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(54) **CORDLESS NAILER WITH SAFETY SENSOR**

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(52) **U.S. Cl.** **173/1; 173/2; 227/8; 227/129**

(58) **Field of Classification Search** **227/8, 120, 227/129, 131, 132, 134, 135, 6, 7; 173/1, 173/2, 11**

See application file for complete search history.

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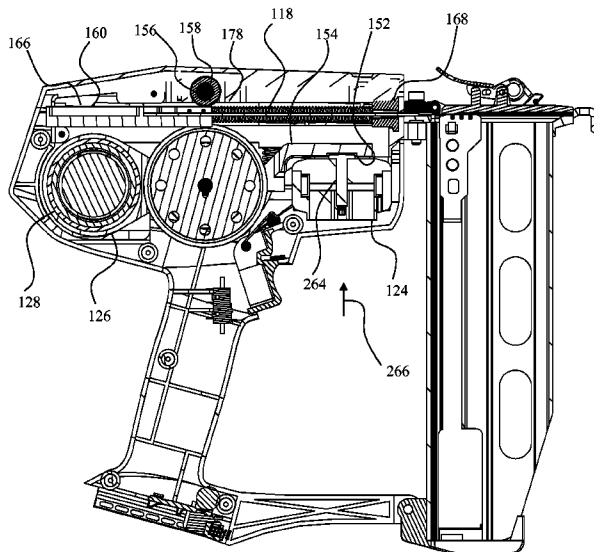
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(57) **ABSTRACT**

A device for impacting a fastener in one embodiment includes a lever arm pivotable between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism, a motor operably connected to the flywheel for storing energy in the flywheel, a trigger sensor assembly for generating a trigger signal indicative of the position of a trigger, a work contact element (WCE) sensor for generating a WCE signal indicative of the position of a WCE, a memory including program instructions, and a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon the WCE signal, and (ii) pivot the lever arm based upon the trigger signal.

20 Claims, 8 Drawing Sheets



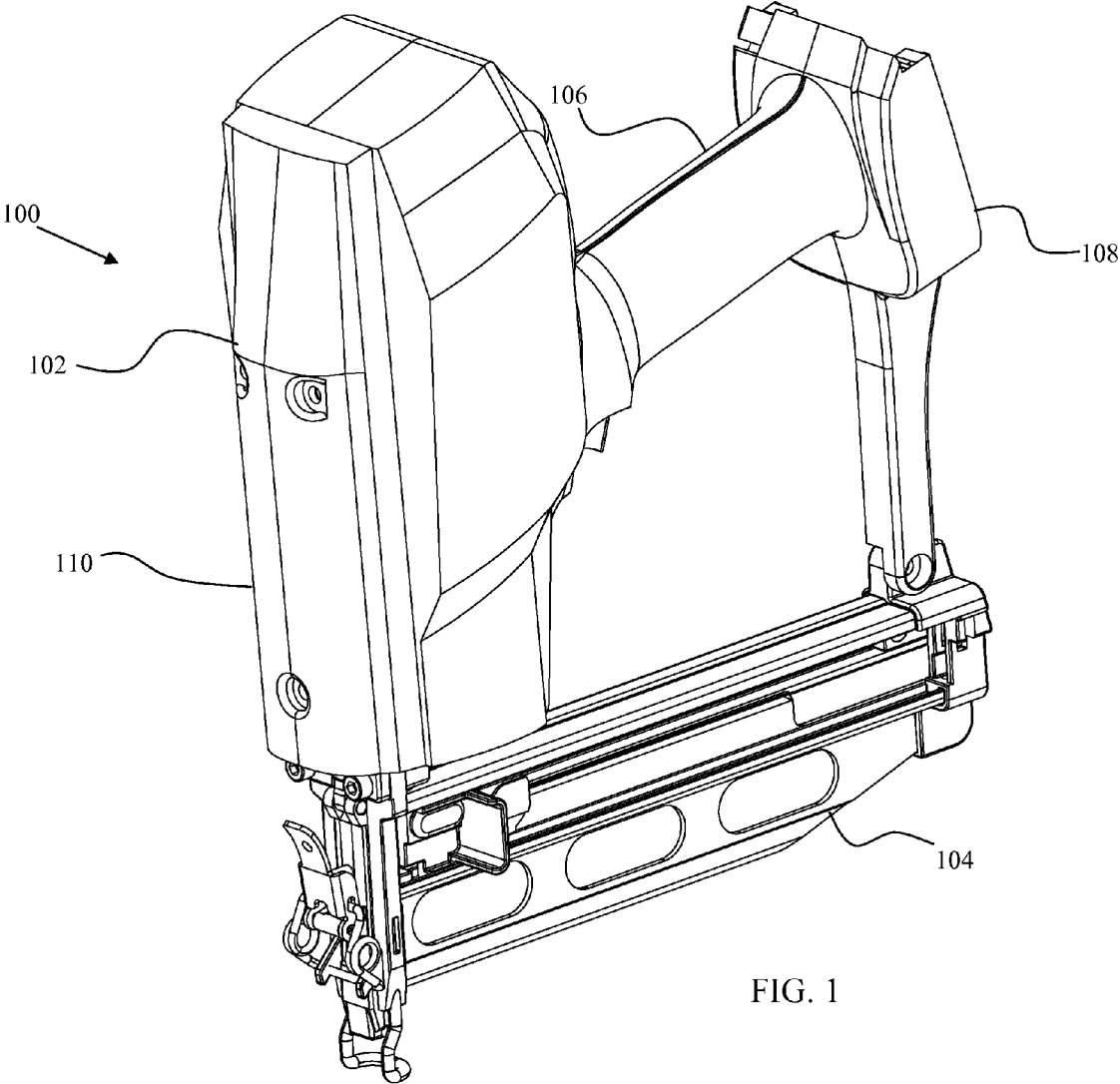
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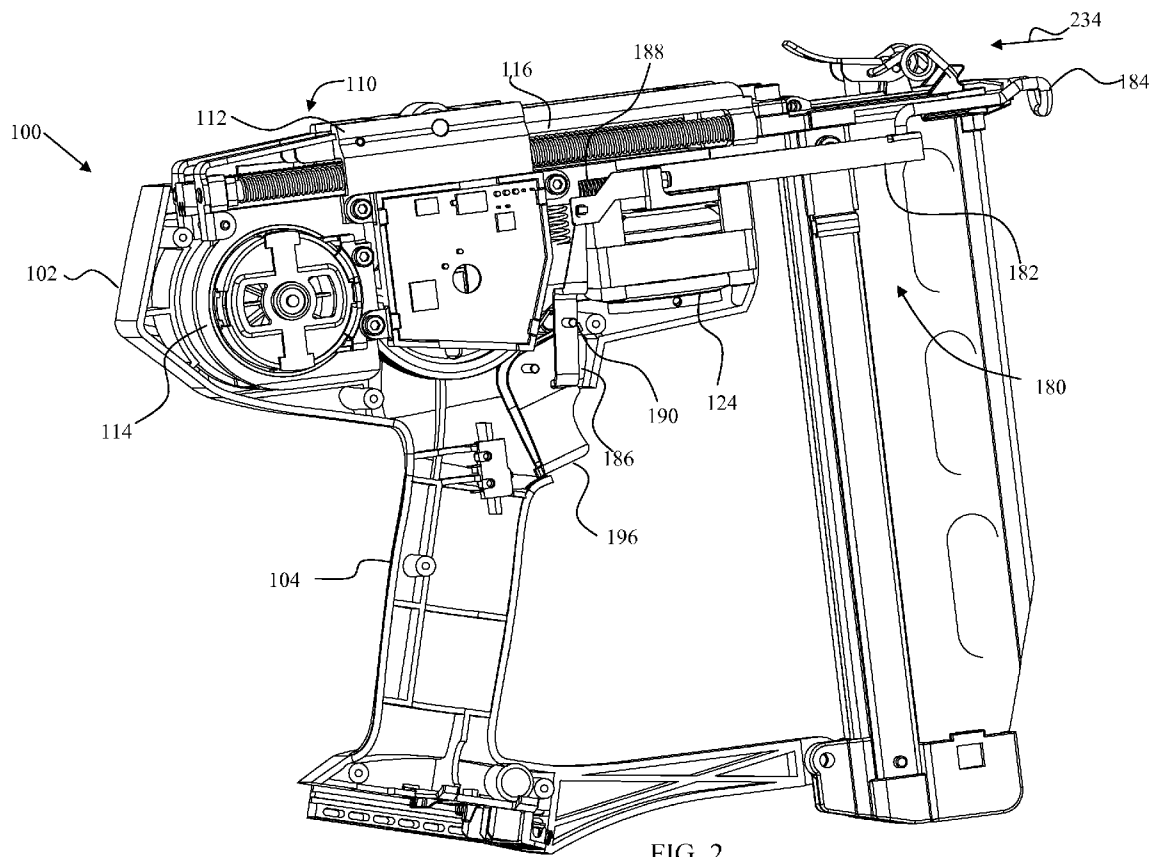


