US 20230079558A1

(19) **United States**
(12) **Patent Application Publication**
(10) **Pub. No.: US 2023/0079558 A1**
(43) **Pub. Date: Mar. 16, 2023**

VAN METER et al.

(54) **ELECTRONIC TRIGGER ASSEMBLIES, SYSTEMS, LOWER RECEIVERS AND FIREARMS INCLUDING THE SAME**

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(21) Appl. No.: **17/839,850**

(22) Filed: **Jun. 14, 2022**

Related U.S. Application Data

(60) Provisional application No. 63/210,366, filed on Jun. 14, 2021.

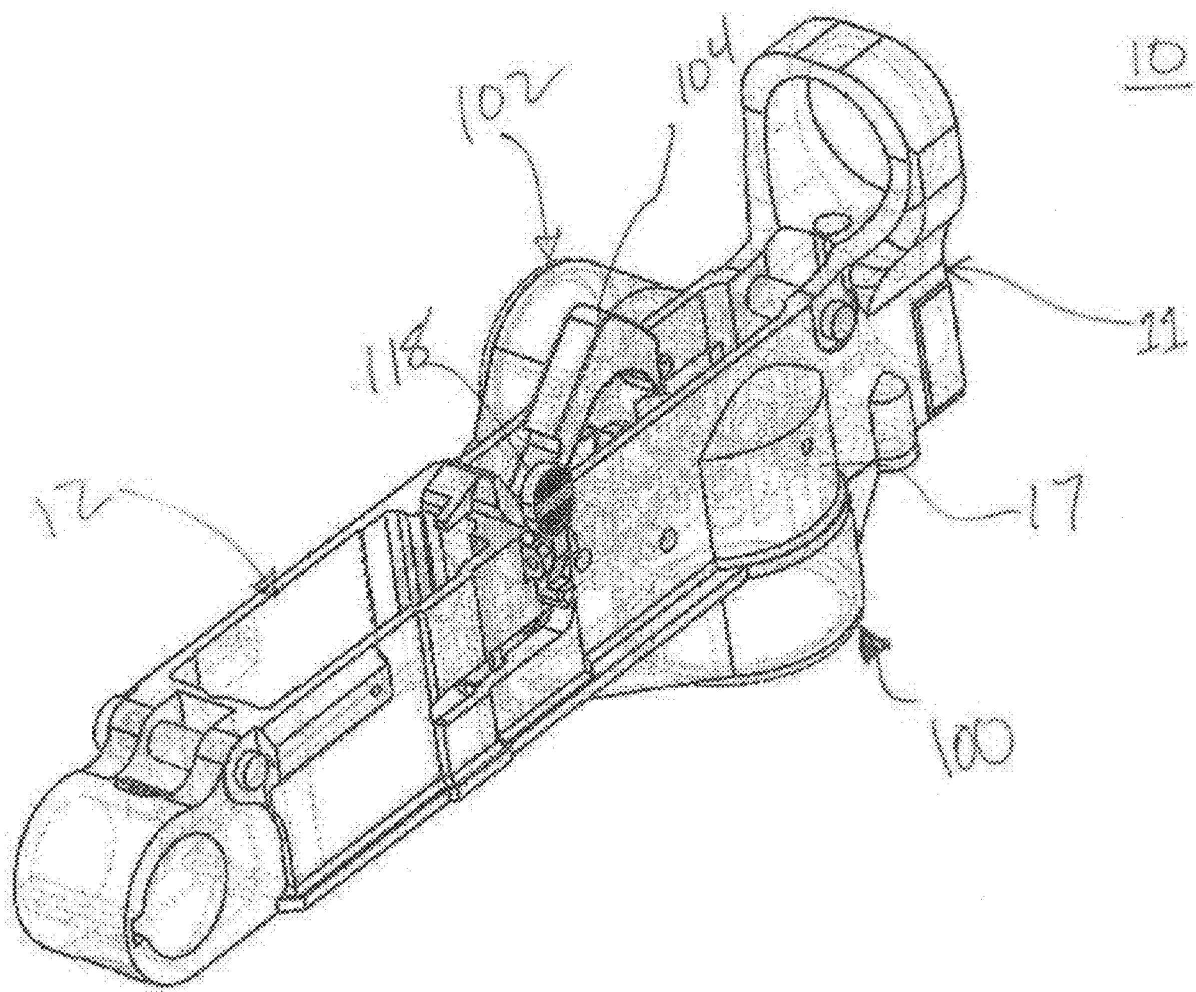
Publication Classification

(51) **Int. Cl.**
F41A 19/59 (2006.01)
F41A 17/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F41A 19/59*** (2013.01); ***F41A 17/063*** (2013.01)

(57) **ABSTRACT**

An electronic trigger assembly for a firearm includes a firearm control mechanism, a safety actuator and a firing actuator. The firing control mechanism is configured to operate in a safe mode or a shot mode. The safety actuator is configured to actuate a safety rod linearly in a first direction to switch the firing control mechanism between the safe mode and the shot mode. The firing actuator is configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode.



