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### Firmware control providing a soft stop on compression drive nailer

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#### Abstract

A method for controlling a motor of a power tool including performing a load test on a battery pack of the power tool, determining, via a first controller, a first mechanism control scheme based on the load test, receiving, via the first controller, a user input indicative of beginning an operation cycle of the power tool, and isolating the first controller from a second controller. The method further including controlling, via the first controller, the motor based on the first mechanism control scheme, sensing a dataset indicative of a result of the operation cycle based on the first mechanism control scheme, receiving, via the second controller, the dataset, connecting the first controller to the second controller upon completion of the operation cycle, transmitting, via the second controller, the dataset to the first controller, and determining, via the first controller, a second mechanism control scheme based on the dataset.

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## **Background/Summary**

RELATED APPLICATIONS (1) This application claims priority to U.S. Provisional Patent Application No. 63/391,620, filed on Jul. 22, 2022, the entire content of which is hereby incorporated by reference.

### **FIELD OF THE DISCLOSURE**

(1) The present disclosure relates to power tools, and more particularly to powered fastener drivers.

### **SUMMARY OF THE DISCLOSURE**

(2) Fastener drivers, or powered fastener drivers, may be used to drive fasteners (e.g., nails, tacks, staples, etc.) into a workpiece. Fastener drivers may operate utilizing various energy sources (e.g., compressed air generated by an air compressor, electrical energy, flywheel mechanisms, etc.), but often these designs are met with power, size, and cost constraints.

(3) The disclosure provides, in one aspect, a method for controlling a motor of a power tool. The method may include performing, via a first controller, a load test on a battery pack of the power tool, determining, via the first controller, a first mechanism control scheme based on the load test, receiving, via the first controller, a user input indicative of beginning an operation cycle of the power tool, and isolating the first controller from a second controller. The method further includes controlling, via the first controller, the motor of the power tool based on the first mechanism control scheme while the first controller is isolated from the second controller, sensing, via one or more sensors, a dataset indicative of a result of the operation cycle of the power tool based on the first mechanism control scheme, receiving, via the second controller, the dataset, connecting the first controller to the second controller upon completion of the operation cycle, transmitting, via the second controller, the dataset to the first controller upon completion of the operation cycle, and determining, via the first controller, a second mechanism control scheme based on the dataset.

(4) In another aspect, the method for controlling a motor of a power tool may include electrically braking the motor, via a command from a first controller, based on a first mechanism control scheme and detecting, via a first controller, a completion of an operation cycle of the motor. The method may further include transmitting, via a second controller, a dataset indicative of a position of a first piston of the power tool to the first controller upon completion of the operation cycle, and determining, via the first controller, a second mechanism control scheme based on the dataset, wherein the first controller is isolated from the second controller during the operation cycle.

(5) The disclosure provides, in another aspect, a powered fastener driver including a first cylinder, a first piston positioned within the first cylinder, the first piston being moveable between a top-dead-center (TDC) position and a bottom-dead-center (BDC) position, a second cylinder in fluid communication with the first cylinder, a second piston positioned within the second cylinder, the second piston being moveable between a top-dead-center (TDC) position and a near bottom-dead-center (BDC) position to initiate a fastener driving cycle, and a control system. The control system may electrically brake the motor, via a command from a first controller, based on a first mechanism control scheme, drive the motor, via a command from the first controller, based on the first mechanism control scheme, detect, via the first controller, a completion of an operation cycle of the

motor, transmit, via a second controller, a dataset indicative of a position of a first piston of the power tool to the first controller upon completion of the operation cycle, and determine, via the first controller, a second mechanism control scheme based on the dataset, wherein the first controller is isolated from the second controller during the operation cycle.

(6) Other aspects of the disclosure will become apparent by consideration of the detailed description and accompanying drawings.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

- (1) FIG. 1 is a perspective view of a powered fastener driver in accordance with an embodiment of the disclosure.
- (2) FIG. 2 is a cross-sectional view of a portion of the powered fastener driver of FIG. 1 taken along line 2-2 in FIG. 1, illustrating an onboard compressor, in accordance with an embodiment of the disclosure.
- (3) FIG. 3 is a perspective view of a portion of the powered fastener driver of FIG. 1 with a portion of a cylinder removed to illustrate a crank arm assembly and a latch, in accordance with an embodiment of the disclosure.
- (4) FIG. 4 is an enlarged perspective view of a portion of the powered fastener driver FIG. 3, illustrating the latch in a locked position, in accordance with an embodiment of the disclosure.
- (5) FIG. 5 is a perspective view of a portion of the powered fastener driver of FIG. 1 with a portion of a cylinder removed to illustrate cylinder head forming a passage between a compression cylinder and a driver cylinder of the onboard compressor, in accordance with an embodiment of the disclosure.
- (6) FIG. 6 is a top, perspective view of a portion of the crank arm assembly of the powered fastener driver of FIG. 1, illustrating a cam lobe formed on a cam of the crank arm assembly, in accordance with an embodiment of the disclosure.
- (7) FIG. 7 is a bottom, perspective view of the crank arm assembly of the powered fastener driver of FIG. 1, illustrating a finger and a hub formed on a crank arm of the crank arm assembly, in accordance with an embodiment of the disclosure.
- (8) FIG. 8 is a top, perspective view of a structural housing of the powered fastener driver of FIG. 1, in accordance with an embodiment of the disclosure.
- (9) FIG. 9 is a perspective view of the structural housing of the powered fastener driver of FIG. 1, illustrating a back-pressure adjustment mechanism and a check door, in accordance with an embodiment of the disclosure.
- (10) FIG. 10A is a partial perspective view of the structural housing of the powered fastener driver of FIG. 1, illustrating the check door in a closed position, in accordance with an embodiment of the disclosure.
- (11) FIG. 10B is a partial perspective view of the structural housing of the powered fastener driver of FIG. 1, illustrating the check door in an open position, in accordance with an embodiment of the disclosure.
- (12) FIG. 11 is a block diagram of a power tool system including a power tool and a battery pack, in accordance with an embodiment of the disclosure.
- (13) FIG. 12 is a flow chart of a method for controlling the motor of a power tool, in accordance with an embodiment of the disclosure.
- (14) FIG. 13 is a flow chart of a method for collecting data from the motor of a power tool, in accordance with an embodiment of the disclosure.
- (15) FIG. 14 is a block diagram of a power tool system including a power tool and a battery pack, in accordance with an embodiment of the disclosure.

(16) FIG. 15 is a flow chart of a method for controlling the motor of a power tool, in accordance with an embodiment of the disclosure.

(17) FIG. 16 is a flow chart of a method for collecting data from the motor of a power tool, in accordance with an embodiment of the disclosure.

(18) Before any embodiments of the disclosure are explained in detail, it is to be understood that the present subject matter is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The present subject matter is capable of other embodiments and of being practiced or of being carried out in various ways.

#### DETAILED DESCRIPTION

(19) Unless the context of their usage unambiguously indicates otherwise, the articles “a,” “an,” and “the” should not be interpreted as meaning “one” or “only one.” Rather these articles should be interpreted as meaning “at least one” or “one or more.” Likewise, when the terms “the” or “said” are used to refer to a noun previously introduced by the indefinite article “a” or “an,” “the” and “said” mean “at least one” or “one or more” unless the usage unambiguously indicates otherwise.

(20) It should also be understood that although certain drawings illustrate hardware and software located within particular devices, these depictions are for illustrative purposes only. In some embodiments, the illustrated components may be combined or divided into separate software, firmware and/or hardware. For example, instead of being located within and performed by a single electronic processor, logic and processing may be distributed among multiple electronic processors. Regardless of how they are combined or divided, hardware and software components may be located on the same computing device or may be distributed among different computing devices connected by one or more networks or other suitable communication links.

(21) Thus, in the claims, if an apparatus or system is claimed, for example, as including an electronic processor or other element configured in a certain manner, for example, to make multiple determinations, the claim or claim element should be interpreted as meaning one or more electronic processors (or other element) where any one of the one or more electronic processors (or other element) is configured as claimed, for example, to make some or all of the multiple determinations. To reiterate, those electronic processors and processing may be distributed.

(22) With reference to FIG. 1, a powered fastener driver 10 is operable to drive fasteners (e.g., nails, tacks, staples, and/or the like) held within a magazine 14 into a workpiece. The powered fastener driver 10 includes an outer housing with a handle portion 18, a structural housing 24, and a user-actuated trigger 26 mounted on the handle portion 18. Notably, the powered fastener driver 10 does not require an external source of air pressure, but rather the powered fastener driver 10 includes an on-board air compressor 30. In this way, the weight and/or size of tool may be reduced. The on-board air compressor 30 is powered by a power source (e.g., a battery pack 20), coupled to a battery attachment portion 22 of the outer housing.