FIG. 2

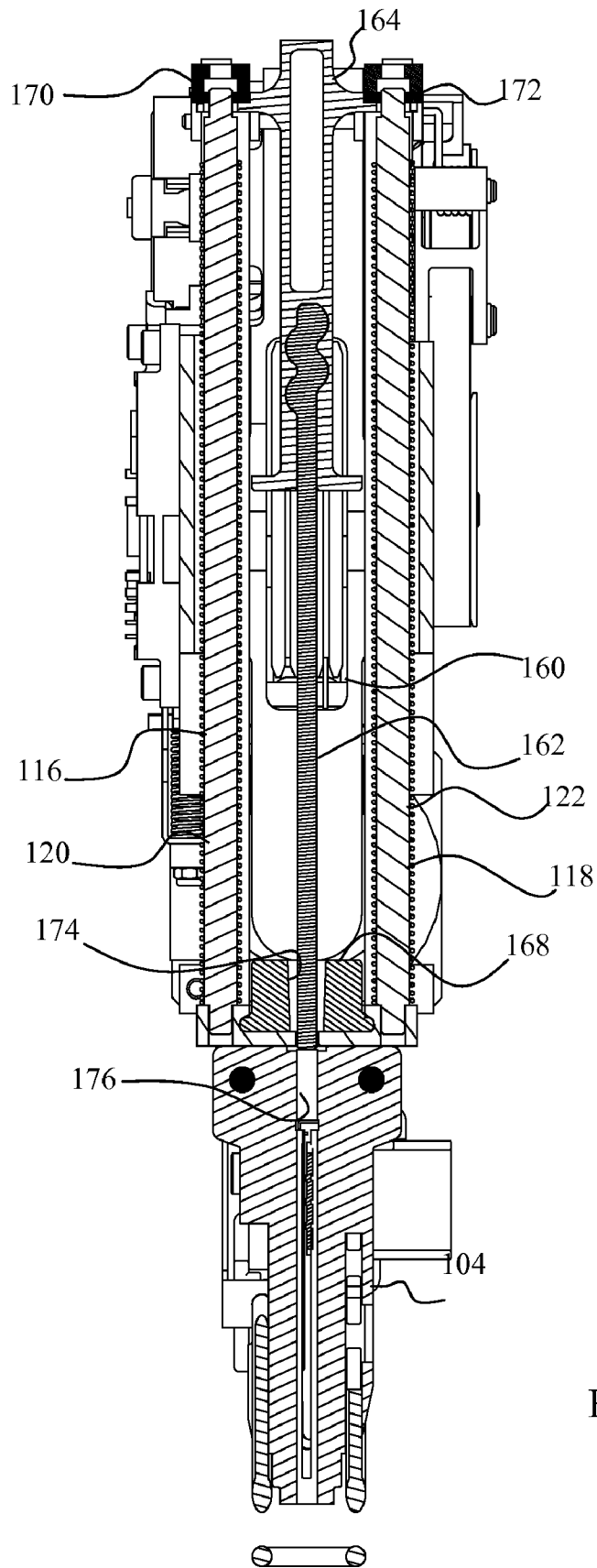


FIG. 3

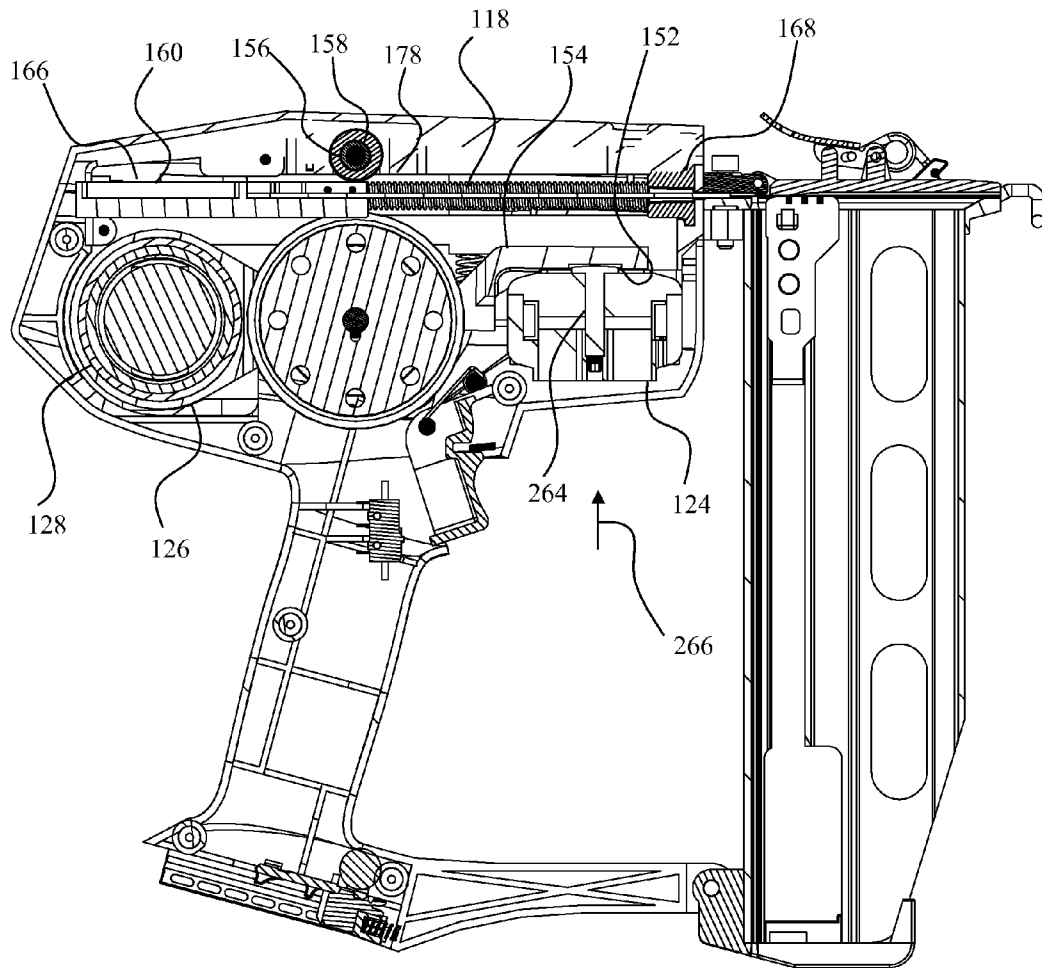


FIG. 4

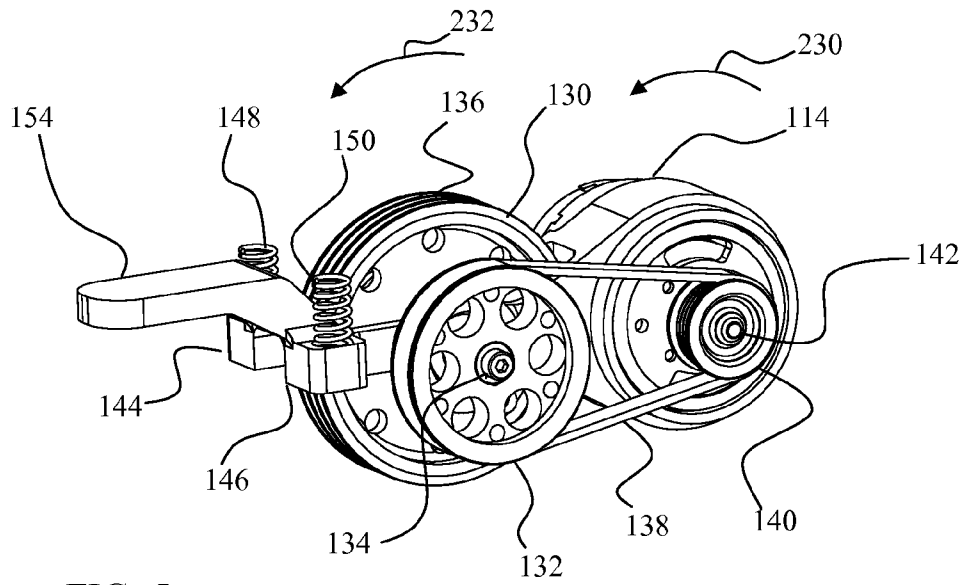


FIG. 5

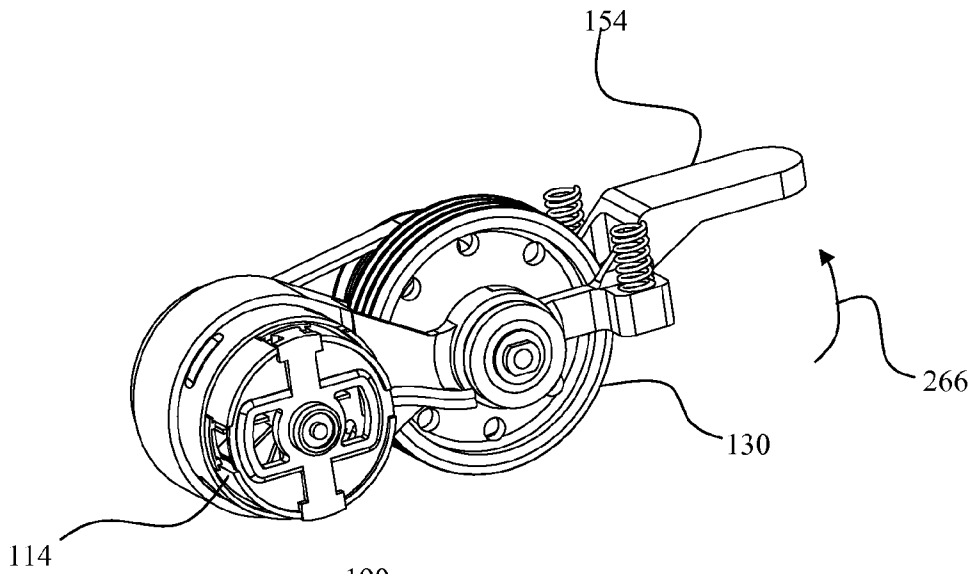


FIG. 6

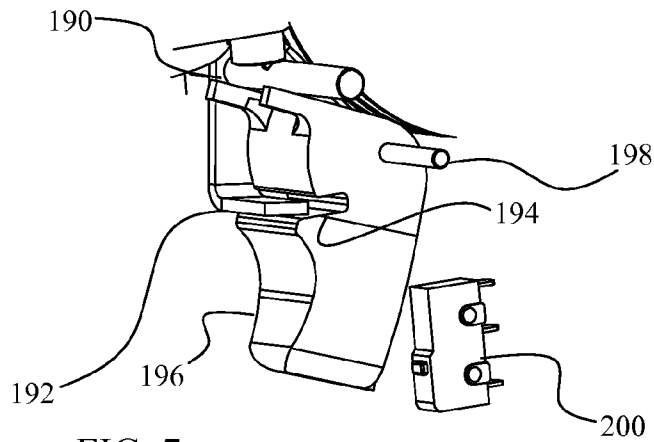


FIG. 7

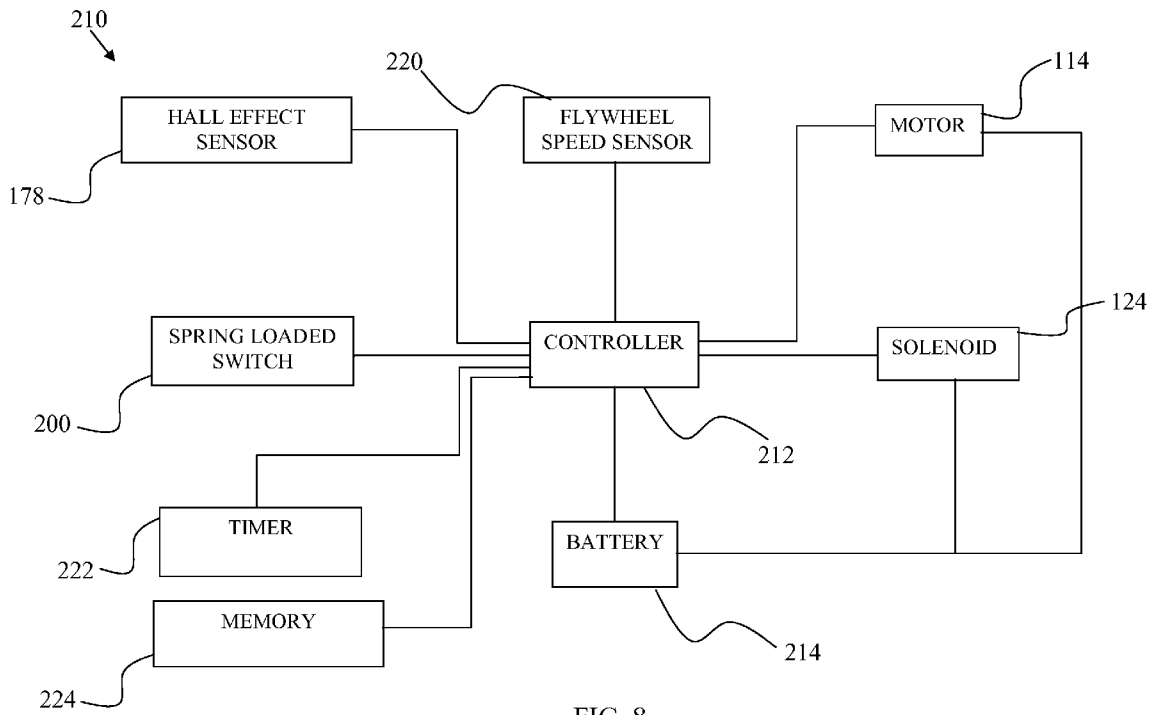
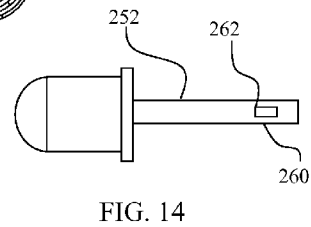
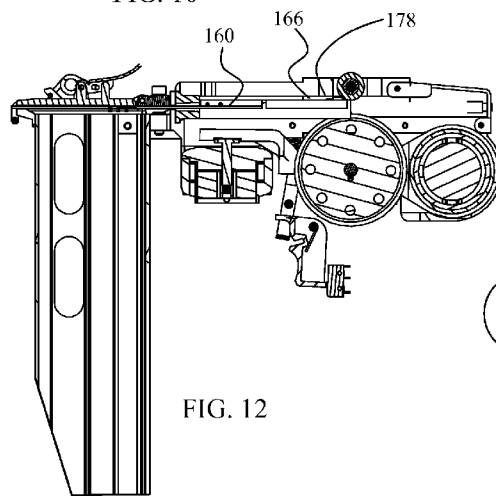
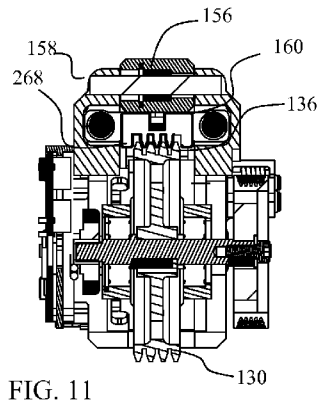
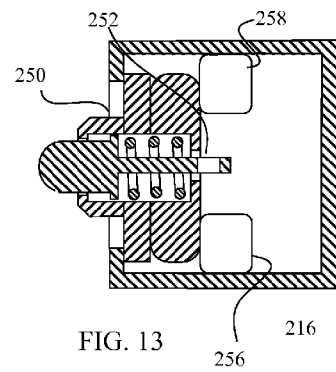
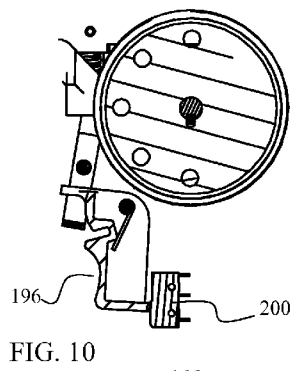
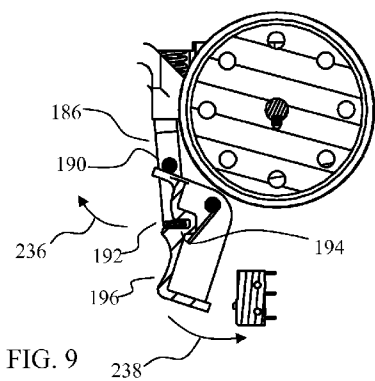


FIG. 8



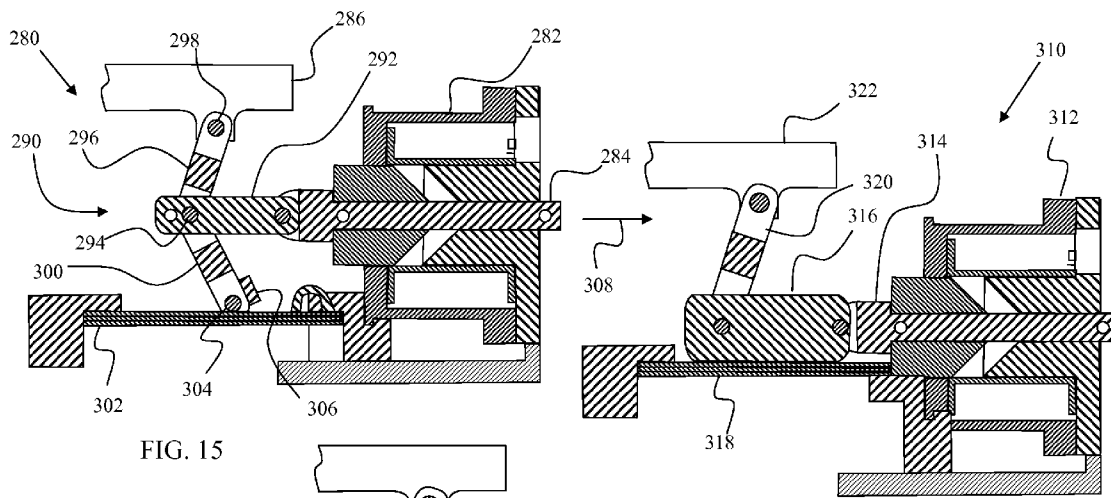


FIG. 15

FIG. 16

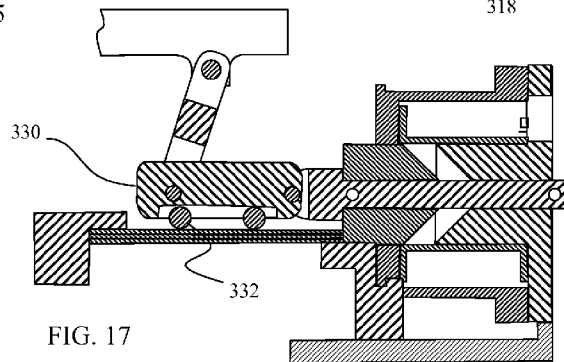


FIG. 17

CORDLESS NAILER WITH SAFETY SENSOR

FIELD OF THE INVENTION

This invention relates to the field of devices used to drive fasteners into work-pieces and particularly to a device for impacting fasteners into work-pieces.

BACKGROUND

Fasteners such as nails and staples are commonly used in projects ranging from crafts to building construction. While manually driving such fasteners into a work-piece is effective, a user may quickly become fatigued when involved in projects requiring a large number of fasteners and/or large fasteners. Moreover, proper driving of larger fasteners into a work-piece frequently requires more than a single impact from a manual tool.

In response to the shortcomings of manual driving tools, power-assisted devices for driving fasteners into wood have been developed. Contractors and homeowners commonly use such devices for driving fasteners ranging from brad nails used in small projects to common nails which are used in framing and other construction projects. Compressed air has been traditionally used to provide power for the power-assisted devices. Specifically, a source of compressed air is used to actuate a cylinder which impacts a nail into the work-piece. Such systems, however, require an air compressor, increasing the cost of the system and limiting the portability of the system. Additionally, the air-lines used to connect a device to the air compressor hinder movement and can be quite cumbersome and dangerous in applications such as roofing.

