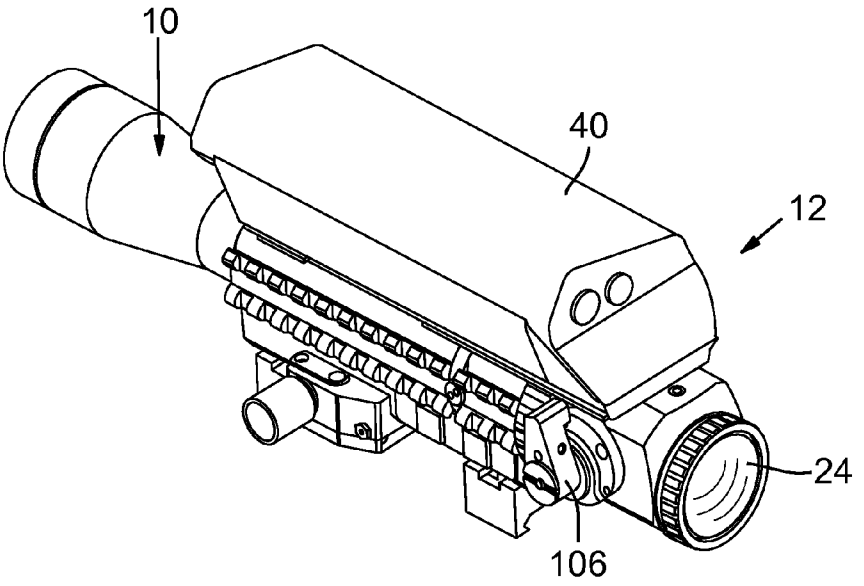


FIG. 3

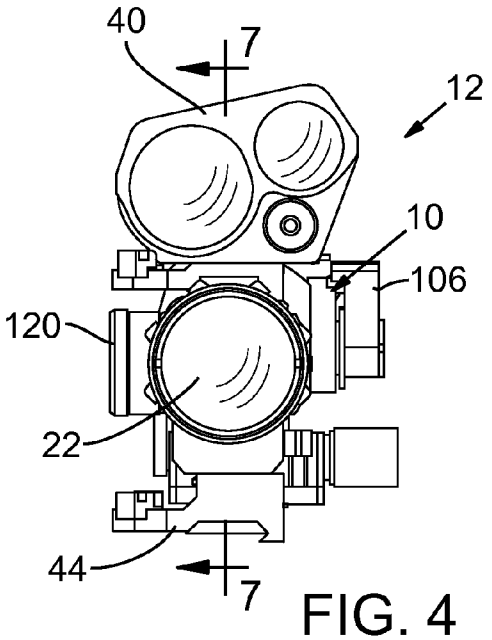


FIG. 4

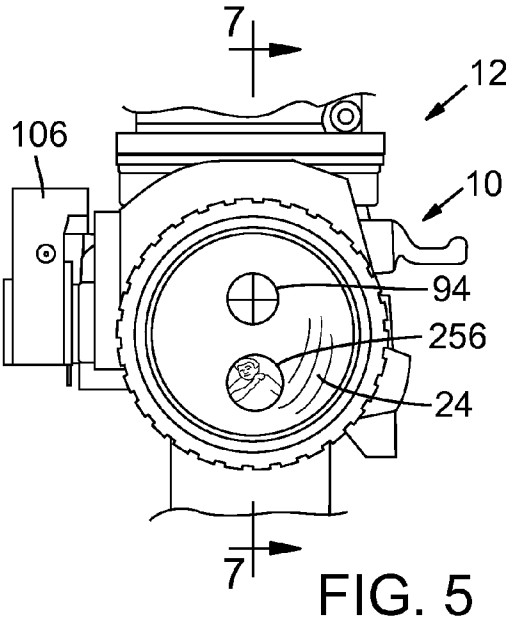


FIG. 5

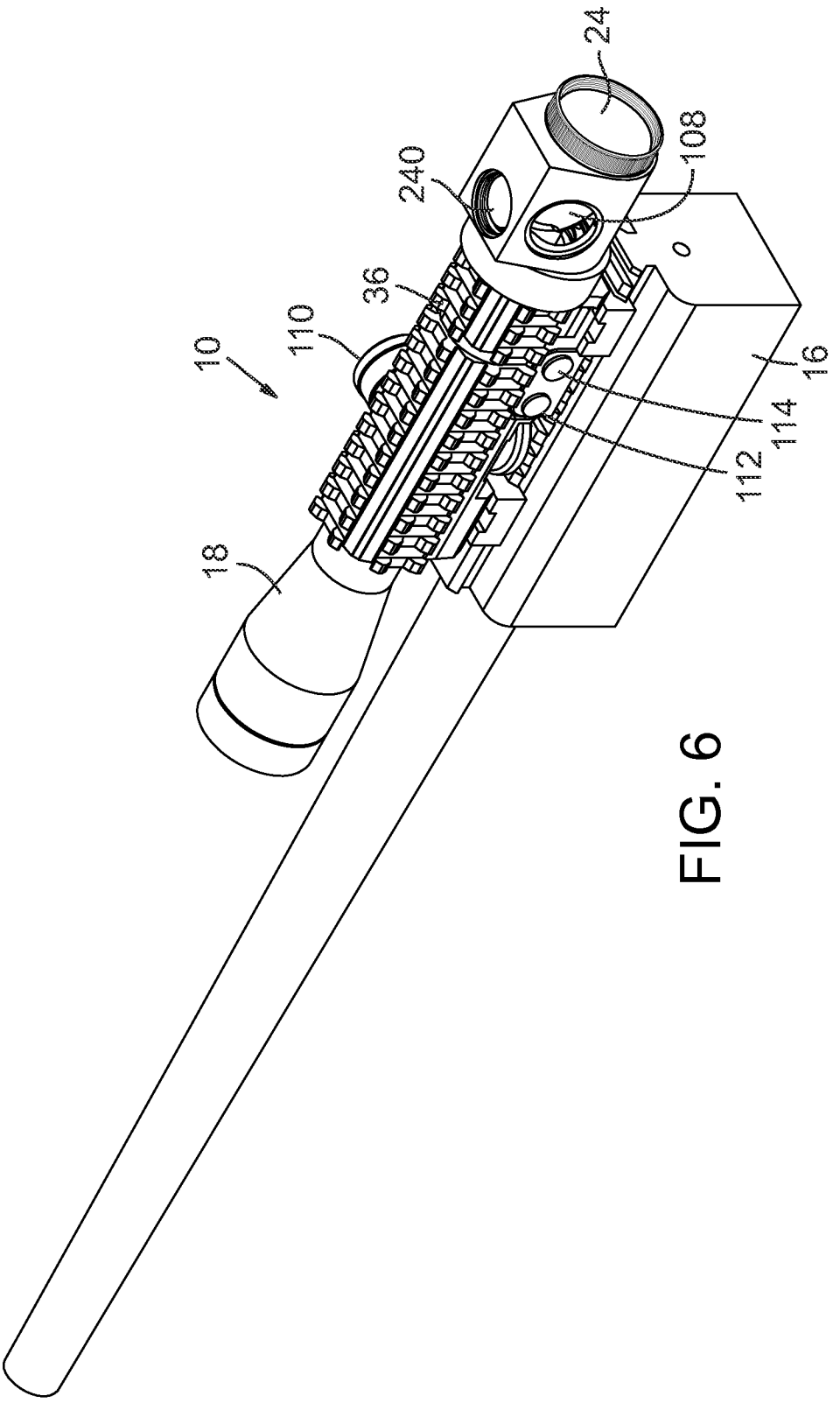


FIG. 6

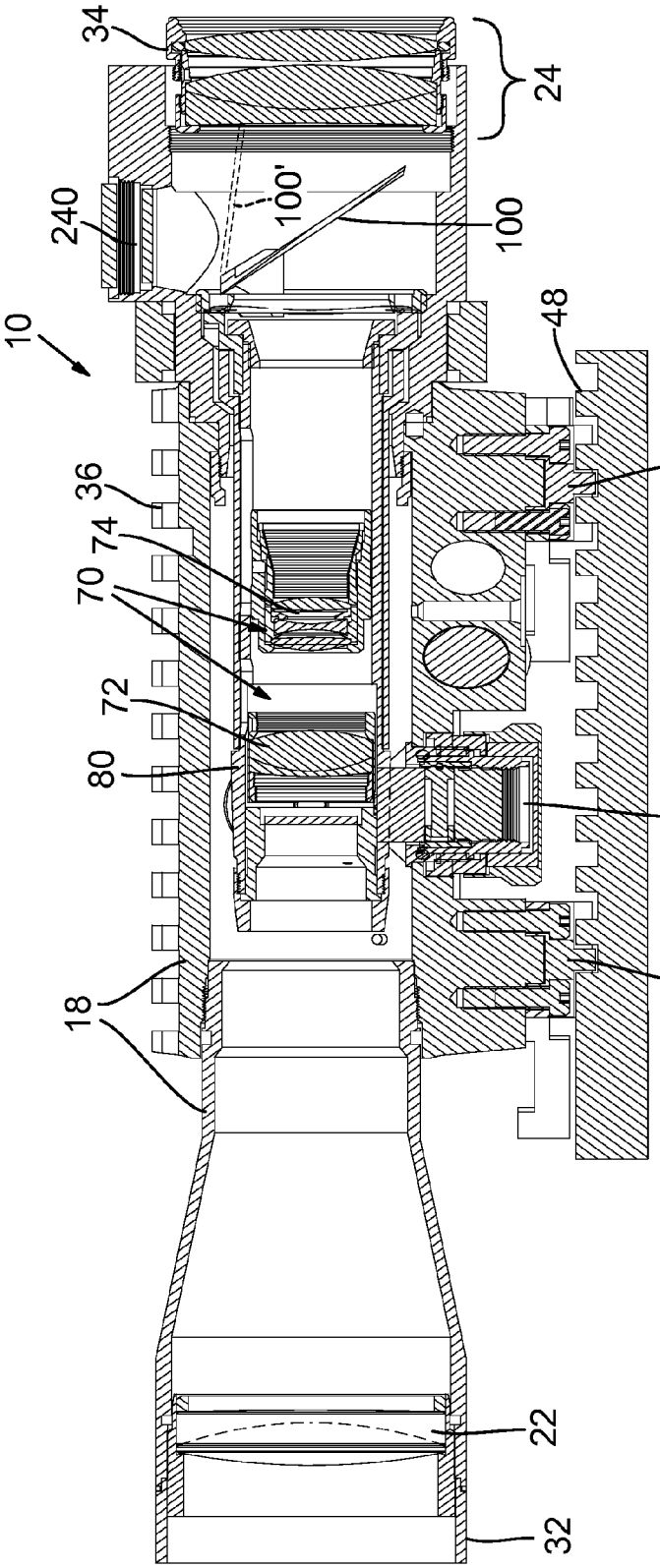


FIG. 7

REPLACEMENT SHEET

5/13

