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(54) **MOVABLE BARRIER OPERATOR**

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Related U.S. Application Data

(63) Continuation of application No. 18/233,479, filed on Aug. 14, 2023, now Pat. No. 12,331,577, which is a continuation of application No. 17/275,098, filed on Mar. 10, 2021, now Pat. No. 11,773,638, filed as application No. PCT/US2019/049265 on Sep. 3, 2019.

(60) Provisional application No. 62/730,303, filed on Sep. 12, 2018.

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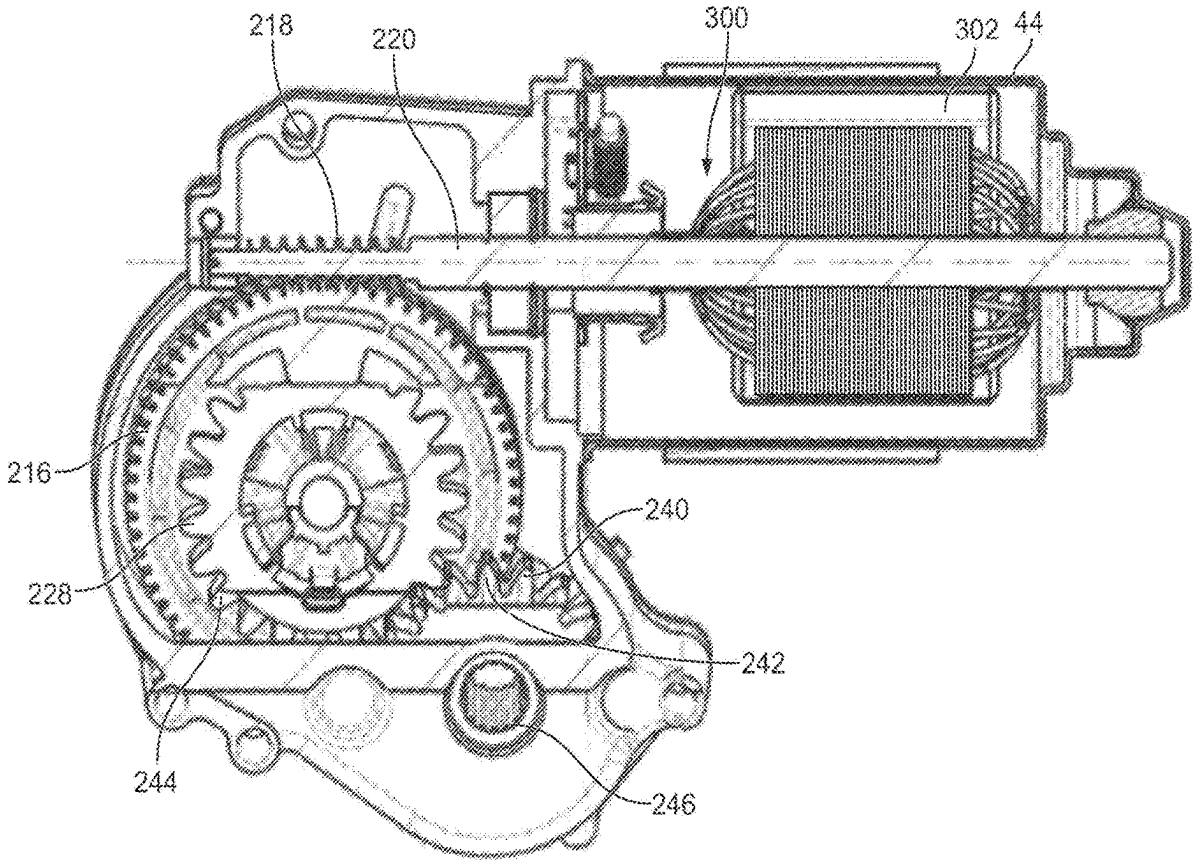
E05F 15/668 (2015.01)

(52) **U.S. Cl.**
CPC ***E05F 15/668*** (2015.01); *E05Y 2201/434* (2013.01); *E05Y 2201/652* (2013.01); *E05Y 2201/656* (2013.01); *E05Y 2201/702* (2013.01); *E05Y 2201/704* (2013.01); *E05Y 2201/716* (2013.01); *E05Y 2900/106* (2013.01)

(57) **ABSTRACT**

A trolley for a garage door opener system, the trolley including a body configured to be connected to an elongated rail of a garage door opener system and be moved longitudinally therealong; a receiving portion of the body configured to receive a trolley connector of an elongated drive member; a flexible actuator extending laterally outward and downward from the body; and a hammer pivotally connected to the body about a longitudinal pivot axis, the hammer connected to the flexible actuator and configured to pivot in response to downward movement of the flexible actuator from an engaged position of the hammer wherein the hammer secures the trolley connector relative to the body to a release position of the hammer wherein the hammer is spaced from the trolley connector and permits the trolley connector to shift relative to the body.