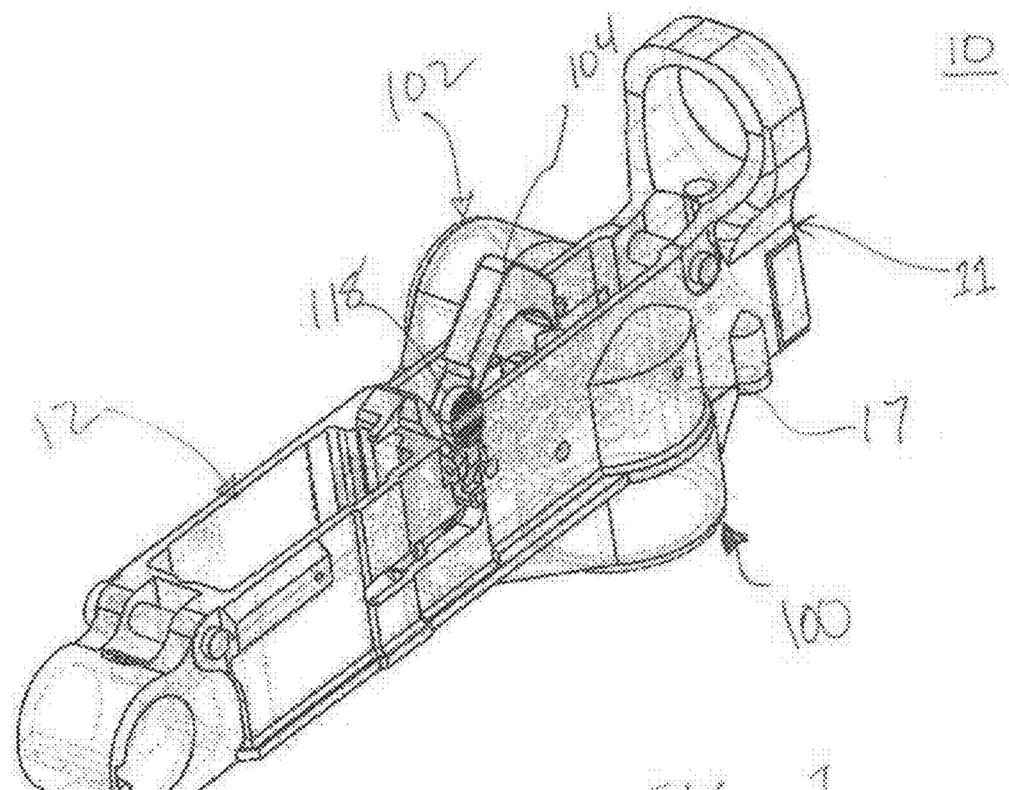


FIG. 1

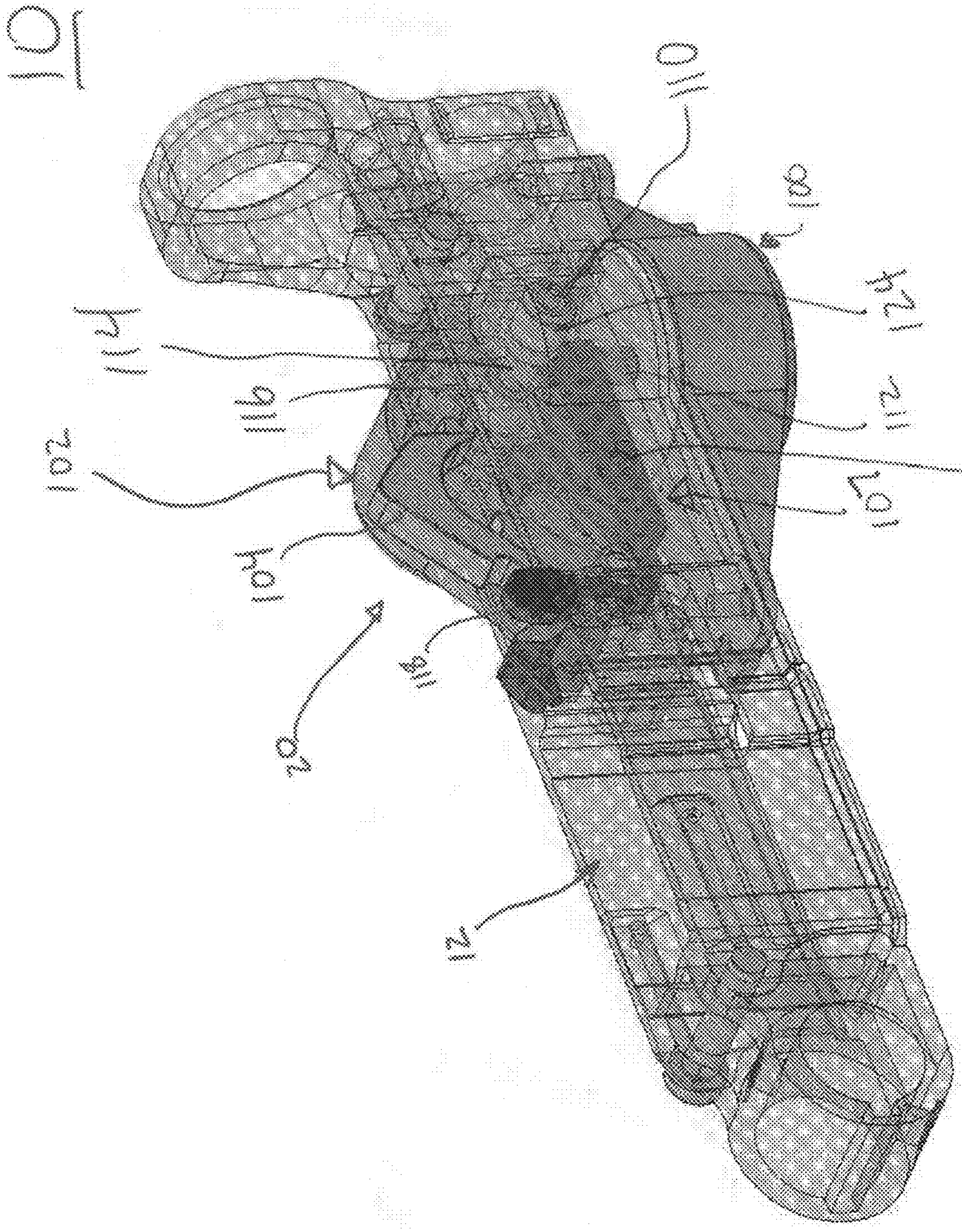


FIG. 2

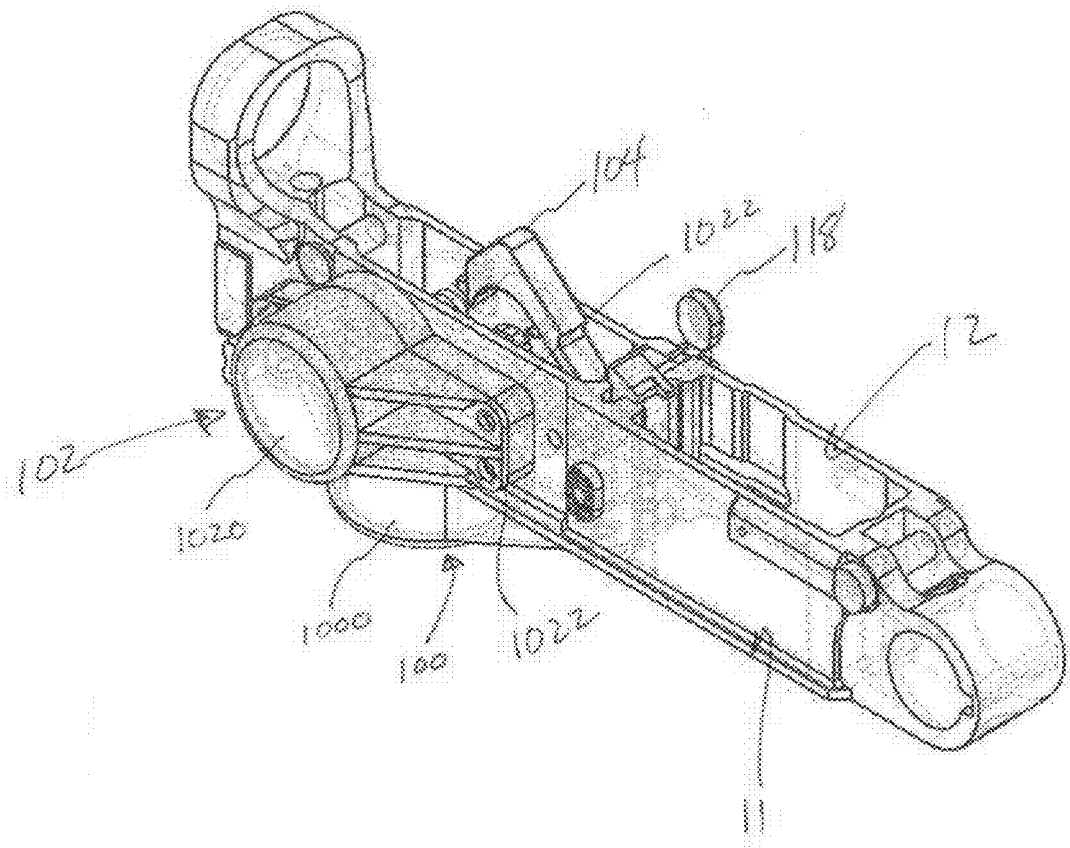


FIG. 3

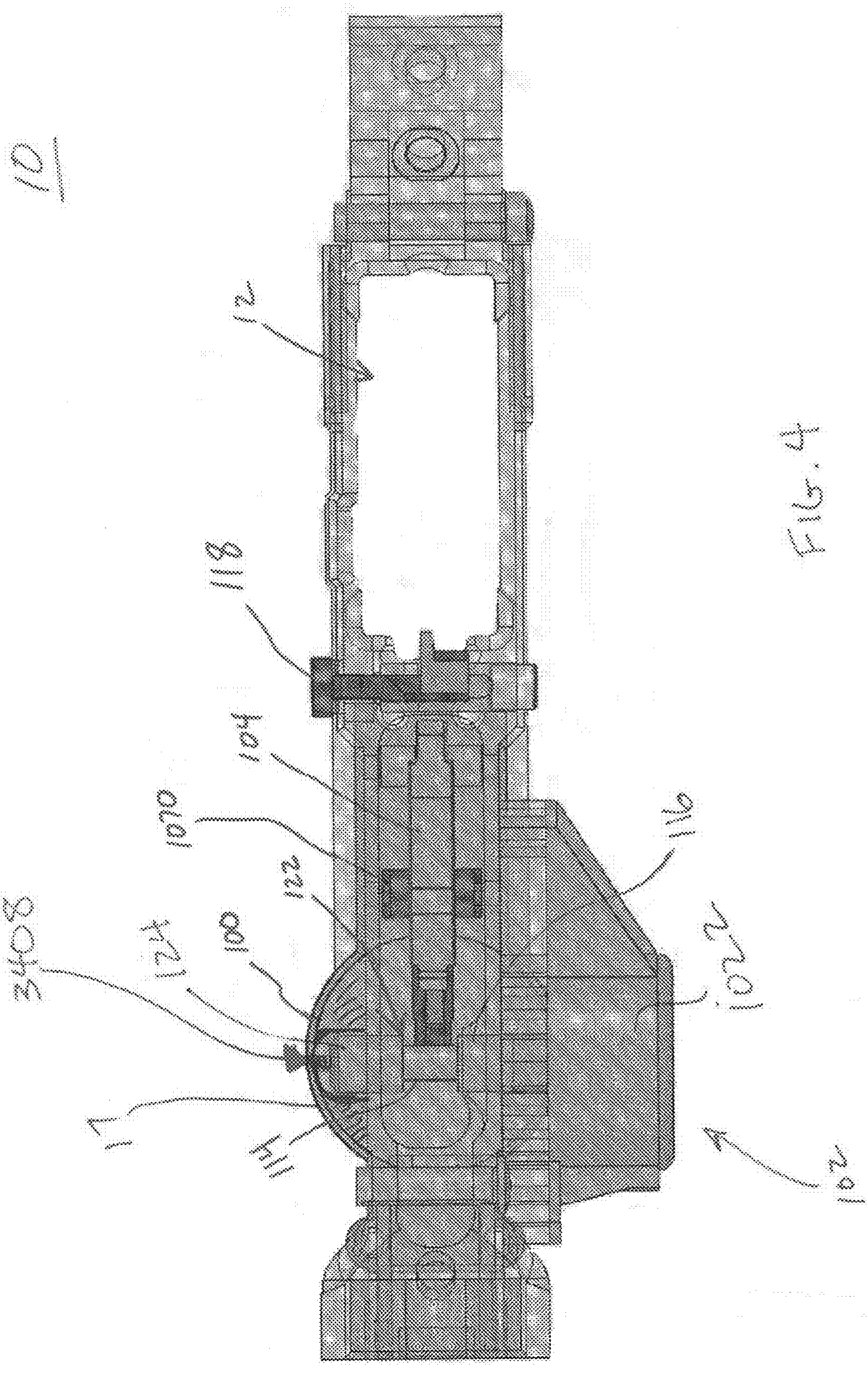


FIG. 4

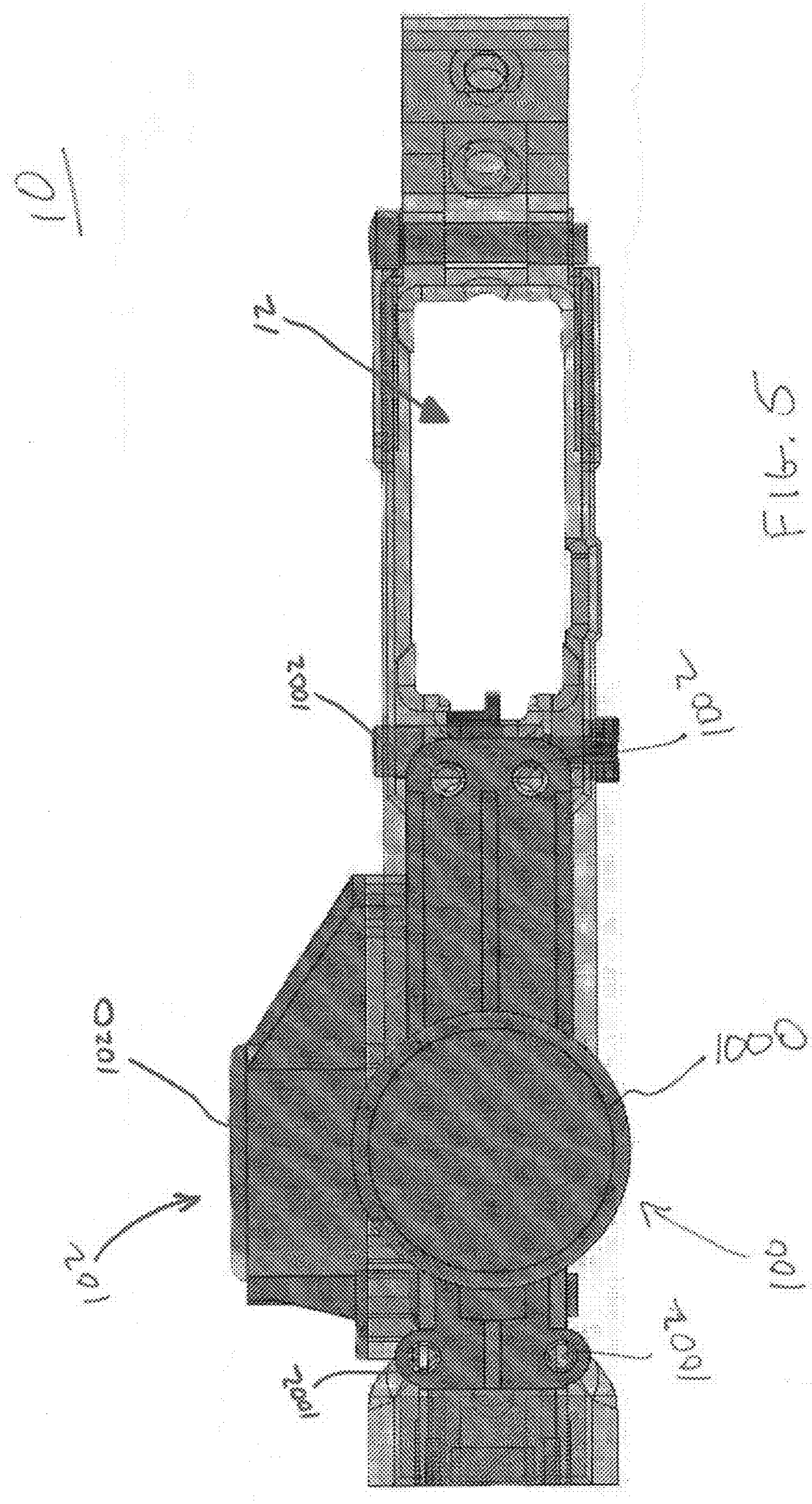


FIG. 5

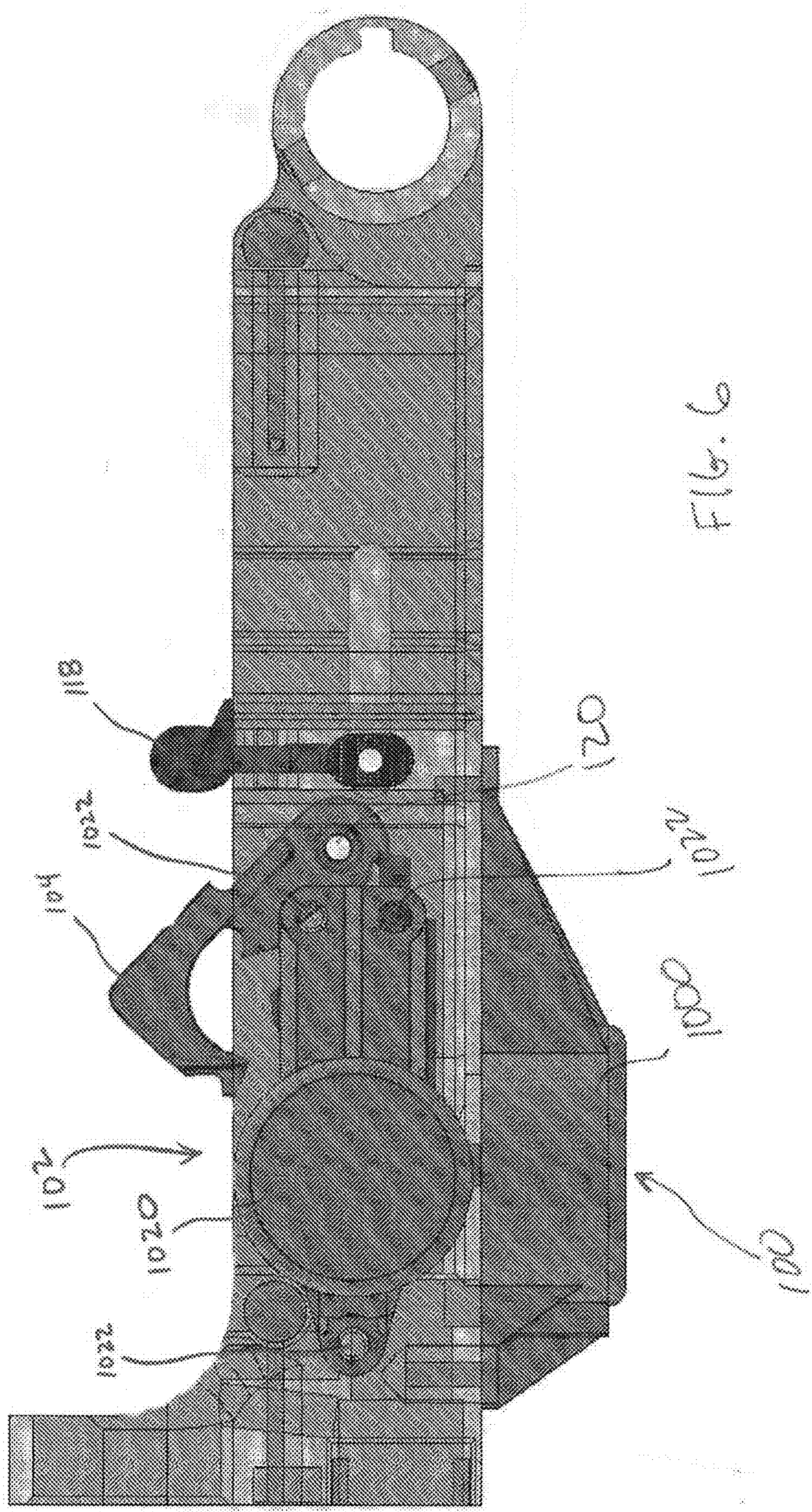


FIG. 6

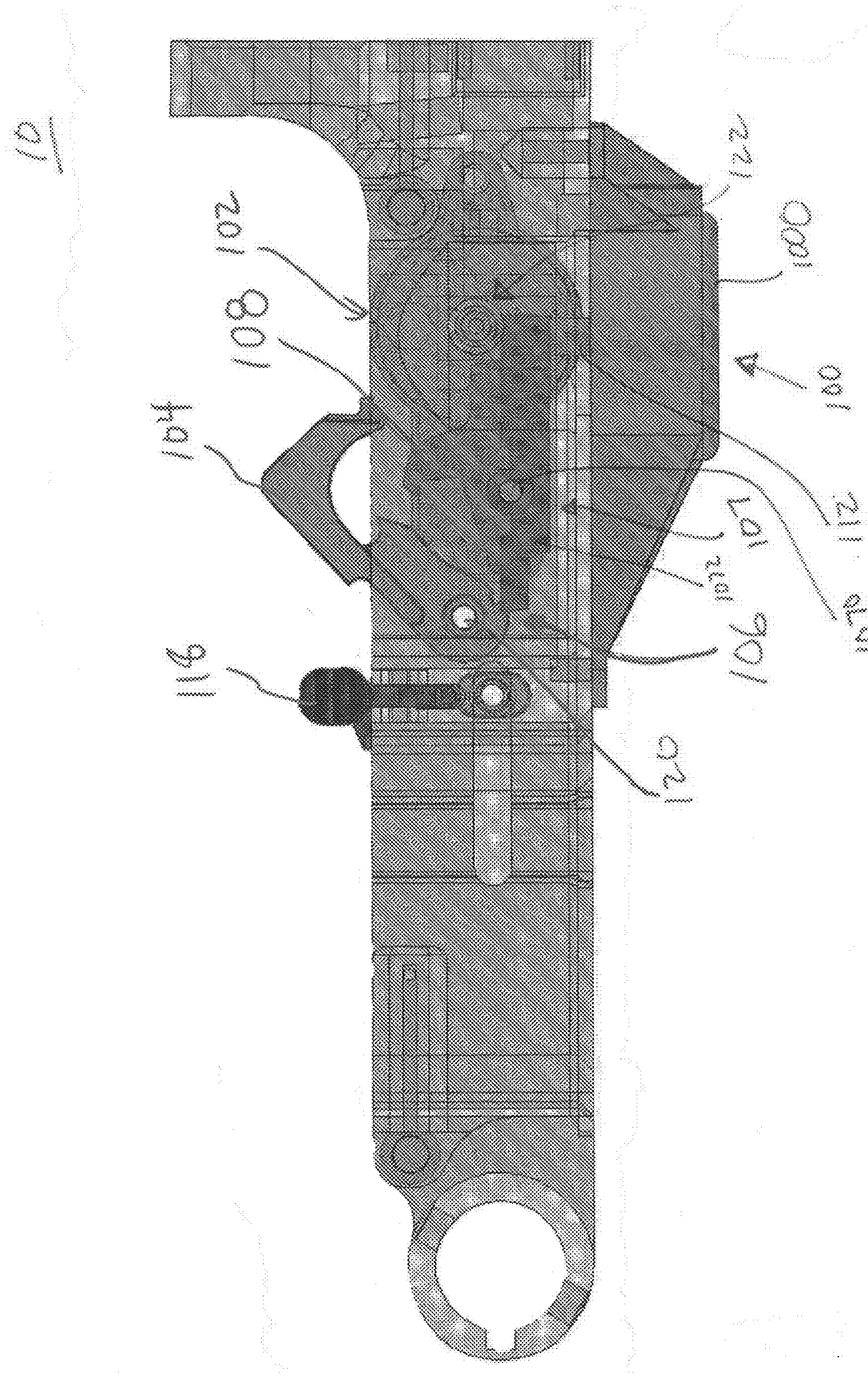


FIG. 7

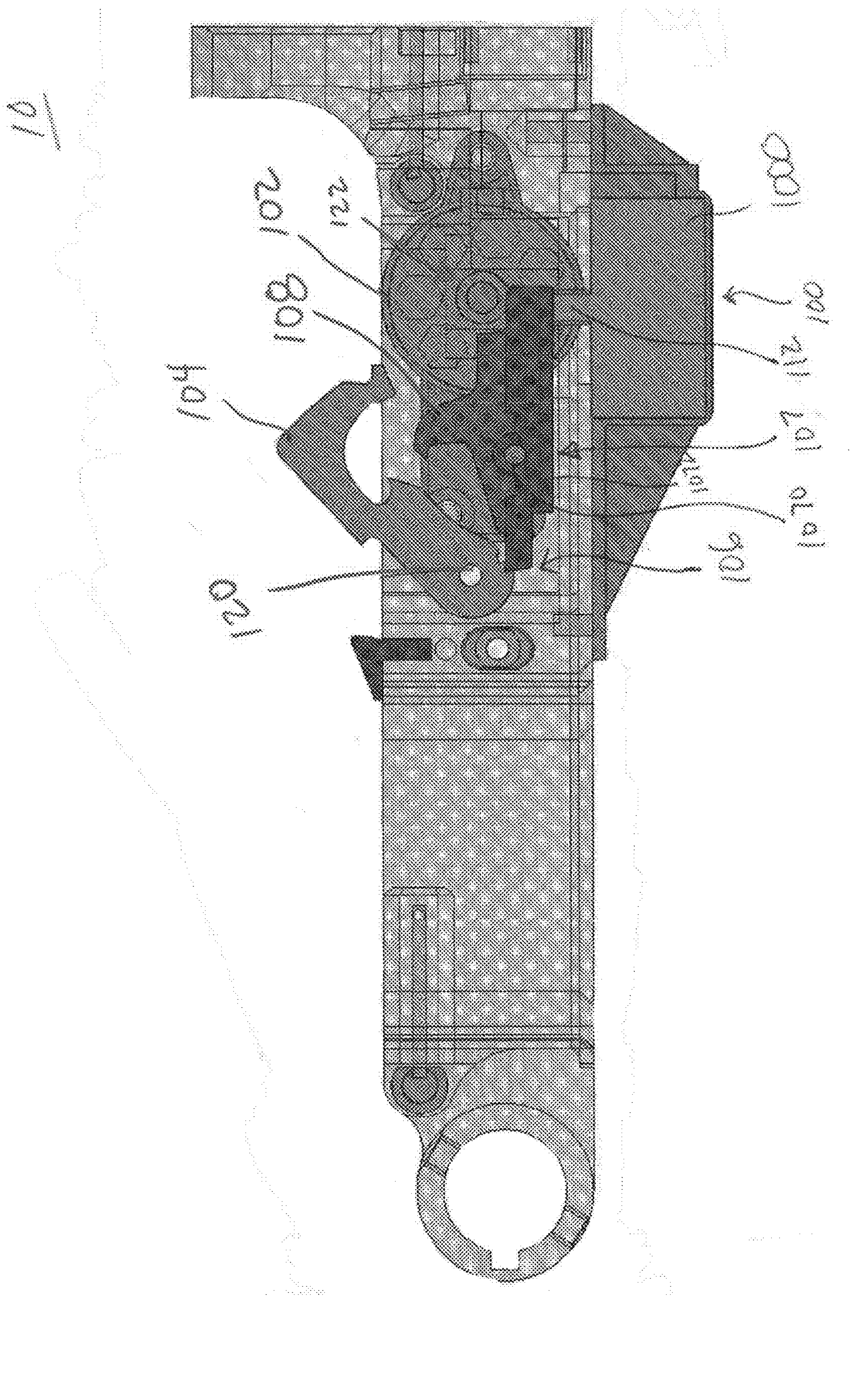


FIG. 8

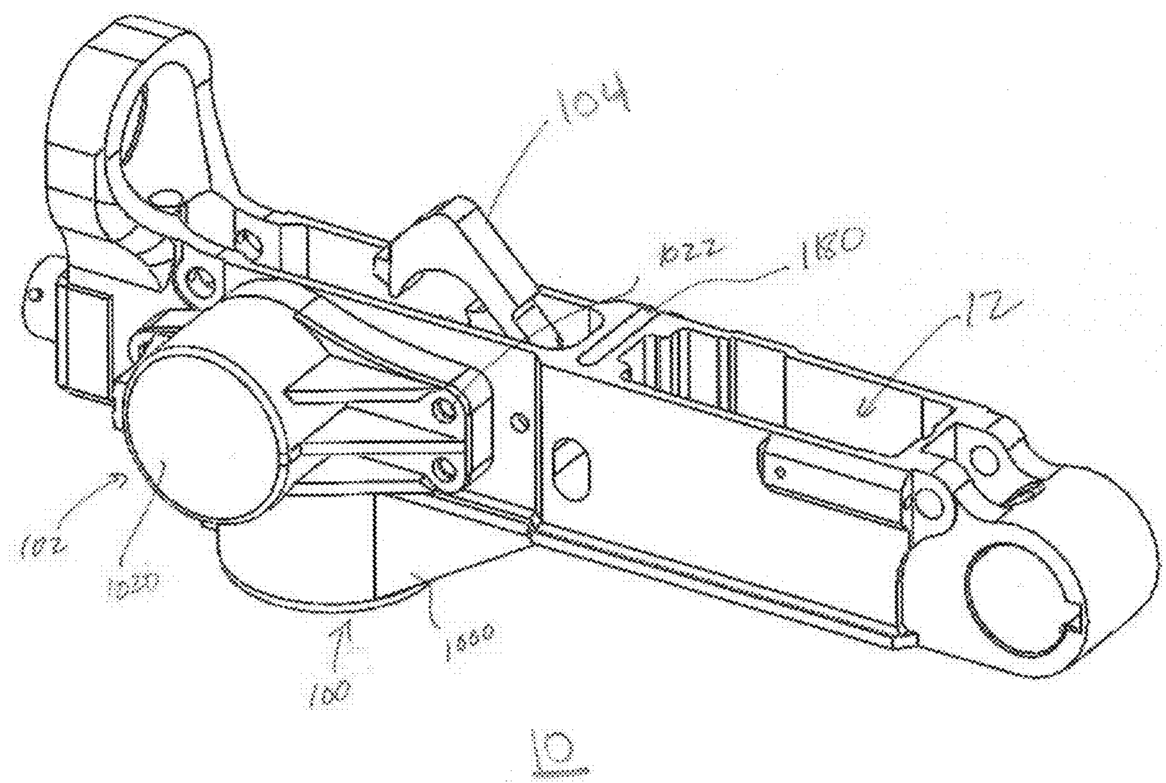


FIG. 9

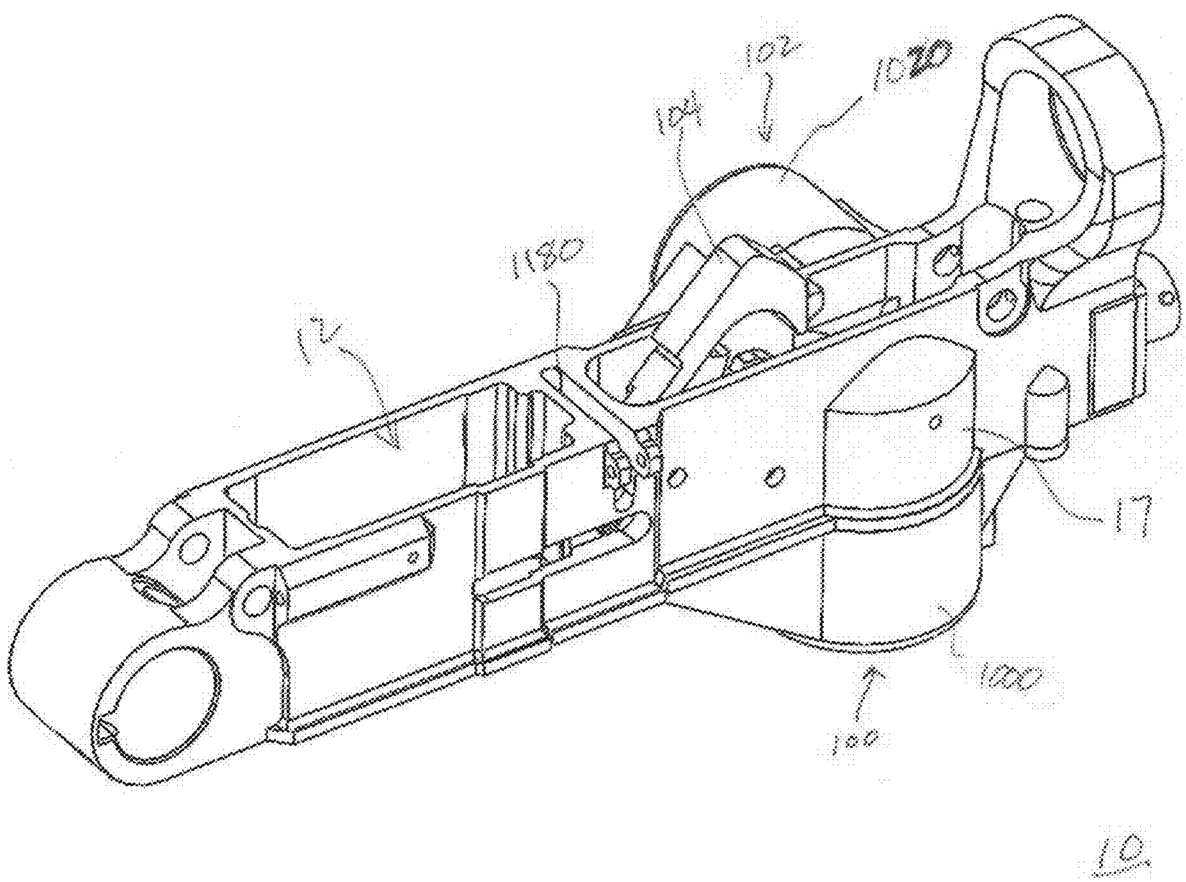


FIG. 10

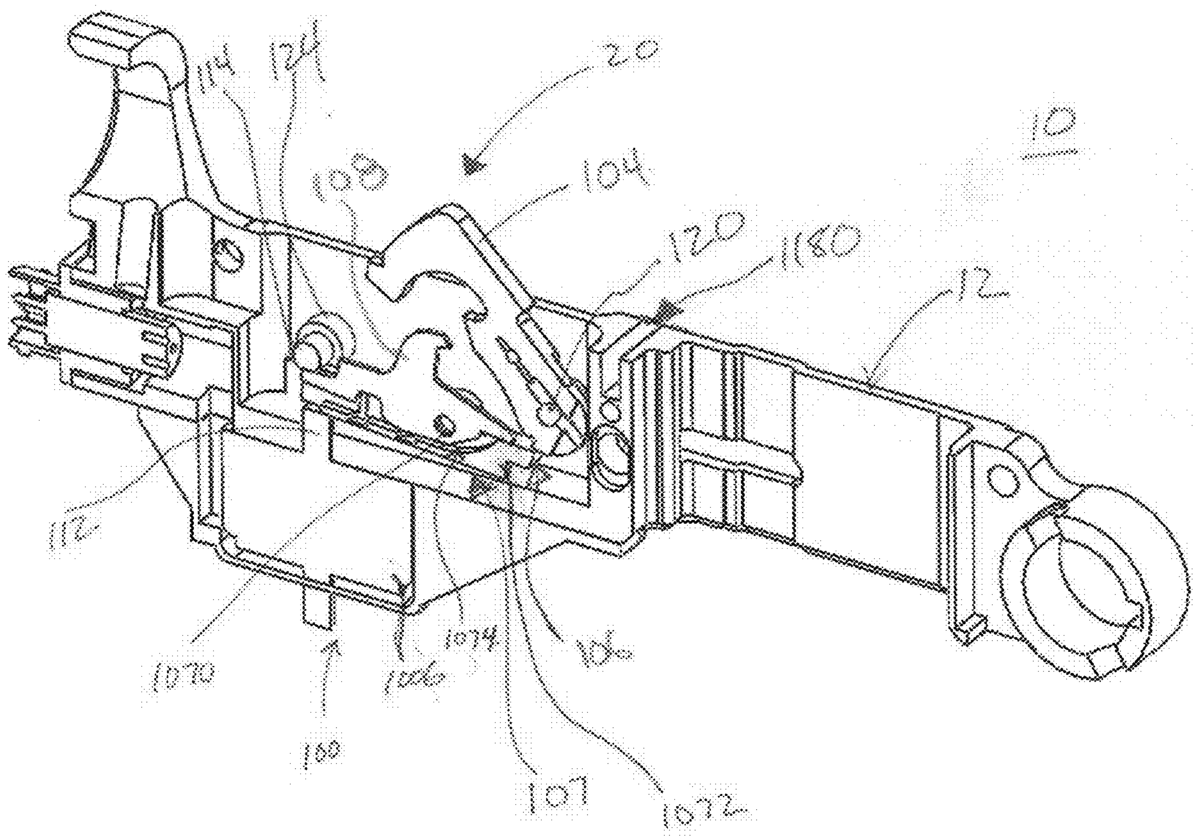

