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(54) **TRIGGER ASSEMBLY AND METHOD OF OPTICAL DETECTION OF A TRIGGER ASSEMBLY STATE**

(71) Applicants: **John Hancock Lupher**, Austin, TX (US); **Hillman Lee Bailey**, Dripping Springs, TX (US); **Michael Eric Reimers**, Austin, TX (US)

(72) Inventors: **John Hancock Lupher**, Austin, TX (US); **Hillman Lee Bailey**, Dripping Springs, TX (US); **Michael Eric Reimers**, Austin, TX (US)

(73) Assignee: **TrackingPoint, Inc.**, Austin, TX (US)

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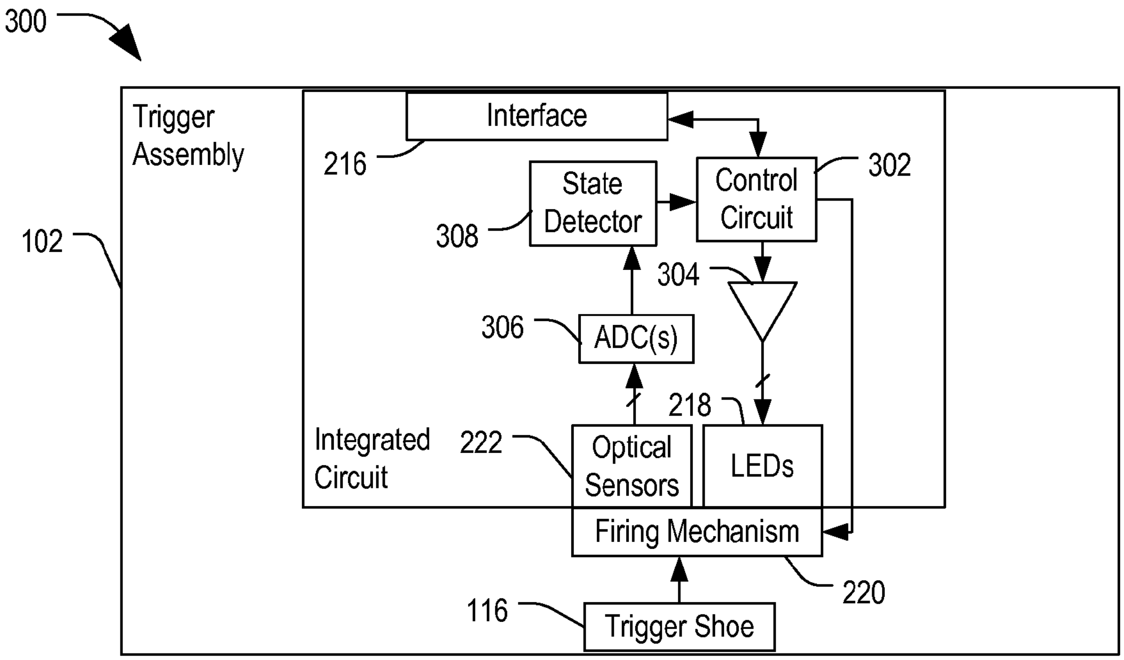
(57) **ABSTRACT**

A trigger assembly includes a plurality of components including a trigger shoe configured to disengage a firing mechanism in response to a force applied by a user. The trigger assembly further includes a first PCB having at least one optical sensor to receive light and a controller configured to determine a positional state of at least one of the trigger shoe and a selected one of the plurality of components in response to the light received by the at least one optical sensor.