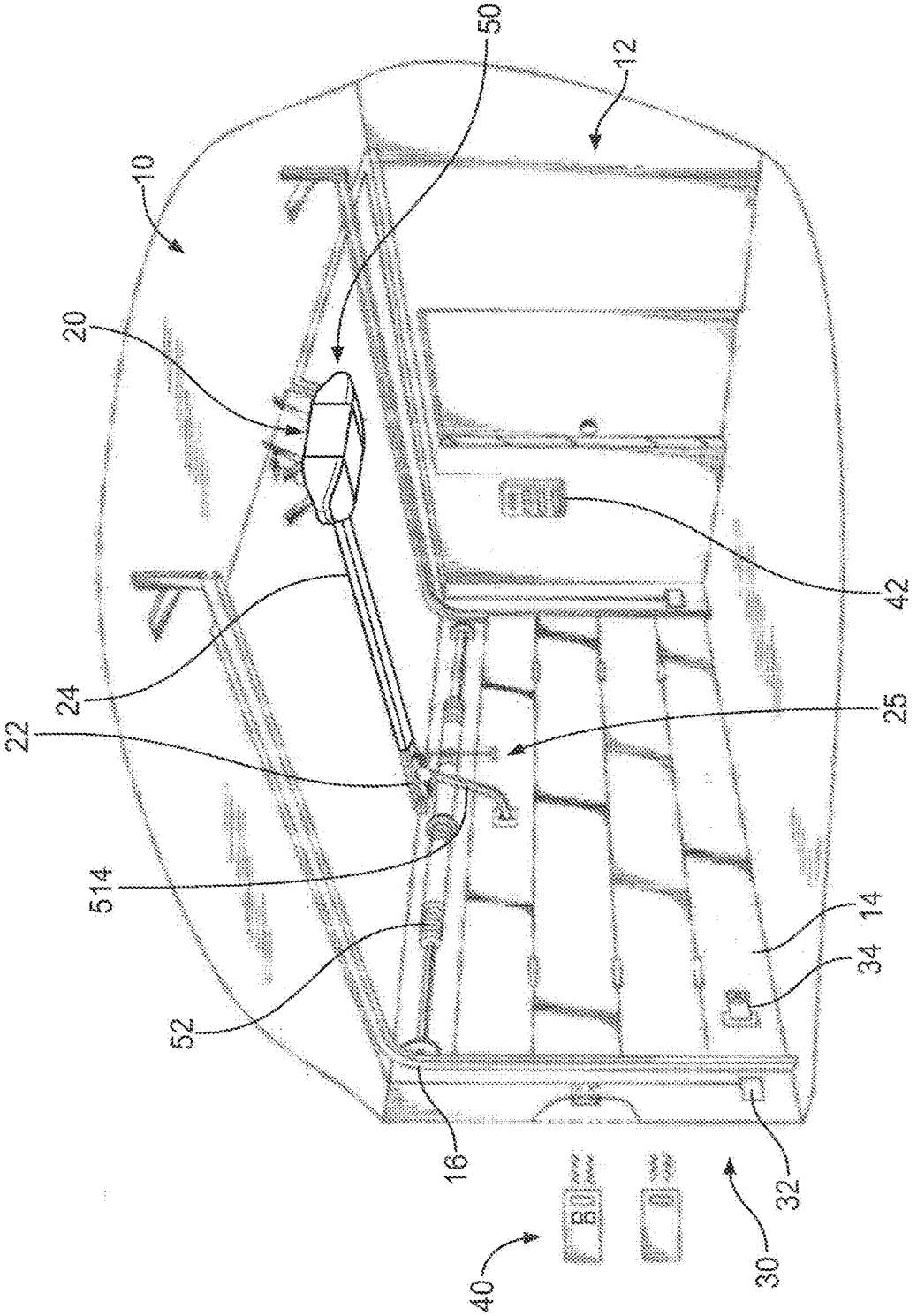
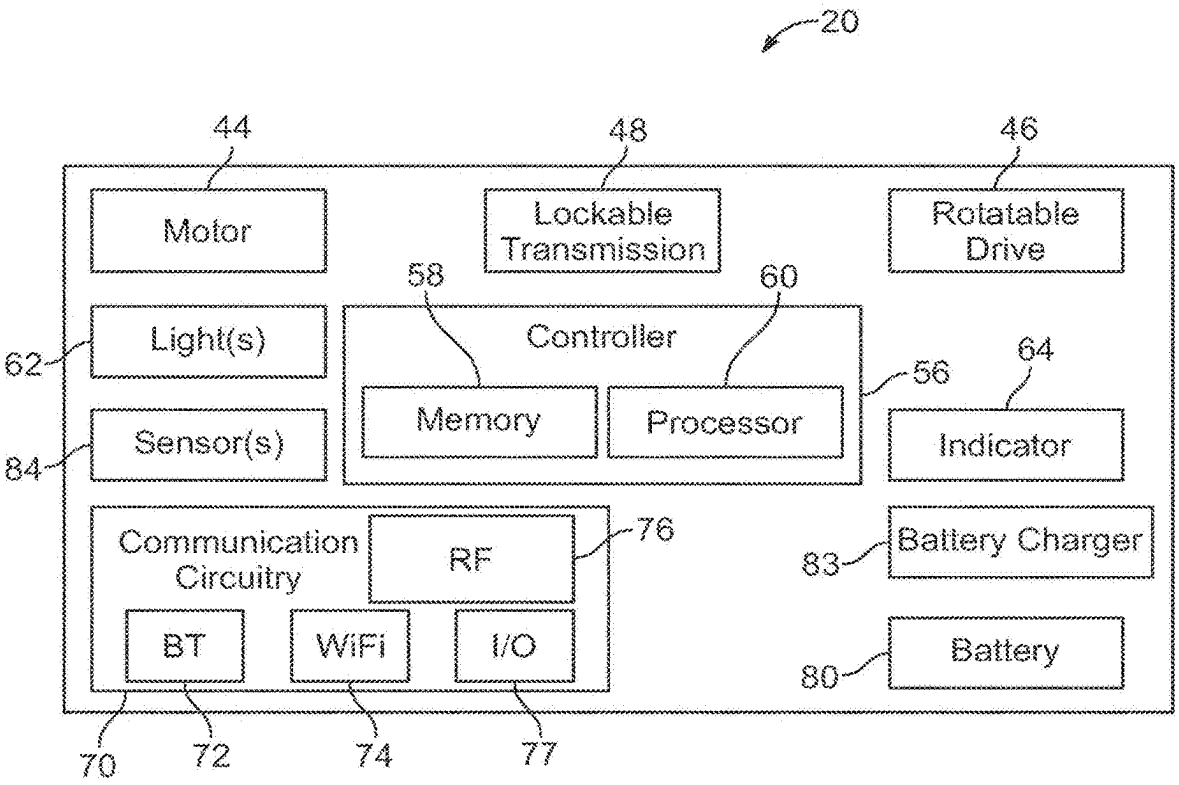


FIG. 1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Motor
Lockable Transmission
Rotatable Drive
58
60
Light(s)
Controller
62
56
64
Memory
Processor
Sensor(s)
Indicator
84
Communication Circuitry
RF
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Battery Charger
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BT
WiFi
I/O
Battery
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FIG. 2