Fuel cells have also been developed for use as a source of power for power-assisted devices. The fuel cell is generally provided in the form of a cylinder which is removably attached to the device. In operation, fuel from the cylinder is mixed with air and ignited. The subsequent expansion of gases is used to push the cylinder and thus impact a fastener into a work-piece. These systems are relatively complicated as both electrical systems and fuel systems are required to produce the expansion of gases. Additionally, the fuel cartridges are typically single use cartridges.

Another source of power that has been used in power assisted devices is electrical power. Traditionally, electrical devices have been mostly limited to use in impacting smaller fasteners such as staples, tacks and brad nails. In these devices, a solenoid driven by electrical power from an external source is used to impact the fastener. The force that can be achieved using a solenoid, however, is limited by the physical structure of the solenoid. Specifically, the number of ampere-turns in a solenoid governs the force that can be generated by the solenoid. As the number of turns increases, however, the resistance of the coil increases necessitating a larger operational voltage. Additionally, the force in a solenoid varies in relation to the distance of the solenoid core from the center of the windings. This limits most solenoid driven devices to short stroke and small force applications such as staplers or brad nailers.

Various approaches have been used to address the limitations of electrical devices. In some systems, multiple impacts are used. This approach requires the tool to be maintained in position for a relatively long time to drive a fastener. Another approach is the use of a spring to store energy. In this approach, the spring is cocked (or activated) through an electric motor. Once sufficient energy is stored within the spring, the energy is released from the spring into an anvil which then impacts the fastener into the substrate. The force delivery

characteristics of a spring, however, are not well suited for driving fasteners. As a fastener is driven further into a work-piece, more force is needed. In contrast, as a spring approaches an unloaded condition, less force is delivered to the anvil.

Flywheels have also been used to store energy for use in impacting a fastener. The flywheels are used to launch a hammering anvil that impacts the nail. A shortcoming of such designs is the manner in which the flywheel is coupled to the driving anvil. Some designs incorporate the use of a friction clutching mechanism that is both complicated, heavy and subject to wear. Other designs use a continuously rotating flywheel coupled to a toggle link mechanism to drive a fastener. Such designs are limited by large size, heavy weight, additional complexity, and unreliability.

The foregoing advances provide increased maneuverability. Such maneuverability, however, implicates various safety issues. Specifically, as the tool becomes more portable, the tool is more likely to be transported to locations which are less safe. In such extended or precarious work sites, a substantial safety risk arises in that the natural human reflex when slipping or falling or losing balance in such precarious positions leads the operator to squeeze and grip the handle or handles of the power tool harder than usual. In many instances, operators subjected to falling or slipping actually instinctively lock onto the handle including the trigger actuator in a "death grip" type reflex action in which great force is applied to the trigger mechanism.

As a result of this tendency or reflex, an impacting device which is actuated solely by a trigger switch can be inadvertently actuated during an accident, leading to increased injuries. Additionally, mechanical switches which are typically used are subject to wear over time.

What is needed is a triggering system which can be used to control delivery of impacting force in a device which is reliable and safe and does not increase the number of mechanical switches. What is needed is a system which can be used to provide impacting force in a device using low voltage energy sources. What is further needed is a system which is reliable and does not require a continuously rotating flywheel.

SUMMARY

In accordance with one embodiment, there is provided a device for impacting a fastener which includes a lever arm pivotable between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism, a motor operably connected to the flywheel for storing energy in the flywheel, a trigger sensor assembly for generating a trigger signal indicative of the position of a trigger, a work contact element (WCE) sensor for generating a WCE signal indicative of the position of a WCE, a memory including program instructions, and a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon the WCE signal, and (ii) pivot the lever arm based upon the trigger signal.

In accordance with another embodiment, a method of impacting a fastener includes sensing the position of a work contact element (WCE), generating a WCE sensor signal indicative of the sensed position of the WCE, energizing a motor based upon the WCE sensor signal, transferring rotational energy from the motor to a flywheel, generating a trigger signal indicative of the position of a trigger, and pivoting the flywheel into contact with a drive mechanism based upon the trigger signal.

In accordance with a further embodiment, a device for impacting a fastener includes a lever arm solenoid configured to pivot a lever arm between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism, a motor operably connected to the flywheel for storing energy in the flywheel, a work contact element (WCE) sensor for generating a WCE signal indicative of the position of a WCE, a memory including program instructions, and a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon the WCE signal, and (ii) energize the lever arm solenoid to pivot the lever arm to the second position based upon a trigger position.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts a front perspective view of a fastener impacting device in accordance with principles of the present invention;

FIG. 2 depicts a side plan view of the fastener impacting device of FIG. 1 with a portion of the housing removed;

FIG. 3 depicts a top cross sectional view of the fastener impacting device of FIG. 1;

FIG. 4 depicts a side cross sectional view of the fastener impacting device of FIG. 1;

FIG. 5 depicts a front perspective view of the lever arm assembly of the device of FIG. 1;

FIG. 6 depicts a rear perspective view of the lever arm assembly of the device of FIG. 1;

FIG. 7 depicts a partial perspective view of the device of FIG. 1 showing a trigger, a trigger sensor switch and a hook portion of a lever arm which can inhibit rotation of the trigger;

FIG. 8 depicts a schematic of a control system used to control the device of FIG. 1 in accordance with principles of the invention;

FIG. 9 depicts a partial cross sectional view of the trigger assembly of the device of FIG. 1 when the actuating mechanism is positioned as shown in FIG. 2;

FIG. 10 depicts a partial cross sectional view of the trigger assembly of the device of FIG. 1 when the work contact element has been pressed against a work piece and the trigger or manual switch has been repositioned by a user;

FIG. 11 depicts a partial cross sectional view of the fastener impacting device of FIG. 1 with the lever arm rotated so as to engage a drive member with the flywheel;

FIG. 12 depicts a partial cross sectional view of the fastener impacting device of FIG. 1 after energization of the solenoid rotates the lever arm into contact with a drive mechanism and the drive mechanism has been moved through a full stroke in accordance with principles of the invention;

FIG. 13 depicts a partial cross sectional view of a spring loaded switch that is activated by combined positioning of the actuating mechanism and manual switch of the device of FIG. 1 so as to interact with a sensor assembly;

FIG. 14 depicts a side plan view of the plunger and stem of the spring loaded switch of FIG. 13;

FIG. 15 depicts a partial cross sectional view of a fastener impacting device incorporating a solenoid mechanism with a knee hinge to provide a mechanical advantage in pivoting a lever arm assembly;

FIG. 16 depicts a partial cross sectional view of a device with a solenoid activated lever arm which is positioned using a sled sliding on a surface; and

FIG. 17 depicts a partial cross sectional view of a solenoid activated lever arm which is positioned using a sled provided with wheels that roll on a surface.

DESCRIPTION

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiments illustrated in the drawings and described in the following written specification. It is understood that no limitation to the scope of the invention is thereby intended. It is further understood that the present invention includes any alterations and modifications to the illustrated embodiments and includes further applications of the principles of the invention as would normally occur to one skilled in the art to which this invention pertains.