(23) With reference to FIG. 2, the powered fastener driver 10 includes a drive blade 34 actuated by the on-board air compressor 30 to drive the fasteners into a workpiece. The compressor 30 includes a compression cylinder 38, a compressor piston 42 disposed in the compression cylinder 38, and a drive mechanism 44 that imparts reciprocating motion to the compressor piston 42 to execute one or more consecutive fastener driving cycles. The drive mechanism 44 includes a motor 46 (e.g., a brushed or brushless DC motor), a transmission 50 (e.g., a multi-stage planetary transmission, and/or the like), and a crank arm assembly 54 that is configured to convert a rotational output of the transmission 50 to a reciprocating input to the compressor piston 42. The fastener driver 10 may additionally include a drive cylinder 58 and a drive piston 62 slidably disposed in the drive cylinder 58. The drive piston 62 is movable between a top-dead-center (TDC) position and a bottom-dead-center (BDC) position. Similarly, the compressor piston 42 is moveable between a TDC position and a position that is near or close to a BDC position. For example, In the illustrated embodiment, the driver cylinder 58 may additionally include a stop member 60 (e.g., a resilient bumper)

positioned to engage and absorb energy from the drive piston **62** when the drive piston **62** reaches the BDC position.

(24) As shown in FIGS. **2** and **5**, the smaller drive cylinder **58** at least partially extends into the larger compression cylinder **38** such that the compressor piston **42** surrounds the entire drive cylinder **58**. By nesting the drive cylinder **58** within the compression cylinder **38**, fully or partially, the size and/or weight of the fastener driver **10** may be advantageously reduced for improved handling, manufacturability, and/or the like. The drive cylinder **58** and the compression cylinder **38** are in fluid communication through a passage **64** (FIGS. **3** and **5**). The passage **64** allows for the transmission of pressure between the two cylinders **38**, **58**. In the illustrated embodiment, a cylinder head **66** is coupled to a distal end (e.g., an upper end) of the compression cylinder **38** and includes a plurality of apertures that define the passage **64**, which allows for continuous fluid communication between the two cylinders **38**, **58**. In other words, there is no valve within the passage **64**.

(25) As shown in FIGS. **3**, **4**, and **5**, the powered fastener driver **10** may additionally include a latch **68** supported within the structural housing **24**, which extends between the drive mechanism **44** and the drive blade **34**. The latch **68** is movable between a locked position, in which the latch **68** engages the drive blade **34** to secure the drive piston **62** in the TDC position, and an unlocked position, in which the latch **68** disengages the drive blade **34** so the drive piston **62** is able to move from the TDC position to the BDC position to perform a fastener driving operation. In the illustrated embodiment, the drive blade **34** includes a slot **70**, a biasing member **74** is configured to bias the latch **68** towards the locked position, and the latch **68** includes a recess **72**. When the latch **68** is in the unlocked position, the recess **72** is aligned with the drive blade **34**. When the latch **68** is in the locked position, the slot **70** formed in the drive blade **34** is configured to receive a portion of the latch **68** to restrict movement of the drive blade **34**. When the crank arm assembly **54** moves the compressor piston **42** towards the TDC position, the crank arm assembly **54** moves the latch **68** to the unlocked position, which releases the blade **34** to initiate a fastener driving operation.

(26) As shown in FIGS. **3**, **4**, and **6**, the crank arm assembly **54** includes a crank arm **76** with a pin **78** and a connecting rod **80** pivotably coupled to the pin **78** at one end and a piston pin **82** (FIG. **2**) at an opposite end. The piston pin **82** may include an end-mounted magnet (not shown) proximate to a printed circuit board assembly (PCBA) **83** located on the exterior of compression cylinder **38** (FIGS. **3** and **5**). The PCBA **83** may include one or more sensors **85** (e.g., Hall switches, Hall effect sensors, optical sensors, ultrasonic sensors, photoelectric sensors, and/or any other suitable position sensor) in electronic communication with a control system **300**, described in more detail below, and configured to be activated by the end-mounted magnet of piston pin **82**. Once activated by the end-mounted magnet of piston pin **82**, each of the one or more sensors **85** may be further configured to generate a signal indicative of the position of the compressor piston **42** (FIGS. **3** and **5**) (based on activation) and transmit the signal to the control system **300**. In some embodiments, the signal may be a dataset indicative of a result of the operation cycle based on the position of the compressor piston **42**.

(27) With reference to FIG. **7**, the crank arm **76** may include a hub **84** coupled for co-rotation with an output shaft of the transmission **50** (e.g., by way of a key and keyway arrangement). With reference to FIG. **6**, the crank arm assembly **54** also includes a cam **86** coupled for co-rotation with the crank arm **76**. The cam **86** includes a first side **88**, a second side **90** opposite the first side **88**, and a cam lobe **92** formed on the first side **88**. In the illustrated embodiment, the cam lobe **92** is formed as a protrusion on the first side **88** of the cam **86** that extends in an axial direction and parallel with a rotational axis of the crank arm **76** and cam **86**. In addition, the crank arm **76** is coupled to the second side **90** of the cam **86** and the cam lobe **92** is formed on the opposite, first side **88**. In other words, the first side **88** and the cam lobe **92** face the transmission **50**, while the second side and crank arm **76** face the drive cylinder **58**.

(28) As explained in further detail below, one end of the latch **68** is biased against the first side **88**



of the cam **86**, resulting in sliding movement between the latch **68** and the cam **86** as the cam **86** rotates. As the latch **68** slides up the cam lobe **92**, the latch **68** is moved towards the unlocked position. In this regard, the latch **68** behaves as a follower in response to rotation of the cam **86**. It should be appreciated that a complete fastener driving cycle may be defined as the compressor piston **42** starting at a position near the BDC position, moving to the TDC position, and finishing at a position at or near the BDC position, while the drive piston **62** starts at TDC position, moves to the BDC position when the compressor piston **42** reaches the TDC position, and finishes in the TDC position. For the compressor piston **42** to execute the complete fastener driving cycle, the crank arm assembly **54** rotates 360 degrees. To initiate a subsequent complete fastener driving cycle, the rotation of the crank arm assembly **54** may continue in the same direction of rotation. In other embodiments, the rotation of the crank arm assembly **54** may be reversed by the motor **46** to initiate the subsequent complete fastener driving cycle. To accomplish this, the motor **46** may rotate the crank arm **76** and cam **86** alternately in a clockwise and a counterclockwise manner (e.g., clockwise then counterclockwise) to complete consecutive fastener driving cycles.

(29) As shown in FIGS. **8-10B**, the fastener driver **10** includes a back-pressure adjustment mechanism **106** supported within the structural housing **24**. The back-pressure adjustment mechanism **106** is configured to vary the amount of air exhausted from the drive cylinder **58** beneath the drive piston **62** (i.e., on a side of the drive piston **62** opposite the cylinder head **66**) during a fastener driving cycle. Because the fastener driver **10** does not include any pressure valves, the pressure of compressed air developed within the compression cylinder **38** is the same as the pressure acting on the drive piston **62**. As such, the back-pressure adjustment mechanism **106** can selectively increase or decrease the amount of air exhausted from the drive cylinder **58** beneath the drive piston **62** as it moves from the TDC position to the BDC position, thus either reducing or increasing, respectively, the back pressure acting on the drive piston **62** during a fastener driving cycle. In this way, the force acting on the drive piston **62** may be increased or decreased for driving different sizes of fasteners (e.g., 16 gauge nails, 18 gauge nails, 1 inch, 2 inch, and/or the like) to appropriate distances within a workpiece to make the fastener driver **10** suitable for use in a variety of different fastening applications.

(30) The back-pressure adjustment mechanism **106** includes a basket **108** rotatably supported within the structural housing **24**, an adjustment member **110** extending from the basket **108** through the structural housing **24**, and an opening **112** formed in the basket **108** to expose a central bore within the basket **108**. The opening **112** in the basket **108** selectively aligns with a window **114** formed in the structural housing **24** which, in turn, is in fluid communication with the external atmosphere. Rotation of the basket **108** (e.g., via the adjustment member **110**), adjusts the positioning of the opening **112** relative to the window **114**, and thus the effective cross-sectional area of the opening **112** that is exposed to the atmosphere. Adjusting the size of the exposed opening **112**, therefore, adjusts the volumetric flow rate of air that is exhausted from the drive cylinder **58** beneath the drive piston **62**, through the exposed opening **112** and window **114**. For example, reducing the size of the exposed opening **112** reduces the flow rate of air that can be exhausted through the opening **112**, which creates a larger back-pressure acting against the drive piston **62** and thus reduces the net force acting on the drive piston **62** during a fastener driving cycle. Increasing the size of the exposed opening **112** increases the amount of air that can be exhausted through the opening **112**, which creates a smaller back-pressure acting against the drive piston **62** and thus increases the net force acting on the drive piston **62** during a fastener driving cycle.