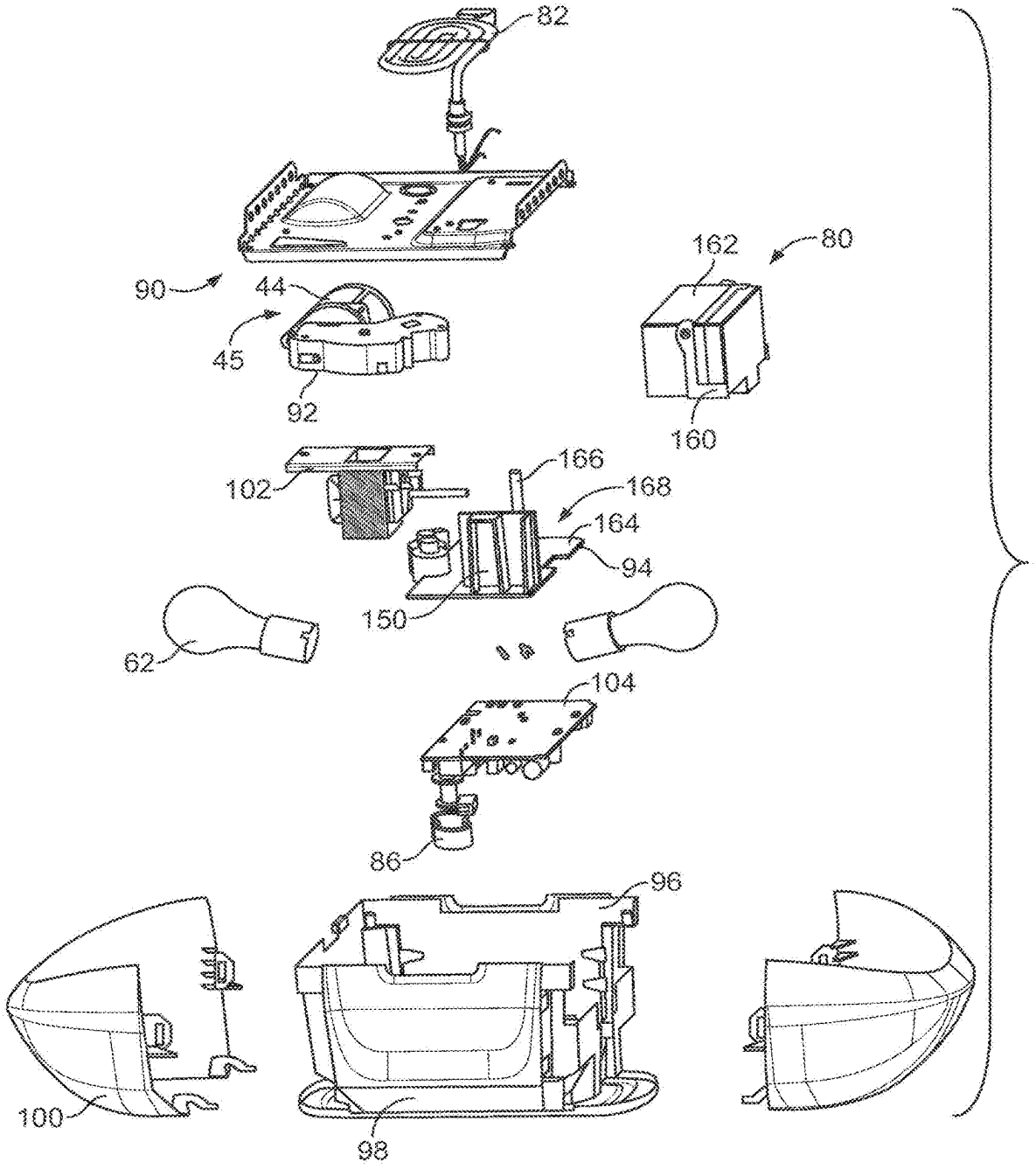

FIG. 3

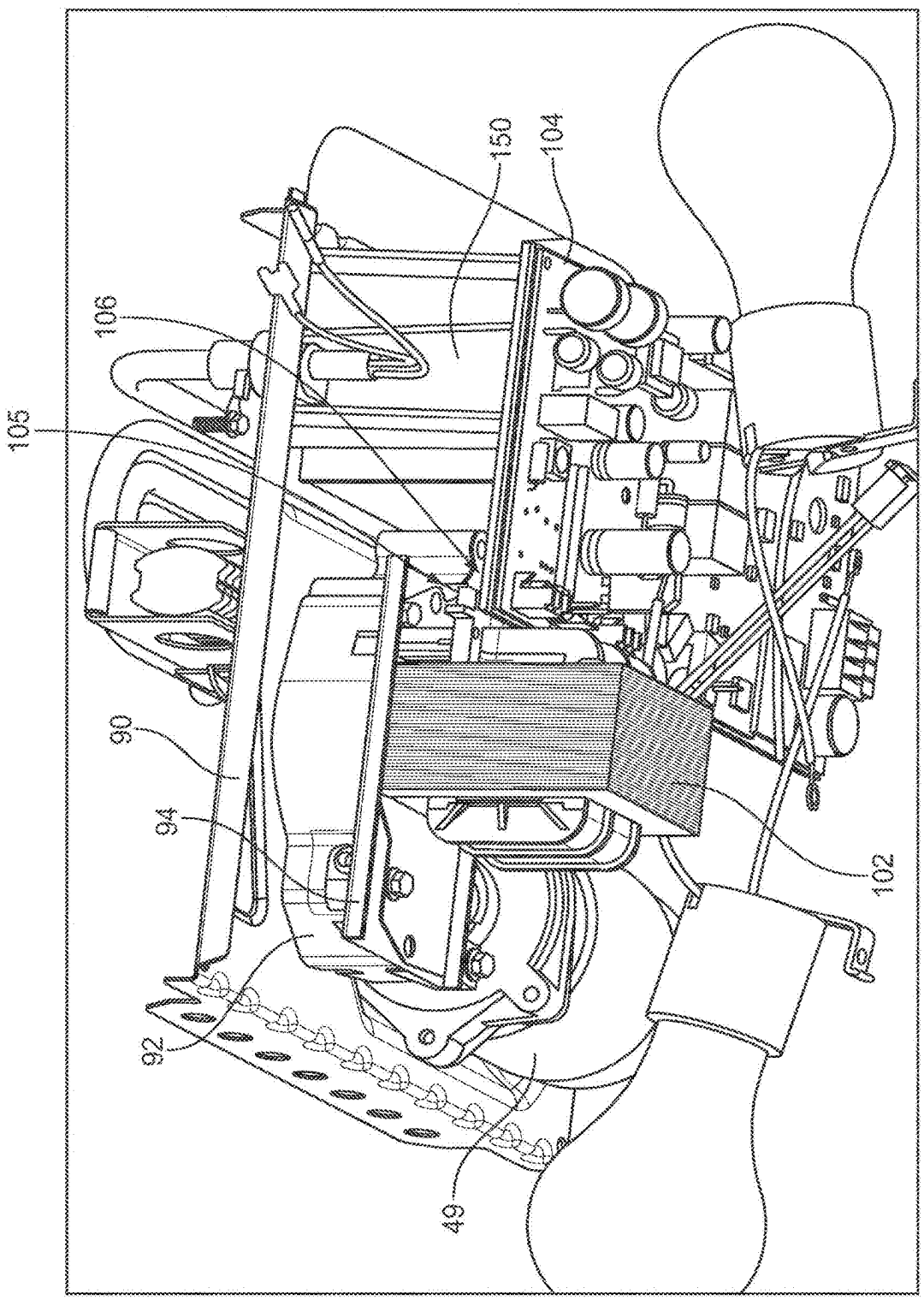

FIG. 4

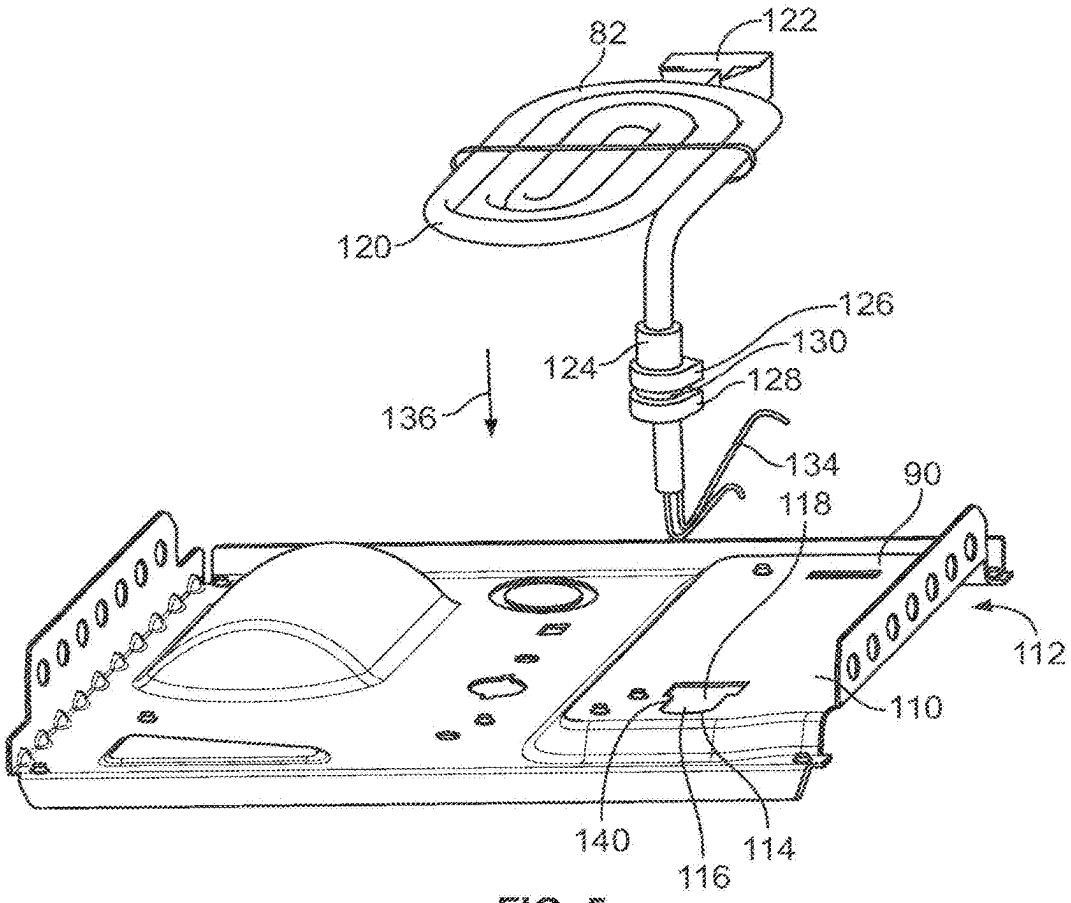