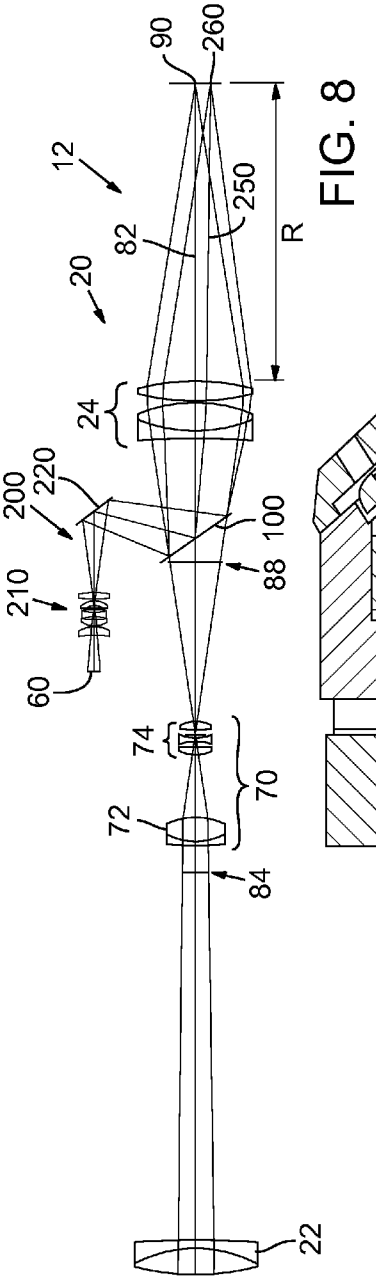


FIG. 8

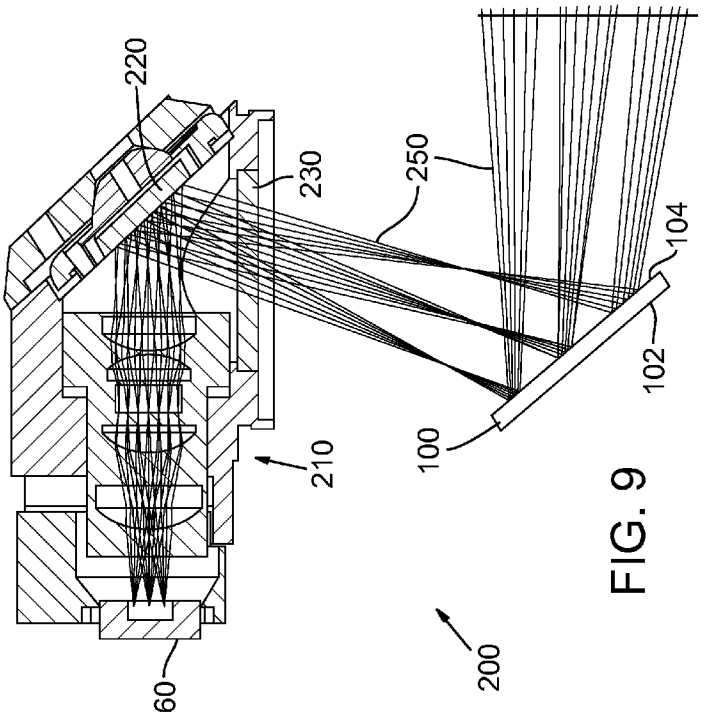


FIG. 9

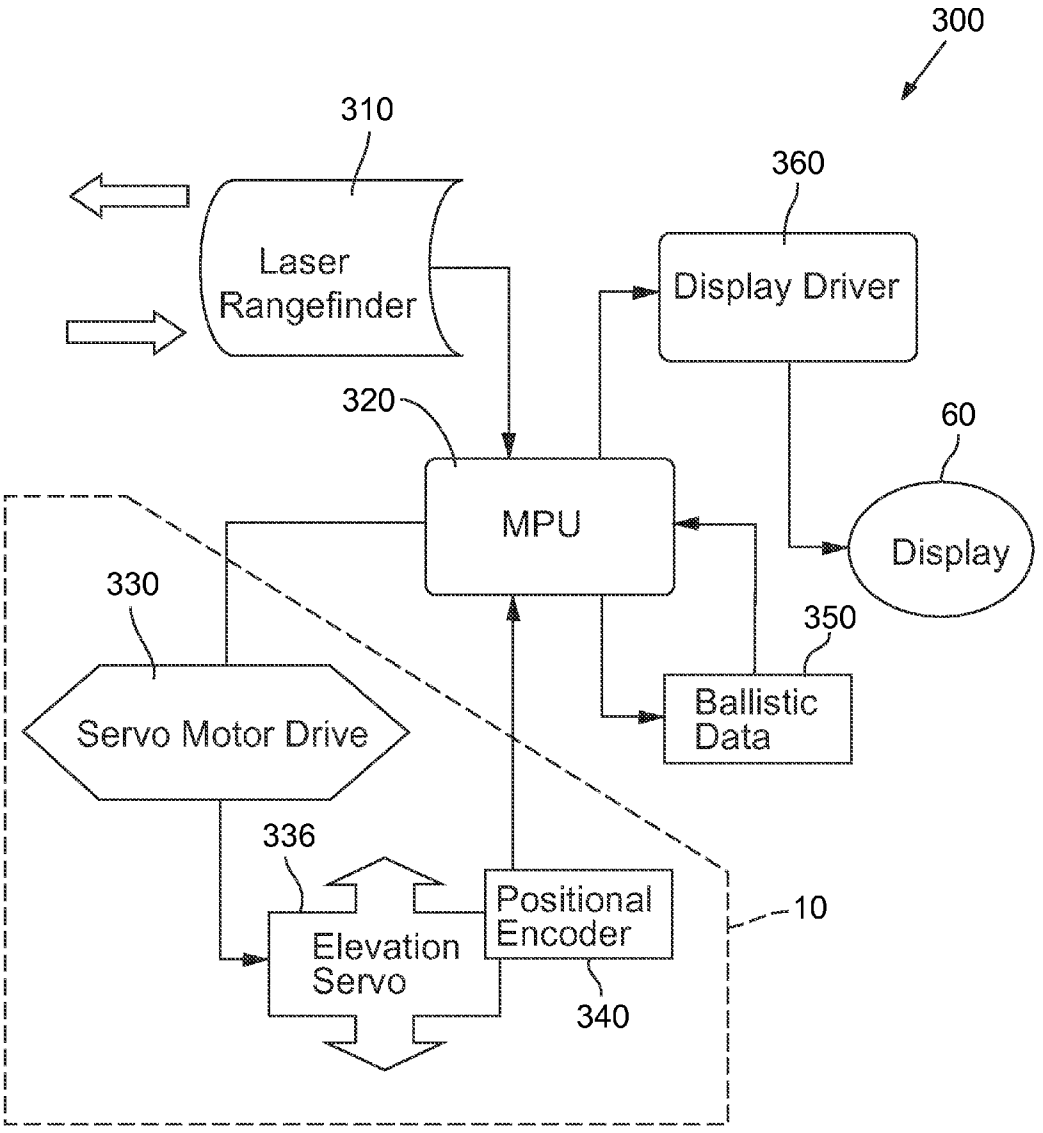

300
310
Laser Rangefinder
360
Display Driver
320
MPU
60
Display
330
Servo Motor Drive
350
Ballistic Data
336
Elevation Servo
Positional Encoder
340
10