(31) With continued reference to FIGS. **9, 10A**, and **10B**, fastener driver **10** may additionally include a check door **116** and a biasing member **118** (e.g., a torsion spring, and/or the like) that biases the check door **116** towards a closed position (FIG. **10A**), which blocks flow (e.g., of air) through a second window **120** (FIG. **10B**) of the basket **108**. In the closed position, the second window **120** is closed and atmospheric air is prevented from exiting the drive cylinder **58** via the

basket **108** in response to the drive piston **62** moving from the TDC position toward the BDC position. The check door **116** may be positioned adjacent the back-pressure adjustment mechanism **106** and be movable to an open position where the second window **120** in the basket **108** is opened to permit atmospheric air to enter the drive cylinder **58** via the basket **108** in response to the drive piston **62** moving from the BDC position toward the TDC position. More specifically, during the movement of the drive piston **62** from the BDC position toward the TDC position, a vacuum is created within the drive cylinder **58** beneath the drive piston **62** that pulls the check door **116** to the open position via force created by a pressure differential as the drive piston **62** moves forward the TDC position. When the check door **116** is in the open position, the entire opening **112** of the basket **108** may be exposed to the atmosphere (via the first and second windows **114**, **120** in the structural housing **24**) to cause replacement air to enter the drive cylinder **58** beneath the drive piston **62**. Once the drive piston **62** is returned the TDC position, the vacuum acting on the check door **116** to hold the door **116** in the open position may dissipate, causing the biasing member (e.g., spring) **118** to rebound and return the check door **116** to a closed position, thereby closing the second window **120**, and resetting the driver **10** for a subsequent fastener driving cycle. As the drive piston **62** and the drive blade **34** return to the TDC position, the biasing member **74** urges the latch **68** into engagement with the slot **70** of the drive blade **34**, which locks the drive blade **34** in a position for the subsequent fastener driving cycle.

(32) At the beginning of a fastener driving cycle, the latch **68** is configured to maintain the drive piston **62** in the TDC position, while the compressor piston **42** is in the BDC position. As described in further detail below, a control system **300** may determine the position of the compressor piston **42** based on the activation of the one or more sensors **85** to ensure that the compressor piston **42** is in the BDC position and the crank arm **76** is in a starting position at the beginning of a fastener driving cycle. If the compressor piston **42** is determined to not be in the near BDC position at the end of a fastener driving cycle (i.e., an abnormal cycle) based on the activation of the one or more sensors **85**, the control system **300** may control rotation of the motor **46** in a direction (e.g., clockwise or counter-clockwise) to drive the compressor piston **42** toward its BDC position prior to the beginning of a subsequent fastener driving cycle.

(33) In some embodiments, an abnormal cycle may occur if the trigger **26** and/or the work contact switch (not shown) is released before the end of a fastener driving cycle. In other embodiments, an abnormal cycle may occur if the battery pack **20** is disconnected from the power tool or if the battery pack **20** shuts down during a fastener driving cycle. In response to determining an abnormal cycle, the subsequent operation cycle may be a recovery cycle. In some embodiments, a recovery cycle may be initiated by the user-actuated trigger **26** and/or actuation of the work contact switch (not shown). In other embodiments, a recovery cycle may be initiated by other suitable user inputs. In some embodiments, upon initiation of a recovery cycle, a flag may be set within a memory of the control system **300** to indicate that the previous operation cycle ended abnormally. The control system **300** may clear the flag once the compressor piston **42** is reset to the BDC position. Once a subsequent drive cycle is initiated, the control system **300** may check the memory for the flag before completing the subsequent operation cycle. In some embodiments, the control system **300** may perform an additional check, based on the state of the one or more sensors **85**, to determine if the starting position of compressor piston **42** is acceptable relative to the BDC position. In some embodiments, a timer may be used to determine a timeout period to end a recovery cycle if the position of the compressor piston **42** cannot be detected relative to the BDC position within the timeout period. The motor **46** may then be rotated in an opposite direction to drive the compressor piston **42** upward toward its TDC position by the crank arm assembly **54**. In some embodiments, if an abnormal cycle is determined and the compressor piston **42** stops at a mid-cycle position or the TDC position, the recovery cycle may be split into at least two or more recovery cycles.

(34) As the compressor piston **42** travels upward, the air in the compression cylinder **38** and above the compressor piston **42** is compressed, while the latch **68** maintains the drive piston **62** in the

TDC position. Once the crank arm **76** and cam **86** reaches a predetermined angular position coinciding with the TDC position of the compressor piston **42**, the latch **68** is moved into its unlocked position by the cam **86**, which releases the drive blade **34** as described above. After the drive blade **34** is released by the latch **68**, the drive piston **62** is accelerated downward within the drive cylinder **58** by the compressed air within the compression cylinder **38**, which causes the drive blade **34** to impact a fastener held in the magazine **14** and drive the fastener into a workpiece until the drive piston **62** reaches the stop member **60** located at the BDC position within the drive cylinder **58**.

(35) Upon the drive piston **62** reaching its BDC position, one-half of the fastener driving cycle is complete, and the compressor piston **42** is driven downwards towards the BDC position by the motor **46** and crank arm assembly **54** to complete the fastener driving cycle and ready the fastener driver **10** for a subsequent fastener driving cycle. As the compressor piston **42** is driven through a retraction stroke (i.e., from the TDC position toward the BDC position), a vacuum is created within the compression cylinder **38** and the drive cylinder **58**, creating a pressure imbalance on the drive piston **62** and a resultant upward force, causing the drive piston **62** to return to its TDC position. During the movement of the drive piston **62** to the TDC position, the check door **116** opens, which allows replacement air to enter the drive cylinder **58** beneath the drive piston **62** to facilitate return of the drive piston **62** to the TDC position as described above. When the drive piston **62** and the drive blade **34** return to the TDC position, the biasing member **74** urges the latch **68** into the slot **70** of the drive blade **34**, which locks the driver blade **34** in position for the subsequent fastener driving cycle.

(36) In the illustrated embodiment, the rotational speed of the motor **46** may be decreased after the fastener driving operation occurs such that the control system **300**, described in more detail below, implements a mechanism control scheme to electrically brake the motor **46** (e.g., via the plurality of FETs). In some embodiments, the mechanism control scheme may control the timings of the compressor piston **42** and the drive piston **62** and/or the position of the compressor **42** and the drive piston **62** during the operation cycle. Electrically braking the motor **46** allows the compressor piston **42** to return to the BDC position at a controlled speed for the subsequent fastener driving cycle. During the operation cycle, the one or more sensors **85** may detect signals indicative of the position of the compressor piston **42**. The control system **300** may receive the signals indicative of the position of the compressor piston **42** and implement the mechanism control scheme based on the received signals. In some embodiments, a timer may be used to set a timer duration for the complete fastener driving operation (e.g., for the compressor piston **42** to return to the BDC position). Accordingly, for the complete fastener driving cycle, the control system **300** is configured to instruct the motor **46** to drive at one or more periods of motor driving time and brake at one or more periods of motor braking time. In some embodiments, the control system **300** ensures that the compressor piston **42** is returned to the near BDC position prior to the subsequent fastener driving cycle.

(37) FIG. **11** is a block diagram of a control system **300** of the powered fastener driver **10**, according to some embodiments. In other embodiments, the control system **300** may be used with other power tools (e.g., drills, saws, oscillating tools, and/or the like). The control system **300** may include a first controller **305a** and a second controller **305b**, as well as other components not pictured in FIG. **11**, for example a motor **46**, a solenoid, or other mechanical and/or electrical components described above. In other embodiments, the first controller **305a** may include a greater number of components or a fewer number of components than the second controller **305b**. For example, the first controller **305a** and second controller **305b** may include an IC chip, PID controller, programmable logic controllers, and/or the like.