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FIG. 11

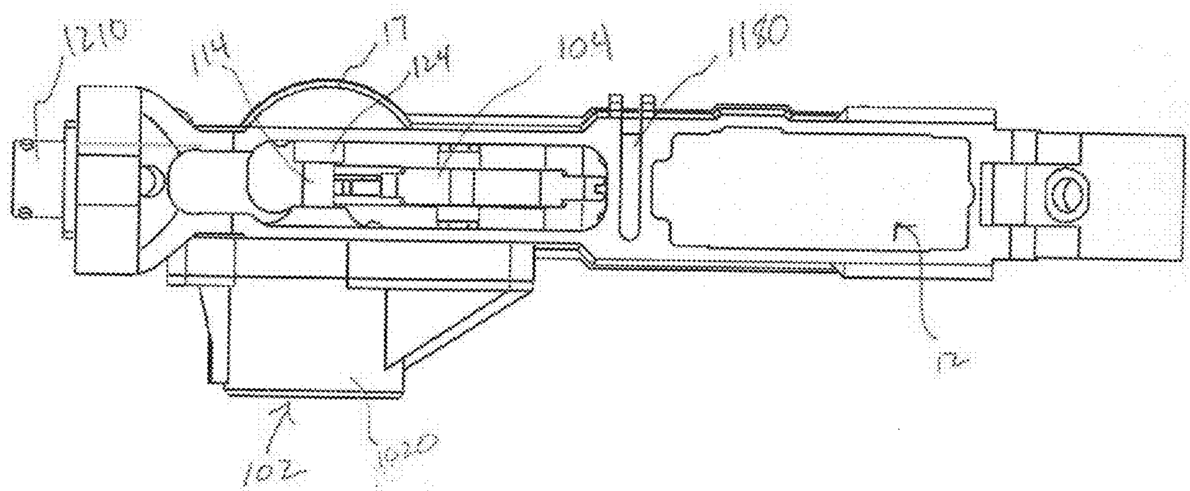


FIG. 12

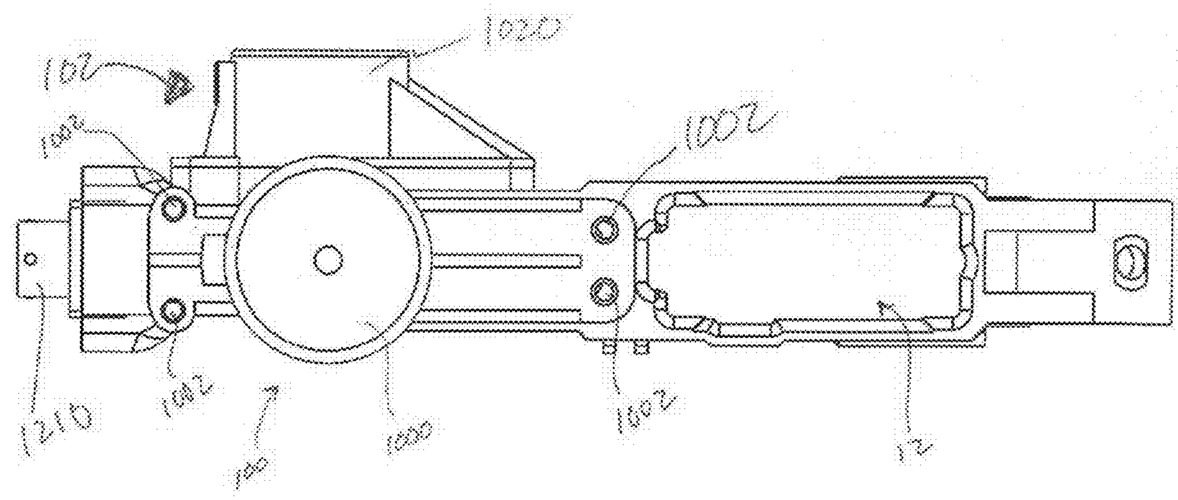


FIG. 13

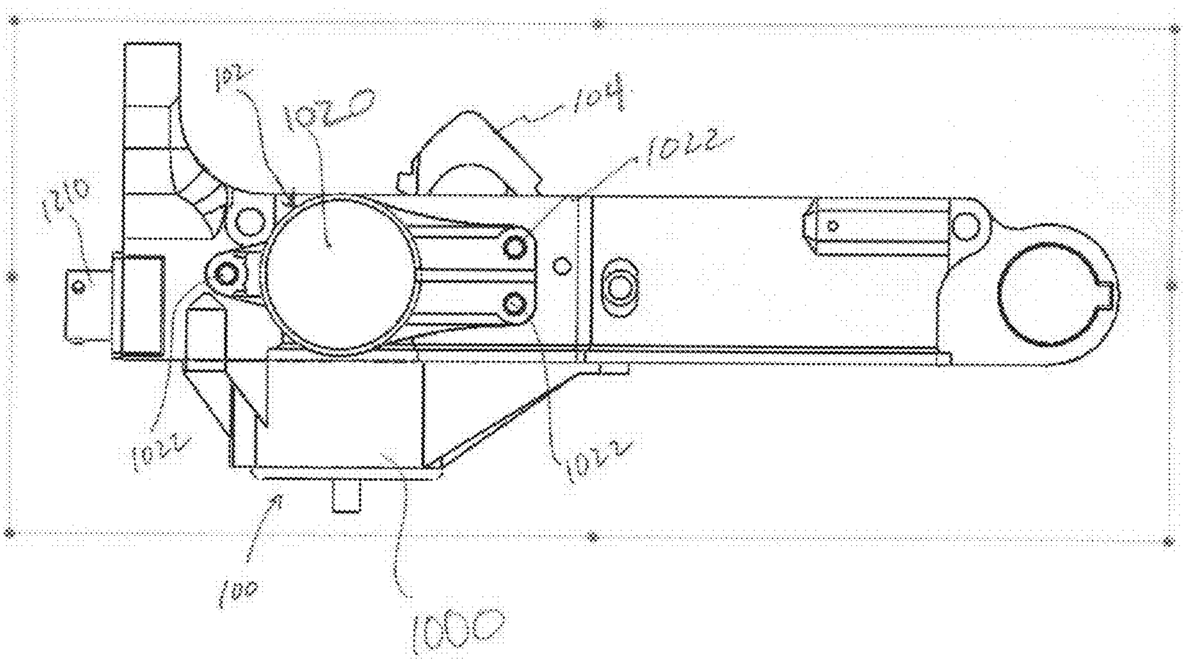


FIG. 14

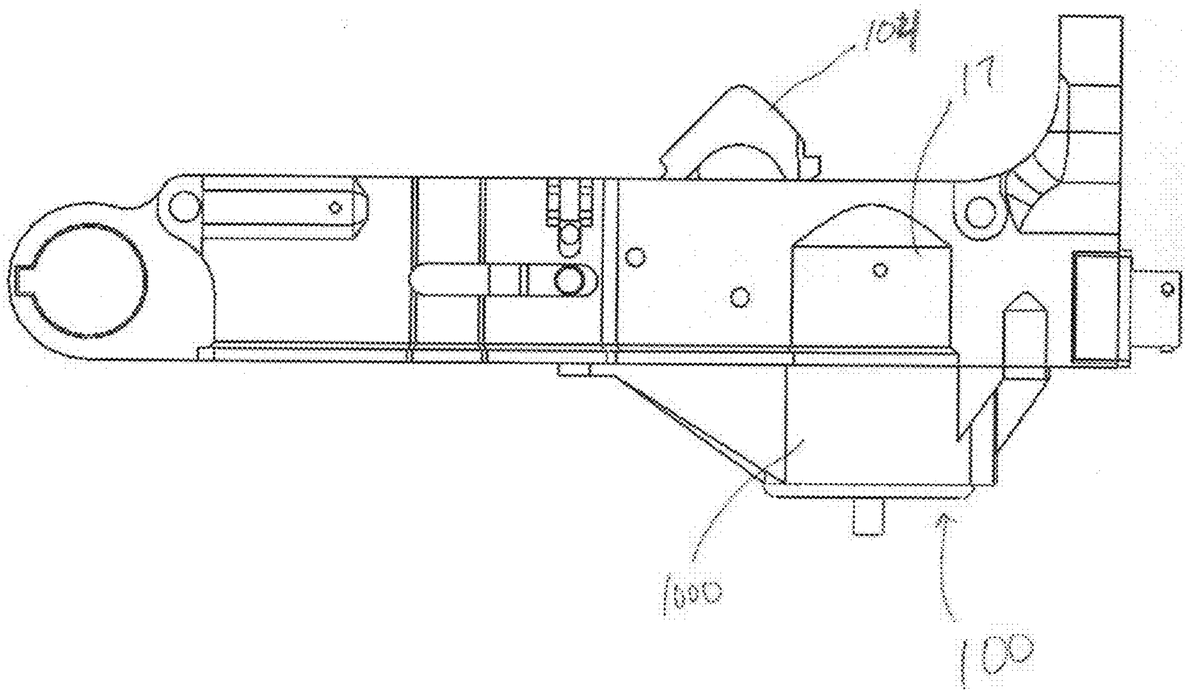


FIG. 15

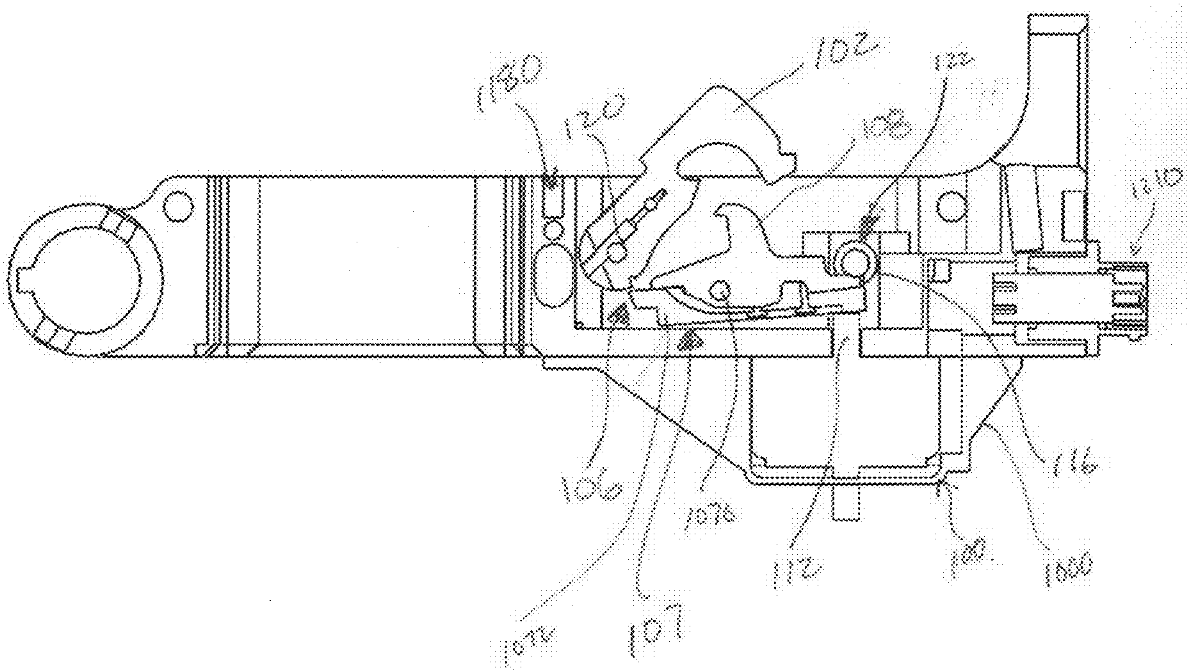


FIG. 16

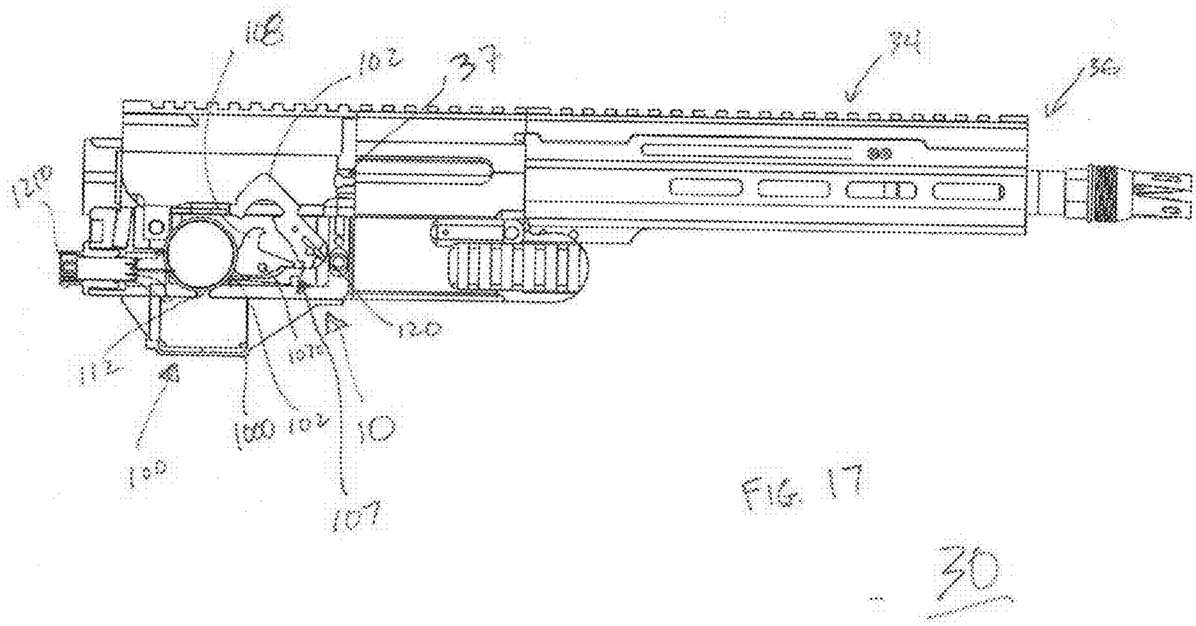
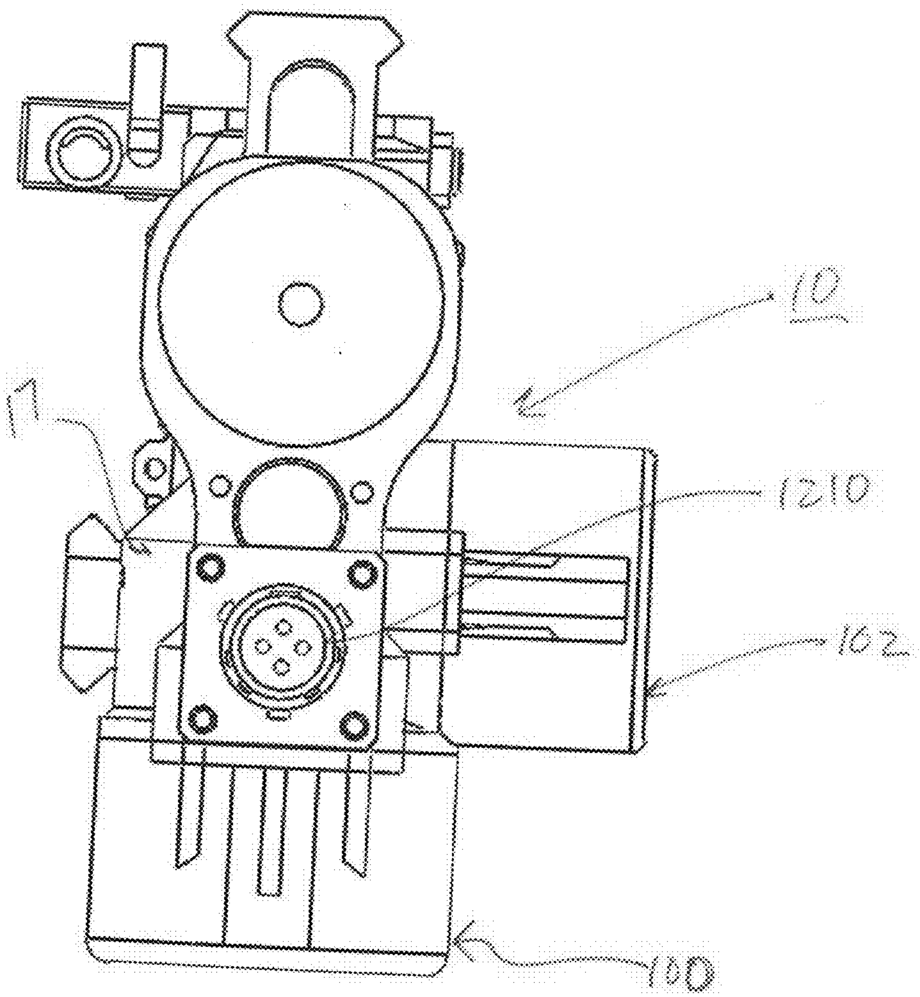


FIG. 17



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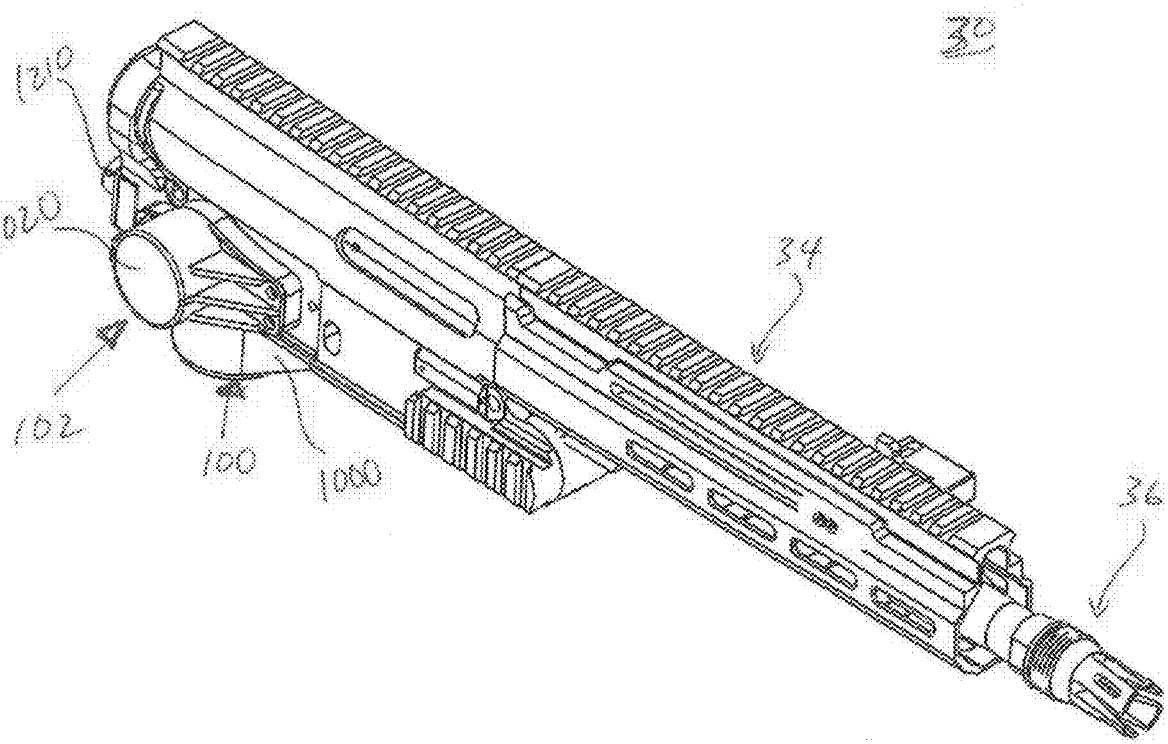