FIG. 1 depicts a fastener impacting device 100 including a housing 102 and a fastener cartridge 104. The housing 102 defines a handle portion 106, a battery receptacle 108 and a drive section 110. The fastener cartridge 104 in this embodiment is spring biased to force fasteners, such as nails or staples, serially one after the other, into a loaded position adjacent the drive section 110. With further reference to FIG. 2, wherein a portion of the housing 102 is removed, the housing 102 is mounted on a two piece frame 112 which supports a direct current motor 114. Two springs 116 and 118, shown more clearly in FIG. 3, are positioned about guides 120 and 122, respectively. A solenoid 124 is located below the guides 120 and 122.

The motor 114, which is fixedly attached to the frame 112, rotatably supports a lever arm assembly 126 through a bearing 128 shown in FIG. 4. Referring additionally to FIGS. 5 and 6, the lever arm assembly 126 includes a flywheel 130 and a flywheel drive wheel 132 rotatably supported by an axle 134. A plurality of grooves 136 are formed in the outer periphery of the flywheel 130. A belt 138 extends between the flywheel drive wheel 132 and a drive wheel 140 attached to the output shaft 142 of the motor 114. The lever arm assembly 126 includes two spring wells 144 and 146 which receive springs 148 and 150, respectively. A pin receiving recess 152, which is best seen in FIG. 4, is located on the lower surface of a tongue 154.

Continuing with FIGS. 3 and 4, a free-wheeling roller 156 is rigidly mounted to the frame 112 through a bearing 158 at a location above a drive member 160. The drive member 160 includes an anvil 162 at one end and a guide rod flange 164 at the opposite end. A permanent magnet 166 is also located on the drive member 160. The drive member 160 is movable between a front bumper 168 located at the forward end portions of the guides 120 and 122 and a pair of rear bumpers 170 and 172 located at the opposite end portions of the guides 120 and 122. The front bumper 168 defines a central bore 174 which opens to a drive channel 176 in the fastener cartridge 104. A Hall effect sensor 178 is located forward of the free wheeling roller 156.

Referring to FIG. 2, an actuating mechanism 180 includes a slide bar 182 which is connected at one end to a work contact element (WCE) 184 and at the opposite end to a pivot arm 186. A spring 188 biases the slide bar 182 toward the WCE 184. The pivot arm 186 pivots about a pivot 190 and includes a hook portion 192 shown in FIG. 7. The hook portion 192 is configured to fit within a stop slot 194 of a trigger 196. The trigger 196 pivots about a pivot 198 and is aligned to activate a spring loaded switch 200.

The spring loaded switch 200 is used to provide input to a control circuit 210 shown in FIG. 8. The control circuit 210 includes a processor 212 that controls the operation of the motor 114 and the solenoid 124. Power to the circuit 210 as well as the motor 114 and the solenoid 124, is provided by a battery 214 coupled to the battery receptacle 108 (see FIG. 1). The processor 212 receives a signal input from the spring

loaded switch **200**, the Hall effect sensor **178**, and a flywheel speed sensor **220**. The control circuit **210** further includes a timer **222** which provides input to the processor **212**. A memory **224** is programmed with command instructions which, when executed by the processor **212**, provide performance of various control functions described here. In one embodiment, the processor **212** and the memory **224** are onboard a microcontroller.

Further detail and operation of the fastener impacting device **100** is described with initial reference to FIGS. **1-8**. When the battery **214** is inserted into the battery receptacle **108** power is applied to the control circuit **210**. Next, the operator presses the work contact element **184** against a work-piece, pushing the work contact element **184** in the direction of the arrow **234** shown in FIG. **2**. The movement of the work contact element **184** causes the slide bar **182** of the actuating mechanism **180** to compress the spring **188** and to pivot the pivot arm **186** about the pivot pin **190**. With reference to FIGS. **9** and **10**, as the pivot arm **186** pivots about the pivot pin **190** in the direction of the arrow **236**, the hook portion **192** of the pivot arm **186** rotates in the direction of the arrow **236** out of the stop slot **194**. This allows the trigger **196** to be rotated in the direction of the arrow **238** to the position shown in FIG. **10**. In FIG. **10**, the trigger **196** is pressed against the spring loaded switch **200**.

As the trigger **196** presses against the spring loaded switch **200**, a signal is generated and sent to the processor **212**. In response to the signal, the processor **212** causes energy from the battery **214** to be provided to the motor **114** causing the output shaft **142** of the motor **114** to rotate in the direction of the arrow **230** of FIG. **5**. Accordingly, the drive wheel **140**, which is fixedly attached to the output shaft **142**, also rotates in the direction of the arrow **230**. This rotational energy is transferred to the flywheel drive wheel **132** through the belt **138**. Rotation of the flywheel drive wheel **132** causes the axle **134** and the flywheel **130** to rotate in the direction of the arrow **232**.

The rotation of the flywheel **130** is sensed by the flywheel speed sensor **220** and a signal indicative of the rotational speed of the flywheel **130** is passed to the processor **212**. The processor **212** controls the motor **114** to increase the rotational speed of the flywheel **130** until the signal from the flywheel speed sensor **220** indicates that a sufficient amount of kinetic energy has been stored in the flywheel **130**.

In response to achieving a sufficient amount of kinetic energy, the processor **212** causes the supply of energy to the motor **114** to be interrupted, allowing the motor **114** to be freely rotated by energy stored in the rotating flywheel **130**. The processor **212** further starts the timer **222** and controls the solenoid **124** to a powered condition whereby a pin **264** is forced outwardly from the solenoid **124** in the direction of the arrow **266** shown in FIG. **4**, and against the pin receiving recess **152**. The pin **264** thus forces the springs **148** and **150** to be compressed within the spring wells **144** and **146**. As the springs **148** and **150** are compressed by the expulsion of the pin **264**, the lever arm **126** rotates about the motor **114** in the direction of the arrow **266** of FIG. **6** since the lever arm **126** is rotatably connected to the frame **112** through the motor **114** and the bearing **128**.

Rotation of the lever arm **126** forces the grooves **136** of the flywheel **130** into complimentary grooves **268** of the drive member **160** shown in FIG. **11**. Accordingly, the drive member **160** is pinched between the freewheeling roller **156** and the fly wheel **130**. The fly wheel **130** transfers energy to the drive member **160** and the flange **164**, which is configured to abut the springs **116** and **118**, presses against the springs **116** and **118**, overcoming the bias of the springs **116** and **118** and

forcing the drive member **160** toward the front bumper **168**. While the embodiment of FIG. **11** incorporates springs, other embodiments may incorporate other resilient members in place of or in addition to the springs **116** and **118**. Such resilient members may include tension springs or elastomeric materials such as bungee cords or rubber bands.

Movement of the drive member **160** along the drive path moves the anvil **162** into the drive channel **176** through the central bore **174** of the front bumper **168** so as to impact a fastener located adjacent to the drive section **110**.

Movement of the drive member **160** continues until either a full stroke has been completed or until the timer **222** has timed out. Specifically, when a full stroke is completed as shown in FIG. **12**, the permanent magnet **166** is located adjacent to the Hall effect sensor **178**. The sensor **178** thus senses the presence of the magnet **166** and generates a signal which is received by the processor **212**. In response to the first of a signal from the sensor **178** or timing out of the timer **222**, the processor **212** is programmed to interrupt power to the solenoid **124**.