FIG. 10

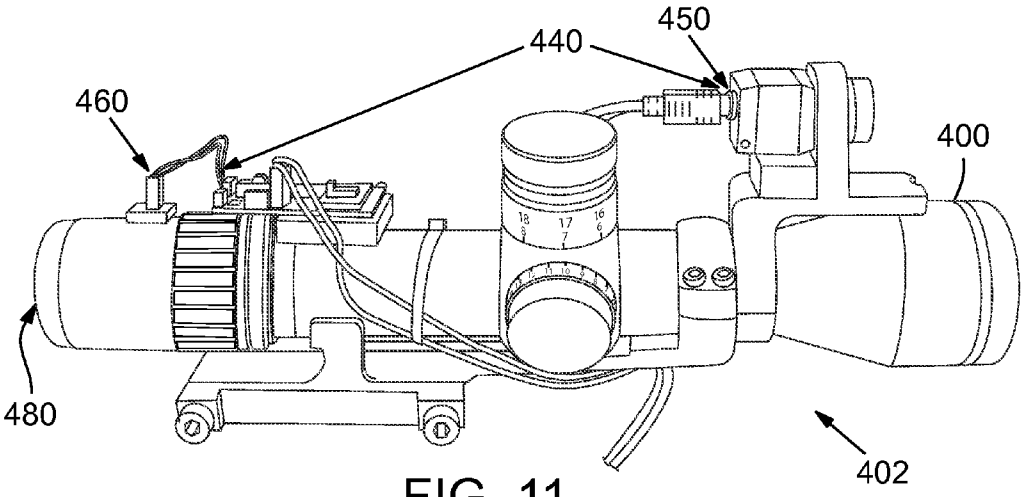


FIG. 11

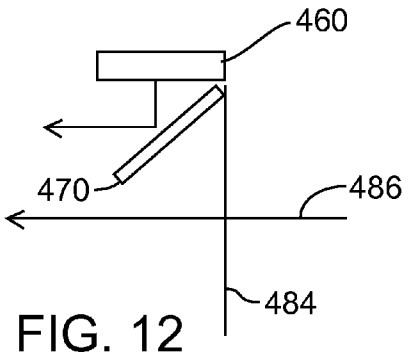


FIG. 12

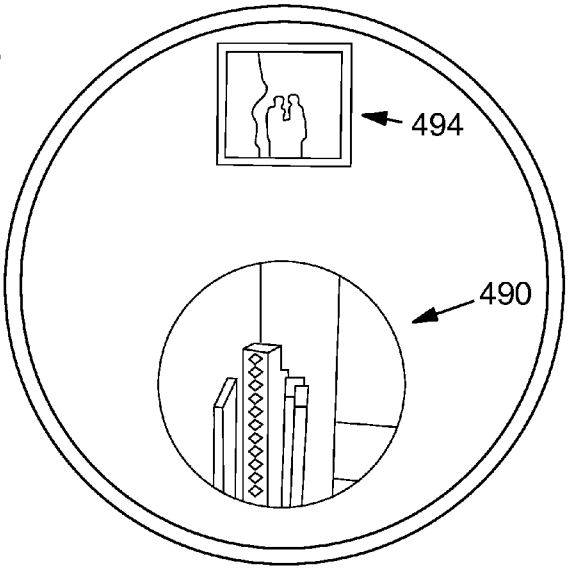


FIG. 13

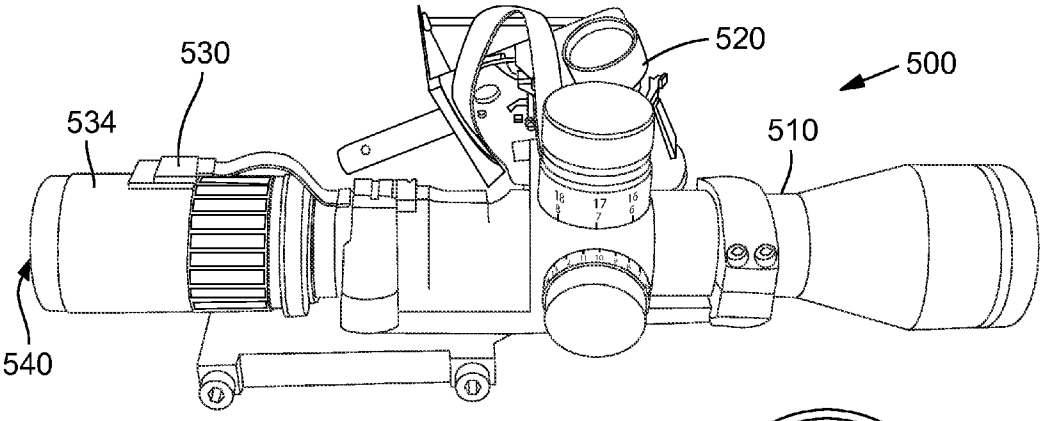


FIG. 14

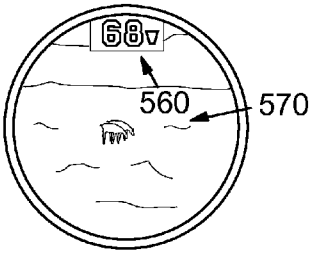


FIG. 16

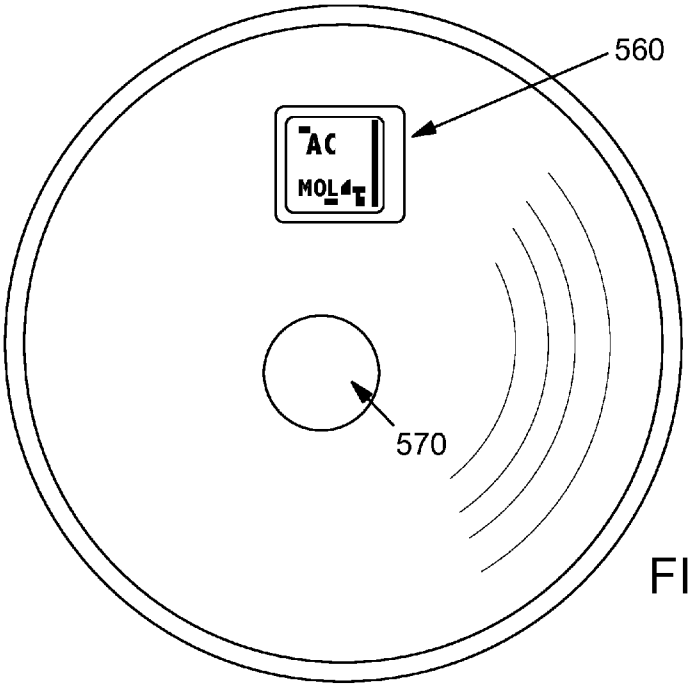


FIG. 15

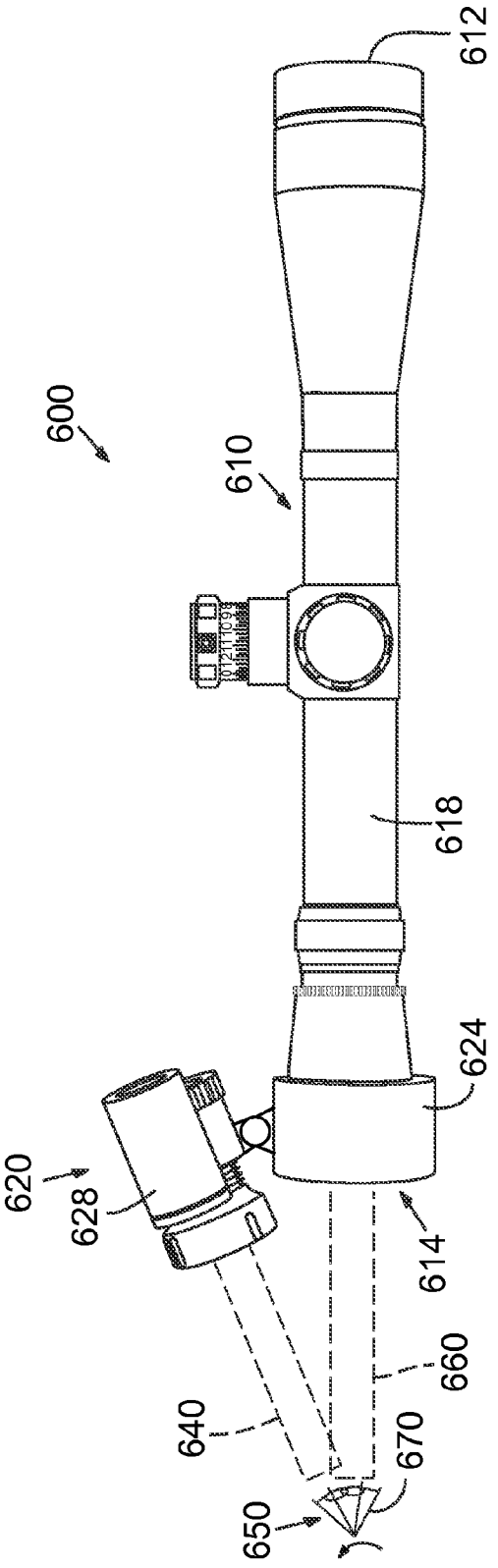


FIG. 17

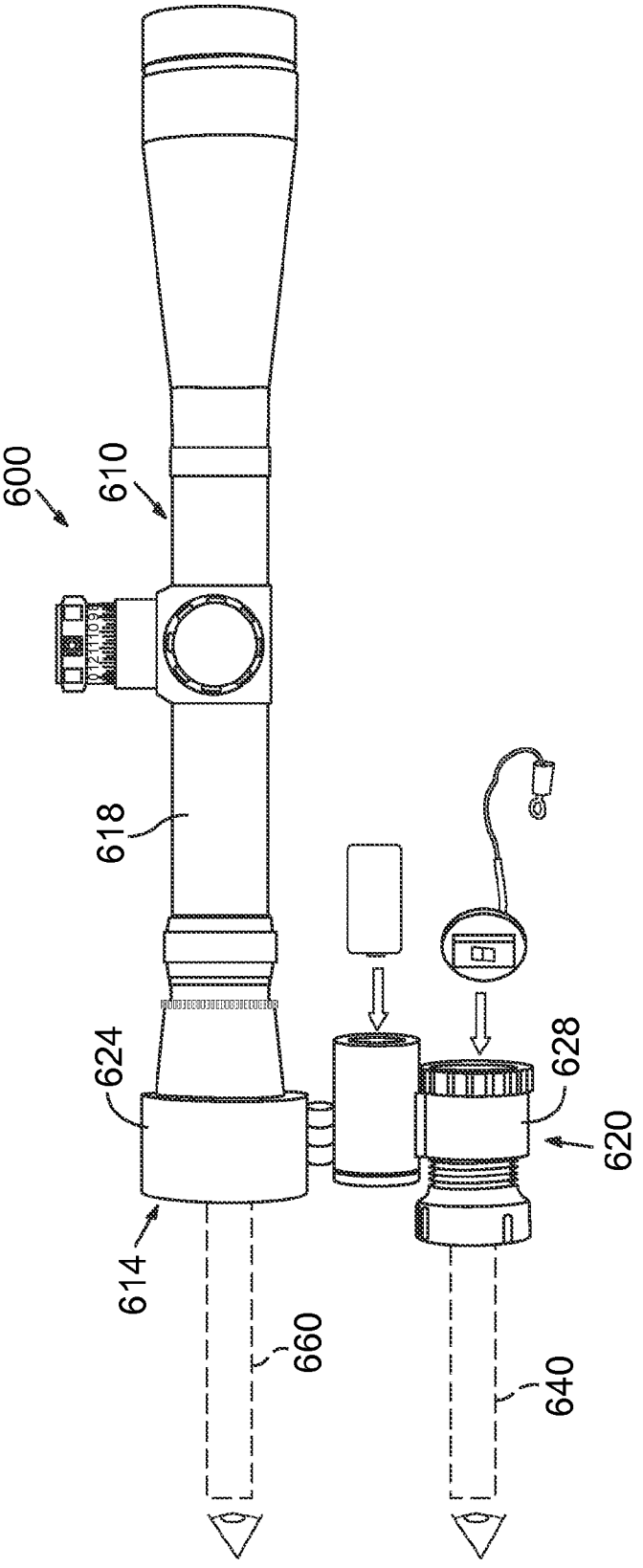


FIG. 18

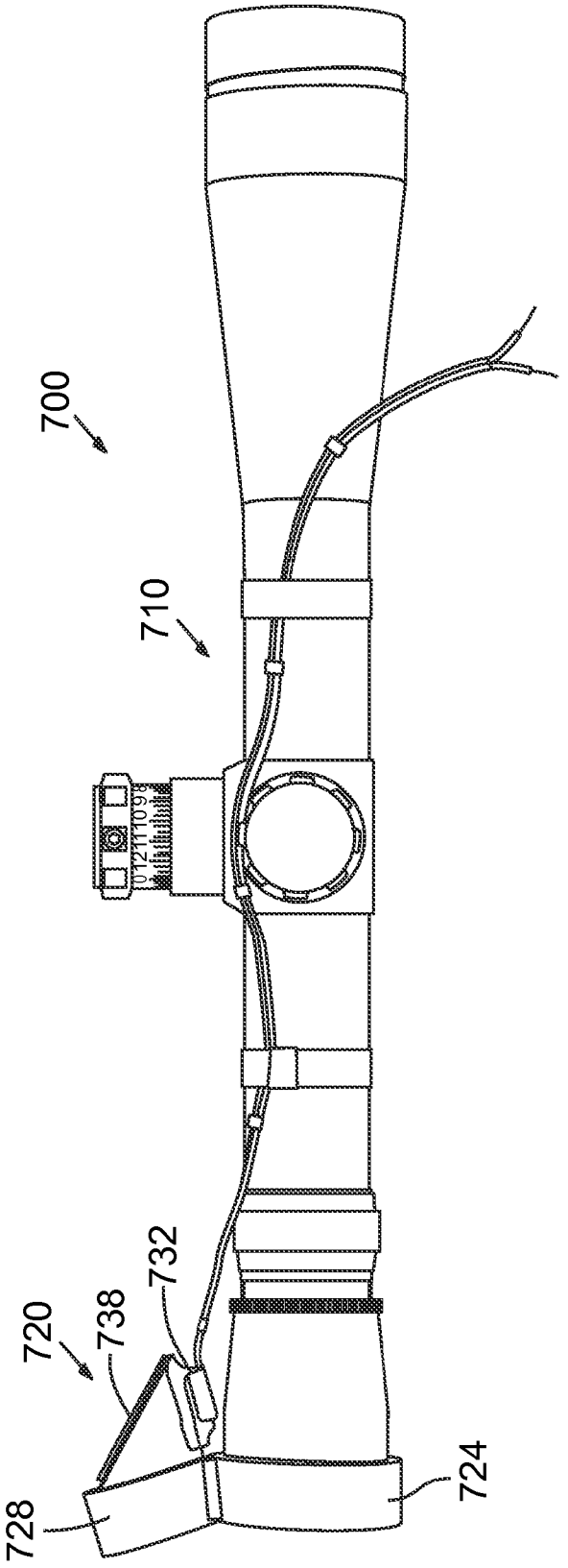


FIG. 19

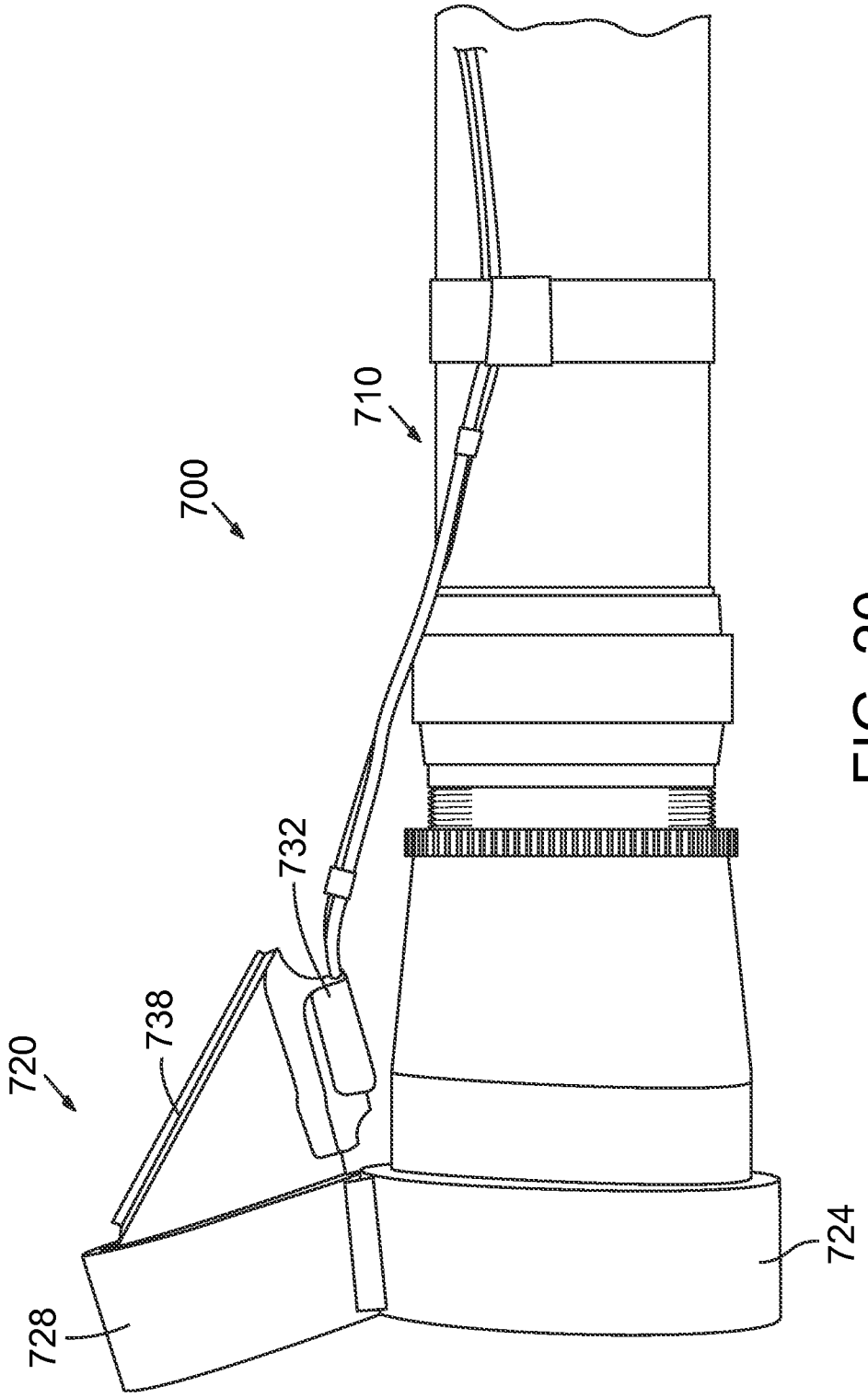


FIG. 20

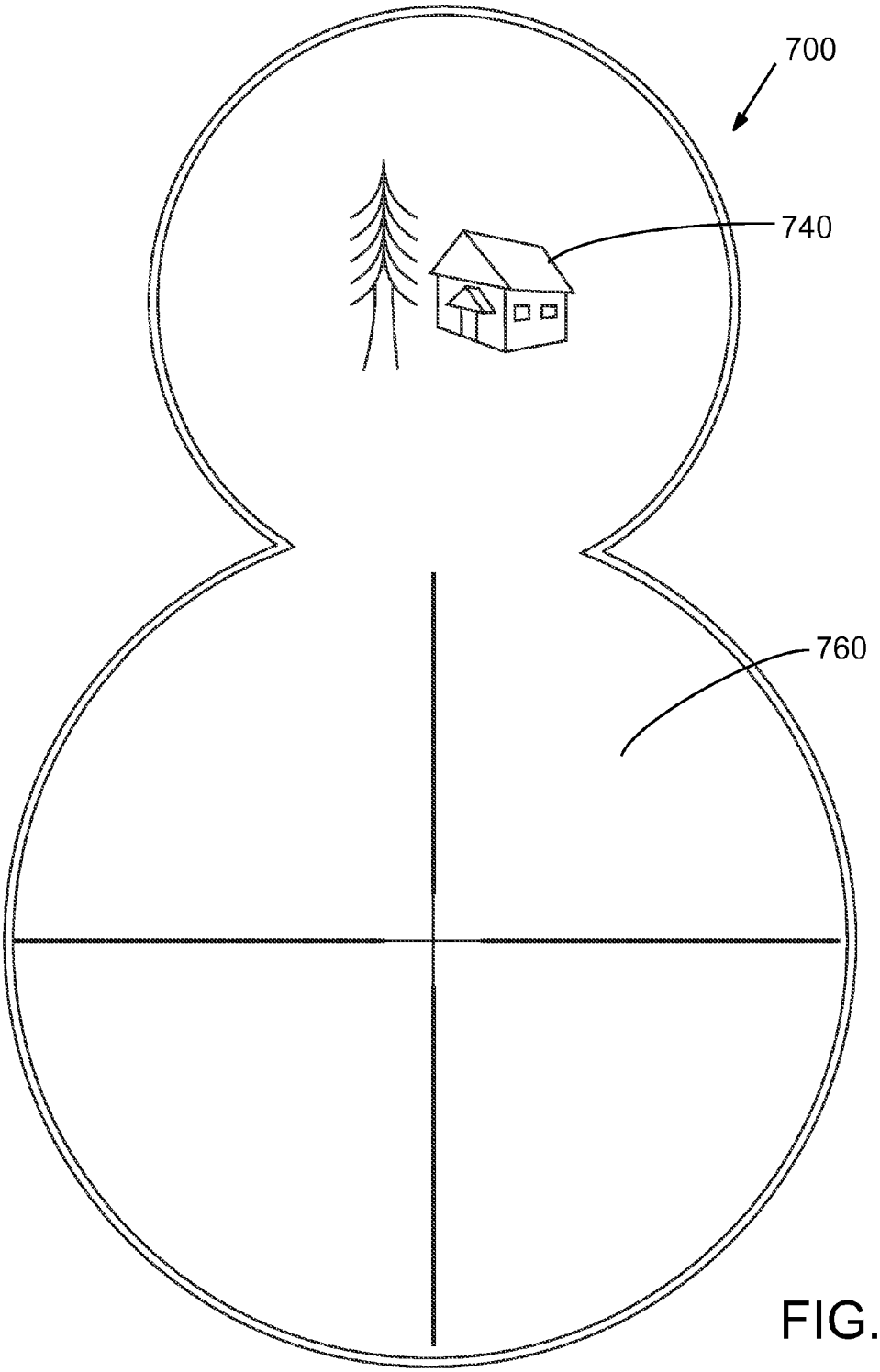


FIG. 21

ACCESSORY DISPLAY FOR OPTICAL SIGHTING DEVICES

RELATED APPLICATION

[0001] This application claims the benefit of priority under 35 U.S.C. § 119(e) of U.S. Provisional Application No. 62/043,780, filed Aug. 29, 2014, which is incorporated herein by reference.

TECHNICAL FIELD

[0002] The present disclosure relates to optical sighting devices, such as riflescopes, for viewing distant targets or objects, and to methods and systems for visually presenting an accessory display or other auxiliary image in conjunction with a primary image of the optical sighting device.

BACKGROUND

[0003] Optical sighting devices, such as binoculars, spotting scopes, telescopic sights, and riflescopes, typically include lenses and other optical elements supported within a housing that is sealed to prevent moisture and contamination from interfering with the optical performance of the device. Riflescopes are specialized telescopic sights that are mounted to a firearm and include a reticle or other aiming mark display for aiming the firearm. Riflescopes have eyepieces (aka oculars) designed for substantial eye-relief between the eyepiece and the user's eye—generally from 2 to 6 inches—to protect the user from injury when the firearm recoils. Pistol scopes are specialized riflescopes designed for use with pistols. Pistol scopes have longer eye relief than conventional riflescopes of the kind used with a rifle or carbine, allowing the pistol and pistol scope to be held at arm's length.

[0004] U.S. Pat. No. 6,295,754 of Otteman et al. describes a riflescope with a housing having exterior mounting features for attaching an auxiliary device, such as a thermal imaging device or range finder. A common tactical sight arrangement involves an auxiliary non-magnifying reflex sight mounted on top of such a riflescope. Because such auxiliary devices are mounted outboard of the riflescope housing a distance above or to the side of the riflescope optics, a user may need to move his or her head vertically or horizontally a significant distance to switch between the auxiliary device and the riflescope. Alternatively, the user may need to move the riflescope (and the weapon to which the riflescope is mounted) when alternating between viewing through the riflescope and viewing the auxiliary device. The significant amount of lateral or vertical head movement or riflescope/weapon movement required when transitioning between the riflescope and the auxiliary device could hinder a user's ability to quickly visually reacquire the target. Transitioning between viewing through the riflescope and viewing the display or image of an auxiliary device is yet more problematic when the eye relief distance of the auxiliary device is different from the eye relief of the riflescope.