FIG. 19

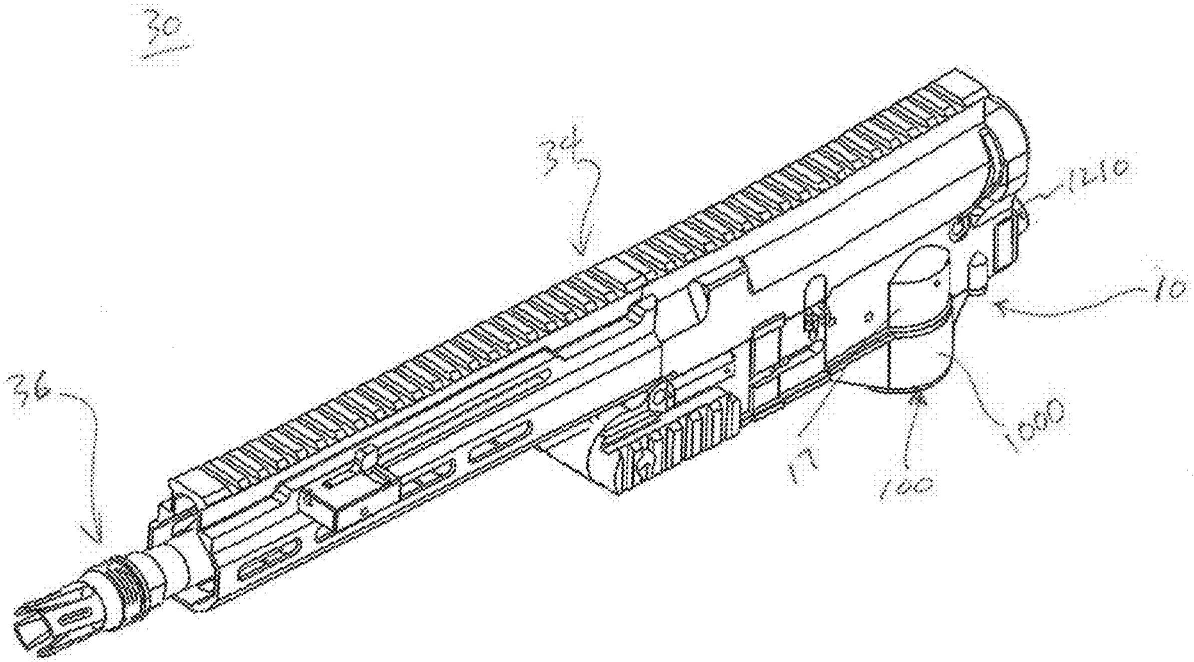
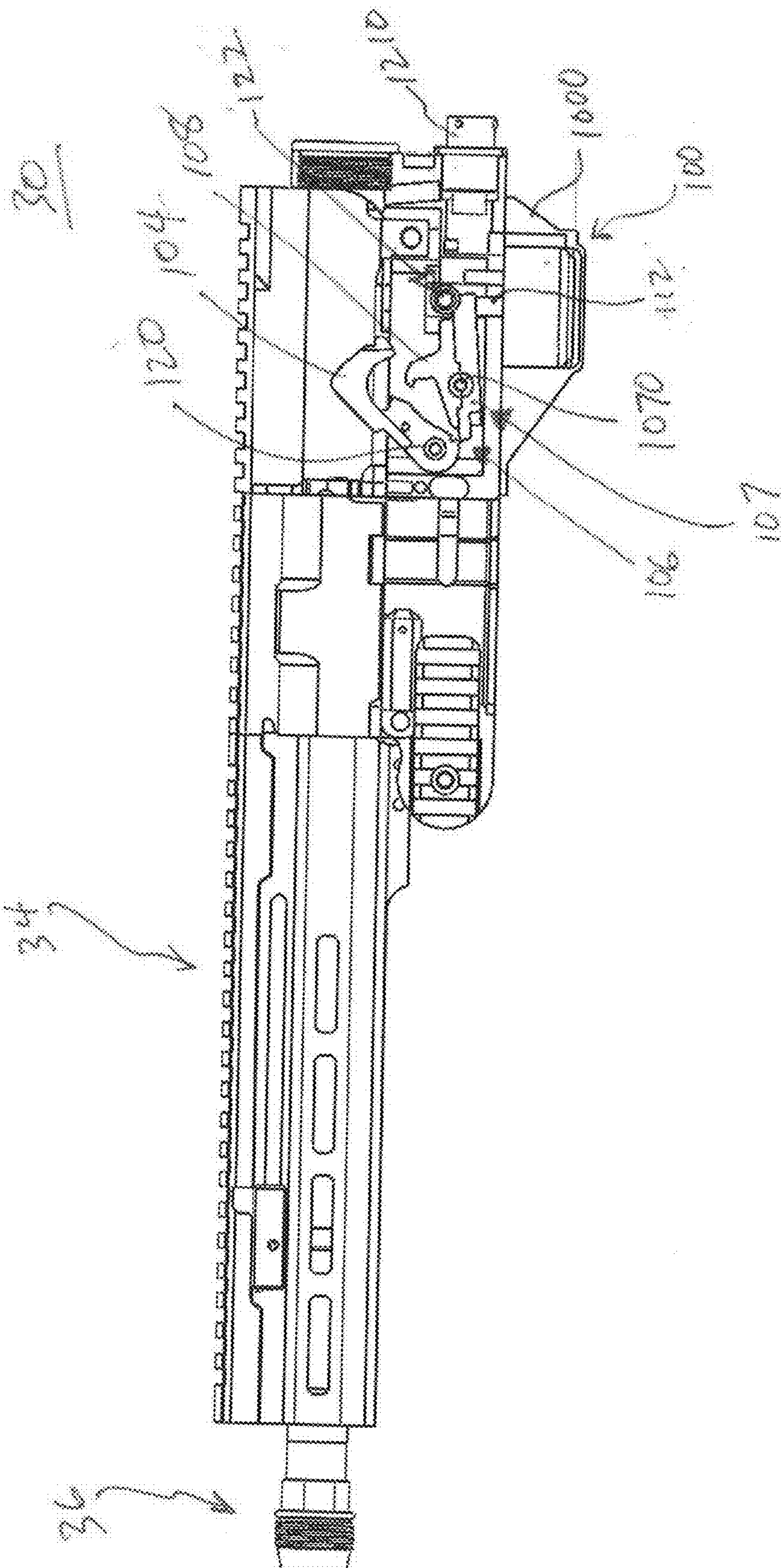


FIG. 20



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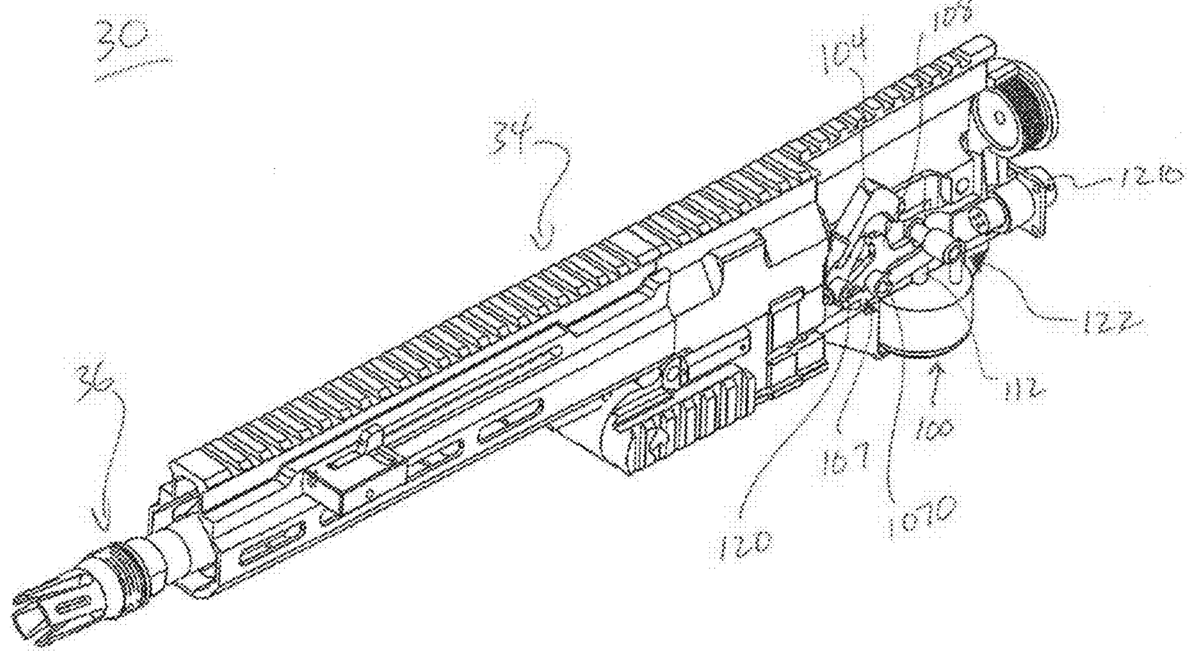


FIG. 22

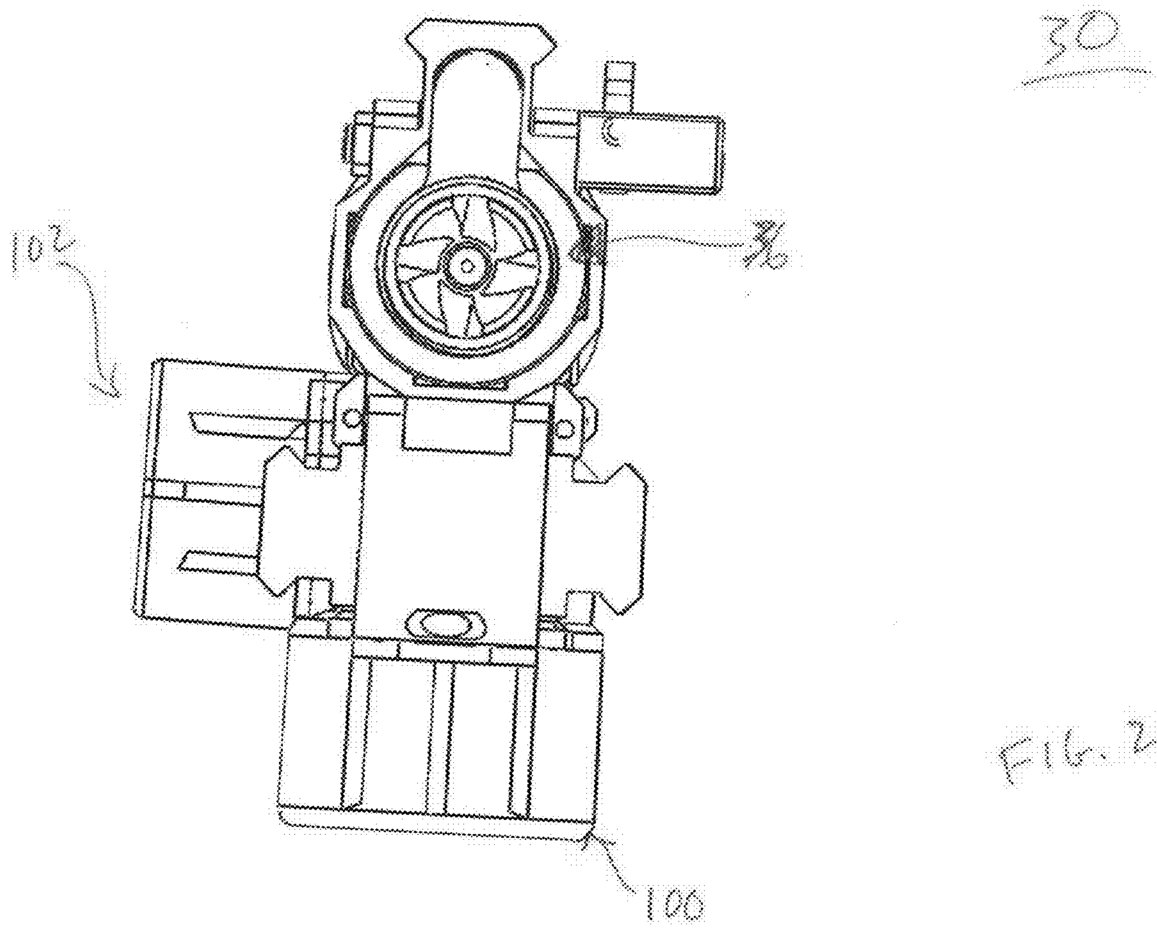


FIG. 23

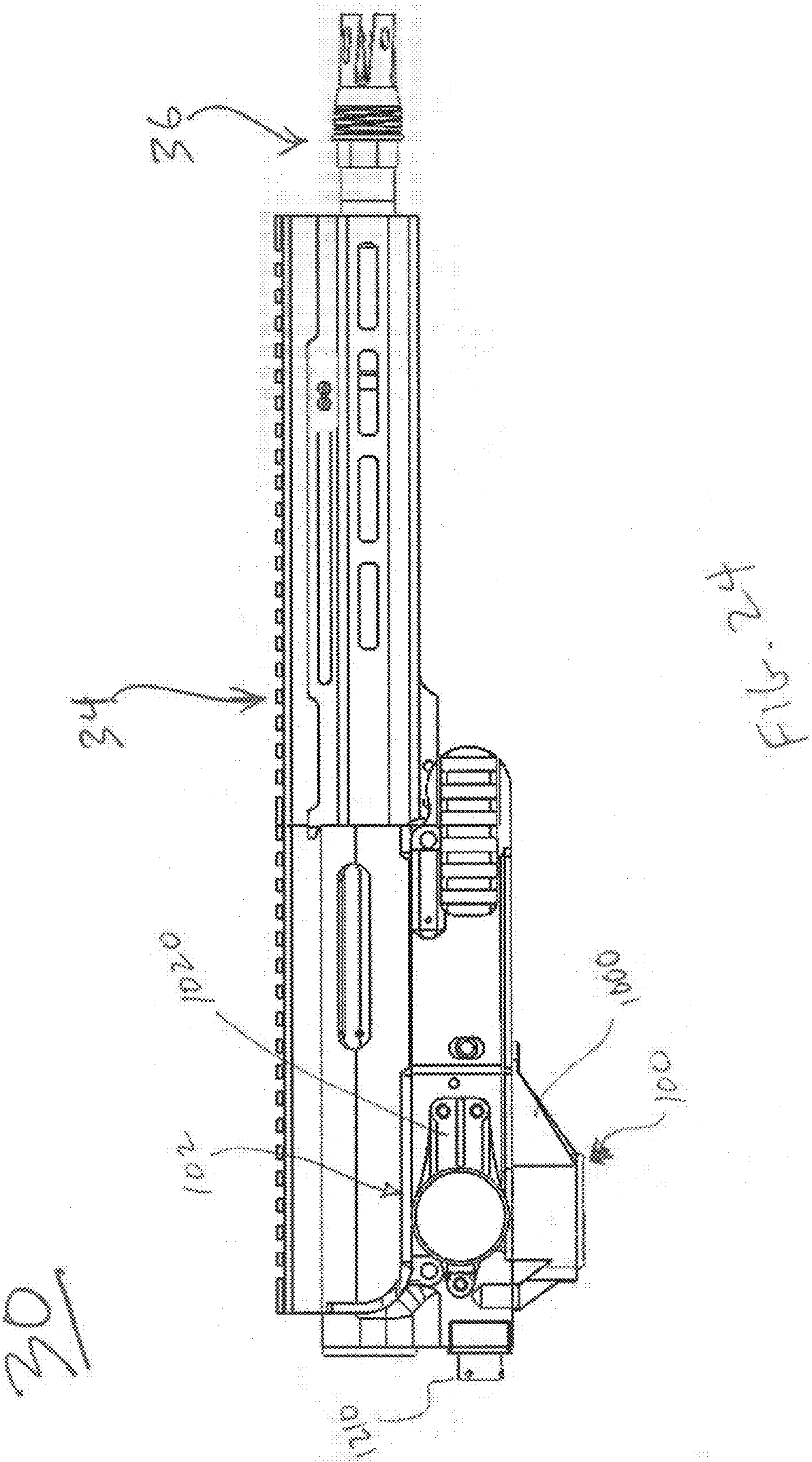


FIG. 24

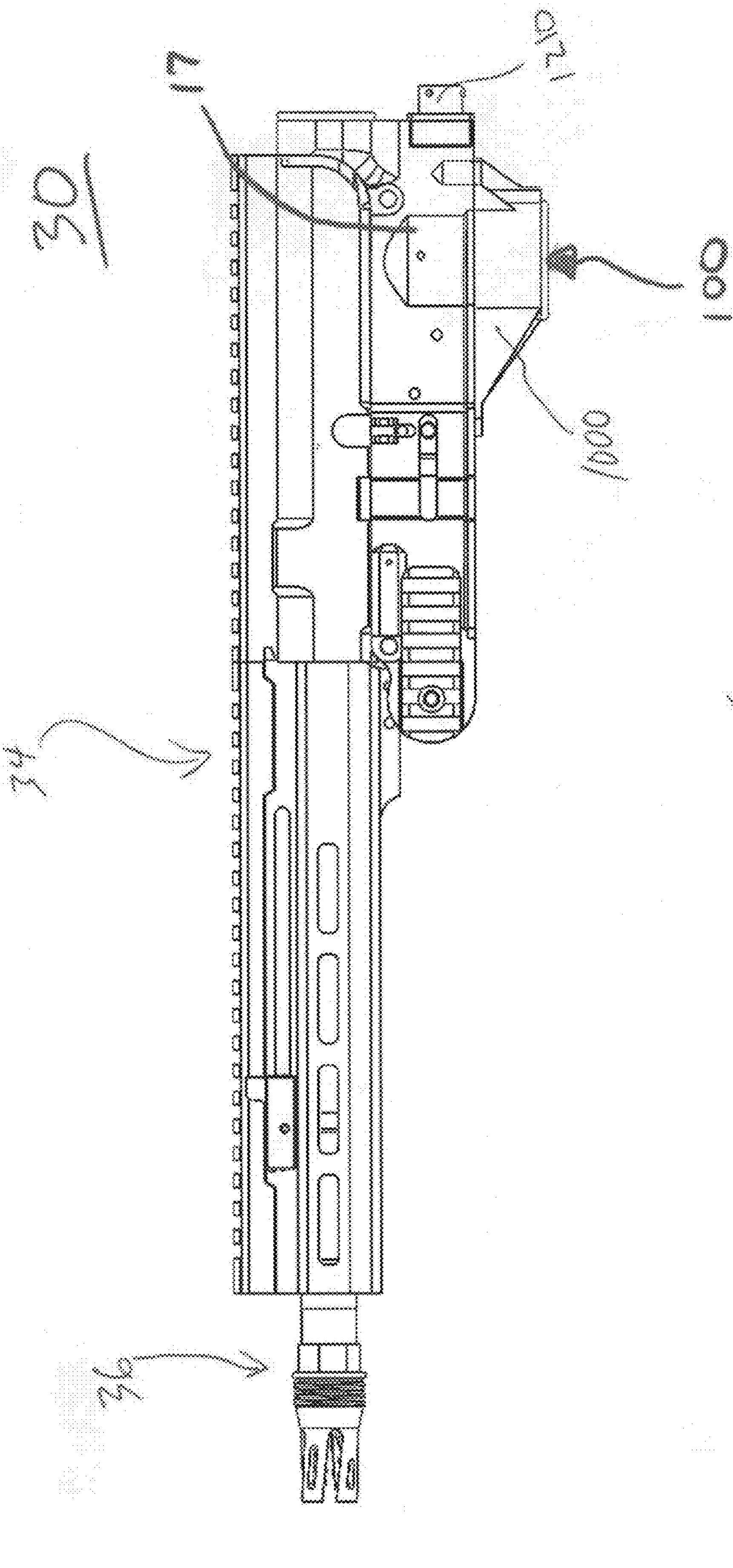
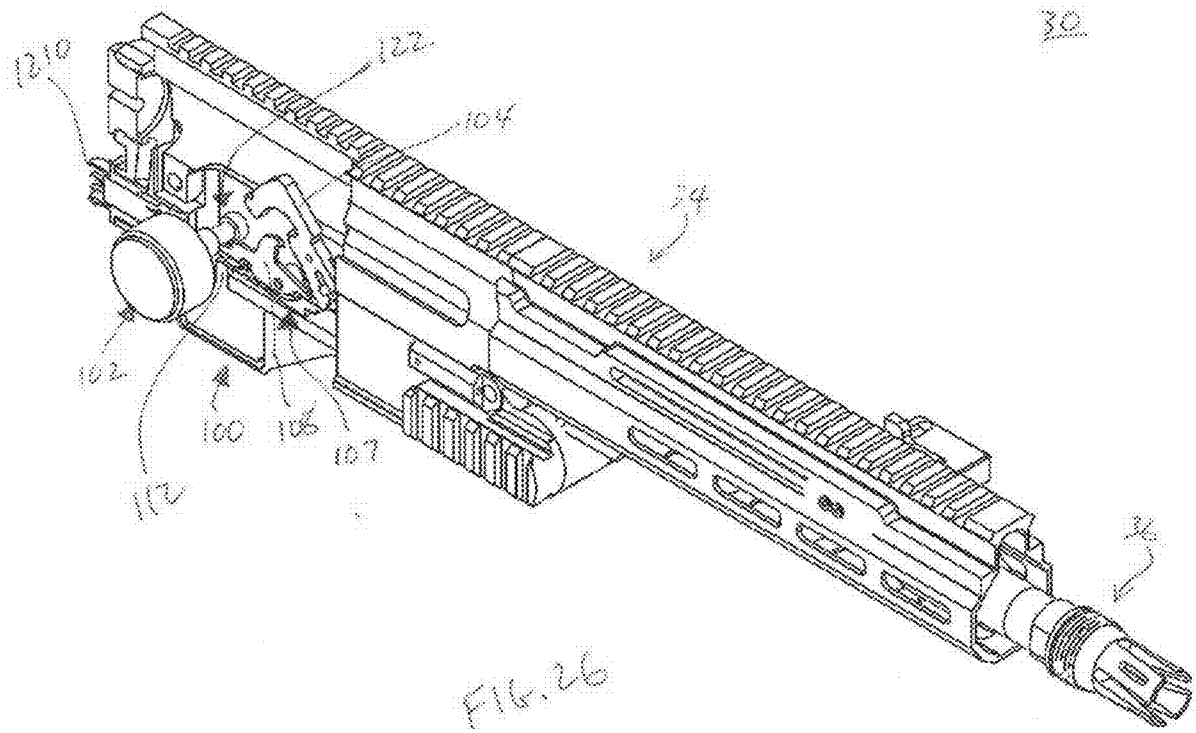