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FIG. 5

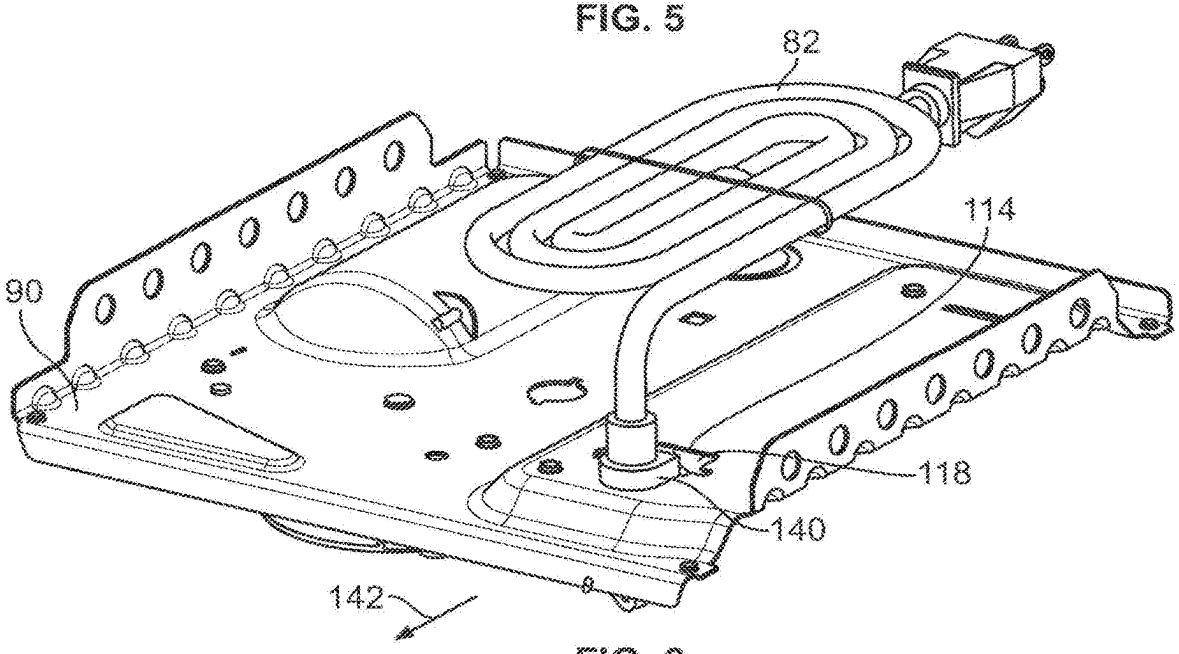
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FIG. 6