In alternative embodiments, the Hall effect sensor may be replaced with a different sensor. By way of example, an optical sensor, an inductive/proximity sensor, a limit switch sensor, or a pressure sensor may be used to provide a signal to the processor **212** that the drive member **160** has reached a full stroke. Depending upon various considerations, the location of the sensor may be modified. For example, a pressure switch may be incorporated into the front bumper **168**. Likewise, the component of the drive member **160** which is sensed, such as the magnet **166**, may be positioned at various locations on the drive member. Additionally, the sensor may be configured to sense different components of the drive member **160** such as the flange **164** or the anvil **162**.

De-energization of the solenoid **124** allows the pin **264** to move back within the solenoid **124** as the energy stored within the springs **148** and **150** causes the springs **148** and **150** to expand thereby rotating the lever arm **126** in the direction opposite to the direction of the arrow **266** (see FIG. **6**). The flywheel **130** is thus moved away from the drive member **160**. When movement of the drive member **160** is no longer influenced by the flywheel **130**, the bias provided by the springs **116** and **118** against the flange **164** causes the drive member **160** to move in a direction toward the rear bumpers **170** and **172**. The rearward movement of the drive member **160** is arrested by the bumpers **170** and **172**.

The solenoid **124** and lever arm **126** are thus returned to the condition shown in FIG. **4**. Accordingly, prior to re-energizing the motor **114** to initiate another impacting sequence, the signal from the from the trigger switch **200** must be interrupted by releasing the trigger **196**.

In the event that the fastener impacting device **100** is moved away from the work-piece after a fastener has been impacted and the trigger **196** has been released, the spring **188** forces the actuating mechanism **180** to return to the position shown in FIG. **2**. In this position, the hook portion **192** of the pivot arm **186** is positioned within the stop slot **194** of the trigger **196** as shown in FIG. **7**. In the configuration of FIG. **7**, the hook portion **192** prevents rotation of the trigger **196** in the direction of the arrow **238** of FIG. **9**. Accordingly, a fastener cannot be impacted before first pressing the WCE **184** against a work piece to allow operation in the manner described above.

In alternative embodiments, the processor **212** can accept a trigger input associated with the trigger **196** and a WCE input associated with the WCE **184**. The trigger input and the WCE input may be provided by switches, sensors, or a combination of switches and sensors. In one embodiment, the WCE **184** no

longer needs to interact with the trigger **196** via an actuating mechanism **180** including a pivot arm **186** and a hook portion **192**. Rather, the WCE **184** interacts with a switch (not shown) that sends a signal to the processor **212** that indicates when the WCE **184** has been depressed. The WCE **184** may also be configured to be sensed rather than engaging with a switch. The sensor (not shown) may be an optical sensor, an inductive/proximity sensor, a limit switch sensor, or a pressure sensor.

In this alternative embodiment, the trigger switch can include a sensor that detects the position of the trigger such as the sensor **216** shown in FIG. **13**. When the trigger **196** is repositioned, a spring **250** in the spring loaded switch **200** is compressed and a stem **252** moves outwardly from the spring loaded switch **200**. The trigger sensor **216** is positioned to detect movement of the stem **252**.

In this embodiment, the trigger sensor **216** includes a light source **256** and a photo sensor **258**. The light source **256** and the photo sensor **258** are positioned such that when the stem **252** is in the position shown in FIG. **13**, a tail portion **260** (see FIG. **14**) of the stem **252** blocks light from the light source **256** from reaching the photo sensor **258**. When the stem **252** is moved to the right from the position shown in FIG. **13**, however, a window **262** allows light from the light source **256** reach the photo sensor **258**. The photo sensor **258** senses the light and provides a signal to the processor **212** indicating that the spring loaded switch **200** has been repositioned.

This alternative embodiment can operate in two different firing modes, which is user selectable by a mode selection switch (not shown). In a sequential operating mode, depression of the WCE **184** causes a WCE signal, based upon a switch or a sensor, to be generated. In response, the processor **212** executes program instructions causing battery power to be provided to the motor **114**. The processor **212** may also energize the sensor **216** based upon the WCE signal. When the flywheel speed sensor **220** indicates a desired amount of kinetic energy has been stored in the flywheel **130**, the processor **212** then controls the motor **114** to maintain the rotational speed of the flywheel **130** that corresponds to the kinetic energy desired.

If desired, an operator may be alerted to the status of the kinetic energy available. By way of example, the processor **212** may cause a red light (not shown) to be energized when the rotational speed of the flywheel **130** is lower than the desired speed and the processor **212** may cause a green light (not shown) to be energized when the rotational speed of the flywheel **130** is at or above the desired speed.

In addition to causing energy to be provided to the motor **114** upon depression of the WCE **184**, the processor **212** starts a timer when battery power is applied to the motor **114**. If a trigger signal is not detected before the timer times out, battery power will be removed from the motor **114** and the sequence must be restarted. The timer **222** may be used to provide a timing signal. Alternatively, a separate timer may be provided.

If the trigger **196** is manipulated, however, the processor **212** receives a trigger signal from the trigger switch or trigger sensor **216**. The processor **212** then causes the supply of energy to the motor **114** to be interrupted, as long as the kinetic energy in the flywheel **130** is sufficient, allowing the motor **114** to be freely rotated by energy stored in the rotating flywheel **130**. The processor **212** further starts the first timer **222** and controls the solenoid **124** to a powered condition. In response to the first of a signal from the driver block sensor **178** or timing out of the timer **222**, the processor **212** is programmed to interrupt power to the solenoid **124**. Both the

WCE switch/sensor and the trigger switch or trigger sensor **216** must be reset before another cycle can be completed.

Alternatively, an operator may select a bump operating mode using the mode selection switch. In embodiments incorporating a trigger sensor, positioning of the selection switch in the bump mode setting causes the trigger sensor to be energized. In this mode of operation, the processor **212** will supply battery power to the motor **114** in response to either the WCE switch/sensor signal or the trigger switch/sensor signal. Upon receipt of the remaining input signal, the processor **212** verifies that the desired kinetic energy is stored in the flywheel **130** and then causes the supply of power to the motor **114** to be interrupted and the battery power is supplied to the solenoid **124**. In response to the first of a signal from the driver block sensor **178** or timing out of the timer **222**, the processor **212** is programmed to interrupt power to the solenoid **124**.

In bump operating mode, only one of the two inputs must be reset. The processor **212** will supply battery power to the motor **114** immediately after the solenoid power is removed as long as at least one of the inputs remains activated when the other input is reset. When the reset input again provides a signal to the processor **212**, the sequence described above is once again initiated.

An alternative solenoid assembly is shown in FIG. **15**. The solenoid assembly **280** may be used in a fastener impacting device which is substantially the same as the fastener impacting device **100**. The solenoid assembly **280** includes a solenoid **282** which is oriented with a pin **284** that moves along an axis somewhat parallel to the tongue **286** of a lever arm assembly (not otherwise shown) configured like the lever arm assembly **126**. The pin **284** is connected to a knee hinge **290** through a shaft **292** and a pin **294**. The knee hinge **290** includes an upper arm **296** which is rotatably connected to the tongue **286** through a pin **298** and a lower arm **300** which is rotatably connected to a frame portion **302** through a pin **304**. A stop **306** is located on the lower arm **300**.

Operation of a fastener impacting device with the solenoid assembly **280** is substantially the same as operation of the fastener impacting device **100**. The main difference is that when the solenoid **282** is controlled to a powered condition, the pin **284** is pulled into the solenoid **282** thereby causing the shaft **292** to move in the direction of the arrow **308** shown in FIG. **15**. The shaft **292** pulls the knee hinge **290** in the direction of the arrow **308**.