(38) In some embodiments, the first controller **305a** may include a processing unit **310a** comprising a control unit **315a**, an arithmetic logic unit **320a**, and one or more registers **325a**. The first controller **305a** may further include a memory **330a** consisting of program storage **335a** and/or

data storage **340a**. The memory **330a** may be flash memory, random access memory, solid state memory, another type of memory, or a combination of these types. The first controller **305a** may further include one or more input units **345a** and/or output units **350a**. In some embodiments, the one or more input units **345a** may be configured to receive a plurality of inputs such as a shark fin switch signal, a work contact switch signal, a mode switch signal, a load voltage signal, a trigger signal, or a control signal from one or more output units **350b**. In some embodiments, the one or more output units **350a** may be configured to transmit a plurality of outputs such as a battery load test signal, a signal to control a plurality of light-emitting diodes (LEDs), or a signal to control a plurality of FETs of the motor **46**.

(39) The first controller **305a** may be in electronic communication with the second controller **305b** via a communication line **322**. For example, the communication line **322** may be a wire, a link communication, and/or the like. The first controller **305a** may be further configured to transmit and/or receive data indicative of the status of a fastener driving cycle with the second controller **305b** via the communication line **322**. The second controller **305b** may include a processing unit **310b** comprising a control unit **315b**, an arithmetic logic unit **320b**, and one or more registers **325b**. The second controller **305b** may further include a memory **330b** consisting of program storage **335b** and/or data storage **340b**. The memory **330b** may be flash memory, random access memory, solid state memory, another type of memory, or a combination of these types. The second controller **305b** may further include one or more input units **345b** and/or output units **350b**, for example one or more input/output interfaces, various connections (e.g., a system bus) connecting the components, and/or the like. In some embodiments, the one or more input units **345b** may be configured to receive a plurality of inputs such as signals from one or more sensors **85** or a battery voltage signal. In some embodiments, the one or more output units **350b** may be configured to transmit a plurality of outputs such as a control signal to one or more input units **345a**. The processing unit **310a**, **310b** may include a microprocessor, a microcontroller, or another suitable programmable device.

(40) The memory **330a**, **330b** is a non-transitory computer readable medium that includes, for example, a program storage area and a data storage area. The program storage area and the data storage area can include combinations of different types of memory, such as read-only memory (“ROM”), random access memory (“RAM”) (e.g., dynamic RAM [“DRAM”], synchronous DRAM [“SDRAM”], etc.), electrically erasable programmable read-only memory (“EEPROM”), flash memory, a hard disk, an SD card, or other suitable magnetic, optical, physical, or electronic memory devices. The processing unit **310a**, **310b** is connected to the memory **330a**, **330b** and executes software instructions that are capable of being stored in a RAM of the memory **330a**, **330b** (e.g., during execution), a ROM of the memory **330a**, **330b** (e.g., on a generally permanent basis), or another non-transitory computer readable medium such as another memory or a disc. Software included in the implementation of the fastener driver **10** can be stored in the memory **330a**, **330b** of the controller **305a**, **305b**. The software includes, for example, firmware, one or more applications, program data, filters, rules, one or more program modules, and other executable instructions. The controller **305a**, **305b** is configured to retrieve from memory and execute, among other things, instructions related to the control of the fastener driver **10** described herein. In other constructions, the controller **305a**, **305b** includes additional, fewer, or different components.

(41) A battery pack **355** (e.g., battery pack **20**) may include a stack **360** consisting of one or more battery cells **365**. In some embodiments, the one or more battery cells **365** are electrically connected to each other in a series-type manner. In other embodiments, the one or more battery cells **365** are electrically connected to each other in a parallel-type manner. In still other embodiments, the one or more battery cells **365** are electrically connected to each other in a combination of a series-type and a parallel-type manner. The battery pack **355** may further include a battery pack controller **370** consisting of a battery processor **375** and a battery memory **380**. The battery pack **355** may further include a positive battery terminal **385** and a negative battery terminal

**390.** The positive battery terminal **385** and the negative battery terminal **390** may be configured to electrically and/or mechanically couple to corresponding terminals of the powered fastener driver **10**. In some embodiments, the battery pack **355** includes a communication terminal **395**, which may be configured to electrically, mechanically, and/or communicatively couple to one or more communication terminals of the powered fastener driver **10**.

(42) In some embodiments, such as the block diagram of FIG. **11**, the one or more battery cells **365** are connected to the battery pack controller **370**. The battery pack controller **370** controls the power delivered to the positive battery terminal **385** and the negative battery terminal **390** (for example, via control of a discharge field-effect transistor (FET), a charge FET, and/or other FETs located within the battery pack). In some embodiments, the battery pack controller **370** controls the power by allowing or prohibiting power. Additionally, in some embodiments, the battery pack controller **370** controls the power by allowing a percentage of power generated by the one or more battery cells **365** to be output. In some embodiments, the amount of power delivered between the battery terminals **385**, **390** is approximately 100% of power possibly generated by the one or more battery cells **365**.

(43) FIG. **12** is an exemplary flowchart illustrating a method **400** for controlling a motor (e.g., the motor **46**) of a power tool (e.g., the powered fastener driver **10**), according to some embodiments. It should be understood that the order of the steps disclosed in the method **400** could vary. For example, additional steps may be added to the process and not all of the steps may be required, or steps shown in one order may occur in a second order. The method **400** begins at step **405** when the first controller **305a** receives a signal to begin an operation of the power tool (e.g., the power tool is powered on). The method **400** then proceeds to step **410**.

(44) At step **410**, the first controller **305a** performs a battery load test on the battery pack **355** prior to a fastener driving cycle. The battery load test may include determining whether the battery pack **355** is electrically, mechanically, and/or communicatively coupled to the power tool when the first controller **305a** determines that the battery pack **355** includes a communication terminal **395**. If the first controller **305a** determines that the battery pack **355** does not include a communication terminal **395**, the first controller **305a** performs load testing on the battery pack **355** by measuring a voltage of the battery pack **355** prior to a fastener driving cycle. The method **400** may further include determining, via the first controller **305a**, an internal resistance of the battery pack **355**. The internal resistance may be determined by measuring a voltage and/or a current of the battery pack **355** prior to a fastener driving cycle. In some embodiments, the internal resistance may be determined based on the one or more battery cells **365** and/or the FETs and/or other electrical or physical components of the battery pack **355**. The method **400** may further include determining, via the first controller **305a**, a type of battery pack based on the determined internal resistance. If the first controller **305a** determines that the battery pack **355** does include a communication terminal **395**, the method **400** may include determining a type of battery pack by receiving a signal from the battery pack communication terminal. The method **400** then proceeds to step **415**.

(45) At step **415**, the first controller **305a** determines a first mechanism control scheme. The first mechanism control scheme may include determining a timing of one fastener driving cycle of the motor **46** (coinciding with one fastener driving cycle of the fastener driver **10**). The first mechanism control scheme includes electrically controlling the motor **46** to drive the crank arm assembly **54**. In some embodiments, the motor **46** drives the crank arm assembly **54** in a first direction. The first mechanism control scheme may further include determining a duty cycle of a pulse-width modulated (PWM) signal to apply to the plurality of FETs, connected to the one or more output units **350a**, of the motor **46** to drive the crank arm assembly **54**. The first mechanism control scheme may further include determining a duty cycle of a PWM signal to apply to the plurality of FETs of the motor **46** to electrically brake the crank arm assembly **54**. Once the first mechanism control scheme is determined, the method **400** proceeds to step **420**.

(46) At step **420**, the first controller **305a** receives a signal from a first user input, via the one or

more input units **345a**, indicative of the beginning of a fastener driving cycle (e.g., the beginning of an operation cycle). In some embodiments, the signal to begin a fastener driving cycle of the motor **46** may be based on an actuation of the trigger **26** or another switch of the power tool. In some embodiments, the first controller **305a** may receive a signal from a mode switch (not shown) indicative of a mode of the fastener driver **10** prior to the actuation of the trigger **26**. In other embodiments, the power tool may begin the fastener driving cycle in response to an actuation of the trigger **26** in combination with an actuation of a work contact element and/or actuation of a second trigger (e.g., a sharkfin switch). Actuation of the work contact element and/or actuation of the second trigger may transmit a signal to the first controller **305a** the beginning of a fastener driving operation. The method **400** then proceeds to step **425**.