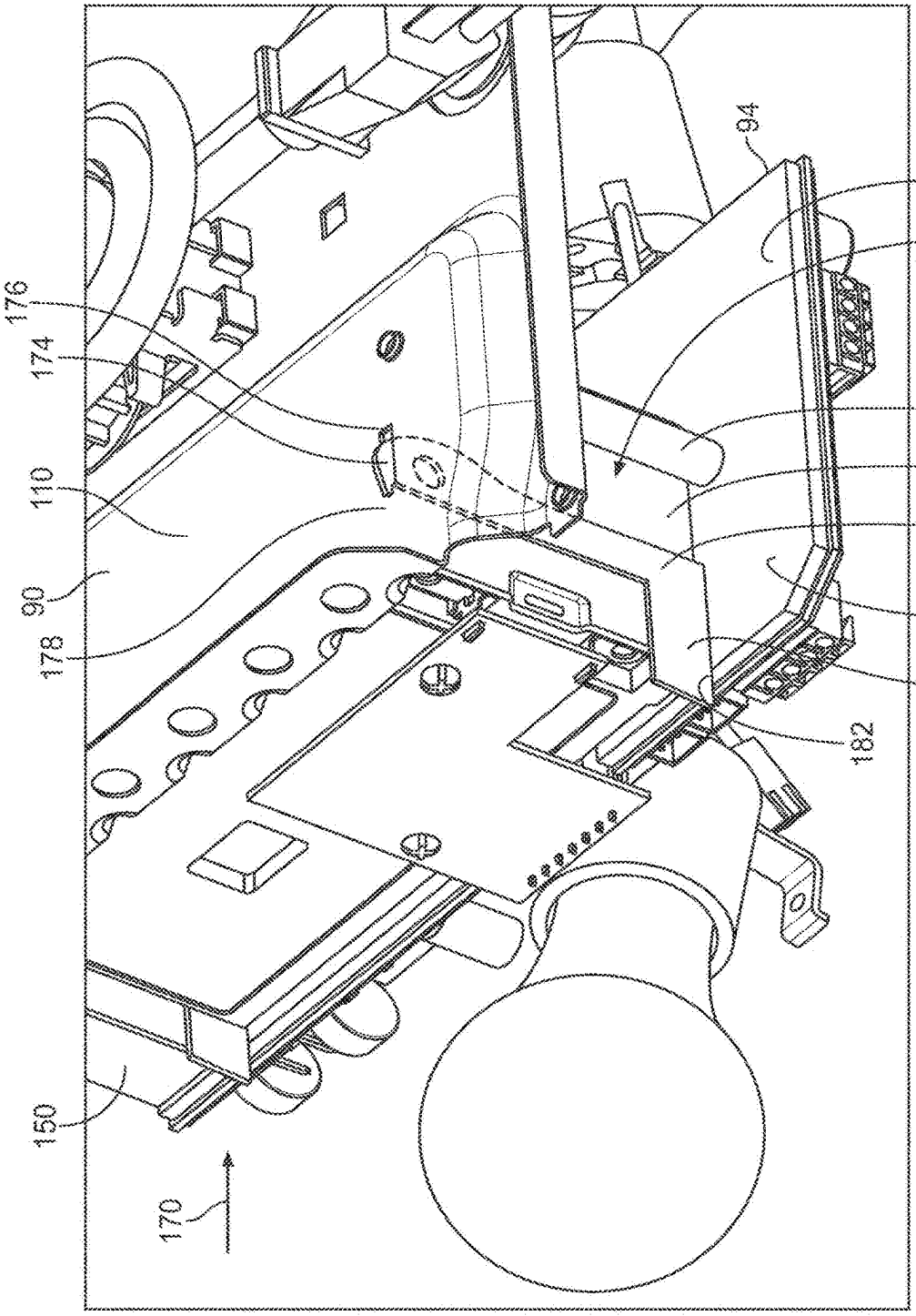


FIG. 7

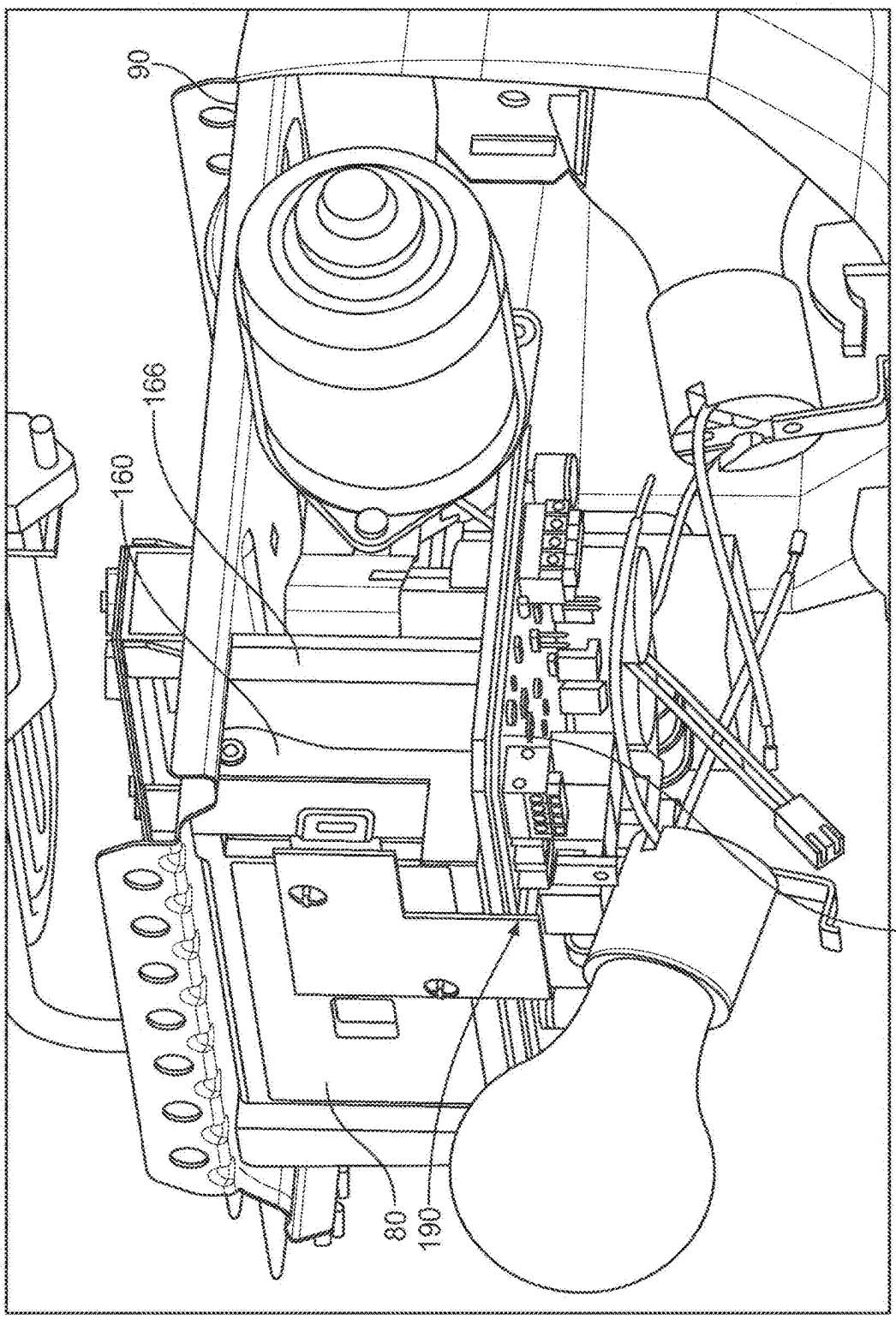


FIG. 8

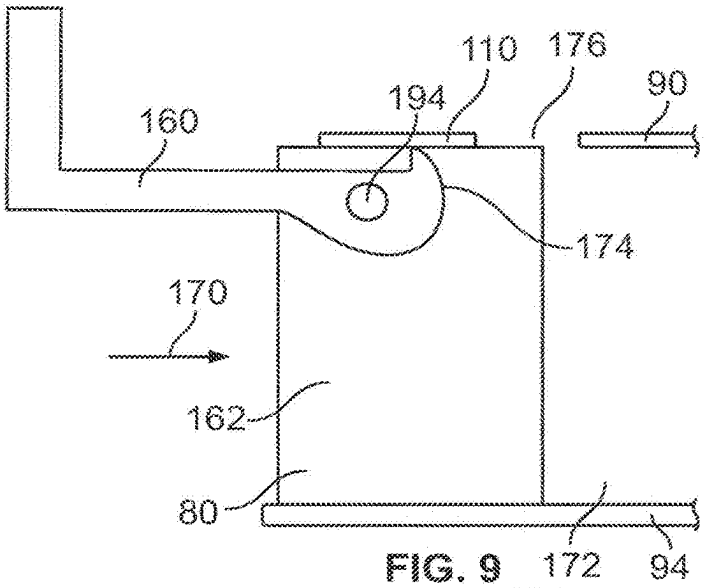