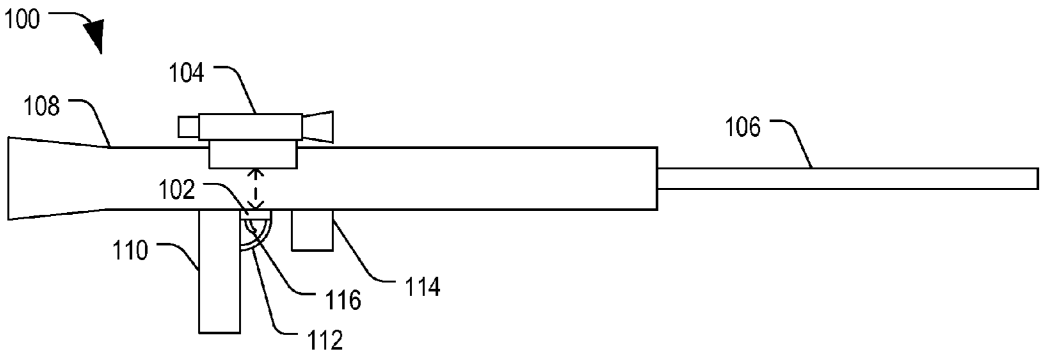

100
104
108
106
102
110
116
114
112

FIG. 1

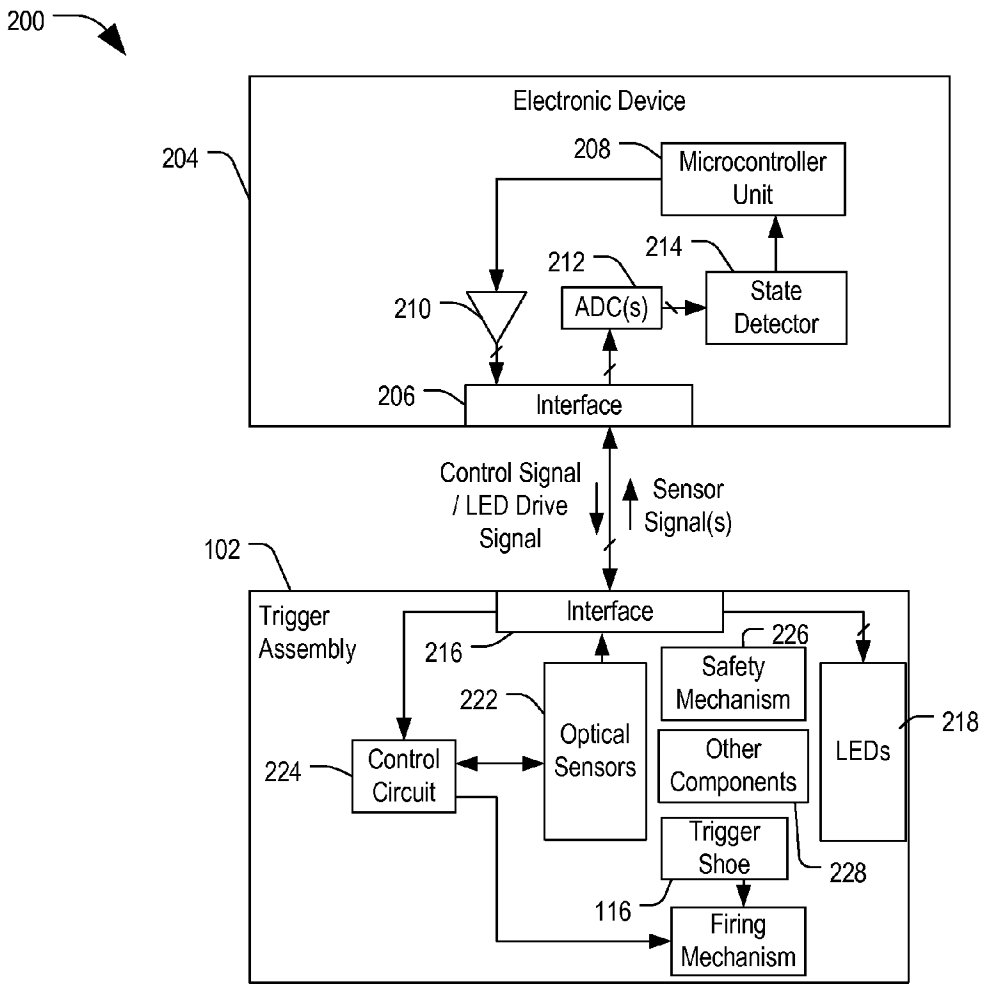

200
Electronic Device
204
208
Microcontroller Unit
212
214
210
ADC(s)
State Detector
206
Interface
Control Signal / LED Drive Signal
Sensor Signal(s)
102
Trigger Assembly
Interface
216
226
Safety Mechanism
222
Optical Sensors
Other Components
LEDs
218
224
Control Circuit
Trigger Shoe
228
116
Firing Mechanism

FIG. 2

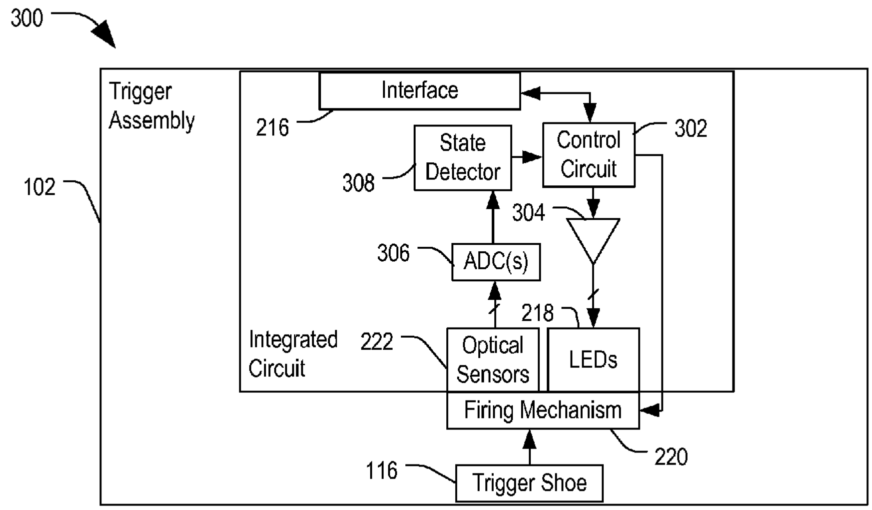

300
Trigger Assembly
102
Interface
216
State Detector
308
Control Circuit
302
304
306
ADC(s)
218
Integrated Circuit
222
Optical Sensors
LEDs
Firing Mechanism
220
116
Trigger Shoe

FIG. 3

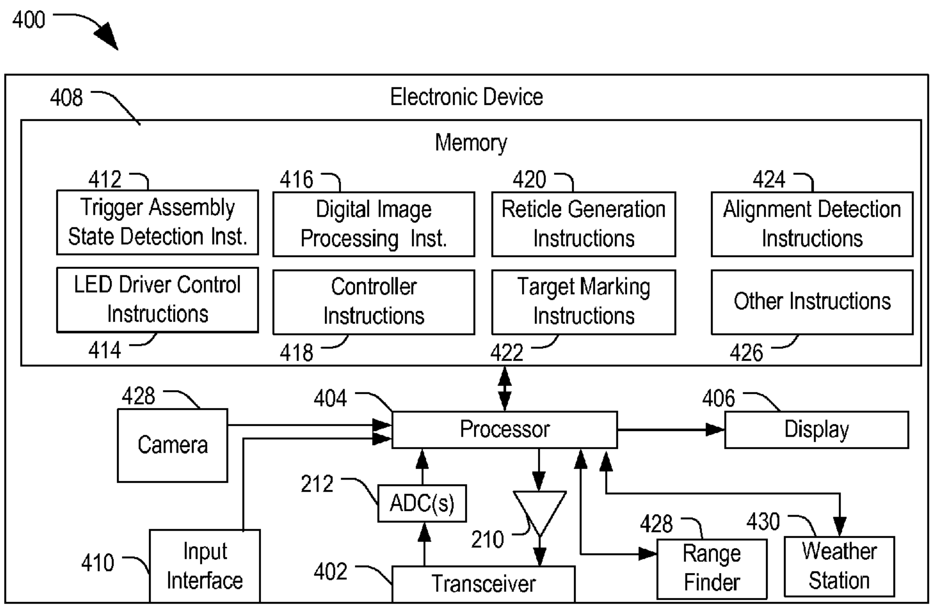

400
Electronic Device
408
Memory
412
Trigger Assembly State Detection Inst.
416
Digital Image Processing Inst.
420
Reticle Generation Instructions
424
Alignment Detection Instructions
LED Driver Control Instructions
414
Controller Instructions
418
Target Marking Instructions
422
Other Instructions
426
428
Camera
404
Processor
406
Display
212
ADC(s)
210
428
Range Finder
430
Weather Station
410
Input Interface
402
Transceiver