[0005] It is known to combine an auxiliary imaging device with an optical riflescope and superpose the auxiliary image with the optical field, as shown for example in U.S. Pat. Nos. 3,699,341 of Quillinan et al., 5,035,472 of Hansen, 5,084,780 of Phillips, 5,497,266 of Owen, 5,745,287 of Sauter, and 6,111,692 of Sauter. These devices typically have primary and secondary optical paths that are merged and coaxially aligned before passing through the ocular lens. The present inventor has recognized that the superposed images in such devices can be confusing or distracting to the user. Furthermore, in some such systems, a failure of the auxiliary imaging device can disable the primary device (i.e., the riflescope) and vice versa.

[0006] There remains a need for an improved optical sighting system that facilitates the viewing of an auxiliary image or information display in addition to a principal image formed by a primary telescopic sight or other optical sighting device.

SUMMARY

[0007] In one embodiment, an optical sighting device includes a first optical system, such as a riflescope, defining a first optical path and configured to form a first image viewable through an ocular of the first optical system. A second optical system defines a second optical path that extends through the same ocular, but that is non-coaxial with the first optical path so that it forms a second image offset from the first image and viewable through the shared ocular. The first and second optical systems preferably produce offset first and second exit pupils both viewable through the shared ocular. The second optical system may be adapted to form an image generated by an accessory device, such as a video camera, laser rangefinder, night vision sight, thermal imaging system, or an electronic display device, for example. In some embodiments the optical sighting device may comprise an optical combiner for combining the first and second optical paths for observation through the shared ocular. The optical combiner and the second optical system may be arranged relative to the first optical system so that the first and second optical paths diverge rearward of the ocular. In some embodiments, a small mirror is used in place of the optical beam combiner and placed near a focal plane at the edge of the field of view for combining the first and second optical paths for observation through the shared ocular. The mirror may be positioned at a rear focal plane of the first optical system near the exit pupil of the first optical system, so that the exit pupil of the first optical system at the rear focal plane is slightly