FIG. 25



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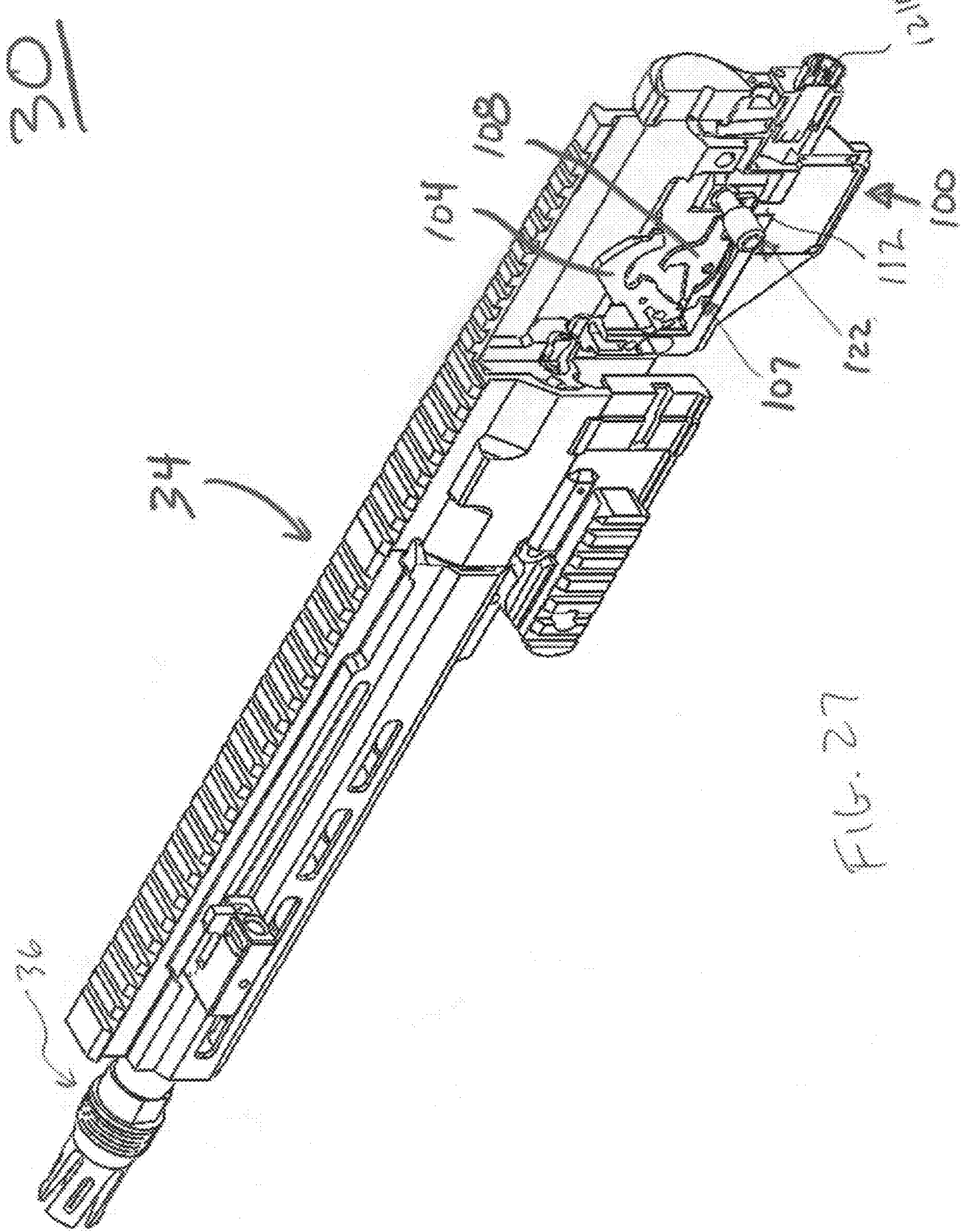


FIG. 27

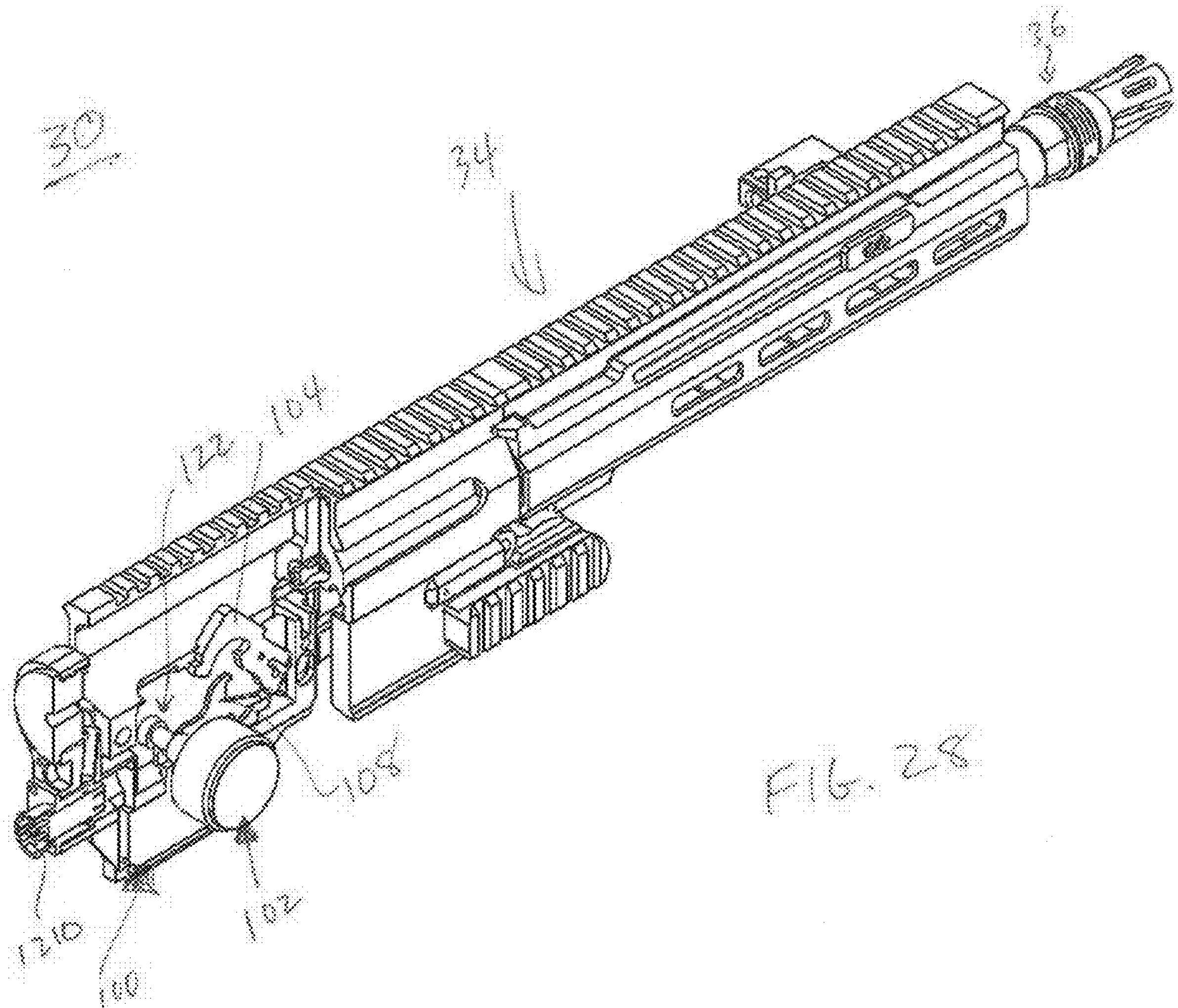


FIG. 28

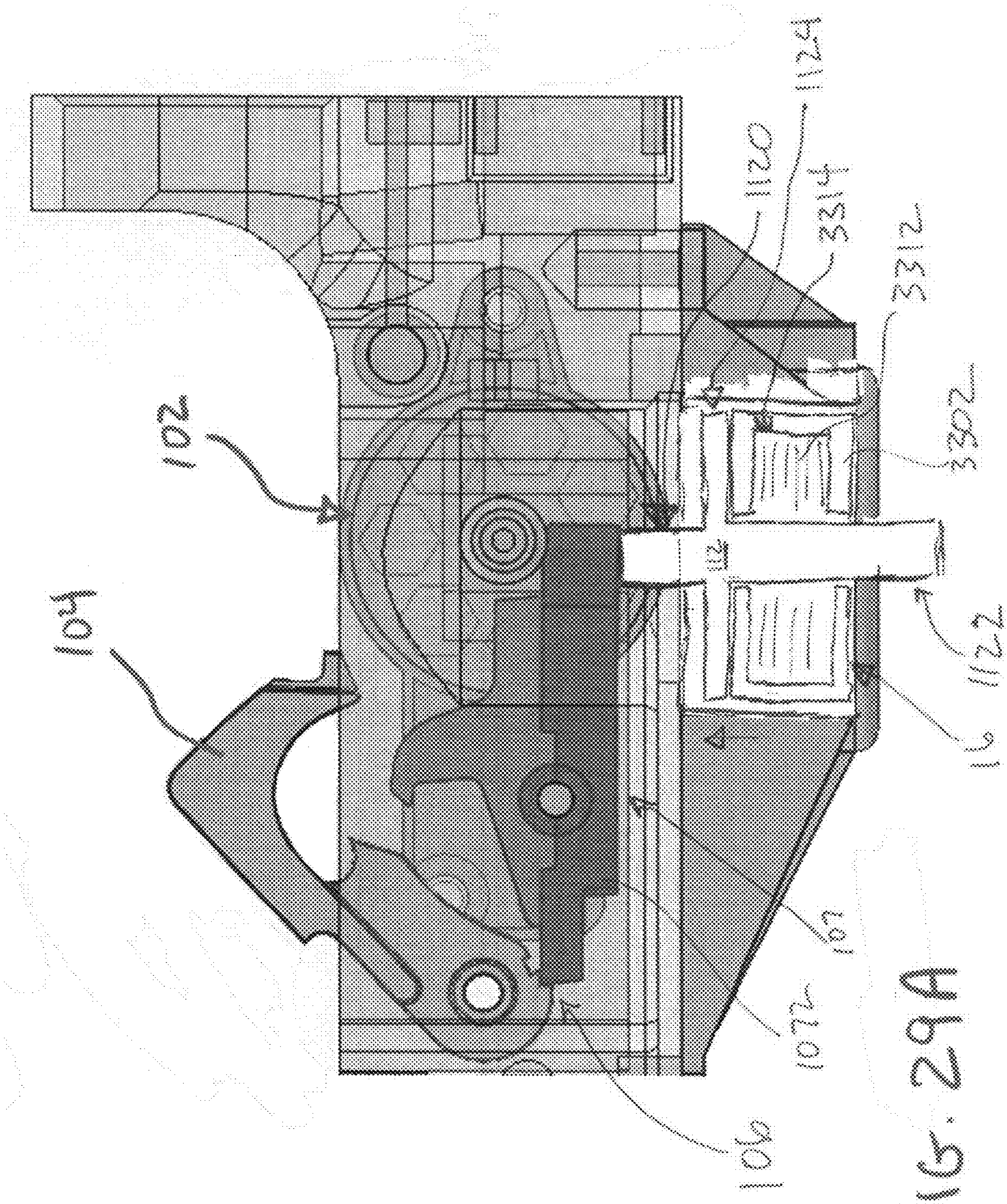


FIG. 29A

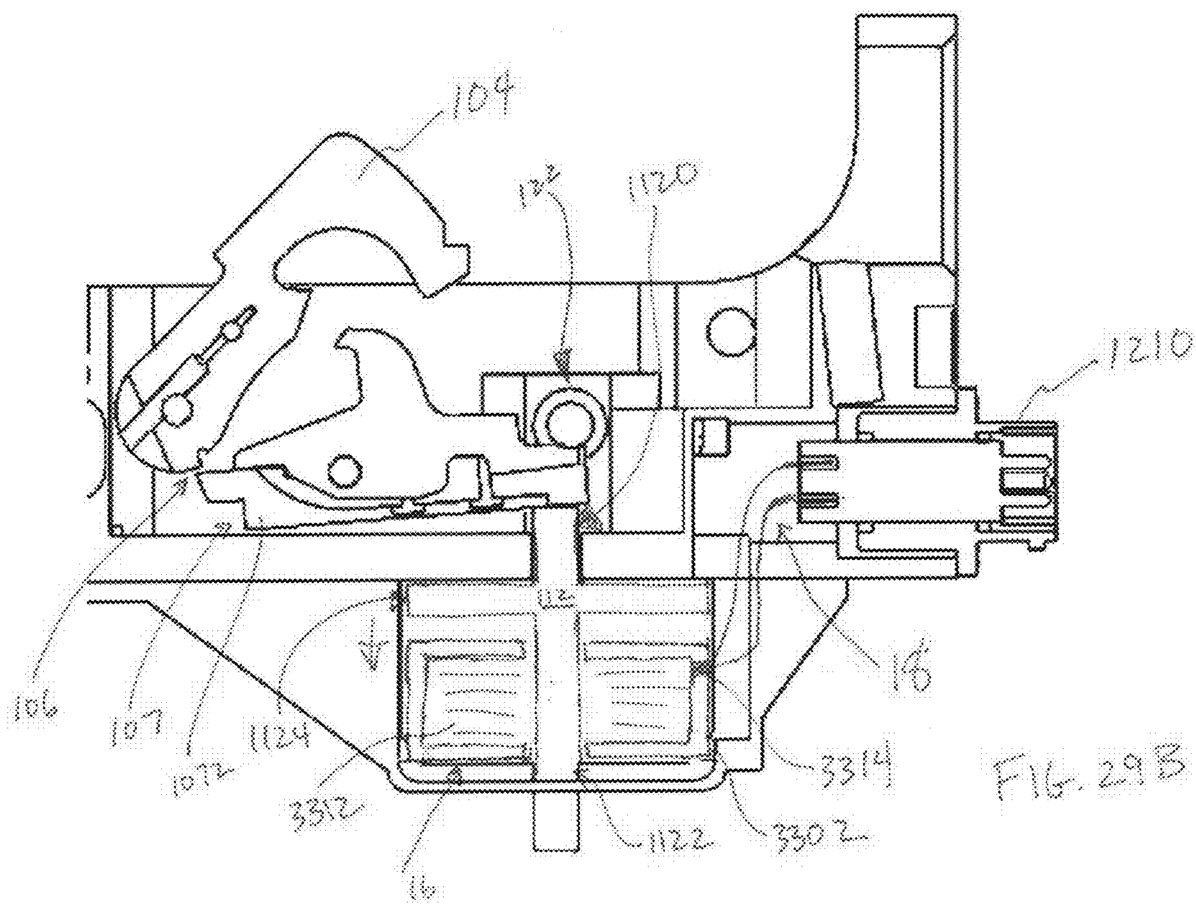
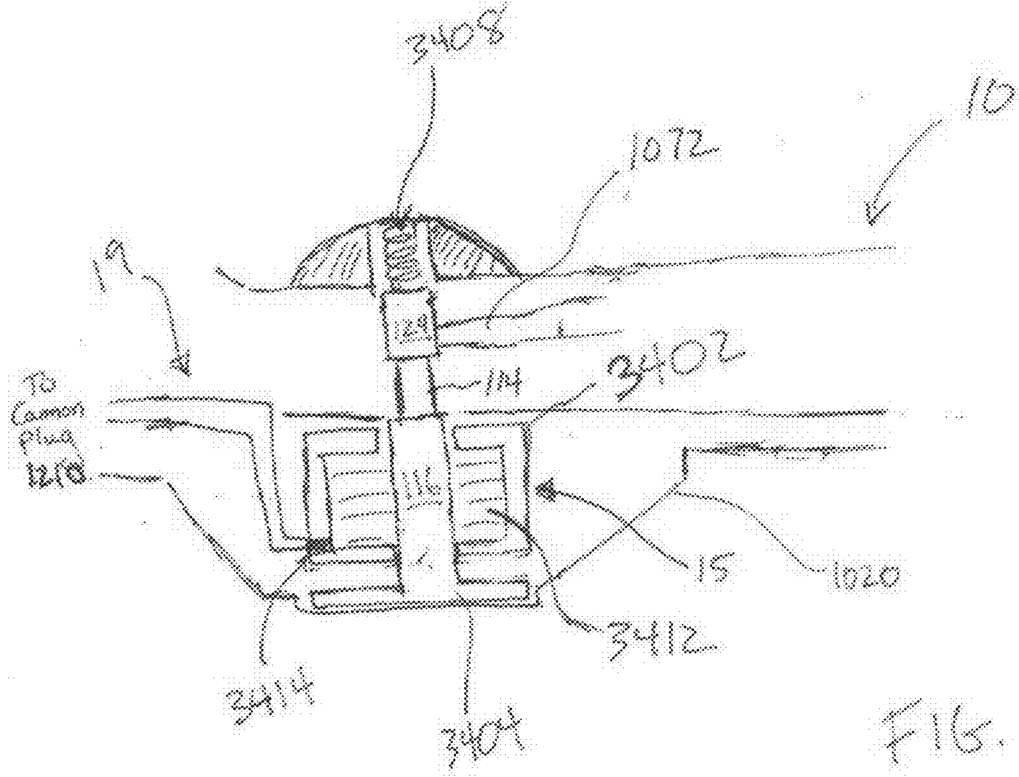


FIG. 29B


3408
10
1072
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To Cannon Plug 1210
114
3402
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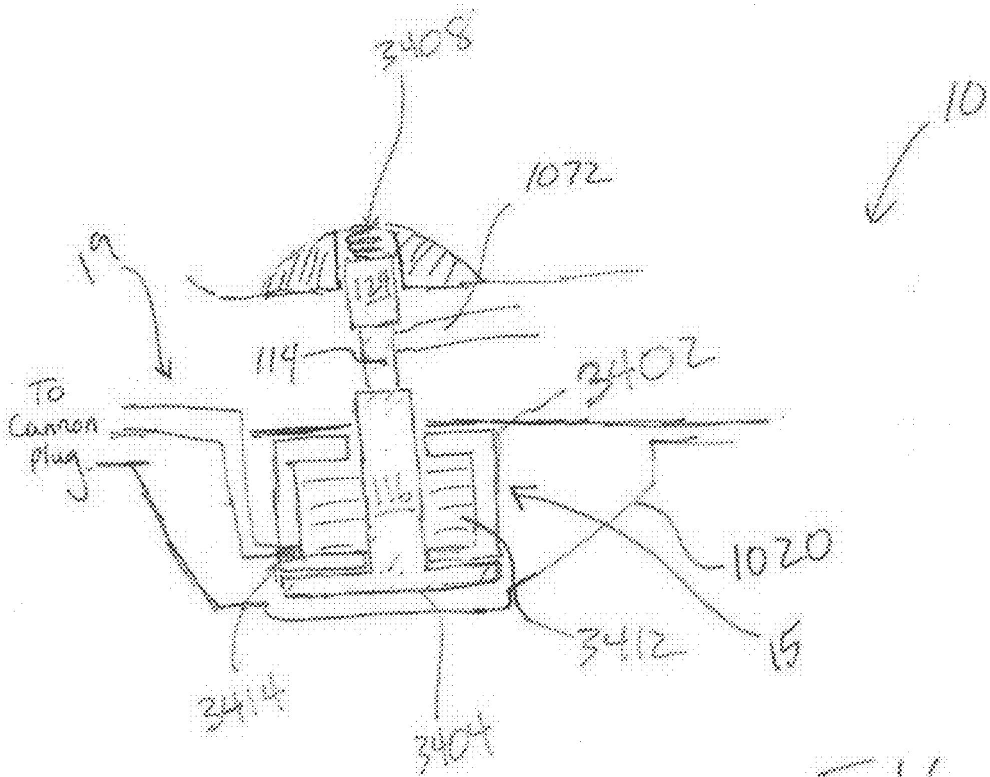
3404