FIG. 4

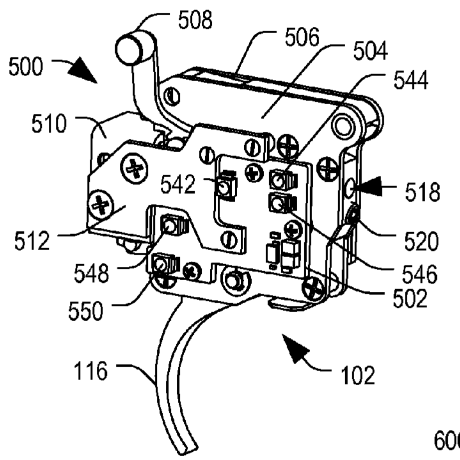


FIG. 5

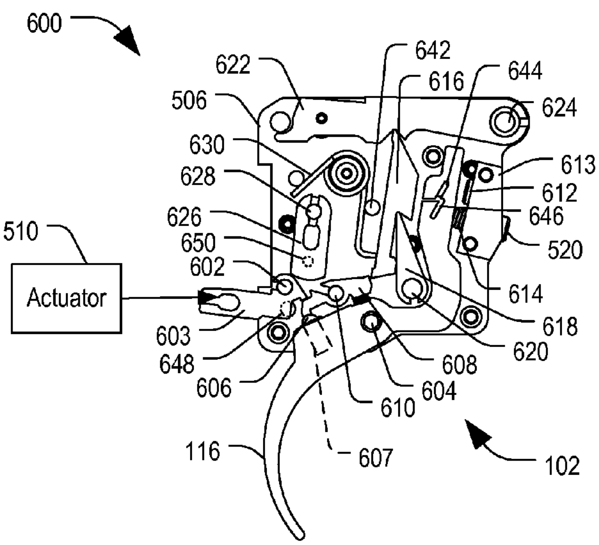


FIG. 6

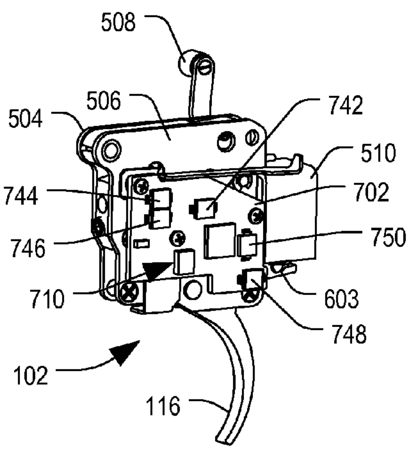


FIG. 7

TRIGGER ASSEMBLY AND METHOD OF OPTICAL DETECTION OF A TRIGGER ASSEMBLY STATE

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application is a continuation of and claims priority to U.S. patent application Ser. No. 13/351,220 filed on Jan. 16, 2012 and entitled "Trigger Assembly and Method of Optical Detection of a Trigger Assembly State", which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure is generally related to trigger assemblies for use in small arms firearms, such as pistols and rifles.

BACKGROUND

[0003] Firearm firing mechanisms generally include a number of components that cooperate to hold a spring-loaded hammer or firing pin in a cocked position and then selectively release the hammer or firing pin, which applies force directly, or through an intermediate device, to an ammunition cartridge loaded within a chamber of the firearm. The components for holding a hammer or firing pin in a cocked position and then releasing the hammer or firing pin may be referred to as a trigger assembly.

[0004] Generally, the trigger assembly includes a trigger shoe that is accessible to the user to apply a pulling force. When the user pulls the trigger shoe with sufficient force to move the trigger shoe a pre-defined distance, the movement of the trigger shoe releases the spring-loaded hammer to fire the ammunition cartridge.

SUMMARY

[0005] In an embodiment, a trigger assembly includes a plurality of components including a trigger shoe configured to disengage a firing mechanism in response to a force applied by a user and includes a first circuit. The first circuit has at least one optical sensor and a controller configured to determine a positional state of at least one of the trigger shoe and a selected one of the plurality of components in response to light received by the optical sensor.

[0006] In another embodiment, a trigger assembly includes a trigger mechanism, a first circuit, a second circuit, and a controller. The trigger mechanism has a first side and a second side and includes a trigger shoe extending between the first and second sides. The trigger mechanism is configured to disengage a firing mechanism in response to a force applied to the trigger shoe. The first circuit is adjacent to the first side and includes a plurality of light-emitting diodes (LEDs) configured to transmit light through the trigger mechanism toward the second side. The second circuit is adjacent to the second side and includes a plurality of optical sensors corresponding to the plurality of LEDs. Each of the plurality of optical sensors is configured to produce an electrical signal proportional to light received from a respective one of the plurality of LEDs. The controller is configured to determine a state of the trigger mechanism based on electrical signals from the plurality of optical sensors.

[0007] In still another embodiment, a method includes directing light from a first side through a trigger mechanism using one or more light-emitting diodes (LEDs) and producing at least one electrical signal proportional to light received through the trigger mechanism by one or more optical sensors at a second side of the trigger mechanism opposite to the first side. The method further includes determining a state of the trigger mechanism based on at least one electrical signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a side view of a firearm including a trigger assembly system with an optical detector for determining a state of a trigger assembly.

[0009] FIG. **2** is a block diagram of an embodiment of the trigger assembly system **200** including trigger assembly of FIG. **1** and an electronic device communicatively coupled to the trigger assembly.