overlapping with the second exit pupil of the second optical system, to present the accessory image at the periphery of the primary field of view of the scope. Alternatively, the second optical path and mirror may be positioned so that the second exit pupil is spaced apart from the first exit pupil, and comparably sized, allowing the user to switch between the primary and secondary images by eye movement, or in some embodiments by a very small head movement. The mirror or optical combiner may be selectively switchable between an active condition, extending into the first optical path, and an inactive condition, substantially removed from the first optical path.

[0008] In some embodiments, the exit pupil of the second optical system may not be a "true" exit pupil, but may instead be an "effective" exit pupil. In such embodiments, the eye relief for the "effective" exit pupil may be defined by where the user places his or her eye along the progression of collimated virtual image-forming rays from the display of the accessory device, in a similar fashion to viewing the red dot of a reflex sight. This may happen for optical systems, such as the embodiment illustrated in FIG. **12** or FIGS. **17-21**, when there is no relay lens and the eyepiece is used as a magnifier.

[0009] The optical sighting device may include an elongate, generally tubular housing supporting the first optical system and the optical combiner or mirror between opposing first and second ends of the housing, with the first optical path extending longitudinally through the housing. In one embodiment, at least a portion of the second optical path extends

through a hermetically sealed window in a side of the housing intermediate the first and second ends of the housing and adjacent the optical combiner or mirror. An exterior accessory mount may be provided for removably attaching and repeatably reattaching the accessory device at a fixed position relative to the first optical system and the window. In some embodiments, the optical sighting device further comprises an automatic bullet drop compensation subsystem operably coupled to at least one of the first optical system, the accessory device, and the second optical system.

[0010] In another embodiment, an accessory electronic display device is mounted to the outside of a primary optical sighting device such as a riflescope having a first optical system and first optical path. The accessory display device includes an electronic micro-display and collimating optics having an optical axis extending entirely outside of the eyepiece and angled relative to the first optical path so that the first and second optical paths converge to an eye point of the first optical system at an eye relief distance rearward of the eyepiece. From this eye point, a user can switch between the primary optical sighting device and the auxiliary display device merely by eye movement and without head movement or refocusing to a different distance.