(47) At step **425**, the first controller **305a** may be isolated from the second controller **305b** via communication line **322**. In some embodiments, the communication line **322** is an electrical connection between one or more output units **350b** and one or more input units **345a**. For example, the one or more output units **350b** may be temporarily disconnected from the one or more input units **345a** during the operation cycle. The first controller **305a** generates a signal, in response to the actuation of the trigger **26**, to initiate isolation of the first controller **305a** from the second controller **305b** through the hardware of the first controller **305a** (i.e., via the communication line **322** or the electrical connection between one or more output units **350b** and one or more input units **345a**). Isolating the first controller **305a** from the second controller **305b** prevents the communication of data indicative of the status of the fastener driving cycle, as further described below, during the fastener driving cycle. In some embodiments, the isolation of the first controller **305a** from the second controller **305b** actuates a timer of the first controller **305a** corresponding to the timing of one fastener driving cycle of the motor. The one fastener driving cycle may be the time between when the motor **46** begins driving the crank arm assembly **54** from a starting position (e.g., when the compressor piston **42** is at or near the BDC position) to when the crank arm assembly **54** drives the compressor piston **42** to complete a fastener driving cycle (e.g., when the compressor piston **42** returns to the BDC position). Once the method **400** isolates the first controller **305a** from the second controller **305b**, the method **400** proceeds to step **430**.

(48) At step **430**, the first controller **305a** controls the motor **46** (in some embodiments, while the first controller **305a** is isolated from the second controller **305b**) based on the first control scheme determined in step **415** via the one or more output units **350a**. At least one of the one or more output units **350a** is electrically connected to the motor **46**. Based on the timing of the fastener driving cycle, the first controller **305a** determines a plurality of time intervals (e.g., a first time, a second time, a third time, a fourth time, etc.). The first mechanism control scheme further includes driving the motor **46** and electrically braking the motor **46** at the plurality of determined time intervals for a plurality of durations corresponding to a duty cycle of a PWM signal. Electrically braking the motor **46** may include electrically shorting the lead wires of the motor **46** together for a determined duration. The method **400** further includes applying a series of voltage pulses to the motor **46**. For example, the voltage pulses may correspond to a duty cycle of a PWM signal. For example, in a complete fastener driving cycle, the first controller **305a** applies a PWM signal to drive the motor **46** at a first time (e.g., a first driving time interval) for a first duration (e.g., at a first duty cycle) (i.e., to compress air via the compressor piston **42** and release the drive piston **62**), applies a PWM signal to electrically brake the motor **46** at a second time (e.g., a first braking time interval) for the first duration (i.e., to slow or stop the motor **46** and allow residual pressure to vent), applies a PWM signal to drive the motor **46** at a third time (e.g., a second driving time interval) for a third duration (e.g., at a second duty cycle) (i.e., to return the compressor piston **42** to the BDC position and create a vacuum to reset the drive piston **62** to the TDC position), and applies a PWM signal to electrically brake the motor **46** at a fourth time (e.g., a second braking time interval) for the second duration (i.e., to stop the compressor piston **42** at or near the BDC position for the subsequent fastener driving cycle). As such, this ensures the compressor piston **42** is

returned to the BDC position prior to the subsequent fastener driving cycle.

(49) In some embodiments, the motor **46** drives the crank arm assembly **54** in a first direction in a first fastener driving cycle of the motor **46**, wherein one fastener driving cycle is the time between when the motor **46** begins driving the crank arm assembly **54** from a starting position (e.g., when the compressor piston **42** is at or near the BDC position) to when the crank arm assembly **54** drives the compressor piston **42** to reach the TDC position. The motor **46** may then drive the crank arm assembly **54** in a second direction, opposite the first direction, in a second fastener driving cycle of the motor **46**. The motor **46** may alternatively drive the crank arm assembly **54** in this fashion in alternative cycles. For example, in the first, third, fifth, and so-on cycles, the motor **46** may drive the crank arm assembly **54** in a clockwise direction, while in the second, fourth, sixth, and so-on cycles, the motor **46** may drive the crank arm assembly **54** in a counterclockwise direction. The method **400** then proceeds to step **435**.

(50) At step **435**, the first controller **305a** determines the completion of a fastener driving cycle based on the completion of the first mechanism control scheme. The completion of the mechanism control scheme is determined by the compressor piston **42** returning to the near BDC position. In some embodiments, the completion of the fastener driving cycle may correspond to the end of the actuation of the trigger **26**. In other embodiments, the completion of the fastener driving cycle may correspond to the end of the timer of the first controller **305a**. Upon completion of the fastener driving cycle, the first controller **305a** terminates the signal indicative of the hardware isolation of the first controller **305a** from the second controller **305b** via the communication line **322** allowing data communication between the first controller **305a** and the second controller **305b**. The method then proceeds to step **440**.

(51) At step **440**, the first controller **305a** receives data indicative of the fastener driving cycle corresponding to the first mechanism control scheme from the second controller **305b**. In some embodiments, the second controller **305b** transmits the data via the communication line **322** only after the completion of the fastener driving cycle. The method **400** then proceeds to step **445**. At step **445**, the first controller **305a** determines a second mechanism control scheme based on the data received from the second controller **305b**. In some embodiments, the first mechanism control scheme is adjusted based on the data received indicative of the fastener driving cycle to determine the second control scheme. In other embodiments, the second control scheme may be determined solely based on the data received by the first controller **305a**. Upon the determination of the second control scheme, the method **400** returns to step **420** where the first controller **305a** waits for a signal indicative of the beginning of a second fastener driving cycle. In some embodiments, the fastener driver **10** may wait to begin the second fastener driving cycle until a second actuation of the trigger **26** or other switch occurs. The method **400** may be advantageous over existing designs because the battery load test and the adjustment of the mechanism control scheme based on previous operation cycles produces a more reliable user experience over a range of battery packs. By performing the battery load test and adjusting the mechanism control scheme based on previous operation cycles, each mechanism control scheme can be altered individually and precisely based on the results of each operation cycle of the fastener driver **10**.

(52) FIG. **13** is a flowchart illustrating a method **500** for collecting the data indicative of the result of a fastener driving cycle via the second controller **305b**, according to some embodiments. It should be understood that the order of the steps disclosed in the method **500** could vary. For example, additional steps may be added to the process and not all of the steps may be required, or steps shown in one order may occur in a second order. The method **500** begins at step **505** when the second controller **305b** receives a signal to begin an operation of the power tool (e.g., the power tool is powered on). The method **500** then proceeds to step **510**.

(53) At step **510**, similar to step **425** of method **400**, the first controller **305a** is isolated from the second controller **305b** via communication line **322**. In some embodiments, the communication line **322** is an electrical connection between one or more output units **350b** and one or more input units

**345a**. The first controller **305a** generates a signal, in response to the actuation of the trigger **26**, to initiate isolation of the first controller **305a** from the second controller **305b** through the hardware of the first controller **305a**. Isolating the first controller **305a** from the second controller **305b** prevents the communication of data indicative of the status of the fastener driving cycle and may allow each mechanism control scheme to be altered based on the results of the previous operation cycle of the fastener driver. The method **500** then proceeds to step **515**. At step **515**, the second controller **305b** clears any previous data stored in the memory **330b** (including, but not limited to data storage **340b**) indicative of data collected during previous fastener driving cycles. The method then proceeds to step **520**.

(54) At step **520**, the second controller **305b** receives, via the one or more input units **345b**, a plurality of signals from the one or more sensors **85** indicative of the position of the compressor piston **42** during the fastener driving cycle. The plurality of signals is indicative of when each of the one or more sensors **85** are activated by the end-mounted magnet of the piston pin **82** corresponding to the position of the compressor piston **42** throughout the operation cycle. For example, the plurality of signals may include data indicative of when the compressor piston **42** is at the BDC position, when the compressor piston **42** reaches a peak torque position, when the compressor piston **42** reaches the TDC position. When the second controller **305b** receives one or more of the plurality of signals, the second controller **305b** initiates a data collection control timer corresponding to the timer duration for the complete fastener driving operation (e.g., for the compressor piston **42** to return to the BDC position). The method **500** then proceeds to step **525**.

(55) At step **525**, the second controller **305b** stores the data indicative of the activation of the one or more sensors **85** within memory **330b** during the fastener driving cycle. When each of the one or more sensors **85** activate, indicative of when the compressor piston **42** reaches a peak torque position and when the compressor piston **42** reaches the TDC position, the second controller **305b** measures a voltage of the battery pack **355** and stores the measured voltage within memory **330b** during the fastener driving cycle. The method **500** then proceeds to step **530**. At step **530**, similar to step **435** of method **400**, the first controller **305a** terminates the signal indicative of the hardware isolation of the first controller **305a** from the second controller **305b** via the communication line **322** allowing data communication between the first controller **305a** and the second controller **305b**. The method **500** then proceeds to step **535**.