[0010] FIG. **3** is a block diagram of a second embodiment of a trigger assembly including light-emitting diodes (LEDs) and optical sensors for determining a state of the trigger assembly.

[0011] FIG. **4** is a block diagram of a second embodiment of an electronic device including driver circuitry and analog-to-digital converter circuitry for communicating with the optical detection circuitry of the trigger assembly of FIG. **2**.

[0012] FIG. **5** is a perspective view of an embodiment of a right side of the trigger assembly of FIGS. **2** and **3**.

[0013] FIG. **6** is a side view of the internal components of the trigger assembly of FIG. **5**.

[0014] FIG. **7** is a perspective view of a left side of the trigger assembly of FIG. **5**.

[0015] In the following discussion, the same reference numerals are used in the various illustrated examples to indicate the same or similar elements.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0016] Embodiments of a trigger assembly are described below that can be utilized with small-arms firearms. The trigger assembly includes trigger components that are configured to release a firing mechanism in response to a force applied to a trigger shoe by a user and includes a circuit includes a sensor configured to detect a position of the trigger shoe. In one instance, the circuit includes a first printed circuit board (PCB) having light-emitting diodes (LEDs) positioned on a first side of the trigger components and a second PCB including optical sensors on a second (opposing) side of the trigger components. The LEDs are configured to emit light toward the second PCB and the optical sensors are configured to generate electrical signals proportional to the received light, which electrical signals indicate the relative positional state of one or more of the trigger components. In another instance, the sensor circuit can include, for example, one or more reed switches, lasers and laser detectors, proximity sensors, capacitive diaphragms, direct contact sensors, Hall effect sensors, or other sensors configured to detect the position of one or more components of the trigger assembly. For example, if a Hall effect sensor configuration were used, a magnet could be embedded within a portion of the trigger shoe, and a pair of sensors could be used to detect the strength of the magnetic field to determine the position of the trigger shoe.

[0017] This state information can be used by a control circuit. In one example, the control circuit may activate another circuit, such as a video camera, in response to optically detecting movement of the trigger shoe from a first position based on a change in the received light. In another instance, absence or presence of received light for an extended period by more than one optical sensor positioned adjacent to a component (such as a safety) may indicate that the safety mechanism is between states (i.e., not fully engaged), causing the controller to indicate an error condition, such as by providing a visual alert (such as illuminating an external LED), or to activate a blocking mechanism to prevent disengagement of the firing mechanism until the safety mechanism is fully engaged or disengaged. One possible example of a small-arms firearm that includes an embodiment of a trigger assembly system is described below with respect to FIG. **1**.

[0018] FIG. **1** is a side view of a firearm **100** including a trigger assembly system with a blocking mechanism. In the illustrated example, the firearm **100** is a rifle with a trigger assembly **102** coupled to a digital scope **104**. Firearm **100** includes a barrel **106**, a stock **108**, a handle **110**, a trigger guard **112**, and a magazine **114**. Trigger assembly **102** includes a trigger shoe **116** to which the user can apply force to discharge the firearm **100**.

[0019] Digital scope **104** includes circuitry for communicating with trigger assembly **102** to determine a state of the trigger assembly. In particular, the circuitry within digital scope **104** can control one or more LEDs within trigger assembly **102** to emit light toward corresponding optical sensors on an opposing side of the trigger assembly **102**, which optical sensors can communicate the received signals to the circuitry within digital scope **104**. The LEDs can be aligned with openings internal to trigger assembly **102** that are aligned with components to detect displacement and/or positional information about the various components. In this manner, control circuitry **104** can determine optically whether a safety mechanism is engaged (or disengaged) and/or whether the trigger shoe **116** has been moved to disengage the firing mechanism.

[0020] In an example, control circuitry within digital scope **104** (or some other electronic device) may determine a state of trigger assembly **102** based on optical signals. The state may be used to provide information to a user, to record information into a storage log, or for a variety of other operations and functions, depending on the specific implementation. However, rather than relying solely on mechanical elements or vibrations to determine the state of the trigger assembly and the firing mechanism, control circuitry within digital scope **104** can also utilize sensor data to determine the state of the trigger assembly. An example of a system that includes LEDs and optical sensors for determining a state of a trigger mechanism is described below with respect to FIG. **2**.

[0021] FIG. **2** is a block diagram of an embodiment of the trigger assembly system **200** including trigger assembly **102** of FIG. **1** and an electronic device **204** communicatively coupled to the trigger assembly **102**. Electronic device **204** can be a digital scope, an electronic safety device, or another electronic device configured to receive sensor signals from trigger assembly **102** and to communicate control signals to trigger assembly **102** through a wired or wireless connection.

[0022] Trigger assembly **102** includes trigger shoe **116** configured to translate a first force (a trigger force) to a firing mechanism **216** in response to a user-applied force. Trigger assembly **102** further includes an interface **216** configured to communicatively couple to electronic device **204**. Interface **216** can be wired or wireless and configured for bi-directional communication with electronic device **204**, such as to receive control signals and to send data. In an example, interface **216** includes pads or contacts for wired interconnection with a controller within electronic device **204**. Interface **216** includes an output coupled to an input of a control circuit **224**. Additionally, interface **216** includes an output coupled to one or more light-emitting diodes (LEDs) **218** and an input coupled to an output of one of more optical sensors **222**. LEDs **218** and optical sensors **222** are positioned on opposing sides of trigger shoe **116**, safety mechanism **226**, and other components **228**. LEDs **218** emit light toward optical sensors **222**, and trigger shoe **116**, safety mechanism **226**, and other components **228** block the emitted light from optical sensors **222** in some instances and allow light to be received by optical sensors **222** in other instances, depending on the relative positions. In a particular example, force applied to trigger shoe **116** by a user causes trigger shoe **116** to move, causing one optical path through trigger shoe **116** to permit light to pass therethrough while another optical path through trigger shoe **116** blocks the light. Optical sensors **222** are configured to sense changes in the emitted light from LEDs **218**. In particular, electrical signals produced by optical sensors **222** vary in proportion to the received light, thereby allowing state detector **214** to determine the positional state of selected components of trigger assembly **102**.