FIG. 30A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3402
To
Cannon
Plug
116
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3414
3404

FIG. 30B

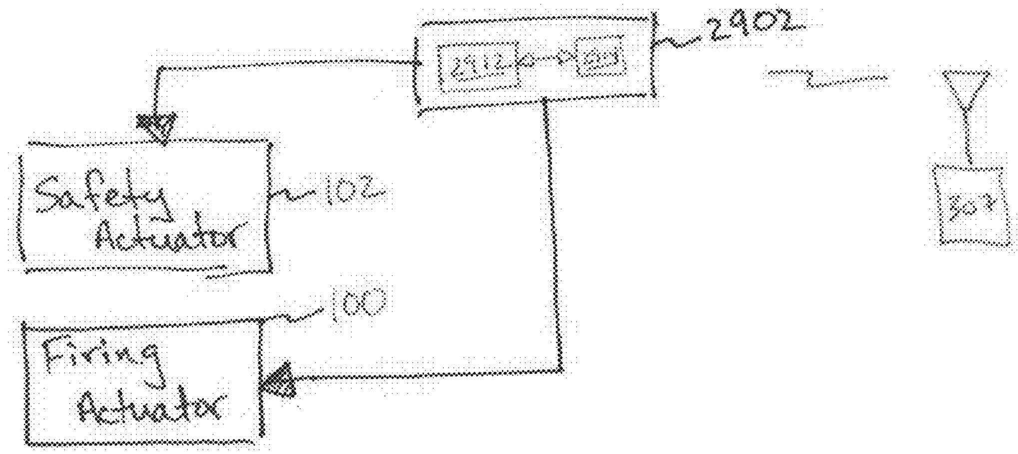

FIG 31

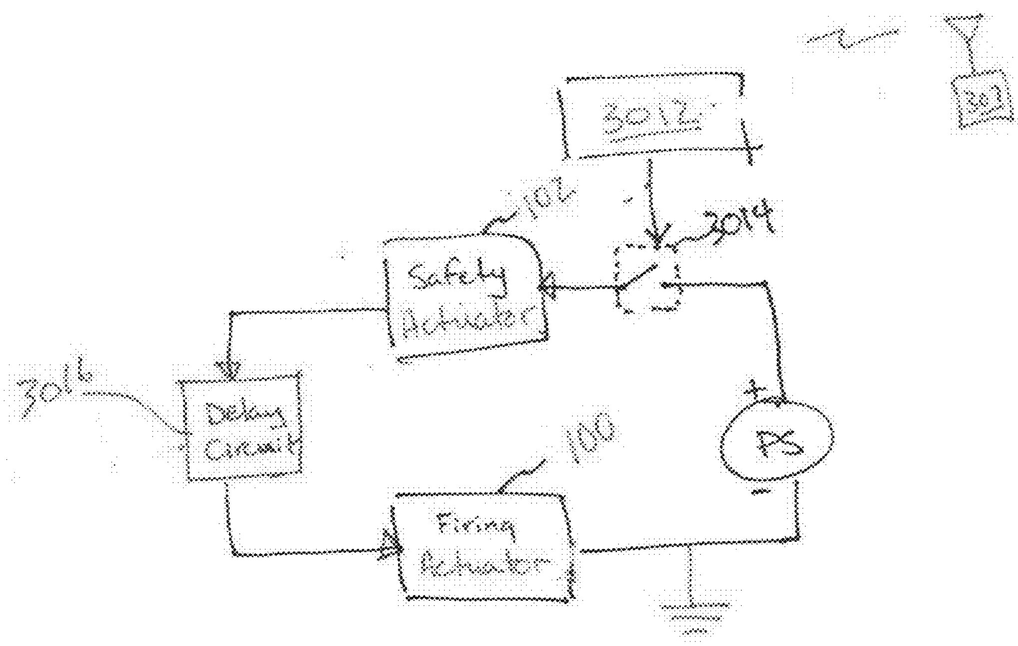
3012
302
102
3014
Safety Actuator
3016
Delay Circuit
100
PS
+
-
Firing Actuator

FIG. 52

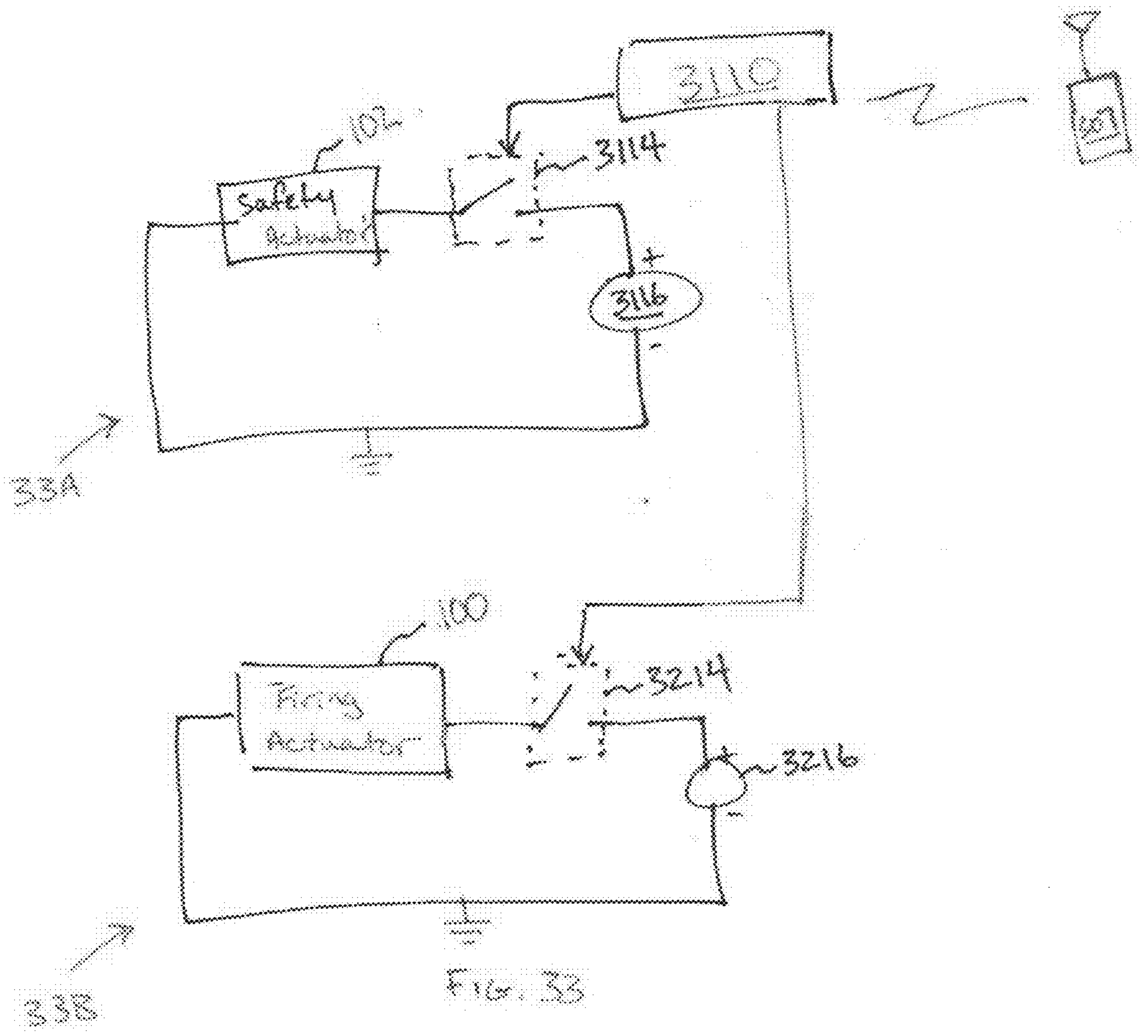
3110
102
Safety Actuator
3114
3116
33A
100
Firing Actuator
3214
3216
33B

FIG. 33

ELECTRONIC TRIGGER ASSEMBLIES, SYSTEMS, LOWER RECEIVERS AND FIREARMS INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority under 35 U.S.C. § 119(e) to provisional U.S. Patent Application No. 63/210,366, filed Jun. 14, 2021, the entire contents of which is incorporated herein by reference.

FIELD

[0002] One or more example embodiments provide electronic trigger assemblies, mechanisms, systems, firearms and/or autonomous weapons including the same, and/or methods of operating the same.

BACKGROUND

[0003] A trigger assembly actuates a firing sequence of a firearm. A conventional trigger assembly has a firearm trigger that can include levers or buttons actuated by the index finger of an adult user. A safety mechanism is used to prevent triggering of the firearm.

SUMMARY

[0004] One or more example embodiments provide an electronic trigger assembly that allows a firearm to be rendered inoperable without a control panel or other controller or control circuitry. In at least one example embodiment, both the safety actuator and the firing actuator must be energized to fire. Even if one attempts to remove the safety actuator, the firearm cannot fire due to the inability of being able to activate the firing actuator manually (e.g., by hand).

[0005] One or more example embodiments provide a lower receiver and/or electronic trigger assembly that may omit a trigger bow for manually actuating the trigger to fire the firearm. Consequently, the firearm may not be fired by manually actuating the trigger assembly.

[0006] One or more example embodiments provide a lower receiver and/or electronic trigger assembly having a safety mechanism that operates linearly in contrast to a conventional rotating safety.

[0007] One or more example embodiments provide a lower receiver and/or electronic trigger assembly that may omit a thumb paddle for actuating the safety mechanism.

[0008] One or more example embodiments may be utilized in conjunction with a single shot, semi-automatic or fully automatic rifle.

[0009] In at least one example embodiment, a safety actuator may be configured to actuate a safety mechanism (e.g., safety rod) to switch the firearm between the safe mode and the shot mode. In the safe mode, (the safety is 'ON'), the safety mechanism prevents upward movement and rotation of a trigger and sear assembly, thereby preventing the firearm from firing. When in the shot mode (the safety is OFF'), the safety mechanism is moved such that upward movement and rotation of the trigger and sear assembly is enabled and the firearm may be fired. The safety mechanism may be move linearly, rather than rotationally, between the safe mode and the shot mode.

[0010] A firing actuator may be configured to push the trigger and sear assembly upward to release the hammer and trigger firing of the firearm when in the shot mode. When the firearm is in the safe mode, upward movement of the trigger and sear assembly, and thus firing of the firearm, is prevented.

[0011] At least one example embodiment provides an electronic trigger assembly for a firearm. The electronic trigger assembly includes: a firing control mechanism configured to operate in a safe mode or a shot mode; a safety actuator configured to actuate a safety rod linearly in a first direction to switch the firing control mechanism between the safe mode and the shot mode; and a firing actuator configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode.

[0012] At least one other example embodiment provides an electronic trigger system including an electronic trigger assembly and control circuitry. The electronic trigger assembly includes: a firing control mechanism configured to operate in a safe mode or a shot mode; a safety actuator configured to actuate a safety rod linearly in a first direction to switch the firing control mechanism between the safe mode and the shot mode; and a firing actuator configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode. The control circuitry is configured to output electrical signals to control the safety actuator and the firing actuator.

[0013] At least one other example embodiment provides a lower receiver including an electronic trigger assembly arranged in a housing. The electronic trigger assembly includes: a firing control mechanism configured to operate in a safe mode or a shot mode; a safety actuator configured to actuate a safety rod linearly in a first direction to switch the firing control mechanism between the safe mode and the shot mode; and a firing actuator configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode.

[0014] At least one other example embodiment provides a firearm including: a lower receiver, an upper receiver attached to the lower receiver, and a barrel attached to the upper receiver. The lower receiver includes an electronic trigger assembly. The electronic trigger assembly includes: a firing control mechanism configured to operate in a safe mode or a shot mode; a safety actuator configured to actuate a safety rod linearly in a first direction to switch the firing control mechanism between the safe mode and the shot mode; and a firing actuator configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode.

[0015] At least one other example embodiment provides a lower receiver for a firearm. The lower receiver includes: a housing; a firing control mechanism arranged within the housing, the firing control mechanism configured to operate in a safe mode or a shot mode; a safety rod assembly arranged at least partially within the housing, the safety rod assembly including a safety rod and a safety spring, the safety rod extending across the housing of the lower receiver and the safety spring arranged between an end of the safety rod and a sidewall of the housing; a safety actuator configured to actuate the safety rod in a first direction against the bias of the safety spring to switch the firing control mechanism from the safe mode to the shot mode; and a firing actuator configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode.

[0016] At least one other example embodiment provides a firearm including a lower receiver, an upper receiver attached to the lower receiver, and a barrel attached to the upper receiver. The lower receiver includes: a housing; a firing control mechanism arranged within the housing, the firing control mechanism configured to operate in a safe mode or a shot mode; a safety rod assembly arranged at least partially within the housing, the safety rod assembly including a safety rod and a safety spring, the safety rod extending across the housing of the lower receiver and the safety spring arranged between an end of the safety rod and a sidewall of the housing; a safety actuator configured to actuate the safety rod in a first direction against the bias of the safety spring to switch the firing control mechanism from the safe mode to the shot mode; and a firing actuator configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode.

[0017] One or more example embodiments also provide corresponding methods of operation.

[0018] According to one or more example embodiments, the second direction may be substantially perpendicular to the first direction.

[0019] The safety actuator may be configured to actuate the safety rod in response to an electrical signal.

[0020] The safety actuator may include a safety solenoid configured to actuate the safety rod in response to an electrical signal. The safety solenoid may be a linear pull-type solenoid configured to push the safety rod in the first direction.

[0021] The safety rod may include: a safety plunger portion, an operational rod portion, and a solenoid plunger portion having a backplate portion. The safety plunger portion, the operational rod portion and the solenoid plunger portion may be arranged sequentially in a longitudinal direction of the safety rod, and the solenoid plunger portion may be configured to function as a moveable plunger of the safety solenoid.

[0022] The firing control mechanism may include a trigger and sear assembly and a disconnector. The disconnector may be secured in a groove of a trigger frame by a trigger pin, and the trigger and sear assembly may be configured to move in the second direction and rotate about the trigger pin. In the safe mode, the safety plunger portion may be positioned to prevent movement of the trigger and sear assembly in the second direction. The firing actuator may be configured to actuate the firing plunger in response to an electrical signal.

[0023] The firing actuator may include a firing solenoid configured to actuate the firing plunger in response to an electrical signal. The firing solenoid may be a linear push-type solenoid.

[0024] The firing control mechanism may not include one or more of a trigger bow or a thumb paddle for a safety mechanism of the firearm.

[0025] The firing control mechanism may include a trigger and sear assembly and a disconnector. The disconnector may be secured in a groove of a trigger frame by a trigger pin, and the trigger and sear assembly may be configured to rotate about the trigger pin. A surface of the firing plunger may contact a surface of the trigger and sear assembly, and the firing actuator may be configured to actuate the firing plunger linearly in the second direction to rotate the trigger and sear assembly to actuate the firing control mechanism.

[0026] The control circuitry may be configured to control the safety actuator and the firing actuator based on wired or wireless signals from a remote control device.

[0027] The firing control mechanism may be arranged within the housing of the lower receiver, the safety actuator may be fixed to a lateral side of the housing, and the firing actuator may be fixed to a lower surface of the housing.

[0028] According to one or more example embodiments, the lower receiver may include a housing. The firing control mechanism may be arranged within the housing, the safety actuator may be fixed to a lateral side of the housing, and the firing actuator may be fixed to a lower surface of the housing. At least one of the safety actuator and the firing actuator may be configured to be actuated in response to one or more electrical signals.

[0029] According to one or more example embodiments, the safety actuator may be fixed to a lateral side of the housing and/or the firing actuator may be fixed to a lower surface of the housing.

[0030] At least one example embodiment provides an electronic trigger assembly for a firearm. The electronic trigger assembly includes: means for operating in a safe mode or a shot mode; means for actuating a safety rod linearly in a first direction to switch the firing control mechanism between the safe mode and the shot mode; and means for actuating a firing plunger linearly in a second direction to actuate the means for operating when in the shot mode.

[0031] At least one other example embodiment provides an electronic trigger system including an electronic trigger assembly and control circuitry or means for controlling. The electronic trigger assembly includes: means for operating in a safe mode or a shot mode; means for actuating a safety rod linearly in a first direction to switch the means for operating between the safe mode and the shot mode; and means for actuating a firing plunger linearly in a second direction to actuate the means for operating in the shot mode. The control circuitry is configured to output electrical signals to control the safety actuator and the firing actuator.

[0032] At least one other example embodiment provides a lower receiver including an electronic trigger assembly arranged in a housing. The electronic trigger assembly includes: means for operating in a safe mode or a shot mode; means for actuating a safety rod linearly in a first direction to switch the means for operating between the safe mode and the shot mode; means for actuating a firing plunger linearly in a second direction to actuate the means for operating in the shot mode.

[0033] At least one other example embodiment provides a firearm including: a lower receiver, an upper receiver attached to the lower receiver, and a barrel attached to the upper receiver. The lower receiver includes an electronic trigger assembly. The electronic trigger assembly includes: means for operating in a safe mode or a shot mode; means for actuating a safety rod linearly in a first direction to switch the means for operating between the safe mode and the shot mode; and means for actuating a firing plunger linearly in a second direction to actuate the means for operating in the shot mode.

[0034] At least one other example embodiment provides a lower receiver for a firearm. The lower receiver includes: a housing; means for operating in a safe mode or a shot mode, the means for operating arranged within the housing; a safety rod assembly arranged at least partially within the housing, the safety rod assembly including a safety rod and a safety spring, the safety rod extending across the housing of the lower receiver and the safety spring arranged between an end of the safety rod and a sidewall of the housing; means for actuating the safety rod in a first direction against the bias of the safety spring to switch the means for operating from the safe mode to the shot mode; and means for actuating a firing plunger linearly in a second direction to actuate the means for operating in the shot mode.

[0035] At least one other example embodiment provides a firearm including a lower receiver, an upper receiver attached to the lower receiver, and a barrel attached to the upper receiver. The lower receiver includes: a housing; means for operating in a safe mode or a shot mode, the means for operating arranged within the housing; a safety rod assembly arranged at least partially within the housing, the safety rod assembly including a safety rod and a safety spring, the safety rod extending across the housing of the lower receiver and the safety spring arranged between an end of the safety rod and a sidewall of the housing; means for actuating the safety rod in a first direction against the bias of the safety spring to switch the means for operating from the safe mode to the shot mode; and means for actuating a firing plunger linearly in a second direction to actuate the means for operating in the shot mode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The various features and advantages of the non-limiting example embodiments described herein may become more apparent upon review of the detailed description in conjunction with the accompanying drawings. The accompanying drawings are merely provided for illustrative purposes and should not be interpreted to limit the scope of the claims. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted. For purposes of clarity, various dimensions of the drawings may have been exaggerated.

[0037] FIG. **1** is a front-right perspective view of a lower receiver, including an electronic trigger assembly, according to example embodiments.

[0038] FIG. **2** is another front-right perspective view of the lower receiver shown in FIG. **1**.

[0039] FIG. **3** is a front-left perspective view of the lower receiver shown in FIG. **1**.

[0040] FIG. **4** is a top plan view of the lower receiver shown in FIG. **1**.

[0041] FIG. **5** is a bottom plan view of the lower receiver shown in FIG. **1**.

[0042] FIG. **6** is an elevational view of the first side of the lower receiver shown in FIG. **1**.

[0043] FIG. **7** is an elevational view of the second side of the lower receiver shown in FIG. **1**.

[0044] FIG. **8** is another elevational view of the second side of the lower receiver shown in FIG. **1**.

[0045] FIG. **9** is another front-left perspective view of the lower receiver shown in FIG. **1**

[0046] FIG. **10** is another front-right perspective view of the lower receiver shown in FIG. **1**.

[0047] FIG. **11** is a cross-section of the front-left perspective of the lower receiver shown in FIG. **10**.

[0048] FIG. **12** is another top plan view of the lower receiver shown in FIG. **1**.

[0049] FIG. **13** is another bottom plan view of the lower receiver shown in FIG. **1**.

[0050] FIG. **14** is another elevational view of the first side of the lower receiver shown in FIG. **1**.

[0051] FIG. **15** is another elevational view of the second side of the lower receiver shown in FIG. **1**.

[0052] FIG. **16** is a cross-section of the side view shown in FIG. **15**.

[0053] FIG. **17** is an elevational view of a first side of an example embodiment of a firearm including an electronic trigger assembly, with a portion of the first side of the lower receiver removed.

[0054] FIG. **18** is a rear elevational view of the firearm shown in FIG. **17**.

[0055] FIG. **19** is a front-left perspective view of the firearm shown in FIG. **17**.

[0056] FIG. **20** is a front-right perspective view of the firearm shown in FIG. **17**.

[0057] FIG. **21** is an elevational view of a second side of the firearm shown in FIG. **17** with a portion of the second side of the lower receiver removed.