FIG. 9

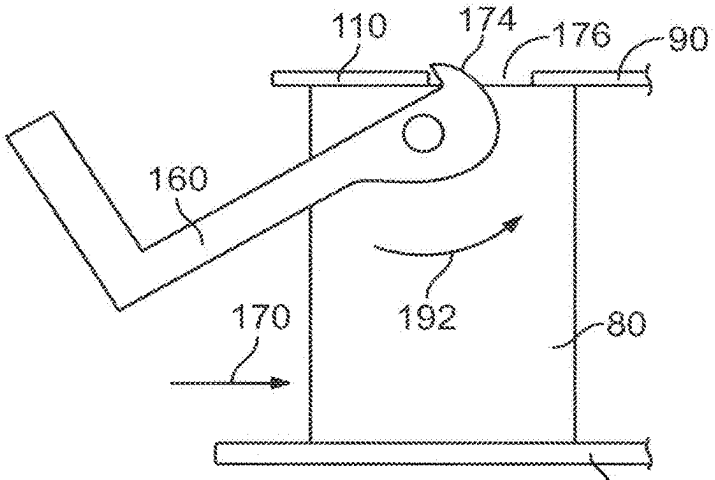


FIG. 10

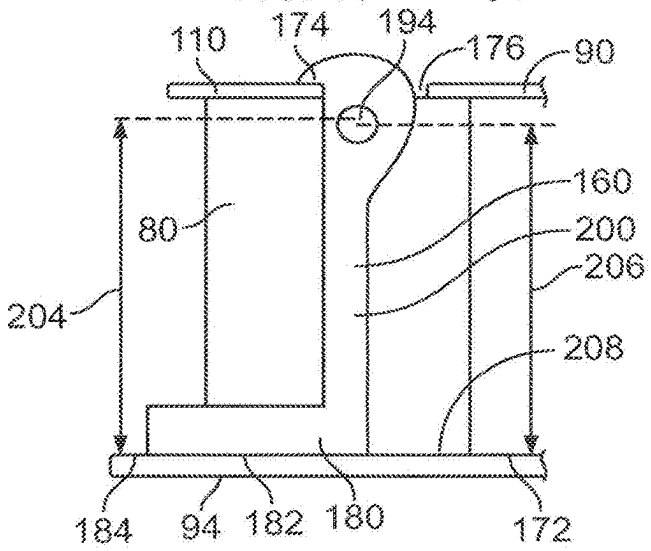


FIG. 11