(56) At step **535**, the second controller **305b** transmits the data indicative of the activation of the one or more sensors **85**, stored in memory **330b**, to the first controller **305a** via the communication line **322** after the completion of the fastener driving cycle. The method **500** returns to step **510** where the second controller **305b** waits for the signal from the first controller **305a** to initiate isolation of the first controller **305a** from the second controller **305b** through the hardware of the first controller **305a**. In some embodiments, if the compressor piston **42** does not completely return to the BDC position at the completion of a fastener driving cycle, the first controller **305a** may use the data indicative of the position of the compressor piston **42** and the measured battery voltage from the second controller **305b** to control the motor **46** to automatically return the compressor piston **42** to the BDC position. In some embodiments, the first controller **305a** may apply a PWM signal to the plurality of FETs connected to the motor **46** to drive the crank arm assembly **54** in a direction to return the compressor piston **42** to the BDC position.

(57) FIG. **14** is a block diagram of a control system **300** of the powered fastener driver **10**, according to some embodiments. In other embodiments, the control system **300** may be used with other power tools. The control system **300** may include a controller **305c**, as well as other components not pictured in FIG. **14**, for example a motor **46**, a solenoid, and/or other mechanical and/or electrical components described above. The controller **305c** may include a processing unit **310c** comprising a control unit **315c**, an arithmetic logic unit **320c**, and one or more registers **325c**. The controller **305c** may further include a memory **330c** consisting of program storage **335c** and/or data storage **340c**. The memory **330c** may be flash memory, random access memory, solid state



memory, another type of memory, or a combination of these types. The controller **305c** may further include one or more input units **345c** and/or output units **350c**. In some embodiments, the one or more input units **345c** may be configured to receive a plurality of inputs such as a shark fin switch signal, a work contact element switch signal, a mode switch signal, a load voltage signal, a trigger signal, signals from one or more sensors **85** or a battery voltage signal. In some embodiments, the one or more output units **350c** may be configured to transmit a plurality of outputs such as a battery load test signal, a signal to control a plurality of light-emitting diodes (LEDs), or a signal to control a plurality of FETs connected to the motor **46**. For example, the controller **305c** may include an IC chip, PID controller, programmable logic controllers, and/or the like. The processing unit **310c** may include a microprocessor, a microcontroller, or another suitable programmable device.

(58) The memory **330c** is a non-transitory computer readable medium that includes, for example, a program storage area and a data storage area. The program storage area and the data storage area can include combinations of different types of memory, such as read-only memory (“ROM”), random access memory (“RAM”) (e.g., dynamic RAM [“DRAM”], synchronous DRAM [“SDRAM”], etc.), electrically erasable programmable read-only memory (“EEPROM”), flash memory, a hard disk, an SD card, or other suitable magnetic, optical, physical, or electronic memory devices. The processing unit **310c** is connected to the memory **330c** and executes software instructions that are capable of being stored in a RAM of the memory **330c** (e.g., during execution), a ROM of the memory **330c** (e.g., on a generally permanent basis), or another non-transitory computer readable medium such as another memory or a disc. Software included in the implementation of the fastener driver **10** can be stored in the memory **330c** of the controller **305c**. The software includes, for example, firmware, one or more applications, program data, filters, rules, one or more program modules, and other executable instructions. The controller **305c** is configured to retrieve from memory and execute, among other things, instructions related to the control of the fastener driver **10** described herein. In other constructions, the controller **305c** includes additional, fewer, or different components.

(59) The battery pack **355** may include a stack **360** consisting of one or more battery cells **365**. In some embodiments, the one or more battery cells **365** (e.g., lithium ion cells or cells having similar chemistry) are electrically connected to each other in a series-type manner. In other embodiments, the one or more battery cells **365** are electrically connected to each other in a parallel-type manner. In still other embodiments, the one or more battery cells **365** are electrically connected to each other in a combination of a series-type and a parallel-type manner. The battery pack **355** may further include a battery pack controller **370** consisting of a battery processor **375** and a battery memory **380**. The battery pack **355** may further include a positive battery terminal **385** and a negative battery terminal **390**. The positive battery terminal **385** and the negative battery terminal **390** may be configured to electrically and/or mechanically couple to corresponding terminals of the powered fastener driver **10**. In some embodiments, the battery pack **355** includes a communication terminal **395**, which may be configured to electrically, mechanically, and/or communicatively couple to one or more communication terminals of the powered fastener driver **10**.

(60) In some embodiments, such as the block diagram of FIG. **14**, the one or more battery cells **365** are connected to the battery pack controller **370**. The battery pack controller **370** controls the power delivered to the positive battery terminal **385** and the negative battery terminal **390** (for example, via control of a discharge field-effect transistor (FET), a charge FET, and/or other FETs located within the battery pack). In some embodiments, the battery pack controller **370** controls the power by allowing or prohibiting power. Additionally, in some embodiments, the battery pack controller **370** controls the power by allowing a percentage of power generated by the one or more battery cells **365** to be output. In some embodiments, the amount of power delivered between the battery terminals **385**, **390** is approximately 100% of power possibly generated by the one or more battery cells **365**.

(61) FIG. **15** is a flowchart illustrating a method **600** for controlling a motor (e.g., the motor **46**) of

a power tool (e.g., the powered fastener driver **10**), according to some embodiments. It should be understood that the order of the steps disclosed in the method **600** could vary. For example, additional steps may be added to the process and not all of the steps may be required, or steps shown in one order may occur in a second order. The method **600** begins at step **605** when the controller **305c** receives a signal to begin an operation of the power tool (e.g., the power tool is powered on). The method **600** then proceeds to step **610**.

(62) At step **610**, the controller **305c** performs a battery load test on the battery pack **355** prior to a fastener driving cycle. The battery load test may further include determining whether the battery pack **355** is electrically, mechanically, and/or communicatively coupled to the power tool when the first controller **305a** determines that the battery pack **355** includes a communication terminal **395**. If the controller **305c** determines that the battery pack **355** does not include a communication terminal **395**, the controller **305c** performs load testing on the battery pack **355** by measuring a voltage of the battery pack **355** prior to a fastener driving cycle. The method **600** may further include determining, via the controller **305c**, an internal resistance of the battery pack. The internal resistance may be determined by measuring a voltage and/or a current of the battery pack **355** prior to a fastener driving cycle. The method **600** may further include determining, via the controller **305c**, a type of battery pack based on the determined internal resistance. If the controller **305c** determines that the battery pack **355** does include a communication terminal **395**, the method **600** includes determining a type of battery pack by receiving a signal from the battery pack communication terminal. The method **600** then proceeds to step **615**.

(63) At step **615**, the controller **305c** determines a first mechanism control scheme. The first mechanism control scheme may include determining a timing of one fastener driving cycle of the motor **46** (coinciding with one fastener driving cycle of the fastener driver **10**). The first mechanism control scheme may include electrically controlling the motor **46** to drive the crank arm assembly **54**. In some embodiments, the motor **46** drives the crank arm assembly **54** in a first direction. The first mechanism control scheme may further include determining a duty cycle of a PWM signal to apply to the plurality of FETs connected to the motor **46** to drive the crank arm assembly **54**. The first mechanism control scheme may further include determining a duty cycle of a PWM signal to apply to the plurality of FETs connected to the motor **46** to electrically brake the crank arm assembly **54**. Once the first mechanism control scheme is determined, the method **600** proceeds to step **620**.

(64) At step **620**, the controller **305c** receives a signal from a first user input, via the one or more input units **345c**, indicative of the beginning of a fastener driving cycle (e.g., the beginning of an operation cycle). In some embodiments, the signal to begin a fastener driving cycle of the motor **46** may be based on an actuation of the trigger **26** or another switch of the power tool. In some embodiments, the controller **305c** may receive a signal from a mode switch (not shown) indicative of a mode of the fastener driver **10** prior to the actuation of the trigger **26**. In other embodiments, the power tool may begin the fastener driving cycle in response to an actuation of the trigger **26** in combination with an actuation of a work contact element switch (not shown) and/or actuation of a second trigger (e.g., a sharkfin switch). Actuation of the work contact element switch transmits a signal to the controller **305c** indicative of the beginning of a fastener driving operation. The method **600** then proceeds to step **625**.

(65) At step **625**, sensor inputs received from the one or more sensors **85** are isolated from the determination of subsequent mechanism control schemes via the software of the controller **305c**. The controller **305c** generates a signal, in response to the actuation of the trigger **26**, to initiate isolation of the sensor inputs received from the one or more sensors **85** from the determination of subsequent mechanism control schemes through the software of the controller **305c**. For example, during the software isolation, the one or more input units **345c** receive a plurality of signals from the one or more sensors **85** during a fastener driving cycle and the plurality of signals from the one or more sensors **85** are stored in the memory **330c**. Isolating the plurality of signals from the one or

more sensors **85** from the determination of subsequent mechanism control schemes prevents the determination of a second mechanism control scheme, as further described below, during the fastener driving cycle (e.g., during the first mechanism control scheme). In some embodiments, the isolation of the plurality of signals from the one or more sensors **85** from the determination of a second mechanism control scheme actuates a timer of the controller **305c** corresponding to the timing of one fastener driving cycle of the motor. The one fastener driving cycle may be the time between when the motor **46** begins driving the crank arm assembly **54** from a starting position (e.g., when the compressor piston **42** is at or near the BDC position) to when the crank arm assembly **54** drives the compressor piston **42** to complete a fastener driving cycle (e.g., when the compressor piston **42** returns to the BDC position). Once the method **600** isolates the controller **305c** from the memory **330c**, the method **600** proceeds to step **630**.