[0011] Additional aspects will be apparent from the following detailed description of preferred embodiments, which proceeds with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a right side view of a riflescope in accordance with a first embodiment, shown mounted to an automatic rifle;

[0013] FIG. **2** is a left side elevation view of an optical sighting system including the riflescope of FIG. **1** and an accessory device mounted thereon;

[0014] FIG. **3** is an isometric view of the optical sighting system of FIG. **2**;

[0015] FIG. **4** is an objective end view of the optical sighting system of FIG. **2**;

[0016] FIG. **5** is an eyepiece end view of the optical sighting system of FIG. **2**, with spaced apart first and second exit pupils illustrated;

[0017] FIG. **6** is an isometric view of the riflescope of FIG. **1** shown mounted to a rifle (only the barrel and receiver of the rifle are illustrated in FIG. **6**), with the accessory device of FIGS. **2-5** omitted and a switching lever of the riflescope omitted from the left side of the eyepiece housing;

[0018] FIG. **7** is a cross section view of the riflescope of FIG. **1** taken along lines **7-7** of FIGS. **4** and **5**, with the accessory device omitted;

[0019] FIG. **8** is a ray trace diagram showing a primary optical system of the riflescope of FIGS. **1-7**, components of a second optical system, and an optical combiner;

[0020] FIG. **9** is a cross section view of an accessory device including an electronic micro-display, and with the optical combiner and ray traces of FIG. **8** shown schematically;

[0021] FIG. **10** is a schematic block diagram showing components of an automatic bullet drop compensation subsystem of the optical sighting system of FIGS. **2-5**;

[0022] FIG. **11** is a pictorial side view of an optical sighting system according to another embodiment, including a riflescope and an accessory infrared camera and display device that injects a night vision video image into the eyepiece of the riflescope;

[0023] FIG. **12** is a schematic side elevation drawing showing the layout of the display device and a mirror positioned within the housing of the riflescope of FIG. **11**;

[0024] FIG. **13** is a pictorial image of the optical sighting system of FIG. **11** from rearward of the eyepiece of the riflescope showing two distinct images including the riflescope exit pupil spaced apart from a night vision video image;

[0025] FIG. **14** is a pictorial side view of an optical sighting system according to an embodiment including a riflescope and an accessory laser rangefinding device and a display device that injects a ranging data readout display into the eyepiece of the riflescope;

[0026] FIG. **15** is a pictorial image of the optical sighting system of FIG. **11** from rearward of the eyepiece of the riflescope showing the riflescope exit pupil and the ranging display readout display offset from the exit pupil;

[0027] FIG. **16** is a pictorial representation of a possible display of the optical sighting system of FIG. **14**, wherein the ranging data readout display overlaps with the exit pupil of the riflescope and is superposed on the field of view of the riflescope;

[0028] FIG. **17** is an annotated side elevation pictorial view of a prototype riflescope and retrofittable accessory image display device for monocular viewing according to yet another embodiment;

[0029] FIG. **18** is an annotated top pictorial view of a prototype riflescope and retrofittable accessory image display device for binocular viewing according to still another embodiment;

[0030] FIG. **19** is a side elevation pictorial view of another prototype riflescope and retrofittable accessory image display device for monocular viewing similar to the embodiment of FIG. **17**;

[0031] FIG. **20** is an enlarged side elevation view of the eyepiece end portion of the riflescope and accessory image display device of FIG. **19**; and

[0032] FIG. **21** is a view of the image displays of the riflescope and accessory image display device of FIG. **19**, as seen from a common eye point rearward of the eyepiece.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0033] This section describes particular embodiments and their detailed construction and operation. The embodiments described herein are set forth by way of illustration only and not limitation. Throughout the specification, reference to "one embodiment," "an embodiment," or "some embodiments" are not necessarily all referring to the same embodiment. The described features, structures, characteristics, and methods of operation may be practiced in isolation or combined in any suitable manner, and can be practiced without one or more of the specific details or with other methods, components, materials, or the like. In other instances, well-known structures, materials, or methods of operation are not shown or not described in detail to avoid obscuring more pertinent aspects of the embodiments.

[0034] FIG. **1** is a right side view of a riflescope **10** shown mounted to an automatic rifle **16** in accordance with a first embodiment of an optical sighting device (optical sighting system **12** illustrated in FIGS. **2-5**). With reference to FIG. **1**, riflescope **10** comprises an elongate housing **18** supporting a first optical system **20** (FIGS. **7** and **8**) including an objective **22** and an ocular (eyepiece) **24** at opposing forward and rearward ends **32**, **34** of housing **18**. Housing **18** preferably

includes a mounting base **36** formed along its exterior surface for mounting an accessory device **40** (FIG. **2**) to riflescope **10** to form the combination optical sighting system **12** (optical sighting device) illustrated in FIGS. **2-5**. Accessory mounting base **36** may be a Picatinny rail (MIL-STD-1913) or Weaver rail formed integrally in housing **18**, as disclosed in U.S. Pat. No. 6,295,754 of Otteman, or accessory rails rigidly attached to housing **18** by way of screws, clamp rings, or otherwise. Accessory device **40** is preferably removably mountable to mounting base **36**, although in other embodiments (not shown) accessory device **40** may be mounted to a smooth housing via clamp rings, sleeves, or other external adapters, as illustrated in FIGS. **11** and **17-20**, or may be an auxiliary display device integrated with riflescope **10** in a common housing.

[0035] With reference to FIG. **2**, riflescope **10** may include an integrated mounting clamp system **44**, for removably attaching riflescope **10** to a primary mounting rail **48** (FIG. **1**) located along the top of the receiver of rifle **16** or in another location on a weapon.

[0036] Accessory device **40**, illustrated in FIGS. **2-4**, may be any of a variety of devices capable of producing an image via an electronic display or otherwise, for injection of image-carrying light into riflescope **10** for viewing via the shared ocular **24**, as further described below. For example, accessory device **40**, in the embodiment shown, is a laser rangefinder system having separate lenses **52**, **54** (FIG. **4**) for the laser transmitter and receiver and having a display device **60** (FIGS. **8** and **9**) such as an LED, LCD, or OLED device that displays range data calculated by the laser rangefinder. Accessory device **40** may alternatively include one or more of a night vision system such as an image intensifier or thermal imaging system, a mapping display, a battlefield awareness system, a text information display, a graphical or stored image display, a digital camera, and a video camera. Accessory device **40** may include communications capability via wired or wireless connection to a separate device, such as a spotting scope or rangefinder operated by a spotter in a shooter-spotter team, as discussed in U.S. Pat. No. 7,654,029 of Peters et al., which is incorporated herein by reference. In one embodiment, data may be received by accessory device **40** via wireless communication using a radio (not illustrated) in the accessory device **40**, operating on any of a variety of short or long-distance communications technologies, such as Bluetooth, WiFi, mobile telephone communications technologies, or others. Accessory device may also include mapping functionality and a GPS receiver for presenting a map display optionally overlaying personal location information, and optionally the location of friendly forces based on such data received via radio-frequency data communication. In another embodiment, data communication and auxiliary display capabilities may be integrated into riflescope **10**.

[0037] With reference to FIGS. **7** and **8**, first optical system **20** further includes an erector lens system **70** which may include first and second movable erector lens groups **72**, **74** mounted in a pivot tube **80** that is pivotably movable within housing **18** to effect windage and elevation aiming adjustments. Erector lens groups **72**, **74** may be longitudinally movable along the pivot tube **80** to adjust an optical power (magnification) of the riflescope **10** while maintaining focus. In other embodiments, erector lens system **70** may be a fixed power system. In still other embodiments, erector lens system may be replaced by a prism erector system. First optical system **20** defines a first optical path **82** along which an image of a distant target is formed at a focal plane. In the embodiment illustrated, a first inverted image is formed at a front focal plane **84** located between objective **22** and erector lens system **70**. Erector lens system **70** relays and erects the first inverted image to form an upright second image at a rear focal plane **88** generally located between erector lens system **70** and eyepiece **24**. The upright second image is then magnified by and viewed via eyepiece **24** from a first eye point **90** located an eye relief distance R rearward of eyepiece **24**. First optical system **20** forms a first exit pupil **94** (FIG. **5**) viewable through eyepiece **24**.

[0038] In the embodiment illustrated in FIGS. **1-9**, an optical combiner **100**, such as a prism beam combiner, pellicle, half-silvered mirror, fiber beam combiner, dichroic mirror, or other partially reflective surface, is located within housing **18** preferably in first optical path **82** between rear focal plane **88** and eyepiece **24**, but may optionally be located elsewhere in first optical path **82**. Optical combiner **100** transmits to eyepiece **24** at least a portion of the light of first optical system **20** incident on a first surface **102** of the optical combiner **100**. A second surface **104** of optical combiner **100** rearwardly reflects (toward eyepiece **24**) at least a portion of light that is directed toward second surface **104** by a second optical system **200**, described below with reference to FIGS. **8** and **9**. Optical combiner **100** may be a passive optical device, such as the pellicle, fiber beam combiner, or may be an active device, such as an LCD-type device, that is electronically switchable. Either way, optical combiner **100** may be mounted on a hinged or rotating mount allowing optical combiner **100** to be moved out of the way of first optical path **82**, for example, to a second position **100'** illustrated in dashed lines in FIG. **7**. Optical combiner **100** may be moved using a manual switching lever **106** (FIGS. **2** and **3**) coupled to optical combiner **100** via a left-side port **108** (FIG. **6**) in housing **18**, or in another manner. Thus, optical combiner **100** can be removed from the primary optical path to allow the best possible image of first optical system **20** to be viewed when the auxiliary display of second optical system **200** is not needed or desired. In other embodiments (not illustrated), the optical combiner may be switched off electronically or moved out of the first optical path in another manner other than by switching lever **106**.

[0039] With reference to FIGS. **2**, **6**, and **7**, riflescope **10** may include a motorized elevation adjustment mechanism including pushbutton switch controls **112**, **114** that activate a motorized screw **118** or other linear adjustment mechanism to effect respective upward and downward pivoting movement of pivot tube **80** and the erector lens assembly **70** to achieve a desired elevation adjustment. Similarly, horizontal (windage) adjustment of pivot tube **80** is accomplished by an adjustment knob **120** (FIGS. **1**, **4**, and **6**), which may be fully manual or motorized.