[0023] Trigger assembly **102** further includes a firing mechanism **220** coupled to trigger shoe **116** and configured to disengage in response to force applied to trigger shoe **116**. Firing mechanism **220** is also coupled to control circuit **224**, which may include an actuator or other component to selectively control whether firing mechanism **220** can be disengaged in response to force applied to trigger shoe **116**.

[0024] Electronic device **204** includes an interface **206** configured to couple to interface **216** within trigger assembly **102**. Electronic device **204** further includes one or more analog-to-digital converters (ADC) having inputs coupled to interface **206** and outputs coupled to a state detector **214**, which may be implemented as a state machine or other configurable logic. State detector **214** includes an output coupled to a micro controller unit (MCU) **208**. In some instances, state detector **214** may be incorporated within MCU **208**. Alternatively, state detector **214** can be omitted, and MCU **208** can be configured to determine the state of trigger assembly **102**. MCU **208** includes an output coupled to an input of one or more drivers **210**, which include outputs coupled to inputs of interface **206**.

[0025] In an example, MCU **208** controls drivers **210** to provide LED drive signals to LEDs **218** through interfaces **206** and **216**. LEDs **218** emit light toward optical sensors **222**, which receive the emitted light based on the relative positions of trigger shoe **116**, safety mechanism **226**, and other components **228**. Optical sensors **222** provide signals proportional to the received light to ADCs **212** through interfaces **216** and **206**. ADCs **212** convert the signals into digital values, which are provided to state detector **214** to determine the state of trigger assembly **102**. Such states can include an initial state, a transitional state, a trigger-pulled state, and an error state with respect to trigger shoe **116**. Further, such states can include a safety “on” state or a safety “off” state with respect to safety mechanism **226**. Such states may also include the states of other components of trigger assembly **102**. In a particular instance, the states may include a blocked state and an unblocked state relative to a blocking mechanism, such as actuator **510** in FIGS. **5** and **6**.

[0026] State detector **214** communicates the detected state of trigger assembly **102** to MCU **208**, which can generate controls signals. In an example, in response to detecting the state of trigger assembly **102**, MCU **208** generates control signals and sends them to control circuit **224** through interface **206** and interface **216** to control operation of firing mechanism **220** within trigger assembly **102**.

[0027] While the above-discussion assumes an LED/optical sensor detection mechanism for determining the state of the trigger shoe **116**, safety mechanism **226** and other components **228**, as previously mentioned, it is also possible to utilize other types of detection circuits, including lasers and laser detectors, reed switches, proximity sensors, capacitive diaphragms, direct contact sensors, and so on. Regardless of the type of sensing mechanism used, the sensors should be arranged and configured to facilitate detection of the position of the particular component, and not just motion of the component. In an example, the sensing mechanism can detect that the trigger shoe is not in a first position and that it is in a second position. Thus, the sensing mechanism allows for determination of the component position, and not just motion.

[0028] While the example described above with respect to FIG. **2** includes the state detector and driver circuitry within electronic device **204**, such circuitry may alternatively be provided within trigger assembly **102**. An example of such an embodiment is described below with respect to FIG. **3**.

[0029] FIG. **3** is a block diagram of a second embodiment **300** of trigger assembly **102** including LEDs **218** and optical sensors **222** for determining a state of trigger assembly **102**. In this example, trigger assembly **102** includes a control circuit **302** coupled to interface **216** and including an output coupled to a driver **304** for driving one or more LEDs **218**, which emit light toward optical sensors **222**. Trigger shoe **116**, safety mechanism **226**, and other components **228** may block at least some of the emitted light, allowing optical sensors **222** to receive at least some of the emitted light and to produce electrical signals proportional to the received light. Optical sensors **222** provide the signals to ADCs **306**, which convert the signals into one or more digital values that are provided to a state detector **308**, which has an output coupled to control circuit **302**.

[0030] In this example, driver **304**, ADCs **306**, and state detector **308** are moved from electronic device **204** into trigger mechanism **102**. In this example, control circuit **302** can control operation of trigger assembly **102** based on the state determined by state detector **308** and/or in response to signals received from electronic device **204** via interface **216**.

[0031] While the example of FIG. **2** depicted an MCU **208** for controlling operation of the drivers **210** and for receiving data from state detector **214** and/or from ADCs **212**, MCU **208** can include a programmable processor configured to execute instructions that, when executed, cause the processor to determine a state of various components of trigger assembly **102**. One example of such a programmable processor implementation is described below with respect to FIG. **4**.

[0032] FIG. **4** is a block diagram of a second embodiment of an electronic device **400** including drivers **210** and ADCs **212** for communicating with the optical detection circuitry of the trigger assembly of FIG. **2**. Electronic device **400** includes a transceiver **402**, which can be implemented as an interface having pads or terminals configured to couple to trigger assembly **102** via wires. Transceiver **402** includes inputs coupled to outputs of drivers **210** for receiving an LED driver signal. Drivers **210** include inputs coupled to processor **404**. Processor **404** is coupled to a display **406** for displaying data, a camera **428** for capturing image data, and an input interface **410** for receiving user input. Processor **404** further includes an input coupled to a range finder **428**, which may utilize a laser to determine a distance, and to a weather station **430**, which can be used to detect ambient conditions, including temperature, humidity, wind speed and direction, and other environmental conditions. Processor **404** is also coupled to ADCs **212**, which have inputs coupled to transceiver **402** and outputs coupled to processor **404**. Processor **404** is further coupled to a memory **408**, which stores data and processor-executable instructions.