(66) At step **630**, the controller **305c** controls the motor **46** based on the first control scheme determined in step **615** via the one or more output units **350c**. At least one of the one or more output units **350c** is electrically connected to the motor **46**. Based on the timing of the fastener driving cycle, the controller **305c** determines a plurality of time intervals (e.g., a first time, a second time, a third time, a fourth time, etc.). The first mechanism control scheme further includes driving the motor **46** and electrically braking the motor **46** at the plurality of determined time intervals for a plurality of durations corresponding to a duty cycle of a PWM signal. Electrically braking the motor **46** may include electrically shorting the lead wires of the motor **46** together for a determined duration. The method **600** further includes applying a series of voltage pulses to the motor **46**. For example, the voltage pulses may correspond to a duty cycle of a PWM signal. For example, in a complete fastener driving cycle, the controller **305c** applies a PWM signal to drive the motor **46** at a first time (e.g., a first driving time interval) for a first duration (e.g., a first duty cycle) (i.e., to compress air via the compressor piston **42** and release the drive piston **62**), applies a PWM signal to electrically brake the motor **46** at a second time (e.g., a first braking time interval) for a first duration (i.e., to slow or stop the motor **46** and allow residual pressure to vent), applies a PWM signal to drive the motor **46** at a third time (e.g., a second driving time interval) for a third duration (e.g., a second duty cycle) (i.e., to return the compressor piston **42** to the BDC position and create a vacuum to reset the drive piston **62** to the TDC position), and applies a PWM signal to electrically brake the motor **46** at a fourth time (e.g., a second braking time interval) for a second duration (i.e., to stop the compressor piston **42** at or near the BDC position for the subsequent fastener driving cycle). As such, this ensures the compressor piston **42** is returned to the BDC position prior to the subsequent fastener driving cycle.

(67) In some embodiments, the motor **46** drives the crank arm assembly **54** in a first direction in a first fastener driving cycle of the motor **46**, wherein one fastener driving cycle is the time between when the motor **46** begins driving the crank arm assembly **54** from a starting position (e.g., when the compressor piston **42** is at or near the BDC position) to when the crank arm assembly **54** drives the compressor piston **42** to reach the TDC position and continues to the near BDC position, completing the fastener driving cycle. The motor **46** may then drive the crank arm assembly **54** in a second direction, opposite the first direction, in a second fastener driving cycle of the motor **46**. The motor **46** may alternatively drive the crank arm assembly **54** in this fashion in alternative cycles. For example, in the first, third, fifth, and so-on cycles, the motor **46** may drive the crank arm assembly **54** in a clockwise direction, while in the second, fourth, sixth, and so-on cycles, the motor **46** may drive the crank arm assembly **54** in a counterclockwise direction. The method **600** then proceeds to step **635**.

(68) At step **635**, the controller **305c** determines the completion of a fastener driving cycle based on the completion of the first mechanism control scheme. The completion of the mechanism control scheme is determined by a timer that times the compressor piston **42** returning to the BDC position. In some embodiments, the completion of the fastener driving cycle may correspond to the end of the actuation of the trigger **26** or other switch. In other embodiments, the completion of the fastener

driving cycle may correspond to the end of the timer of the controller **305c**. Upon completion of the fastener driving cycle, the controller **305c** terminates the signal indicative of the software isolation of the sensor inputs received from the one or more sensors **85** from the determination of subsequent mechanism control schemes via the software of the controller **305c** allowing the controller **305c** to process the plurality of signals from the one or more sensors **85** stored in the memory **330c**. The method then proceeds to step **640**.

(69) At step **640**, the controller **305c** receives data indicative of the fastener driving cycle corresponding to the first mechanism control scheme from the memory **330c**, as described in greater detail below. The memory **330c** transmits the data via electronic communication with the controller **305c** only after the completion of the fastener driving cycle. The method **600** then proceeds to step **645**. At step **645**, the controller **305c** determines the second mechanism control scheme based on the data received from the memory **330c**. In some embodiments, the first mechanism control scheme is adjusted based on the data received indicative of the fastener driving cycle to determine the second control scheme. Upon the determination of the second control scheme, the method **600** returns to step **620** where the controller **305c** waits for a signal indicative of the beginning of a second fastener driving cycle. In some embodiments, the fastener driver **10** may wait to begin the second fastener driving cycle until a second actuation of the trigger **26** or other switch occurs.

(70) FIG. **16** is a flowchart illustrating a method **700** for collecting the data indicative of the result of a fastener driving cycle via the memory **330c**, according to some embodiments. It should be understood that the order of the steps disclosed in the method **700** could vary. For example, additional steps may be added to the process and not all of the steps may be required, or steps shown in one order may occur in a second order. The method **700** begins at step **705** when the memory **330c** receives a signal to begin an operation of the power tool (e.g., the power tool is powered on). The method **700** then proceeds to step **710**.

(71) At step **710**, similar to step **625** of method **600**, the sensor inputs received from the one or more sensors **85** are isolated from the determination of subsequent mechanism control schemes via software isolation. For example, the software isolation may prevent the determination of a second mechanism control scheme during a fastener driving cycle. The controller **305c** generates a signal, in response to the actuation of the trigger **26**, to initiate isolation of the plurality of signals from the one or more sensors **85** from the determination of subsequent mechanism control schemes through the software of the controller **305c**. Isolating the plurality of signals from the one or more sensors **85** from the determination of subsequent mechanism control schemes prevents the processing of data indicative of the status of the fastener driving cycle. The method **700** then proceeds to step **715**. At step **715**, the memory **330c** clears any previous data stored indicative of data collected during previous fastener driving cycles. The method then proceeds to step **720**.

(72) At step **720**, the memory **330c** receives, via the one or more input units **345c**, a plurality of signals from the one or more sensors **85** indicative of the position of the compressor piston **42** during the fastener driving cycle. The plurality of signals is indicative of when each of the one or more sensors **85** are activated by the end-mounted magnet of the piston pin **82** corresponding to the position of the compressor piston **42** throughout the operation cycle. For example, the plurality of signals may include data indicative of when the compressor piston **42** is at the BDC position, when the compressor piston **42** reaches a peak torque position, when the compressor piston **42** reaches the TDC position. When the memory **330c** receives one or more of the plurality of signals, the memory **330c** initiates a data collection control timer corresponding to the timer duration for the complete fastener driving operation (e.g., for the compressor piston **42** to return to the BDC position). The method **700** then proceeds to step **725**.

(73) At step **725**, the memory **330c** stores the data indicative of the activation of the one or more sensors **85** during the fastener driving cycle. When each of the one or more sensors **85** close, indicative of when the compressor piston **42** reaches a peak torque position and when the

compressor piston **42** reaches the TDC position, the memory **330c** measures a voltage of the battery pack **355** and stores the measured voltage during the fastener driving cycle. The method **700** then proceeds to step **730**. At step **730**, similar to step **635** of method **600**, the controller **305c** terminates the signal indicative of the software isolation of the plurality of signals from the one or more sensors **85** from the determination of subsequent mechanism control schemes via the software of the controller **305c** allowing the controller **305c** to process the plurality of signals from the one or more sensors **85** stored in the memory **330c**. The method **700** then proceeds to step **735**.

(74) At step **735**, the memory **330c** transmits the data indicative of the activation of the one or more sensors **85** to the controller **305c** only after the completion of the fastener driving cycle. The method **700** returns to step **710** where the memory **330c** waits for the signal from the controller **305c** to initiate isolation of the plurality of signals from the one or more sensors the determination of subsequent mechanism control schemes through the software of the controller **305c**. In some embodiments, if the compressor piston **42** does not completely return to the BDC position at the completion of a fastener driving cycle, the controller **305c** may use the data indicative of the position of the compressor piston **42** and the measured battery voltage from the memory **330c** to control the motor **46** to automatically return the compressor piston **42** to the BDC position. In some embodiments, the controller **305c** may automatically apply a PWM signal to the plurality of FETs connected to the motor **46** to drive the crank arm assembly **54** in a direction to return the compressor piston **42** to the BDC position. In other embodiments, the controller **305c** may apply a PWM signal to the plurality of FETs connected to the motor **46** to drive the crank arm assembly **54** in a direction to return the compressor piston **42** to the BDC position following the completion of the fastener driving cycle.