[0040] FIG. **8** is a ray trace diagram showing a primary optical system of the riflescope of FIGS. **1-7**. It should be understood that the ray trace diagram of FIG. **8** locates the pupils of the primary optical system, unlike a conventional ray trace diagram which locates the image planes of the system. With reference now to FIGS. **7** and **8**, a second optical system **200** includes an image-forming optical device such as display device **60**, a relay lens system **210**, a mirror **220**, and an exit window **230**. When auxiliary device **40** is mounted to riflescope **10**, light from second optical system **200** is directed through a transparent entrance window **240** in housing **18** and reflected by optical combiner **100** to allow a user to view a relayed image of display device **60** via eyepiece **24**. Second

optical system **200** and optical combiner **100** define a folded second optical path **250** that extends through eyepiece **24**, but may preferably be non-coaxial with first optical path **82**, as best illustrated in FIG. **8**, so that second optical system **200** produces a second exit pupil **256** (FIG. **5**) viewable through eyepiece **24** as being distinct from first exit pupil **94** of first optical system **20**. The portion of second optical path **250** extending through eyepiece **24** is preferably angularly displaced relative to the first optical path **82** as the two optical paths pass through the shared eyepiece **24**, as best illustrated in FIG. **8**. The first and second optical paths **82**, **250** diverge rearward of the eyepiece **24** as long as their respective exit pupils are not coincident. Second optical system **200** preferably forms an image at a location near rear focal plane **88** that is spatially offset from the location on rear focal plane **88** at which the first optical system **20** forms an erect image. The image formed by the relay lens system **210** of second optical system **200** may be formed at an image plane (not illustrated) that is angularly displaced relative to rear focal plane **88** by an angle of **90** degrees plus the same angle by which the first and second optical paths **82**, **250** are angularly displaced.

[0041] By producing two distinct exit pupils, optical sighting system **12** enables the user to switch alternatingly between viewing the image of first optical system **20** and the image of second optical system **200** (i.e., to view first and second viewing channels) with only a very small head movement, or without any head movement by merely rotating the user's eye in its socket. In some embodiments, the optical systems **20**, **200** may be arranged so that the first and second viewing channels overlap, causing all or a portion of the image produced by second optical system **200** to overlap the image produced by first optical system **20** near the periphery of the image of the first optical system **20**. In other embodiments the first and second exit pupils **94**, **256** may be spaced apart such that a second eye point **260** from which the second channel is viewed, is vertically spaced apart from first eye point **90**. In still other embodiments, the first and second exit pupils may be concentric (i.e. not offset) so that the image of the second optical system is fully superposed on the image of the first optical system, in which case the first and second optical paths **82** and **250** would be substantially coincident (not illustrated) at the eyepiece **24** and eye points **92**, **260**.

[0042] Second surface **104** of optical combiner **100** may be inclined between approximately 30 degrees and approximately 44 degrees relative to an optical axis of eyepiece **24**, or between approximately 46 degrees and approximately 60 degrees, or at approximately 45 degrees, or between approximately 30 and 60 degrees. More preferably, second surface **104** of optical combiner **100** is inclined between approximately 40 degrees and approximately 44 degrees, or between approximately 46 degrees and approximately 50 degrees.

[0043] Both the exit window **230** and the entrance window **240** may be hermetically sealed to inhibit moisture and contamination from entering accessory device **40** and riflescope **10**, respectively, thereby preventing fogging and image degradation. Riflescope **10** and accessory device **40** may both be filled with a dry gas such as nitrogen to prevent condensation from forming on internal lens and window surfaces when the devices are exposed to cold weather.

[0044] In the embodiment illustrated in FIGS. **2-8**, entrance window **240** and optical combiner **100** are positioned near rear focal plane **88**, to allow second optical path **250** to be injected between erector system **70** and eyepiece **24**. However, in other embodiments (not illustrated), the entrance window **240** and optical combiner **100** may be located near front focal plane **84**, or at another location in riflescope **10**.

[0045] FIG. **10** illustrates an automatic ranging and ballistic adjustment system **300** that could be implemented in the riflescope **10** and accessory device **40** of FIGS. **1-9**. With reference to FIG. **10**, a laser rangefinder **310** is coupled to a microprocessor unit (MPU) **320**. Laser rangefinder **310** determines a range to a distant target and provides the range data to MPU **320**. Laser rangefinder **310** may also include an inclinometer for determining an angle of inclination of a line of sight to the target, and other sensors measuring variables affecting ballistics. MPU controls a servo motor drive **330** which moves an elevation servo device **336** such as motorized screw **118** (FIG. **7**). A positional encoder **340** associated with servo device **336** senses the position of the elevation servo device **336** and provides accurate positional feedback data to MPU **320**, allowing MPU **320** to accurately determine the elevation adjustment of riflescope **10** and accurately control servo **336** via motor drive **300**. MPU **320** is also coupled to a memory **350** for accessing ballistic data stored thereon. A user interface or electronic data interface (not shown) may be provided for inputting ballistic data into memory **350** or selecting from one of several ballistic profiles or sets of ballistic data stored in memory **350**. Utilizing the measured distance and other information determined by laser rangefinder **310** along with the ballistic data retrieved from memory **350**, MPU **320** calculates a ballistic adjustment or other ballistic solution for aiming a projectile at the distant target, then produces a display via display driver **360** that is displayed on display device **60** for viewing via eyepiece **24**. In some embodiments, the display produced by ballistic adjustment system **300** may be an information display at the edge of or just outside of the field of view of the target scene. In other embodiments, an image produced by display **60** may be superimposed on the first image of the first optical system **20** to provide a ballistically adjusted aiming point overlaid with the target scene.

[0046] Other aspects of riflescope **10** and accessory device are described in the Exemplary Features section below.

[0047] Turning now to FIG. **11**, a riflescope **400** and an auxiliary device **440** form an optical sighting system **402** according to another embodiment. Auxiliary device **440** includes a miniature night vision camera, such as a FLIR Quark™ infrared imaging device **450**, mounted to riflescope **400** facing forward toward a target scene, and a miniature electronic display device **460** in communication with the infrared imaging device and mounted horizontally over a window or aperture in the side of a housing of riflescope **400**. A small mirror **470**, illustrated schematically in FIG. **12**, is located within riflescope **400** and below electronic display **460** so as to reflect light emitted from display **460** and redirect it toward an eyepiece **480** of riflescope **400**. By locating the electronic display device **460** and mirror **470** immediately adjacent the rear focal plane **484** of riflescope **400**, the auxiliary device **440** may avoid the need for expensive reimaging optics such as relay lens system **210** of the system of FIGS. **1-9**.

[0048] Mirror **470** is preferably smaller than the image generated by riflescope **400** at the rear focal plane **484** and spaced apart from the optical axis **486** of riflescope **400** so that the image generated by display device **460** and reflected by mirror **470** is spaced apart from the image of the field of view of riflescope **400**. Thus, the image of display device **460** as viewed through eyepiece **480** may be spaced apart from the

exit pupil of the primary optical system of riflescope **400**. The images generated by riflescope **400** and display device **460** may both be viewed from a common head position and common eye point, merely by rotating the user's eye in its socket. The direct view optics of riflescope **400** are unimpeded by mirror **470** so that there is no reduction in light transmission or color shift. In other embodiments (not illustrated), the image of display device **460** relayed by mirror **470** is overlapping or superposed on the image of the field of view of riflescope **400** while being distinct and not obstructing aiming points of a reticle of riflescope **400**. FIG. **13** illustrates a view through eyepiece **480** of riflescope **400**, showing both an exit pupil **490** of the direct view optics of riflescope **400** and an auxiliary image **494** generated by the infrared imaging device **450** and displayed via display device **460** and reflected by mirror **470** (itself forming an exit pupil), so as to appear spaced above exit pupil **490**.

[0049] Infrared imaging device **450** and display device **460** are shown integrated with optical sighting system **402**, but may alternatively be detachably mounted to housing **418** of riflescope **400**, with display device **460** mounted adjacent a transparent window in the side wall of housing **418** as in the embodiment of FIGS. **1-9**. Also, although a thermal image from the FLIR Quark device **450** is illustrated in FIG. **13**, any other kind of still or video image may be displayed via display device **460**, similarly to the embodiment of FIGS. **1-9**. Displayed video can be of a different magnification than that of riflescope. In one embodiment, a sensor (not illustrated) may be associated with a manually adjustable optical power setting of riflescope **400** to sense the optical power setting (magnification) of riflescope **400**. Auxiliary device **440** may receive signals from the sensor and adjust a magnification of the auxiliary image in response to and/or in coordination with the optical power setting of riflescope **400**.

[0050] Mirror **470** may be mounted to a hinge or other movable mounting structure that allows mirror **470** to be flipped between the active position shown, wherein mirror **470** is inclined approximately **45** degrees relative to the optical axis **486**, and an inactive position out of the primary optical path of riflescope **400**—for example, in which the mirror is flipped up or rotated about its top edge to a horizontal orientation (not shown) closely adjacent and covering display device **460**. In some embodiments, the active position may be between 40 degrees and 50 degrees relative to the optical axis **486** and the inactive position may be parallel to the optical axis **486** (0 degrees).

[0051] FIG. **14** illustrates an embodiment of an optical sighting system **500** including a riflescope **510** similar to riflescope **400** of the embodiment of FIG. **11**. In this embodiment, the auxiliary device is a laser rangefinder module **520**, which may be supported on and aligned with riflescope **510** or handheld separately from riflescope **510**, for example by a spotter. A rangefinder data readout is presented on an OLED display unit **530** mounted on housing adjacent a window or opening (not shown) in a housing **534** of riflescope **510** adjacent its eyepiece **540**. As in the embodiment of FIGS. **11-13**, a mirror (not illustrated) is provided within housing **534** near the rear focal plane of riflescope **510** for reflecting light from display unit **530** through eyepiece **540** to provide the auxiliary device information display **560** shown in FIG. **15**, spaced apart from or adjacent an exit pupil **570** of riflescope **510**. FIG. **16** illustrates that auxiliary information display **560** may be positioned (by virtue of the position of the mirror and display unit **530**) so as to overlap and occlude a portion of the field of view of riflescope **510**. As in the embodiment of FIGS. **11-13**, the mirror may be selectively removable from the field of view by the user, such as by a mechanical or electromechanical actuation to flip the mirror out (and back into) the field of view, or by electronically changing the reflective properties of an electronically controllable mirror.