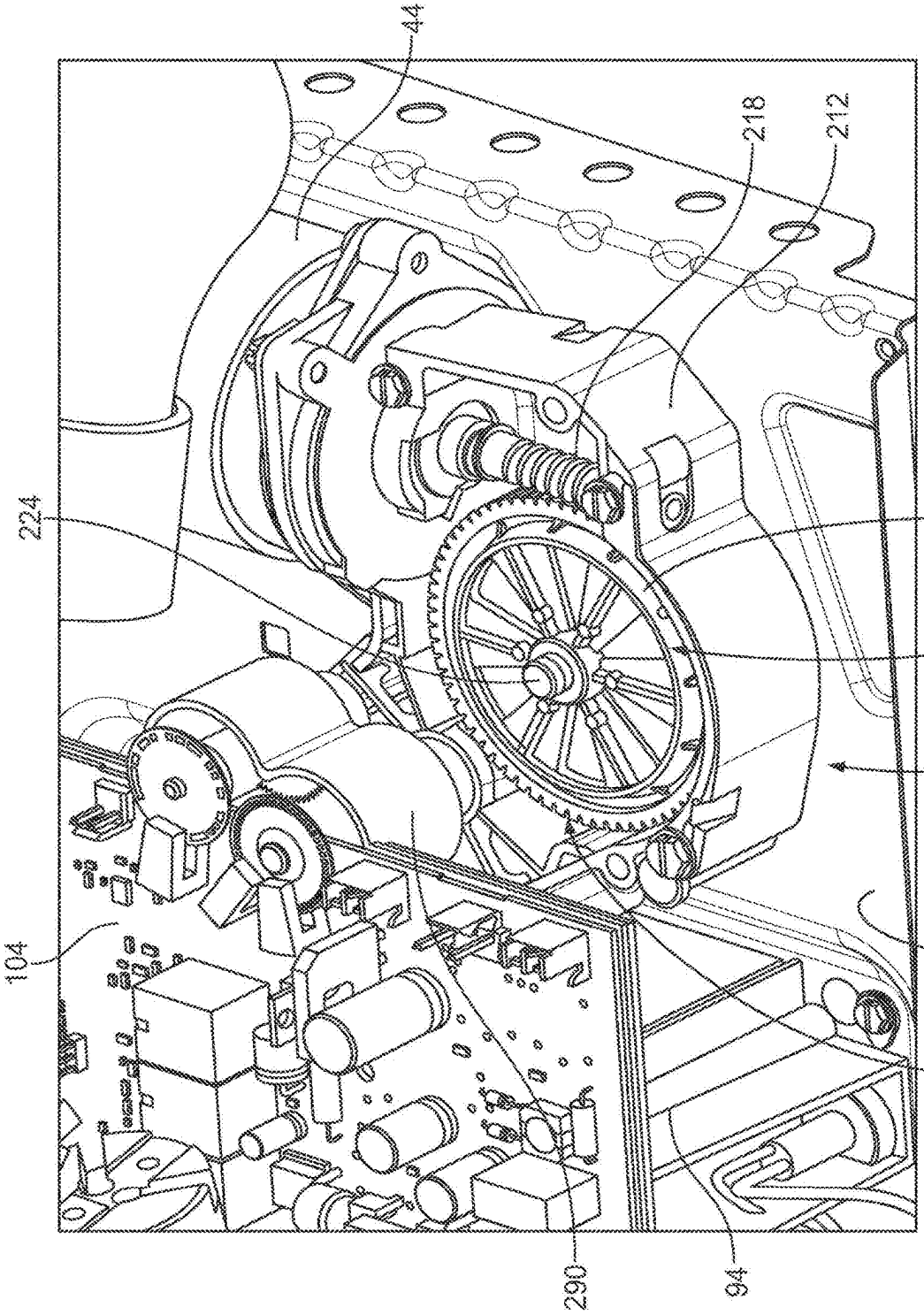


FIG. 12

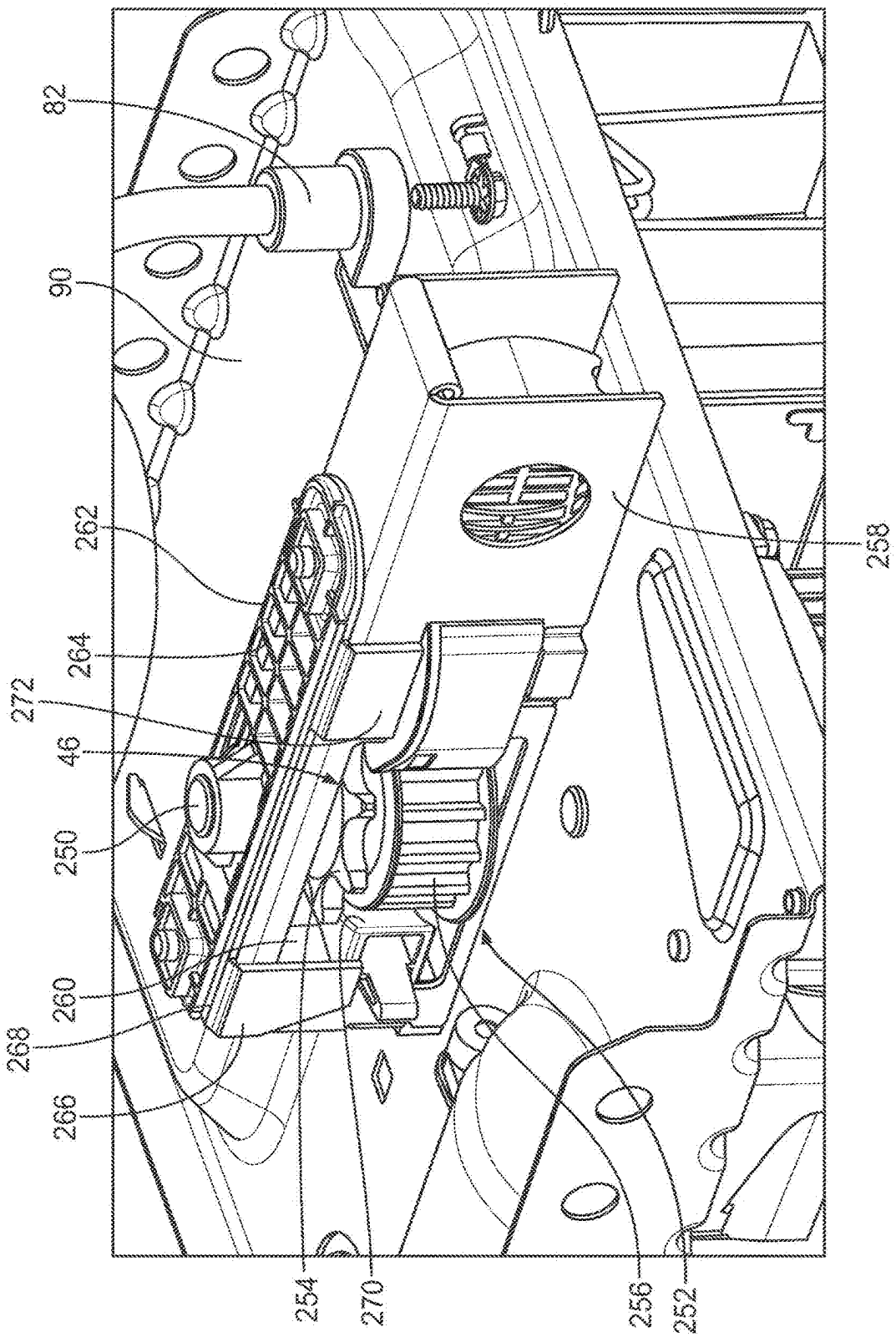


FIG. 13

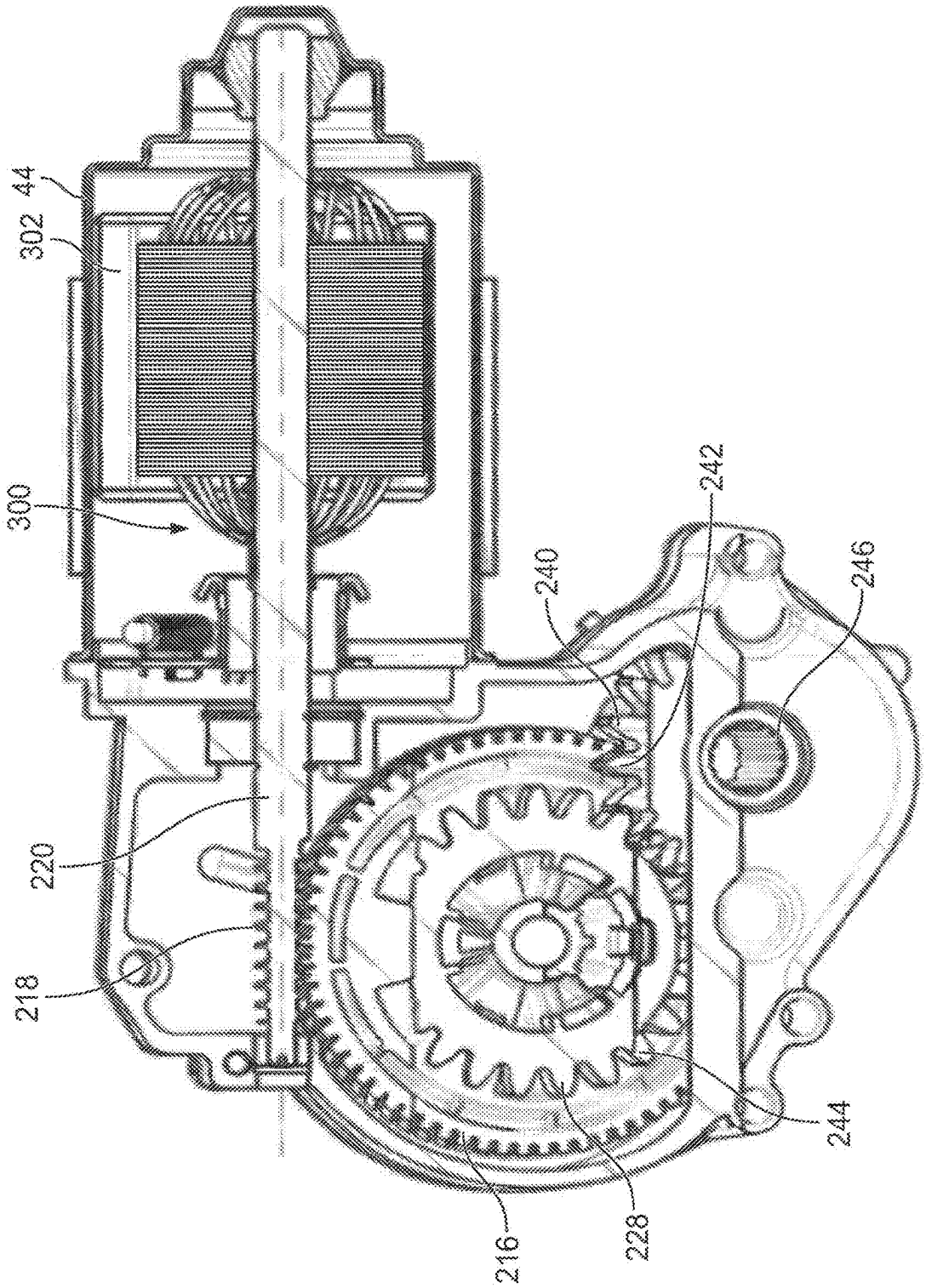