(75) Although the present subject matter has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope of one or more independent aspects of the present subject matter as described.

## Claims

1. A method of controlling a motor of a power tool, the method comprising: performing, via a first controller, a load test on a battery pack of the power tool; determining, via the first controller, a first mechanism control scheme based on the load test; receiving, via the first controller, an input indicative of beginning an operation cycle of the power tool; isolating the first controller from a second controller; controlling, via the first controller, the motor of the power tool based on the first mechanism control scheme while the first controller is isolated from the second controller; sensing, via one or more sensors, a dataset indicative of a result of the operation cycle of the power tool based on the first mechanism control scheme; receiving, via the second controller, the dataset; connecting the first controller and the second controller upon completion of the operation cycle; transmitting, via the second controller, the dataset to the first controller upon completion of the operation cycle; and determining, via the first controller, a second mechanism control scheme based on the dataset.
2. The method of claim 1, further comprising: receiving, via the first controller, a second user input indicative of beginning a second operation cycle of the power tool; controlling, via the first controller, the motor of the power tool based on the second mechanism control scheme while the first controller is isolated from the second controller.
3. The method of claim 1, wherein the first mechanism control scheme includes applying a pulse-width modulated (PWM) signal to control the motor.
4. The method of claim 1, wherein the first mechanism control scheme includes applying a braking signal to control the motor.
5. The method of claim 1, wherein the one or more sensors are Hall effect sensors.
6. The method of claim 5, wherein the method further comprises: sensing, via the one or more

sensors, a position of a first piston of the power tool.

7. The method of claim 1, wherein the isolating the first controller from the second controller prevents data communication while the motor is powered via an external circuit.

8. The method of claim 1, wherein the second mechanism control scheme is implemented for a second operation cycle of the power tool.

9. A non-transitory computer-readable medium storing a program for controlling the motor of the power tool including instructions that, when executed by a processor, causes the first controller connected to the processor, to be configured to implement the method of claim 1.

10. A method of controlling a motor of a power tool, the method comprising: electrically braking the motor, via a command from a first controller, based on a first mechanism control scheme; detecting, via the first controller, a completion of an operation cycle of the motor; transmitting, via a second controller, a dataset indicative of a position of a first piston of the power tool to the first controller upon completion of the operation cycle; and determining, via the first controller, a second mechanism control scheme based on the dataset, wherein the first controller is isolated from the second controller during the operation cycle.

11. The method of claim 10, wherein electrically braking the motor includes dynamically braking with a plurality of motor control field effect transistors (FETs).

12. The method of claim 10, wherein the second mechanism control scheme is implemented for a second operation cycle of the power tool.

13. The method of claim 10, wherein the first mechanism control scheme is based on a load test of a battery pack of the power tool.

14. The method of claim 10, wherein the operation cycle comprises: driving the motor for a first driving time interval; dynamically braking the motor for a first braking time interval; driving the motor for a second driving time interval, wherein the second driving time interval is different from the first driving time interval; dynamically braking the motor for a second braking time interval, wherein the second braking time interval is different from the first braking time interval.

15. A non-transitory computer-readable medium storing a program for controlling the motor of the power tool including instructions that, when executed by a processor, causes the first controller connected to the processor, to be configured to implement the method of claim 10.

16. A powered fastener driver comprising: a first cylinder; a first piston positioned within the first cylinder, the first piston being moveable between a top-dead-center (TDC) position and a near bottom-dead-center (BDC) position; a second cylinder in fluid communication with the first cylinder; a second piston positioned within the second cylinder, the second piston being moveable between a TDC position and a BDC position to initiate a fastener driving cycle; and a control system including a first controller configured to: electrically brake a motor based on a first mechanism control scheme; drive the motor based on the first mechanism control scheme; detect a completion of an operation cycle of the motor; receive, from a second controller, a dataset indicative of a position of the first piston of the power tool completion of the operation cycle; and determine a second mechanism control scheme based on the dataset, wherein the first controller is isolated from the second controller during the operation cycle.

17. The powered fastener driver of claim 16, wherein the control system is further configured to: receive a second user input indicative of beginning a second operation cycle of the power tool; and control the motor of the power tool based on the second mechanism control scheme while the first controller is isolated from the second controller.

18. The powered fastener driver of claim 16, wherein braking the motor includes dynamically braking with a plurality of motor control field effect transistors (FETs).

19. The powered fastener driver of claim 16, wherein the second mechanism control scheme is implemented for a second operation cycle of the power tool.

20. The powered fastener driver of claim 16, wherein the first mechanism control scheme is based on a load test of a battery pack of the power tool.

21. The powered fastener driver of claim 16, wherein the power fastener driver further includes one or more sensors configured to sense signals to generate the dataset.
22. The power fastener driver of claim 21, wherein the one or more sensors are Hall effect sensors.
23. A method of controlling a motor of a power tool, the method comprising: performing, via a controller, a load test on a battery pack of the power tool; determining, via the controller, a first mechanism control scheme based on the load test; receiving, via the controller, an input indicative of beginning an operation cycle of the power tool; isolating sensor inputs via one or more sensors from a determination of subsequent mechanism control schemes via the controller; controlling, via the controller, the motor of the power tool based on the first mechanism control scheme while sensor inputs via one or more sensors are isolated from a determination of subsequent mechanism control schemes; sensing, via the one or more sensors, a dataset indicative of a result of the operation cycle of the power tool based on the first mechanism control scheme; receiving, via a memory of the controller, the sensor inputs including the dataset; connecting the sensor inputs and the determination of subsequent mechanism control schemes via the controller upon completion of the operation cycle; transmitting, via the memory, the dataset to the controller upon completion of the operation cycle; and determining, via the controller, a second mechanism control scheme based on the dataset.
24. The method of claim 23, further comprising: receiving, via the controller, a second user input indicative of beginning a second operation cycle of the power tool; controlling, via the controller, the motor of the power tool based on the second mechanism control scheme while sensor inputs via one or more sensors are isolated from a determination of subsequent mechanism control schemes.
25. The method of claim 23, wherein the first mechanism control scheme includes applying a pulse-width modulated (PWM) signal to control the motor.
26. The method of claim 23, wherein the first mechanism control scheme includes applying a braking signal to control the motor.
27. The method of claim 23, wherein the one or more sensors are Hall effect sensors.
28. The method of claim 27, wherein the method further comprises: sensing, via the one or more sensors, a position of a first piston of the power tool.
29. The method of claim 23, wherein isolating sensor inputs via one or more sensors from the determination of subsequent mechanism control schemes via the controller prevents processing the dataset via the controller while the motor is powered via an external circuit.
30. The method of claim 23, wherein the second mechanism control scheme is implemented for a second operation cycle of the power tool.
31. A powered fastener driver comprising: a first cylinder; a first piston positioned within the first cylinder, the first piston being moveable between a top-dead-center (TDC) position and a near bottom-dead-center (BDC) position; a second cylinder in fluid communication with the first cylinder; a second piston positioned within the second cylinder, the second piston being moveable between a TDC position and a BDC position to initiate a fastener driving cycle; and a control system including a controller configured to: electrically brake a motor based on a first mechanism control scheme; drive the motor based on the first mechanism control scheme; detect a completion of an operation cycle of the motor; receive, from a memory of the controller, sensor inputs including a dataset indicative of a position of the first piston of the power tool completion of the operation cycle; and determine a second mechanism control scheme based on the dataset, wherein the sensor inputs via one or more sensors are isolated from a determination of subsequent mechanism control schemes, via the controller, during the operation cycle.
32. The powered fastener driver of claim 31, wherein the control system is further configured to: receive a second user input indicative of beginning a second operation cycle of the power tool; and control the motor of the power tool based on the second mechanism control scheme while the sensor inputs via one or more sensors are isolated from a determination of subsequent mechanism control schemes.

33. The powered fastener driver of claim 31, wherein braking the motor includes dynamically braking with a plurality of motor control field effect transistors (FETs).
34. The powered fastener driver of claim 31, wherein the second mechanism control scheme is implemented for a second operation cycle of the power tool.
35. The powered fastener driver of claim 31, wherein the first mechanism control scheme is based on a load test of a battery pack of the power tool.
36. The power fastener driver of claim 31, wherein the one or more sensors are Hall effect sensors.
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