[0033] Memory **408** includes LED driver control instructions **414** that, when executed, cause processor **404** to control drivers **210** to drive LEDs within trigger assembly **102**. Memory **408** further includes trigger assembly state detection instructions **412** that, when executed, cause processor **404** to determine a state of trigger assembly **102** as a function of the values at the outputs of ADCs **212**. Memory **408** further stores digital image processing instructions **416** that, when executed, cause processor **404** to operate as an image processing device to process pixel data captured by camera **428**. Memory **408** also stores reticle generation instructions **420** that, when executed, cause processor **404** to produce a digital representation of a reticle (calibrated to the small arms firearm) and to display the digital reticle within the digital view area.

[0034] Memory **408** further includes target marking instructions **422** that, when executed, cause processor **404** to receive user input to assign a digital marker onto an object within the digital view area. In a hunting application, the user may interact with input interface **410** (which may include one or more buttons) to apply a digital marker onto a target (such as a deer) that is within the digital view area. Digital image processing instructions **416** can isolate the portion of the digital view area that corresponds to the target having the digital marker so that the digital marker can move with the target as the target moves through the view area captured by camera **428**. Memory **408** includes alignment detection instructions **424** that, when executed, cause processor **404** to determine a difference between cross-hairs of the digital reticle from the digital marker.

[0035] Memory **408** further includes controller instructions **418** that, when executed, cause processor **404** to control, for example, an actuator within trigger mechanism **102** (such as actuator **510** depicted in FIGS. **5** and **6**). In particular, if the difference determined using alignment detection instructions **424** is less than a threshold difference, controller instructions **418** cause processor **404** to generate a control signal to adjust the actuator to release a blocking mechanism to allow the small arms firearm to be discharged. If the difference is greater than the threshold, controller instructions **418** cause processor **404** to generate the control signal to prevent discharge. Memory **408** may also include other instructions **426**, such as upgrade instructions, user configuration instructions, and so on. Further, memory **408** may store ballistics data, calibration data, user settings, and/or other information.

[0036] FIG. **5** is a perspective view **500** of an embodiment of a right side of the trigger assembly **102** of FIGS. **1** and **2**. Trigger assembly **102** includes a PCB **502** that includes circuitry, such as LEDs **542**, **544**, **546**, **548**, and **550**, and other circuitry, such as drivers for driving signals to cause LEDs **542**, **544**, **546**, **548**, and **550** to emit light. PCB **502** may also include at least a portion of interface **216** in FIG. **2**. PCB **502** is also coupled to an actuator **510**, which is part of a blocking mechanism configured to selectively delay or prevent disengagement of the firing mechanism. In an alternative example, actuator **510** may be replaced with a solenoid or another electrically controllable transducer configured to prevent disengagement of the firing mechanism. Trigger assembly **102** includes side plates **504** and **506** and a safety engagement lever **508** that engages a safety mechanism between side plates to prevent disengagement of the firing mechanism. Trigger assembly **102** further includes an opening **518** for a trigger stop adjustment and a spring force adjustment element **520**, which can allow for adjustment of the trigger pull resistance and stop position.

[0037] In this example, LEDs **544** and **546** emit light through openings in a portion of trigger shoe **116** that extends between PCB **502** and a corresponding circuit board (PCB **702** in FIG. **7**) on the other side of trigger assembly **102**. Such openings define light paths through which the emitted light of LEDs **542**, **544**, **546**, **548**, and **550** may pass, provided that a component of trigger assembly **102** does not interfere with or otherwise block the light path. Corresponding receivers on PCB **702** receive such emitted light that is not obstructed or blocked by trigger shoe **116**. LEDs **542** and **548** emit light through openings in a substrate within trigger assembly **102** that are positioned to correspond to engaged and disengaged positions of a safety lever (safety lever **626** in FIG. **6**). LED **550** corresponds to a location associated with a blocking lever (blocking lever **603** in FIG. **6**) that is moveable by actuator **510** in response to a control signal to prevent discharge of the firing mechanism.

[0038] In operation, control signals from electronic device **204** are received by a transceiver on PCB **502** and are provided to one or more of LEDs **542**, **544**, **546**, **548**, and **550** to cause them to emit light through corresponding openings toward optical sensors or receivers on the corresponding PCB on the opposing side of trigger assembly **102**. Optical sensors on the corresponding PCB receive emitted light, and the pattern of received light versus blocked light can be used to determine the state of the trigger shoe **116**, safety lever **626**, and blocking lever **603**, for example. Depending on the position of LEDs and corresponding openings, the position of other components may also be determined. In an example, the position of the safety lever **626** can be determined and a controller can send a control signal to actuator **510** to position blocking lever **603** to prevent disengagement of the firing mechanism to assist the safety lever **626**, providing a secondary safety mechanism in the event the safety mechanism is not fully engaged. An example of the trigger assembly **102** with the side plate **504** removed showing the blocking lever is described below with respect to FIG. **6**.

[0039] FIG. **6** is a side view **600** of the trigger assembly **102** of FIG. **5**. Trigger assembly **102** includes trigger shoe **116** configured to move about an axis **604** in response to force applied by a user, causing a spring plunger **606** recessed in a bore **607** within trigger shoe **116** to contact a sear lever **608** at a contact location. Sear lever **608** contacts a proximal end of a lever **616** at a sear location. A distal end of lever **616** contacts a striker block **622**. Lever **618** is configured to pivot about an axis **620** and to contact lever **616** to secure lever **616** against striker block **622**. Trigger assembly **102** includes a trigger block **613** including the spring force adjustment element **520** for adjusting a pull force spring **614** and a trigger stop **612**.

[0040] Trigger assembly **102** further includes striker block **622** configured to pivot about an axis **624** and to engage lever **616**. Trigger assembly **102** includes a lever return spring **630** configured to return lever **616** to a firing position. Trigger assembly **102** also includes a safety lever **626** configured to pivot about an axis **628** and to couple to safety engagement lever **508**. When engaged, safety lever **626** contacts lever **616** to prevent release of striker block **622**.