[0058] FIG. **22** is a front-right perspective view of the firearm shown in FIG. **17** with a portion of the second side of the lower receiver removed.

[0059] FIG. **23** is a front elevational view of the firearm shown in FIG. **17**.

[0060] FIG. **24** is an elevational view of the first side of the firearm shown in FIG. **17**.

[0061] FIG. **25** is an elevational view of the second side of the firearm shown in FIG. **17**.

[0062] FIG. **26** is a front-left perspective view of the firearm shown in FIG. **17** with an actuator cover and a portion of the lower receiver removed.

[0063] FIG. **27** is a rear-left perspective view of the firearm shown in FIG. **17** with a portion of the second side of the lower receiver removed.

[0064] FIG. **28** is a rear-right perspective view of the firearm shown in FIG. **17** with a portion of the first side of the lower receiver removed.

[0065] FIGS. **29**A and **29**B illustrate elevational views of a portion of a lower receiver including a firing actuator according to one or more example embodiments.

[0066] FIGS. **30**A and **30**B illustrate top plan views of a portion of a lower receiver including a safety actuator according to one or more example embodiments.

[0067] FIG. **31** is a block diagram illustrating an electronic trigger system according to one or more example embodiments.

[0068] FIG. **32** is a block diagram illustrating another electronic trigger system according to one or more example embodiments.

[0069] FIG. **33** is a block diagram illustrating yet another electronic trigger system according to one or more example embodiments.

DETAILED DESCRIPTION

[0070] One or more example embodiments provide electronic trigger assemblies, electronic trigger systems, firearms and/or autonomous weapons including the same, and/or methods of operating the same.

[0071] According to one or more example embodiments, the electronic trigger assemblies, systems and/or firearms may be adapted and/or configured to be utilized in conjunction with multiple aerial, sea, and/or ground vehicles or autonomous platforms.

[0072] Example embodiments may be adapted to multiple caliber and platforms of upper receiver groups. Consequently, example embodiments may be modular to current readily available, or future developed, upper receivers of firearms. For example, electronic trigger assemblies and/or systems may be utilized in conjunction with single shot and/or automatic firearms capable of automatic or semiautomatic fire. In at least one example, one or more example embodiments may be utilized in conjunction with a rifle or carbine with a direct gas impingement operating system, such as the M4 or M16 rifles and their associated variants (sometimes referred to herein as the M4 platform). In this regard, electronic trigger assemblies, according to one or more example embodiments, may replace conventional manual trigger assemblies (e.g., both single shot, semi-automatic and fully automatic assemblies).

[0073] Electronic trigger assemblies and/or electronic trigger systems, according to one or more example embodiments, may also be adapted and/or configured to be utilized in conjunction with multiple targeting and/or gimble systems.

[0074] According to at least some example embodiments, an electronic trigger assembly includes actuating mechanisms and a modified trigger. In at least one example, the actuating mechanisms may include linear actuators (e.g., linear solenoids).

[0075] An electronic trigger system may include an electronic trigger assembly and associated control circuitry or system. The control circuitry may include a controller (e.g., microcontroller or the like) and/or a transceiver configured to receive control commands from a remote location.

[0076] According to at least one example embodiment, with regard to the M4 platform, for example, a side mounted linear solenoid actuator (safety actuator) may actuate the safing mechanism (safety) for the trigger according to an electrical signal and mechanical spring tension. A lower (or bottom) solenoid actuator (firing actuator) may actuate (e.g., extend, retract, or otherwise move linearly) a firing plunger arranged perpendicular to the longitudinal axis of the trigger frame, such that the firing plunger applies upward pressure to the rear of the modified trigger moving the trigger into the firing position and releasing the disconnect and hammer. When electrical current is not present (the solenoid actuators are de-energized), the safety and firing actuators return to their respective safe states through mechanical spring force.

[0077] According to one or more example embodiments, an electronic trigger assembly, and/or lower receiver including the same, may have a cohesive mounting system that is interchangeable during manufacture to couple the electronic trigger assembly and/or lower receiver with multiple targeting or third-party mounting systems depending on application. The mounting systems may be monolithically integrated to add structural integrity to the receiver mounting system.

[0078] Wiring for the actuating mechanisms (e.g., firing and/or safety actuators) may be integral to the lower receiver and may terminate at, for example, an end user defined quick disconnect 4-pin plug (e.g., a cannon plug). An external power supply and/or control circuitry may be connected to the actuating mechanisms via the 4-pin plug.

[0079] According to at least some example embodiments, each actuation of the firing actuator may cause the firearm to fire a chambered round. The cyclic rate of fire may be adjusted by controlling the electrical signal input to the firing actuator (e.g., the linear solenoid) to increase and/or decrease the rate of fire or round count. In one example, the cyclic rate of fire may be controlled by controlling the duty cycle of the electrical signal via a switch, switching circuit or the like. The cyclic rate of fire may be similar, substantially similar, or even greater than a cyclic rate of fire for a fully automatic rifle (e.g., in excess of about 550 rounds per minute). In at least one example, the cyclic rate of fire may be between about 1 and 700 rounds per minute or more.

[0080] FIGS. **1-16** are various views of a lower receiver of a firearm, including an electronic trigger assembly, according to example embodiments. The lower receiver shown in FIGS. **1-16** is configured to be utilized in conjunction with the M4 platform and its associated variants. For example purposes, example embodiments will be described with regard to this example. However, example embodiments should not be limited to this example. Rather, as discussed above, electronic trigger assemblies and/or systems, according to one or more example embodiments, may be utilized in conjunction with other rifles or carbines with direct gas impingement or other operating systems.

[0081] Referring to FIGS. **1-16**, a lower receiver **10** includes a lower receiver housing **11** configured to house, among other things, a fire control mechanism **20** at a central portion of the lower receiver **10** behind a bolt catch recess **1180** for a bolt catch **118** and a magazine well **12**. The fire control mechanism **20** includes, for example, a hammer **104**, hammer spring (not shown), a trigger and sear assembly **107**, disconnector **108**, a safety rod assembly, a safety actuator **102** (sometimes referred to herein as a side or lateral actuator) and a firing actuator **100** (sometimes referred to herein as a bottom or lower actuator).

[0082] The trigger and sear assembly **107** is pivotally secured within the lower receiver **10** by a trigger pin **1070**. The hammer **104** is pivotally secured within the lower receiver **10** by a hammer pin **120**.

[0083] The trigger and sear assembly **107** includes a trigger frame **1072** having a longitudinally elongated shape. In at least this example embodiment, the trigger frame **1072** does not include a trigger bow. The trigger frame **1072** has a groove in which the disconnector **108** is arranged and seated. When assembled, the disconnector **108** is secured within the groove **1074** by the trigger pin **1070**. Tension of a trigger spring (not shown) presses the bottom or lower surface of the trigger frame **1072** against an upper surface of a firing plunger **112**. As will be discussed in more detail later, the force of the trigger spring maintains the firing plunger **112** in the unfired position until actuated by the firing actuator **100**.

[0084] The safety rod assembly includes a safety rod **122** and a safety spring **3408** and may be arranged at least partially within the housing **11** of the lower receiver **10**. The safety rod **122** extends across the lower receiver **10** in a direction perpendicular to the longitudinal axis of the trigger frame **1072** and the lower receiver **10**. In the example embodiment shown in FIGS. **1-16**, the safety rod **122** is a cylindrical rod assembly having multiple different diameters in the longitudinal direction of the safety rod **122**. As shown in FIG. **4**, for example, the safety rod **122** may include an operational rod portion **114** (also sometimes referred to as an operational rod or op-rod), a solenoid plunger portion **116** and a safety plunger portion **124**. The operational rod portion **114** has a diameter that is less than the solenoid plunger portion **116** and the safety plunger portion **124**. The solenoid plunger portion **116** and the safety plunger portion **124** may have the same or different diameters. As also shown in FIG. **4**, for example, the safety spring **3408** and the safety plunger portion **124** are positioned at least partially within a cavity formed at the second side in the rounded side portion **17** toward the rear of the lower receiver **10**.

[0085] The safety rod **122** is configured to move in a direction perpendicular to the longitudinal axis of the lower receiver **10** to switch between safe mode and shot mode.

[0086] When in the shot mode (e.g., when the safety actuator **102** is energized), the safety rod **122** is pushed (e.g., via the safety actuator **102**) against the force of the safety spring **3408** and toward the second side of the lower receiver **10** (toward the safety spring **3408** and away from the safety actuator **102**). The movement of the safety rod **122** exposes the operational rod portion **114** above the trigger frame **1072** (e.g., as shown in FIG. **4**) enabling the firing plunger **112** to rotate the trigger and sear assembly **107** about the trigger pin **1070** to release the hammer **104** from the sear **106** and cause the firearm to fire a chambered round.

[0087] When in the safe mode (e.g., when the safety actuator **102** is de-energized), the force of the safety spring **3408** pushes and biases the safety rod **122** axially toward the first side of the lower receiver **10** (toward the safety actuator **102**). The movement of the safety rod **122** positions the safety plunger portion **124** above the trigger frame **1072** preventing upward movement and rotation of the trigger and sear assembly **107**, which prevents release of the hammer **104** from the sear **106**.

[0088] The firing actuator **100** may include a linear solenoid seated or arranged in a firing actuator housing **1000** (also referred to as a firing solenoid housing), which is fixed (either removably or permanently) to the bottom or lower surface of the housing **11** of the lower receiver **10** via one or more firing actuator housing fasteners **1002**. In the example embodiment shown in FIGS. **1-16**, the firing actuator housing **1000** is fixed via four safety actuator housing fasteners **1002**. However, example embodiments should not be limited to this example. The firing actuator housing fasteners **1002** may be screws, rivets, bolts, or other fasteners suitable to permanently or removably fix the firing actuator housing **1000** to the lower receiver **10**.

[0089] When in the shot mode, the firing actuator **100** moves the firing plunger **112** to push the bottom side of the trigger frame **1072** toward the operational rod portion **114** (e.g., upward or vertically) causing the trigger frame **1072** to rotate around the trigger pin **1070**. As the trigger frame **1072** rotates, the hammer **104** is released from the sear **106** to fire a chambered round.

[0090] The safety rod **122** may be actuated or moved by the safety actuator **102** arranged on the lateral side of the lower receiver **10**. In the example embodiment shown in FIGS. **1-16**, the safety actuator **102** may include a linear solenoid seated or arranged in a safety actuator housing **1020** (also referred to as a safety solenoid housing), which is fixed (either removably or permanently) to a lateral sidewall of the housing **11** of the lower receiver **10** via one or more safety actuator housing fasteners **1022**. In the example embodiment shown in FIGS. **1-16**, the safety actuator housing **1020** is fixed via three safety actuator housing fasteners **1022**. However, example embodiments should not be limited to this example. The safety actuator housing fasteners **1022** may be screws, rivets, bolts, or other fasteners suitable to permanently or removably fix the safety actuator housing **1020** to the lower receiver **10**.

[0091] As discussed in more detail later, when implemented with a linear solenoid, the solenoid plunger portion **116** of the safety rod **122** may function as the movable solenoid plunger for the linear solenoid. Consequently, at least the solenoid plunger portion **116** may be formed of a ferromagnetic material. Alternatively, the safety rod **122** may be formed entirely of a ferromagnetic material. The safety rod **122** may pass through the linear solenoid and then into the lower receiver **10** through a hole (not shown) in the first side of the lower receiver **10**.

[0092] An example embodiment of the safety actuator **102** will now be described. For example purposes, the safety actuator **102** will be discussed with regard to a linear solenoid actuator, and more particularly, a linear pull-type solenoid (sometimes referred to herein as the safety solenoid). However, example embodiments should not be limited to this example. Rather, other suitable linear and/or electronic actuators may be used. For example, suitable (e.g., rod-style) servo actuators, push-type solenoid actuators, pneumatic or hydraulic actuators, piston actuators (e.g., electro-mechanical, pneumatic, or hydraulic) may be used.

[0093] FIGS. **30**A and **30**B illustrate top plan views of a portion of the lower receiver **10** including the safety actuator **102** and safety rod **122** according to example embodiments.

[0094] FIG. **30**A illustrates the safety actuator **102** and safety rod **122** in the safe mode or rest position (when the safety actuator and solenoid are de-energized), whereas FIG. **30**B illustrates the safety actuator **102** when in the shot mode (when the safety actuator and solenoid are energized).

[0095] Referring to FIGS. **30**A and **30**B, as mentioned above, the safety rod **122** includes the safety plunger portion **124**, the operational rod portion **114** and the solenoid plunger portion **116**. In this example, the solenoid plunger portion **116** has a backplate portion **3404** such that the solenoid plunger portion **116** has an upside-down T-shape. In one example, the safety plunger portion **124**, the operational rod portion **114** and the solenoid plunger portion **116** may be formed integrally. In another example, one or more of these elements may be a discrete component fixed to the others. In the plan view, the safety solenoid **15** may have a cylindrical shape, and the backplate portion **3404** may have a circular, or substantially circular shape, which is similar, or substantially similar, to the surface shape of the safety solenoid **15**.

[0096] The safety actuator **102** includes a safety solenoid **15**.

[0097] The safety solenoid **15** includes a coil winding **3412** within a housing **3402**. The housing **3402** has openings at opposite ends to accommodate inserting of the safety rod **122** there through. The coil winding **3412** is wound helically around the solenoid plunger portion **116**, which is positioned along a central axis of the coil winding **3412** and the housing **3402**.

[0098] The coil winding **3412** is connected to a power supply (not shown in FIG. **30**A) via an electrical connection **3414**, internal wiring **19** through the lower receiver **10** and cannon plug **1210**.

[0099] When de-energized, as shown in FIG. **30**A, the spring tension of the safety spring **3408** presses the outer surface of the backplate portion **3404** against the inner surface of the safety actuator housing **1020** to maintain the safety rod **122** in the safe mode where the safety plunger portion **124** is positioned above the trigger frame **1072**.

[0100] As shown in FIG. **30**B, when power is applied to the safety actuator **102** and electrical current passes through the coil windings **3412** to energize the safety solenoid **15**, the resultant magnetic flux pulls the backplate portion **3404** towards the outer surface of the housing **3402** (away from the inner surface of the safety actuator housing **1020**), thereby pushing against the safety spring **3408** to move the safety rod **122** into the shot mode where the operational rod portion **114** is positioned above the trigger frame **1072**. When the electrical current is interrupted (application of power to the safety actuator **102** is stopped) and the safety solenoid **15** is de-energized, the spring tension of the safety spring **3408** returns the safety rod **122** to the safe mode as shown in FIG. **30**A.

[0101] As will be discussed in more detail below, actuation of the safety actuator **102** and/or energizing and de-energizing of the safety solenoid **15** may be controlled by control circuitry.

[0102] An example embodiment of the firing actuator **100** will now be described. As with the safety actuator **102**, for example purposes, the firing actuator **100** will be discussed with regard to a linear solenoid actuator (also referred to as a firing solenoid), and more particularly, a linear push-type solenoid. However, example embodiments should not be limited to this example. Rather, other suitable linear and/or electronic actuators may be used. For example, suitable (e.g., rod-style) servo actuators, push-type solenoid actuators, pneumatic or hydraulic actuators, piston actuators (e.g., electro-mechanical, pneumatic, or hydraulic) may be used.

[0103] FIGS. **29**A and **29**B illustrate cross-sectional views of a portion of the lower receiver **10** including the firing actuator **100** according to one or more example embodiments.

[0104] FIG. **29**A illustrates the firing actuator **100** in the unfired or rest position (when the firing solenoid is de-energized), whereas FIG. **29**B illustrates the firing actuator **100** when fired (when the firing solenoid is energized).

[0105] Referring to FIGS. **29**A and **29**B, the firing actuator **100** includes a firing solenoid **16** and the firing plunger **112**. In this example, the firing solenoid **16** a push-type linear solenoid, which may have a cylindrical shape. The firing plunger **112** has a t-shape, including a lower solenoid plunger portion **1122**, a middle stopper portion **1124** and an upper firing plunger portion **1120**. The elements of the firing plunger **112** may include one or more separate, discrete components fixed to one another, or may be a single integral piece. The length of the lower solenoid plunger portion **1122** may be greater than a length of the upper firing plunger portion **1120**. In the plan view, the middle stopper portion **1124** may have a circular, or substantially circular shape, which is similar, or substantially similar, to the surface shape of the firing solenoid **16**.

[0106] The firing solenoid **16** includes a coil winding **3312** within a housing **3302**. The housing **3302** has openings on opposite ends to accommodate inserting of the firing plunger **112** there through. The coil winding **3312** is wound helically around the lower solenoid plunger portion **1122**, which is positioned along a central axis of coil winding **3312** and the housing **3302**.

[0107] When power is not applied to the firing actuator **100** and the firing solenoid **16** is de-energized, the middle stopper portion **1124** rests on the upper surface of the housing **3302**.

[0108] The upper surface of the upper firing plunger portion **1120** contacts the bottom surface of the trigger frame **1072**. According to at least this example embodiment, the firing solenoid **16** does not include a separate spring within or outside the housing **3302**. Rather, as mentioned above, the tension of the trigger spring holds the bottom surface of the trigger frame **1072** against the upper surface of the upper firing plunger portion **1120**, such that the firing plunger **112** remains in the rest (or down) position until the firing solenoid **16** is energized. Additionally, the force of the trigger spring acts on the upper surface of the upper firing plunger portion **1120** to return the firing plunger **112** to the rest position when the firing solenoid **16** is de-energized (e.g., after firing).

[0109] The coil winding **3312** may be connected to a power supply (e.g., an external power supply) (not shown in FIGS. **29**A and **29**B) via an electrical connection **3314**, internal wiring **18** through the lower receiver **10** and the cannon plug **1210**.

[0110] As shown in FIG. **29**B, when power is applied to the firing actuator **100** and electrical current passes through the coil windings **3312** to energize the firing solenoid **16**, the resultant magnetic flux pushes the firing plunger **112** upward to rotate the trigger frame **1072** about the trigger pin **1070**, which in turn disengages the surface of the sear **106** and releases the hammer **104** to fire a chambered round. The middle stopper portion **1124** contacts the bottom surface of the lower receiver **10** to limit the upward movement of the firing plunger **112**. When the electrical current to the coil windings **3312** is interrupted, the spring tension of the trigger spring returns the firing plunger **112** to the rest position as shown in FIG. **29**A.

[0111] As will be discussed in more detail later, actuation of the firing actuator **100** and/or energizing and de-energizing of the firing solenoid **16** may be controlled control circuitry.

[0112] FIG. **31** is a block diagram illustrating an electronic trigger system according to one or more example embodiments.

[0113] Referring to FIG. **31**, the electronic trigger system includes control circuitry **2902** electrically connected to each of the safety actuator **102** and the firing actuator **100**. The control circuitry **2902** may include a controller **2912** and/or a communications interface (or transceiver device) **2914**. The control circuitry **2902** may be configured to output electrical signals to control the safety actuator **102** and/or the firing actuator **100**. The control circuitry **2902** may also be configured for two-way communication with a remote device **307** (also referred to as a remote control device) such as a satellite communications device, a terrestrial mobile transceiver, mobile phone, laptop computer, tablet, combination thereof, or any other electronic device capable of wireless or wired communication with the control circuitry **2902**. According to one or more example embodiments, the remote device **307** may send commands to remotely control the electronic trigger assembly (e.g., to fire the firearm) via a wired or wireless connection to the control circuitry **2902**. The control circuitry **2902** may be integrated within, or attached to, the firearm. Alternatively, the control circuitry **2902** may be arranged on a device or apparatus on which the firearm is mounted (e.g., an unmanned aerial vehicle, land vehicle, etc.).

[0114] The controller **2912** may include processing circuitry such as hardware including logic circuits; a hardware/software combination such as a processor executing software; or a combination thereof. For example, the processing circuitry more specifically may include, but is not limited to, a central processing unit (CPU), an arithmetic logic unit

(ALU), a digital signal processor, a microcomputer, a field programmable gate array (FPGA), a System-on-Chip (SoC), a programmable logic unit, a microprocessor, application-specific integrated circuit (ASIC), etc.

[0115] The communications interface **2914** may be configured for terrestrial and/or satellite-based communication between the control circuitry **2902** and a remote device **307**. Example terrestrial wireless communications interfaces may include, but are not limited to, a Bluetooth chip, ZigBee device, RFID circuitry, Li-Fi communication circuitry, an NFC-enabled chip configured for NFC communication, enhanced Wi-Fi or Bluetooth communication where NFC is used for link setup, and/or a subscriber identity module (SIM) card on board of the vaporizer, a Nano-SIM card, or the like (e.g., allowing 3G/4G/5G cellular network communication).

[0116] Example satellite communications interfaces may include SATCOM interfaces, Defense Satellite Communications System (DSCS) interfaces, L-band, Ka-band, S-band communications systems, partially satellite-based Code Division Multiple Access (CDMA) communications systems, and/or any other commercial or military-based satellite communications system.