[0052] FIG. **17** is an annotated side elevation pictorial view of another embodiment of an optical sighting system **600** including a riflescope **610** and retrofittable accessory image display device **620** for monocular viewing. With reference to FIG. **17**, riflescope **610** may be of a conventional design, including an objective **612** and an eyepiece **614** at opposite ends of a housing **618** of riflescope **610**. Accessory image display device **620** includes a mount **624** that is attachable to riflescope **610**, for example by sliding or threading onto the eyepiece end of housing **618**. A display housing **628** may be connected to mount **624** via a hinge (not shown) allowing an angle of display housing accessory image display device **620** to be adjusted relative to the optical axis of riflescope **610**. Although not illustrated in FIG. **17**, display housing **628** contains an electronic display device and display electronics. Display housing **628** may contain collimation optics with a manual diopter adjustment, a power source, and a radio-frequency receiver that receives a video or data signal wirelessly from a remote source of data or video. Alternatively, a video or data feed may be received by image display device **620** via a wired connection, such as a USB connection for example.

[0053] Accessory image display device **620** preferably generates an accessory display channel **640** viewable from a common eye point **650** whereat a primary optical channel **660** of riflescope **610** is also viewable without requiring head movement. A user may switch between primary and accessory channels **660**, **640** merely by rotating the user's eye **670** in its socket and without any substantial movement of the user's head.

[0054] When using riflescope **610**, a shooter would normally place his eye **670** at the eye point **650** of riflescope **610**, which is located approximately 2-6 inches (and more typically 3-4 inches) rearward of eyepiece **614**. The display housing **628** of accessory image display device **620** is mounted above or to the side of the last (rearward) lens element of eyepiece **614**. An output beam from the accessory display device **620** is adjustable for aiming at the eye point **650** by means of the hinged mounting connection between display housing **628** and mount **624**. In the embodiment illustrated, accessory image display device **620** is retrofittable on riflescope **610** and easily installed and removed in the field when needed. In another embodiment (not illustrated), accessory image display device **620** could be integrated into riflescope **610** and contained within the housing **618** of riflescope **610**.

[0055] FIG. **18** illustrates optical sighting system **600** with riflescope **610** and accessory image display device **620** configured in a binocular mode. With reference to FIG. **18**, display housing **628** is rotated relative to the binocular hinge (not shown) to the binocular viewing position, in which display housing **628** and the video/image display and collimation optics contained within it are aligned parallel to the optical axis of the optical viewing channel **660** of riflescope **610**. The display housing may also be rotated around its own viewing axis to substantially align the horizontal and vertical aspects of its image to the horizontal and vertical aspects of the scope's image. In the binocular viewing position illustrated, the accessory display channel **640** of the accessory image

display device **620** is aligned with the optical viewing channel **660** of riflescope **610**. The accessory display channel **640** is spaced apart to the side of the optical viewing channel **660** by an interpupillary distance that is adjustable by rotating display housing **628** about the hinge in substantially the same manner as a hinged bridge of conventional binoculars. In the binocular viewing configuration of FIG. **18**, the images of the riflescope **610** and auxiliary display device **620** are viewed by different eyes and fused by the user's vision. The hinge arrangement is adaptable for left-handed and right-handed shooters by twisting the mount **624** about the eyepiece **614** of riflescope **610** to position the hinge either to the left or right side of eyepiece **614**.

[0056] FIGS. **19** and **20** illustrate an optical sighting system **700** including a riflescope **710** and accessory image display device **720** that provides monocular viewing similar to the system **600** of FIG. **17** (in its monocular configuration). In the system **700** of FIGS. **19** and **20**, the mount **724** and display housing **728** portions of image display device **720** are formed of a one-piece or monolithic construction and no hinge is provided therebetween. The display housing portion **728** is fixedly angled relative to mount portion **724** to align collimation optics within the display housing portion **728** relative to the optical path of riflescope **710**. An OLED micro-display **732** is mounted to an underside of display housing portion **728** where it will be protected from damage, and a mirror **738** reflects light from display **732** through collimation optics (not shown) for viewing from a common eye point (not illustrated) with riflescope **710**. FIG. **21** shows a view of system **700** from the common eye point, including a primary direct optical viewing channel **760** of riflescope **710** an a video display channel **740** of accessory image display device **720**.

[0057] It will be obvious to those having skill in the art that many changes may be made to the details of the above-described embodiments without departing from the underlying principles of the invention. The scope of the present invention should, therefore, be determined only by the following claims.

1. An optical sighting system, comprising:

a first optical system including an objective and an ocular, the first optical system configured to form at a focal plane a first image of a distant target viewable through the ocular from an eye point location along a first optical path;

an accessory device that forms a second image; and

a second optical system cooperating with the accessory device and the first optical system such that the second image is viewable from the eye point location along a second optical path angularly displaced relative to the first optical path.

2. The optical sighting system of claim **1**, further comprising an optical combiner positioned in the first optical path between the objective and the ocular, the optical combiner transmitting light from the first optical system and positioned and oriented to reflect light from the second optical system through the ocular.

3. The optical sighting device of claim **2**, wherein the optical combiner is selectively switchable between an active condition, extending into the first optical path, and an inactive condition, substantially removed from the first optical path.

4. The optical sighting system of claim **2**, wherein:

the ocular has an optical axis; and

the optical combiner includes a partially reflecting surface that is inclined between approximately 30 degrees and approximately 44 degrees relative to the optical axis of the ocular.

5. The optical sighting system of claim **2**, wherein:

the ocular has an optical axis; and

the optical combiner includes a partially reflecting surface that is inclined between approximately 46 degrees and approximately 60 degrees relative to the optical axis of the ocular.

6. The optical sighting system of claim **1**, further comprising an exterior accessory mount and wherein the accessory device is removably attached to the exterior accessory mount at a fixed position relative to the first optical system.

7. The optical sighting system of claim **1**, further comprising an automatic bullet drop compensation device operably coupled to at least one of the first optical system, the accessory device, and the second optical system.

8. The optical sighting system of claim **1**, wherein the accessory device includes a device selected from the group consisting of a range finder, a night vision sight, a thermal imaging system, a mapping system, a communication device, and an electronic display device.

9. The optical sighting system of claim **1**, wherein the first optical system comprises a riflescope.

10. The optical sighting system of claim **1**, further comprising:

a generally tubular housing supporting the first optical system; and

a window located in the housing, the second optical path extending through the window.

11. The optical sighting system of claim **10**, wherein a hermetic seal is formed between the window and the housing.

12. The optical sighting system of claim **1**, wherein the second image is viewable through the ocular.

13. The optical sighting system of claim **1**, further comprising a mirror positioned adjacent a focal plane of the first optical path between the objective and the ocular, the mirror positioned and oriented to reflect light from the second optical system through the ocular.

14. The optical sighting device of claim **13**, wherein the mirror is selectively switchable between an active condition and an inactive condition.

15. An optical sighting system, comprising:

a first optical system defining a first optical path;

a second optical system defining a second optical path; and

a shared ocular through which the first and second optical paths extend, the first and second optical systems arranged so that the first and second optical paths are non-coaxial and produce respective first and second viewing channels through the shared ocular, the first and second viewing channels producing offset first and second exit pupils, respectively.

16. The optical sighting system of claim **15**, further comprising an optical combiner positioned in the first optical path forward of the shared ocular, the optical combiner transmitting light from the first optical system and arranged to direct light from the second optical system through the shared ocular.

17. The optical sighting system of claim **16**, wherein the optical combiner is selectively switchable between an active

condition, extending into the first optical path, and an inactive condition, substantially removed from the first optical path.

18. The optical sighting system of claim **15**, wherein second optical path is angularly displaced relative to the first optical path as they pass through the shared ocular.

19. The optical sighting system of claim **15**, further comprising:

an exterior accessory mount; and

an accessory device removably attached to the exterior accessory mount and cooperating with the second optical system and the shared ocular for generating the second exit pupil.

20. The optical sighting system of claim **15**, further comprising an automatic bullet drop compensation device operably coupled to at least one of the first optical system and the second optical system.

21. The optical sighting system of claim **15**, wherein the first optical system comprises a riflescope.

22. The optical sighting system of claim **15**, further comprising:

an elongate, generally tubular housing supporting the first optical system between opposing first and second ends of the housing; and

a window located in the housing intermediate of the first and second ends, the second optical path extending through the window.

23. A riflescope, comprising:

an elongate housing supporting a primary optical system including objective and ocular lenses positioned proximate respective forward and rearward ends of the housing, the primary optical system defining a primary optical path extending within the housing;

a transparent window formed in a side of the housing intermediate the objective and ocular lenses; and

an optical combiner positioned in the primary optical path adjacent the window and oriented to direct through the ocular lens a plurality of image-carrying light rays entering the housing through the window.

24. The riflescope of claim **23**, wherein:

the primary optical system has a first exit pupil viewable through the ocular;

the image-carrying light rays emanate from a second optical system outside the housing that cooperates with the ocular to form a second exit pupil; and

the second optical system and the optical combiner are arranged to direct the image-carrying light rays through the ocular so that the second exit pupil is viewable through the ocular and offset relative to the first exit pupil.

25. The riflescope of claim **23**, wherein the optical combiner is selectively removable from the primary optical path.

26. The riflescope of claim **23**, further comprising an exterior accessory mount for removably attaching to the riflescope an accessory device for projecting image-carrying light rays through the window.

27. The riflescope of claim **23**, wherein a hermetic seal is formed between the window and the housing.

28-30. (canceled)

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