[0041] Trigger assembly **102** further includes blocking lever **603** configured to pivot about axis **602** and to contact sear lever **608** when engaged by actuator **510**. In an example, actuator **510** is responsive to control signals from electronic device **204** to selectively move blocking lever **603** into or out of contact with sear lever **608** to selectively prevent or allow disengagement of the firing mechanism (e.g., movement of lever **616** to disengage striker block **622**.

[0042] Trigger assembly **102** includes openings **642**, **644**, **646**, **648**, and (not shown, behind Safety Lever **626**), which correspond to LEDs **542**, **544**, **546**, **548**, and **550** (in FIG. **5**) and optical sensors **742**, **744**, **746**, **748**, and **750** (in FIG. **7**), respectively. Openings **642** and (not shown, behind Safety Lever **626**) correspond to LEDs **542** and **550** and optical sensors **742** and **750** to detect a position of safety lever **626**. Openings **644** and **646** correspond to LEDs **544** and **546** and optical sensors **744** and **746** to detect a position of trigger shoe **116**. Optical sensor **648** corresponds to LED **548** and to optical sensor **748** to detect a position of blocking lever **603**.

[0043] In an example, trigger shoe **116** is moveable in response to force applied by the user. Spring plunger **606** applies a force proportional to the pressure applied by the user up to a limit set by the spring force of spring plunger **606**. Trigger stop **612** prevents the trigger shoe **116** from advancing far enough to physically contact sear lever **608**, allowing spring plunger **606** to supply the force to disengage lever **616**. Before the force is applied to trigger shoe **116**, LED **544** emits light through opening **644** and trigger shoe **116** blocks light from LED **546**. When force is applied to trigger shoe **116**, trigger shoe **116** moves allowing emitted light from LEDs **544** and **546** through openings **644** and **646**. When trigger shoe **116** reaches its end stop position, LED **546** emits light through opening **646** and trigger shoe **116** blocks light from LED **544**. In an alternative embodiment, the relative positions of openings **644** and **646** may be adjusted such that emitted light initially passes only through opening **646**, then through both openings **644** and **646**, and then only through opening **644**.

[0044] In another example, safety lever **626** is moveable about axis **628** in response to force applied by a user to safety engagement lever **508**. In this instance, LEDs **542** and **548** emit light through corresponding openings **642** and (not shown, behind Safety Lever **626**). Safety lever **626** is depicted in the "OFF" position, blocking light from LED **548** so that is does not reach detector **750**. Light from LEDs **542** and **548** passes through opening **642** (not shown, behind Safety Lever **626**). In a safety "ON" state, safety lever **626** blocks opening **642**, and in a safety "OFF" state, safety lever **626** blocks the opening that is hidden behind Safety Lever **626**. In the intermediate state, a controller within electronic device **204** or within trigger assembly **102** can control actuator **510** to engage blocking lever **603** to prevent disengagement of the firing mechanism until the safety lever **626** is in a fully "ON" or "OFF" state.

[0045] FIG. **7** is a perspective view **700** of a left side of the trigger assembly **102** of FIG. **5**. Trigger assembly **102** includes plates **504** and **506** and a PCB **702** including at least a portion of interface **216**, which is coupled to actuator **510**.

Actuator **510** is configured to selectively move blocking lever **603** to engage sear lever **608** to prevent discharge of the firearm, for example. PCB **702** further includes a transceiver **710**, which is configured to encode digital signals for communication of signals relating to the state of trigger mechanism **102**. PCB **702** also includes optical sensors **742**, **744**, **746**, **748**, and **750**, which correspond to openings **642**, **644**, **646**, **648**, and **650** (shown in phantom behind Safety Lever **626**) (in FIG. **6**) and to LEDs **542**, **544**, **546**, **548**, and **550** (in FIG. **5**).

[0046] In an example, optical sensors **742**, **744**, **746**, **748**, and **750** are configured to receive emitted light through openings **642**, **644**, **646**, **648**, and **650** (shown in phantom behind Safety Lever **626**). Each of the optical sensors **742**, **744**, **746**, **748**, and **750** is configured to produce an electrical signal proportional to the received light. When light is received through an opening, each of optical sensors **742**, **744**, **746**, **748**, and **750** is configured to produce a logical "1" value, and when light is blocked, each is configured to produce a logical "0" value. The logical values can be used to determine the state of components within trigger mechanism **102**, as described above.

[0047] In some instances, the values produced by optical sensors **742**, **744**, **746**, **748**, and **750** can be used to determine the state of components within trigger assembly **102**, which state information can be used by a controller (either within electronic device **204** or within trigger mechanism **102** itself) to control operation of trigger assembly **102**. In one instance, the controller can selectively control actuator to move blocking lever **603** into a position to prevent disengagement of the firing mechanism when the state of safety lever **626** is indeterminate (i.e., between "ON" and "OFF" states). In another instance, the controller can trigger operation of another circuit in response to detecting movement of trigger shoe **116** based on changes in the optical signals received by optical sensors **744** and **746**. In an example, the controller may trigger processor **404** to execute alignment detection instructions **424** in response to movement of trigger shoe **116**, and processor **404** may execute controller instructions **418** to control actuator **510** to prevent disengagement of the firing mechanism until a target is aligned with a reticle within a threshold distance. In still another instance, controller can trigger operation of camera **428** to begin recording a video stream. Other operations may also be triggered based on detection of movement of trigger shoe **116**.

[0048] While above-examples describe some control operations that may be activated or deactivated based on the state of components of trigger assembly **102**, including a secondary safety mechanism, video camera functionality, tracking/alignment functionality, and so on, other functionality may also be activated. In an example, an error detection function may be triggered when components fail to reach their expected position within a period of time, which may be used to alert a user. In one instance, an LED on a peripheral edge of trigger mechanism **102** may be activated to emit light or to flash to alert the user that the safety mechanism is neither fully engaged nor disengaged. Other circuitry may also be included that can be used to provide indications to the user and/or to control operation of trigger mechanism **102** to prevent disengagement of the firing mechanism when the state of particular components is indeterminate (i.e., between known states).