Because the upper arm **296** of the knee hinge **290** is pivotably connected to the tongue **286** through the pin **298**, and the lower arm **300** of the knee hinge **290** is pivotably connected to the frame portion **302** through the pin **304**, the knee hinge **290** is forced toward an extended condition. In other words, the upper arm **296** pivots in a counter-clockwise direction about the pin **298** while the lower arm **300** pivots in a clockwise direction about the pin **304**. Extension of the knee hinge **290** causes rotation of the lever arm assembly **288** about a pivot in a manner similar the rotation of the lever arm assembly **126**.

An alternative solenoid mechanism is depicted in FIG. **16**. The solenoid mechanism **310** includes a solenoid **312** with a solenoid pin **314**. The solenoid pin **314** is operatively connected to a sled **316** positioned on a slide **318**. An arm **320** is pivotably connected to the sled **316** at one end and to a lever arm **322** at the other end.

The solenoid mechanism **310** operates in a fastener impacting device in substantially in the same manner as the solenoid mechanism **280**. The main difference is that in place of a knee hinge such as the knee hinge **290**, the solenoid mechanism **310** includes the sled **316**. Accordingly, energization of the solenoid **312** causes the sled **316** to move across the slide **318**,

thereby forcing the lever arm **322** to rotate. In a further embodiment, frictional forces are reduced by providing a sled **330** with wheels **332** as shown in FIG. 17.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same should be considered as illustrative and not restrictive in character. It is understood that only the preferred embodiments have been presented and that all changes, modifications and further applications that come within the spirit of the invention are desired to be protected.

The invention claimed is:

1. A method of impacting a fastener comprising: sensing the position of a work contact element (WCE); generating a WCE sensor signal indicative of the sensed position of the WCE; energizing a motor based upon the WCE sensor signal; transferring rotational energy from the motor to a flywheel; generating a trigger signal indicative of the position of a trigger; and pivoting the flywheel into contact with a drive mechanism based upon the trigger signal.
2. The method of claim 1, wherein pivoting the flywheel comprises: energizing a lever arm solenoid.
3. The method of claim 2, wherein pivoting the flywheel further comprises: pivoting the flywheel about an axis defined by the motor.
4. The method of claim 1, wherein transferring rotational energy comprises: transferring energy from the motor to the flywheel through a belt.
5. The method of claim 1, further comprising: de-energizing the motor prior to pivoting the flywheel into contact with the drive mechanism.
6. The method of claim 1, further comprising: detecting the rotational speed of the flywheel; generating a speed signal indicative of the rotational speed of the flywheel; and pivoting the flywheel into contact with the drive mechanism based upon the speed signal.
7. The method of claim 6, wherein sensing the position of the WCE comprises: inductively sensing the position of the WCE.
8. A device for impacting a fastener comprising: a lever arm solenoid configured to pivot a lever arm between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism; a motor operably connected to the flywheel for storing energy in the flywheel; a trigger sensor for generating a trigger signal indicative of the position of a trigger; a memory including program instructions; and a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon a work contact element (WCE) position, and (ii) energize the lever arm solenoid to pivot the lever arm to the second position based upon the trigger signal.
9. The device of claim 8, further comprising: a WCE sensor assembly for providing a signal to the processor indicative of the position of the WCE.
10. The device of claim 8, further comprising a sensor for providing a speed signal to the processor indicative of the speed of the flywheel, wherein: the memory further includes program instructions for energizing the lever arm solenoid based upon the speed signal.

11. The device of claim 8, wherein the memory further includes program instructions for de-energizing the motor prior to pivoting the flywheel to the second position.

12. The device of claim 8, wherein the memory further includes program instructions for de-energizing the lever arm solenoid based upon a timer signal.

13. The device of claim 12, wherein the memory further includes program instructions for de-energizing the lever arm solenoid based upon a sensed position of the drive mechanism.

14. The device of claim 8, wherein the memory includes program instructions which, when executed by the processor, energize the trigger sensor based upon the WCE position.

15. A device for impacting a fastener comprising: a lever arm pivotable between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism; a motor operably connected to the flywheel for storing energy in the flywheel; a trigger sensor assembly for generating a trigger signal indicative of the position of a trigger; a work contact element (WCE) sensor for generating a WCE signal indicative of the position of a WCE; a memory including program instructions; a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon the WCE signal, and (ii) control the lever arm to pivot between the first position and the second position based upon the trigger signal; and a lever arm solenoid configured to pivot the lever arm between the first position and the second position.

16. The device of claim 15, wherein the memory includes program instructions which, when executed by the processor, energizes the trigger sensor assembly based upon the WCE signal.

17. A device for impacting a fastener comprising: a lever arm pivotable between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism; a motor operably connected to the flywheel for storing energy in the flywheel; a trigger sensor assembly for generating a trigger signal indicative of the position of a trigger; a work contact element (WCE) sensor for generating a WCE signal indicative of the position of a WCE; a memory including program instructions; and a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon the WCE signal, and (ii) control the lever arm to pivot between the first position and the second position based upon the trigger signal, wherein the trigger sensor assembly comprises a photo sensor.

18. A device for impacting a fastener comprising: a lever arm pivotable between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism; a motor operably connected to the flywheel for storing energy in the flywheel; a trigger sensor assembly for generating a trigger signal indicative of the position of a trigger; a work contact element (WCE) sensor for generating a WCE signal indicative of the position of a WCE; a memory including program instructions;

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a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon the WCE signal, and (ii) control the lever arm to pivot between the first position and the second position based upon the trigger signal;

a belt operably connected to the motor and the flywheel for transferring energy from the motor to the flywheel; and a sensor for providing a speed signal to the processor indicative of the speed of the flywheel,

wherein the memory includes program instructions which, when executed by the processor, de-energizes the motor prior to pivoting the lever arm into the second position.

19. A device for impacting a fastener comprising:

a lever arm pivotable between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism;

a motor operably connected to the flywheel for storing energy in the flywheel;

a trigger sensor assembly for generating a trigger signal indicative of the position of a trigger;

a work contact element (WCE) sensor for generating a WCE signal indicative of the position of a WCE;

a memory including program instructions;

a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon the WCE signal, and (ii) control the lever arm to pivot between the first position and the second position based upon the trigger signal;

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a belt operably connected to the motor and the flywheel for transferring energy from the motor to the flywheel; and a sensor for providing a speed signal to the processor indicative of the speed of the flywheel,

wherein the memory includes program instructions which, when executed by the processor, controls the lever arm to pivot between the first position and the second position based upon the speed signal.

20. A device for impacting a fastener comprising:

a lever arm pivotable between a first position whereat a flywheel is spaced apart from a drive mechanism and a second position whereat the flywheel can contact the drive mechanism;

a motor operably connected to the flywheel for storing energy in the flywheel;

a trigger sensor assembly for generating a trigger signal indicative of the position of a trigger;

a work contact element (WCE) sensor for generating a WCE signal indicative of the position of a WCE;

a memory including program instructions; and

a processor operably connected to the memory for executing the program instructions to (i) energize the motor based upon the WCE signal, and (ii) control the lever arm to pivot between the first position and the second position based upon the trigger signal,

wherein the WCE sensor comprises an inductive sensor.

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