[0117] In example operation, in response to an activation command or signal (e.g., from remote device **307**), the control circuitry **2902** controls the safety actuator **102** (e.g., by energizing the safety solenoid **15**) to move the safety rod **122** to enter the shot mode as discussed above. Once in the shot mode (e.g., a relatively short delay after initiating movement of the safety rod **122**), the control circuitry **2902** controls the firing actuator **100** (e.g., by energizing the firing solenoid **16**) to push the firing plunger **112** upward to fire a chambered round as discussed above. The activation command may be a command for a single shot or may provide a fire command along with a cyclic rate of fire to be used until receipt of a cancel or stop command, or until a threshold number of cycles or rounds have been fired. According to one or more example embodiments, any suitable activation command or signal, and any suitable protocol, including encrypted protocols, may be used.

[0118] FIG. **32** is a block diagram illustrating another electronic trigger system according to example embodiments. In this example, the same switch, power supply and associated control circuitry are utilized to control both the safety actuator **102** and the firing actuator **100**.

[0119] Referring to FIG. **32**, the electronic trigger system includes the safety actuator **102**, a delay circuit **3016** and the firing actuator **100** connected in series between positive terminal of a power supply PS and ground. A switch **3014** is connected between the positive terminal of the power supply PS and the safety actuator **102** to selectively apply power to the circuit elements based on electrical signals from the control circuitry **3012**. The switch **3014** may be any suitable electronic switch, such as a transistor or the like, and may be controlled by logic voltage signals.

[0120] Control circuitry **3012** is electrically connected to the switch **3014** to control application of power (current and voltage) to the safety actuator **102**, the delay circuit **3016** and the firing actuator **100**. The control circuitry **3012** may be the same or substantially the same as the control circuitry **2902** discussed above with regard to FIG. **31**. The control circuitry **3012** may control the switch **3014** according to commands from the remote device **307** as discussed above with regard to FIG. **31**. In at least one example embodiment, the control circuitry **3012** may output logic voltage control signals to control the switch **3014**.

[0121] In example operation, in response to an activation command (e.g., from remote device **307**), the control circuitry **3010** closes the switch **3014** to apply power (allow current to flow) to the safety actuator **102**, then to the delay circuit **3016** and then to the firing actuator **100**.

[0122] In response to the applied current, the safety solenoid **15** energizes thereby pushing the safety rod **122** into the shot mode and allowing movement of the trigger/sear assembly **107** when the firing solenoid **16** is subsequently energized.

[0123] The delay circuit **3016** delays application of the current to the firing solenoid **16** to allow the safety rod **122** to move the safety plunger portion **124** and operational rod portion **114** into the shot mode. After the delay, the current is applied to the firing actuator **100** to energize the firing solenoid **16** and actuate the firing plunger **112** to fire a chambered round. In at least one example embodiment, the delay may be about 1-5 milliseconds (ms).

[0124] FIG. **33** is a block diagram illustrating another electronic trigger system according to one or more example embodiments. In this example embodiment, separate actuator circuits **33**A and **33**B, including separate switches and separate power supplies, are provided for each of the safety actuator **102** and the firing actuator **100**. Although shown as separate power supplies, it should be understood that a single power supply may be used. Moreover, in this example embodiment, control circuitry **3110** is configured to control each of the actuator circuits **33**A and **33**B. However, it should be understood that separate control circuitry (or controllers within the control circuitry) may be used. The control circuitry **3110** may be the same or substantially the same as the control circuitry **2902** discussed above with regard to FIG. **31**.

[0125] Referring to FIG. **33**, actuator circuit **33**A includes a switch **3114** connected in series with the safety actuator **102** between the positive terminal of power supply **3116** and ground. The switch **3114** may be the same or substantially the same as the switch **3014** in FIG. **32**.

[0126] The control circuitry **3110** is electrically connected to the switch **3114** to control application of power (selectively apply power) to the safety actuator **102**. The control circuitry **3110** may control the switch **3114** according to commands from the remote device **307** as discussed above with regard to FIG. **31**.

[0127] Actuator circuit **33**B includes a switch **3214** connected in series with the firing actuator **100** between the positive terminal of the power supply **3216** and ground. The switch **3214** may be the same or substantially the same as the switch **3014** in FIG. **32**.

[0128] The control circuitry **3110** is also electrically connected to the switch **3214** to control application of power (selectively apply power) to the firing actuator **100**. The control circuitry **3210** may also control the switch **3214** according to commands from the remote device **307** as discussed above with regard to FIG. **31**.

[0129] In example operation, in response to an activation command (e.g., from remote device **307**), the control circuitry **3110** closes the switch **3114** to apply power (allow current to flow) to the safety actuator **102**. The applied power causes the safety solenoid **15** to energize thereby pushing the safety rod **122** to enter the shot mode and allow movement of the trigger/sear assembly **107** when the firing solenoid **16** is subsequently energized.

[0130] After a relatively short delay to allow the safety rod **122** to move the safety plunger portion **124** and operational rod portion **114** into the shot mode, the control circuitry **3110** closes the switch **3214** to apply power to the firing actuator **100** to energize the firing solenoid **16** and move the firing plunger **112** to fire a chambered round.

[0131] FIGS. **17-28** illustrate various views of a firearm **30**, more particularly an M4 rifle, including a lower receiver and electronic trigger assembly shown in FIGS. **1-16**.

[0132] In addition to example embodiments and other aspects discussed herein, the firearm **30** may have one or more operational features such as disclosed in U.S. Pat. Nos. 5,726,377, 5,760,328, 4,658,702, 4,433,610, 7,654,187, 7,775,150 and 8,051,595, all of which are hereby incorporated by reference herein in their entirety.

[0133] Referring to FIGS. **17-28**, the firearm **30** includes, among other things, an upper receiver **34** (also referred to as an upper receiver section or portion) engaged with the lower receiver **10** (also referred to as a lower receiver section or portion), a barrel **36**, and a gas piston system (not shown). The barrel **36** is removably connected to the upper receiver **34**, which is engaged with the lower receiver **10**.

[0134] In example operation, when the hammer **104** is released as discussed herein, the hammer **104** strikes the firing pin **37** igniting the primer and causing a chambered round to fire.

[0135] According to one or more example embodiments, lower receivers and/or components thereof including solenoid covers, for example, may be formed using additive manufacturing (e.g., 3-dimensional (3-D) printing), wherein processes in which successive layers of one or more materials are formed are used to produce a 3-D object (e.g., the lower receiver or component thereof). Example additive manufacturing processes include, but are not limited to, Binder Jetting, Directed Energy Deposition, Material Extrusion, Material Jetting, Powder Bed Fusion, Sheet Lamination, and Vat Photopolymerization. Example embodiments, or components thereof, may also be formed using subtractive manufacturing or a combination of additive and subtractive manufacturing.

[0136] The foregoing description of example embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of an example embodiment are generally not limited to that particular example embodiment, but, where applicable, are interchangeable and can be used in a selected example embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure. Equivalent alterations and modifications will occur to others skilled in the art based upon a reading and understanding of this specification and the annexed drawings. The disclosure includes all such modifications and alterations and is limited only by the scope of the following claims. In particular regard to the various functions performed by the above described components (e.g., elements, resources, etc.), the terms used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (e.g., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated example implementations of the disclosure.

[0137] While a particular feature of the disclosure may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application. To the extent that the terms "includes", "having", "has", "with", or variants thereof are used in either the detailed description or the claims, such terms are intended to be inclusive in a manner similar to the term "comprising."

[0138] Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

[0139] Any aspect or design described herein as an "example" is not necessarily to be construed as advantageous over other aspects or designs. Rather, use of the word "example" is intended to present one possible aspect and/or implementation that may pertain to the techniques presented herein. Such examples are not necessary for such techniques or intended to be limiting. Various example embodiments of such techniques may include such an example, alone or in combination with other features, and/or may vary and/or omit the illustrated example.

[0140] As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. That is, "a" and "an" as used in this application and the appended claims may generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form. As used in this application, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or". That is, unless specified otherwise, or clear from context, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then "X employs A or B" is satisfied under any of the foregoing instances. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. It is also to be understood that additional or alternative steps may be employed.

[0141] When an element or layer is referred to as being "on," "engaged to," "connected to," or "coupled to" another element or layer, it may be directly on, engaged, connected or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to," "directly connected to," or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.)

[0142] Although the terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as "first," "second," and other numerical terms when used herein do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example embodiments.

[0143] Spatially relative terms, such as "inner," "outer," "beneath," "below," "lower," "above," "upper," and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. Spatially relative terms may be intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the example term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0144] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which example embodiments belong. It will be further understood that terms, including those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0145] It should also be noted that in some alternative implementations, the functions/acts noted may occur out of the order noted in the figures. For example, two figures shown in succession may in fact be executed substantially concurrently or may sometimes be executed in the reverse order, depending upon the functionality/acts involved.

[0146] Specific structural and functional details disclosed herein are merely representative for purposes of describing example embodiments. The present invention may, however, be embodied in many alternate forms and should not be construed as limited to only the embodiments set forth herein.

[0147] In addition, or alternative, to that discussed above, units and/or devices such as controllers, according to one or more example embodiments, may be implemented using hardware, software, and/or a combination thereof. For example, hardware devices may be implemented using processing circuitry such as, but not limited to, a processor, Central Processing Unit (CPU), a controller, an arithmetic logic unit (ALU), a digital signal processor, a microcomputer, a field programmable gate array (FPGA), a System-on-Chip (SoC), a programmable logic unit, a microprocessor, or any other device capable of responding to and executing instructions in a defined manner. Portions of the example embodiments and corresponding detailed description may be presented in terms of software, or algorithms and symbolic representations of operation on data bits within a computer memory. These descriptions and representations are the ones by which those of ordinary skill in the art effectively convey the substance of their work to others of ordinary skill in the art. An algorithm, as the term is used here, and as it is used generally, is conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of optical, electrical, or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

[0148] In this application, including the definitions below, the term 'module' or the term 'controller' may be replaced with the term 'circuit.' The term 'module' may refer to, be part of, or include processor hardware (shared, dedicated, or group) that executes code and memory hardware (shared, dedicated, or group) that stores code executed by the processor hardware.

[0149] Software may include a computer program, program code, instructions, or some combination thereof, for independently or collectively instructing or configuring a hardware device (e.g., controller) to operate as desired. The computer program and/or program code may include program or computer-readable instructions, software components, software modules, data files, data structures, and/or the like, capable of being implemented by one or more hardware devices, such as one or more of the hardware devices mentioned above. Examples of program code include both machine code produced by a compiler and higher level program code that is executed using an interpreter.

[0150] For example, when a hardware device is a computer processing device (e.g., a processor, Central Processing Unit (CPU), a controller, an arithmetic logic unit (ALU), a digital signal processor, a microcomputer, a microprocessor, etc.), the computer processing device may be configured to carry out program code by performing arithmetical, logical, and input/output operations, according to the program code. Once the program code is loaded into a computer processing device, the computer processing device may be programmed to perform the program code, thereby transforming the computer processing device into a special purpose computer processing device. In a more specific example, when the program code is loaded into a processor, the processor becomes programmed to perform the program code and operations corresponding thereto, thereby transforming the processor into a special purpose processor.

[0151] Software and/or data may be embodied permanently or temporarily in any type of machine, component, physical or virtual equipment, or computer storage medium or device, capable of providing instructions or data to, or being interpreted by, a hardware device.

[0152] Even further, any of the disclosed methods may be embodied in the form of a program or software. The program or software may be stored on a non-transitory computer readable medium and is adapted to perform any one of the aforementioned methods when run on a computer device (a device including a processor). Thus, the non-transitory, tangible computer readable medium, is adapted to store information and is adapted to interact with a data processing facility or computer device to execute the program of any of the above mentioned embodiments and/or to perform the method of any of the above mentioned embodiments.

[0153] According to one or more example embodiments, computer processing devices may be described as including various functional units that perform various operations and/or functions to increase the clarity of the description. However, computer processing devices are not intended to be limited to these functional units. For example, in one or more example embodiments, the various operations and/or functions of the functional units may be performed by other ones of the functional units. Further, the computer processing devices may perform the operations and/or functions of the various functional units without sub-dividing the operations and/or functions of the computer processing units into these various functional units.

[0154] Units and/or devices (e.g., control circuitry) according to one or more example embodiments may also include one or more storage devices. The one or more storage devices may be tangible or non-transitory computer-readable storage media, such as random access memory (RAM), read only memory (ROM), a permanent mass storage device (such as a disk drive), solid state (e.g., NAND flash) device, and/or any other like data storage mechanism capable of storing and recording data. The one or more storage devices may be configured to store computer programs, program code, instructions, or some combination thereof, for one or more operating systems and/or for implementing the example embodiments described herein. The computer programs, program code, instructions, or some combination thereof, may also be loaded from a separate computer readable storage medium into the one or more storage devices and/or one or more computer processing devices using a drive mechanism. Such separate computer readable storage medium may include a Universal Serial Bus (USB) flash drive, a memory stick, a Blu-ray/DVD/CD-ROM drive, a memory card, and/or other like computer readable storage media. The computer programs, program code, instructions, or some combination thereof, may be loaded into the one or more storage devices and/or the one or more computer processing devices from a remote data storage device via a network interface, rather than via a local computer readable storage medium. Additionally, the computer programs, program code, instructions, or some combination thereof, may be loaded into the one or more storage devices and/or the one or more processors from a remote computing system that is configured to transfer and/or distribute the computer programs, program code, instructions, or some combination thereof, over a network. The remote computing system may transfer and/or distribute the computer programs, program code, instructions, or some combination thereof, via a wired interface, an air interface, and/or any other like medium.

[0155] The one or more hardware devices, the one or more storage devices, and/or the computer programs, program code, instructions, or some combination thereof, may be specially designed and constructed for the purposes of the example embodiments, or they may be known devices that are altered and/or modified for the purposes of example embodiments.

[0156] Further, at least one example embodiment relates to the non-transitory computer-readable storage medium including electronically readable control information (processor executable instructions) stored thereon, configured in such that when the storage medium is used in a controller of a device, at least one example embodiment of may be carried out.

[0157] For clarity, not all elements are identified by reference characters in every drawing so as not to distract from the description of elements. It should be understood that like reference characters refer to like elements in the drawings.

[0158] While a number of example embodiments have been disclosed herein, it should be understood that other variations may be possible. Such variations are not to be regarded as a departure from the spirit and scope of the present disclosure, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

1. An electronic trigger assembly for a firearm, the electronic trigger assembly comprising:
- a firing control mechanism configured to operate in a safe mode or a shot mode;
- a safety actuator configured to actuate a safety rod linearly in a first direction to switch the firing control mechanism between the safe mode and the shot mode; and
- a firing actuator configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode.

2. The electronic trigger assembly according to claim **1**, wherein the second direction is substantially perpendicular to the first direction.

3. The electronic trigger assembly of claim **1**, wherein the safety actuator is configured to actuate the safety rod in response to an electrical signal.

4. The electronic trigger assembly of claim **1**, wherein the safety actuator comprises:
- a safety solenoid configured to actuate the safety rod in response to an electrical signal.

5. The electronic trigger assembly of claim **4**, wherein the safety solenoid is a linear pull-type solenoid configured to push the safety rod in the first direction.

6. The electronic trigger assembly of claim **4**, wherein the safety rod comprises:
- a safety plunger portion,
- an operational rod portion, and
- a solenoid plunger portion having a backplate portion, wherein
  - the safety plunger portion, the operational rod portion and the solenoid plunger portion are arranged sequentially in a longitudinal direction of the safety rod, and
  - the solenoid plunger portion is configured to function as a moveable plunger of the safety solenoid.

7. The electronic trigger assembly of claim **6**, wherein
- the firing control mechanism includes a trigger and sear assembly and a disconnector, the disconnector being secured in a groove of a trigger frame by a trigger pin, and the trigger and sear assembly configured to move in the second direction and rotate about the trigger pin, and
- in the safe mode, the safety plunger portion is positioned to prevent movement of the trigger and sear assembly in the second direction.

8. The electronic trigger assembly of claim **1**, wherein the firing actuator is configured to actuate the firing plunger in response to an electrical signal.

9. The electronic trigger assembly of claim **1**, wherein the firing actuator comprises:

a firing solenoid configured to actuate the firing plunger in response to an electrical signal.

10. The electronic trigger assembly of claim **9**, wherein the firing solenoid is a linear push-type solenoid.

11. The electronic trigger assembly of claim **1**, wherein the firing control mechanism does not include one or more of a trigger bow or a thumb paddle for a safety mechanism of the firearm.

12. The electronic trigger assembly of claim **1**, wherein the firing control mechanism includes a trigger and sear assembly and a disconnector, the disconnector being secured in a groove of a trigger frame by a trigger pin, and the trigger and sear assembly configured to rotate about the trigger pin,

a surface of the firing plunger contacts a surface of the trigger and sear assembly, and

the firing actuator is configured to actuate the firing plunger linearly in the second direction to rotate the trigger and sear assembly to actuate the firing control mechanism.

13. An electronic trigger system comprising:

the electronic trigger assembly of claim **1**; and

control circuitry configured to output electrical signals to control the safety actuator and the firing actuator.

14. The electronic trigger system of claim **13**, wherein the control circuitry is configured to control the safety actuator and the firing actuator based on wired or wireless signals from a remote control device.

15. A lower receiver for a firearm, the lower receiver comprising:

a housing; and

the electronic trigger assembly of claim **1**, wherein

the firing control mechanism is arranged within the housing,

the safety actuator is fixed to a lateral side of the housing, and

the firing actuator is fixed to a lower surface of the housing.

16. A lower receiver for a firearm, the lower receiver comprising:

a housing;

a firing control mechanism arranged within the housing, the firing control mechanism configured to operate in a safe mode or a shot mode;

a safety rod assembly arranged at least partially within the housing, the safety rod assembly including a safety rod and a safety spring, the safety rod extending across the housing of the lower receiver and the safety spring arranged between an end of the safety rod and a sidewall of the housing;

a safety actuator configured to actuate the safety rod in a first direction against the bias of the safety spring to switch the firing control mechanism from the safe mode to the shot mode; and

a firing actuator configured to actuate a firing plunger linearly in a second direction to actuate the firing control mechanism in the shot mode.

17. The lower receiver of claim **16**, wherein

the safety actuator is fixed to a lateral side of the housing, and

the firing actuator is fixed to a lower surface of the housing.

18. The lower receiver of claim **16**, wherein the safety actuator is configured to actuate the safety rod in response to an electrical signal.

19. The lower receiver of claim **18**, wherein the safety actuator comprises:

a safety solenoid configured to actuate the safety rod in response to the electrical signal.

20. The lower receiver of claim **19**, wherein the safety rod comprises:

a safety plunger portion,

an operational rod portion, and

a solenoid plunger portion having a backplate portion, wherein

the safety plunger portion, the operational rod portion and the solenoid plunger portion are arranged sequentially in a longitudinal direction of the safety rod, and

the solenoid plunger portion is configured to function as a moveable plunger of the safety solenoid.

21. The lower receiver of claim **20**, wherein

the firing control mechanism includes a trigger and sear assembly and a disconnector, the disconnector being secured in a groove of a trigger frame by a trigger pin, and the trigger and sear assembly being configured to move in the second direction and rotate about the trigger pin, and

in the safe mode, the safety plunger portion is positioned to prevent movement of the trigger and sear assembly in the second direction.

22. The lower receiver of claim **16**, wherein the firing actuator is configured to actuate the firing plunger in response to an electrical signal.

23. The lower receiver of claim **22**, wherein the firing actuator comprises:

a firing solenoid configured to actuate the firing plunger in response to the electrical signal.

24. The lower receiver of claim **16**, wherein the firing control mechanism does not include one or more of a trigger bow or a thumb paddle for a safety mechanism of the firearm.

25. The lower receiver of claim **16**, wherein

the firing control mechanism includes a trigger and sear assembly and a disconnector, the disconnector being secured in a groove of a trigger frame by a trigger pin, and the trigger and sear assembly being configured to rotate about the trigger pin,

a surface of the firing plunger contacts a surface of the trigger and sear assembly, and

the firing actuator is configured to actuate the firing plunger linearly in the second direction to rotate the trigger and sear assembly to actuate the firing control mechanism.

26. A firearm comprising:

a lower receiver including the electronic trigger assembly of claim **1**;

an upper receiver attached to the lower receiver; and

a barrel attached to the upper receiver.

27. The firearm of claim **26**, wherein

the lower receiver includes a housing,

the firing control mechanism is arranged within the housing,

the safety actuator is fixed to a lateral side of the housing, and the firing actuator is fixed to a lower surface of the housing.

28. The firearm of claim **26**, wherein at least one of the safety actuator and the firing actuator is configured to be actuated in response to one or more electrical signals.

29. The firearm of claim **26**, wherein the firing control mechanism does not include one or more of a trigger bow or a thumb paddle for a safety mechanism of the firearm.

30. A firearm comprising:

the lower receiver of claim **16**;

an upper receiver attached to the lower receiver; and

a barrel attached to the upper receiver.

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