[0049] In conjunction with the systems and trigger assemblies described above with respect to FIGS. **1-7**, a trigger assembly includes a pair of PCBs on opposing sides of a portion of a trigger shoe and other components. One of the PCBs includes LEDs to emit light and the other includes optical receivers or sensors to receive the emitted light and to produce electrical signals proportional to the received light. Control circuitry on one of the PCBs or within an electronic device coupled to one of the PCBs utilizes the electrical signals to determine a state of one or more components of the trigger assembly. In some instances, the control circuitry utilizes the determined state information to control one or more elements of the trigger assembly. In other instances, the control circuitry controls one or more components, such as LEDs, cameras, and other circuits in response to determining the state.

[0050] While the above-discussion has largely assumed that a single type of sensing mechanism, such as an optical sensing configuration using LEDs and optical sensors, is used within a single trigger assembly, it should be appreciated that multiple types of sensors may be used in a given trigger assembly. In an example, optical sensors and proximity sensors may be employed in a particular trigger assembly. In general, a particular trigger assembly can include optical sensors, reed switches, laser sensors, proximity sensors, capacitive sensors, direct contact sensors, Hall effect sensors, or any combination thereof.

[0051] Additionally, while the above-discussion discussed utilizing the trigger assembly in connection with a rifle, it should be understood that the trigger assembly can be used with a pistol, an airsoft gun, a paintball gun, a crossbow, or any type of firing system that utilizes a trigger to disengage the firing mechanism.

[0052] 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. A trigger assembly comprising:

a trigger shoe configured to disengage a firing mechanism in response to a force applied by a user;

a safety mechanism configured to prevent movement of the trigger shoe; and

a circuit including at least one optical sensor proximate to the safety mechanism and configured to determine a positional state of the safety mechanism in response to the light received by the at least one optical sensor.

2. The trigger assembly of claim **1**, wherein the circuit further comprises a second optical sensor proximate to a portion of the trigger shoe and configured to determine a positional state of the trigger shoe in response to the light received by the second optical sensor.

3. The trigger assembly of claim **1**, wherein the at least one optical sensor is configured to generate an electrical signal proportional to light received by the at least one optical sensor.

4. The trigger assembly of claim **1**, further comprising a second circuit on a side of the plurality of components opposite that of the circuit, the second circuit including at least one light emitting diode (LED) configured to emit light toward the at least one optical sensor.

5. The trigger assembly of claim **4**, wherein the trigger shoe comprises:

a first opening; and

a second opening;

wherein the at least one LED includes a first LED adjacent to the first opening and a second LED adjacent to the second opening on the side opposite that of the first optical sensor; and

the at least one optical sensor includes a first optical sensor configured to receive first light emitted from the first LED and includes a second optical sensor configured to receive second light emitted from the second LED.

6. The trigger assembly of claim **5**, wherein the circuit comprises a control circuit configured to determine the positional state of the trigger shoe in response to receiving at least one of the first light and the second light.

7. The trigger assembly of claim **1**, comprising an interface configurable to couple to an optical device and to communicate electrical signals proportional to at least one of the first light and the second light received by the first optical sensor and the second optical sensor to the optical device.

8. A trigger assembly comprising:

a trigger shoe;

a safety mechanism configured to prevent movement of a trigger shoe; and

a circuit including a first optical sensor proximate to the safety mechanism and configured to determine a positional state of the safety mechanism in response to the light received by the at least one optical sensor.

9. The trigger assembly of claim **8**, wherein the trigger shoe is configured to disengage a firing mechanism in response to a force applied by a user.

10. The trigger assembly of claim **9**, further comprising a second optical sensor proximate to a portion of the trigger shoe and configured to determine a positional state of the trigger shoe in response to the light received by the second optical sensor.

11. The trigger assembly of claim **8**, wherein the at least one optical sensor is configured to generate an electrical signal proportional to light received by the at least one optical sensor.

12. The trigger assembly of claim **8**, further comprising a second circuit on a side of the plurality of components opposite that of the circuit, the second circuit including at least one light emitting diode (LED) configured to emit light toward the at least one optical sensor.

13. The trigger assembly of claim **12**, wherein the trigger shoe comprises:

a first opening; and

a second opening;

wherein the at least one LED includes a first LED adjacent to the first opening and a second LED adjacent to the second opening on the side opposite that of the first optical sensor; and

the at least one optical sensor includes a first optical sensor configured to receive first light emitted from the first LED and includes a second optical sensor configured to receive second light emitted from the second LED.

14. The trigger assembly of claim **13**, wherein the circuit comprises a control circuit configured to determine the positional state of the trigger shoe in response to receiving at least one of the first light and the second light.

15. The trigger assembly of claim **8**, comprising an interface configurable to couple to an optical device and to communicate electrical signals proportional to at least one of the first light and the second light received by the first optical sensor and the second optical sensor to the optical device.

16. A trigger assembly comprising:

a safety mechanism;

a first circuit including a light emitting component proximate to a first side of the safety mechanism;

a second circuit proximate to a second side of the safety mechanism opposite to the first side, the second circuit including at least one optical sensor configured to generate a signal proportional to received light from the first circuit; and

a controller coupled to the at least one optical sensor and configured to determine a physical state of the safety mechanism in response to the signal.

17. The trigger assembly of claim **16**, wherein at least one of the first circuit and the second circuit includes the controller.

18. The trigger assembly of claim **16**, further comprising the controller configured to selectively engage a blocking lever of the safety mechanism when the physical state corresponds to one of a safety on state and a transitional state between the safety on state and a safety off state.

19. The trigger assembly of claim **16**, further comprising:

a trigger shoe; and

wherein the first circuit includes at least one second light emitting component configured to direct light toward the trigger shoe; and

wherein the second circuit includes at least one second optical sensor configured to generate a second signal proportional to received light from the at least one second light emitting component.

20. The trigger assembly of claim **19**, further comprising a controller configured to determine a positional state of the trigger shoe in response the second signal.

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