FIG. 14

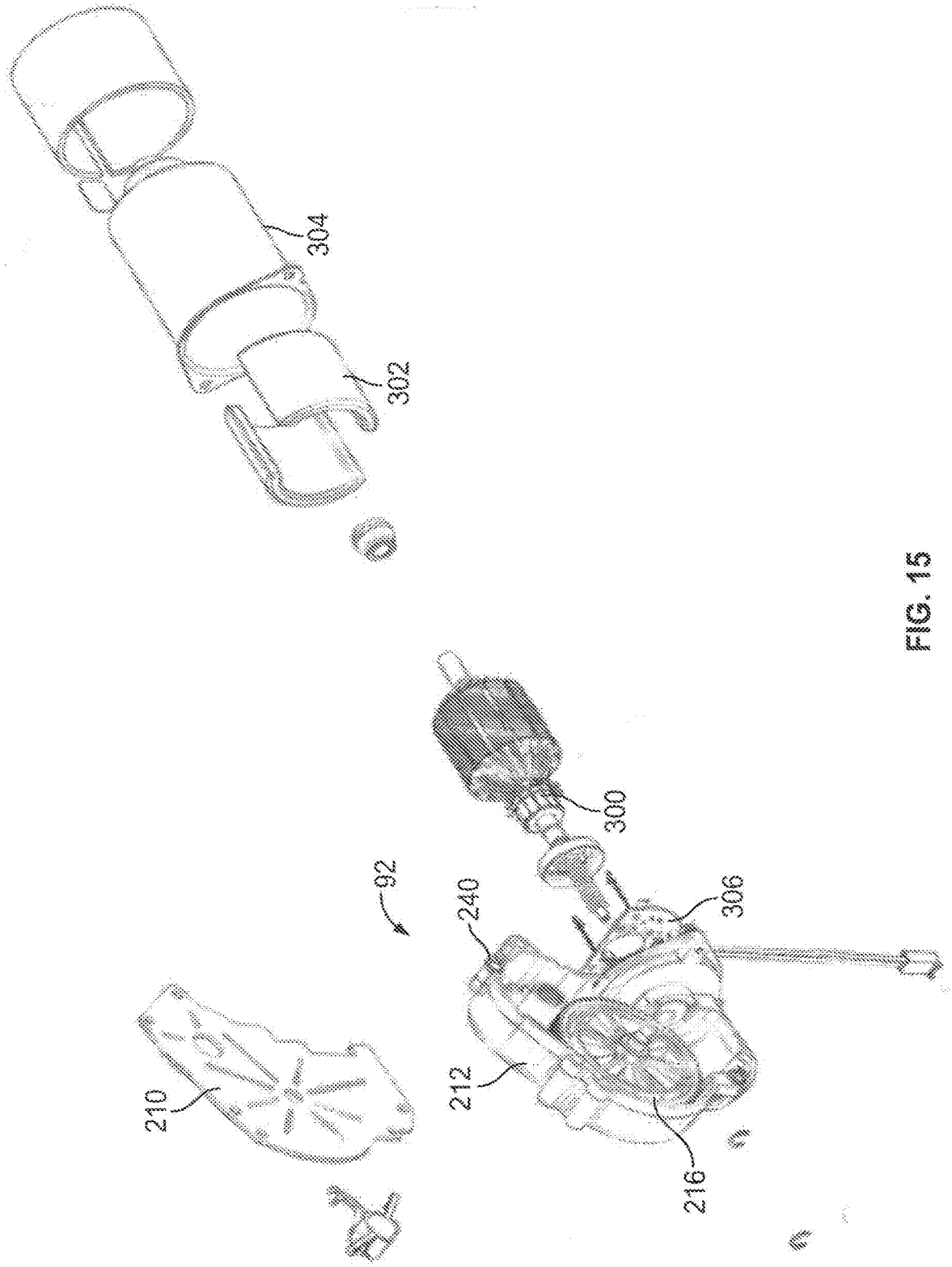


FIG. 15

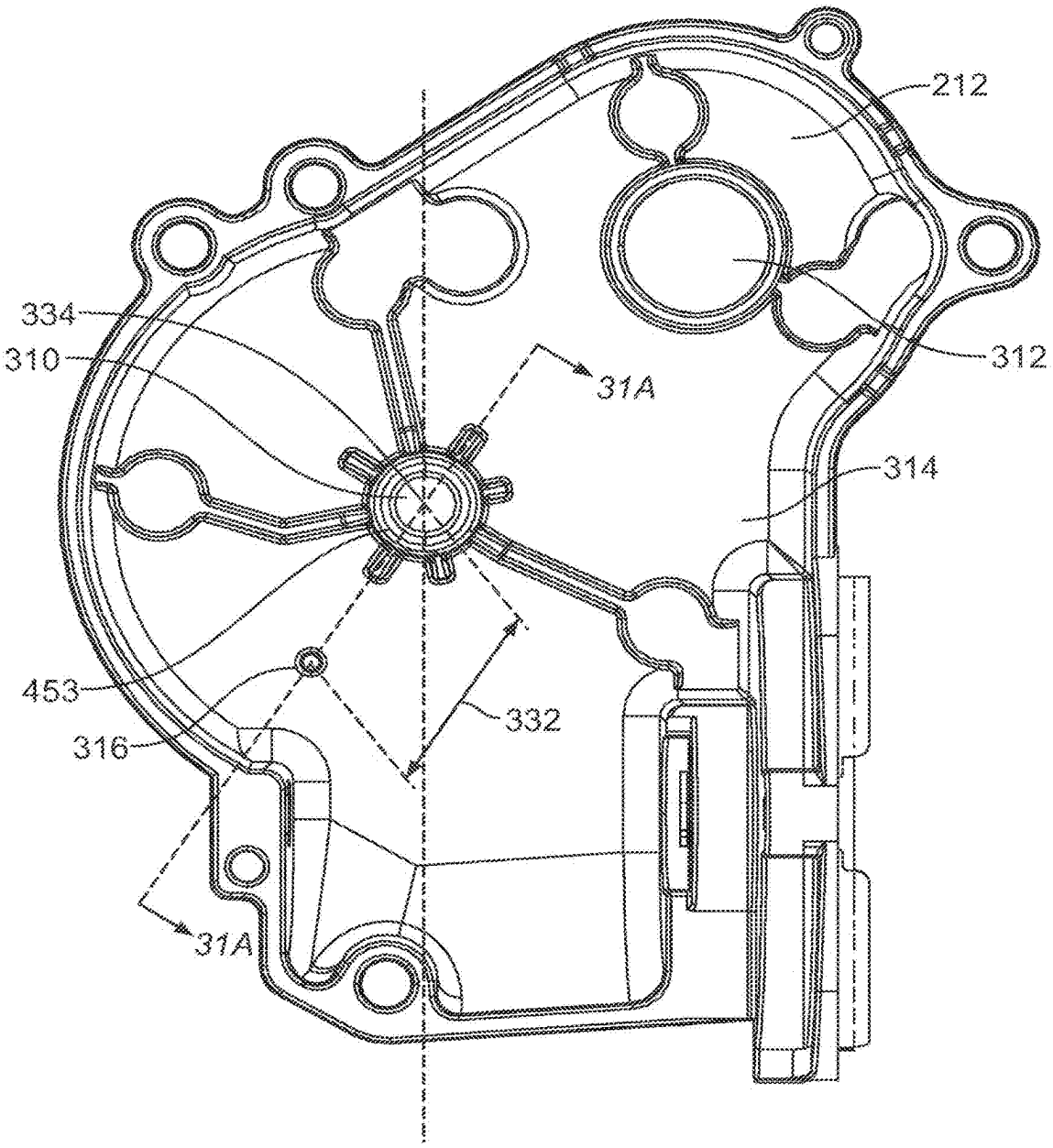


FIG. 16

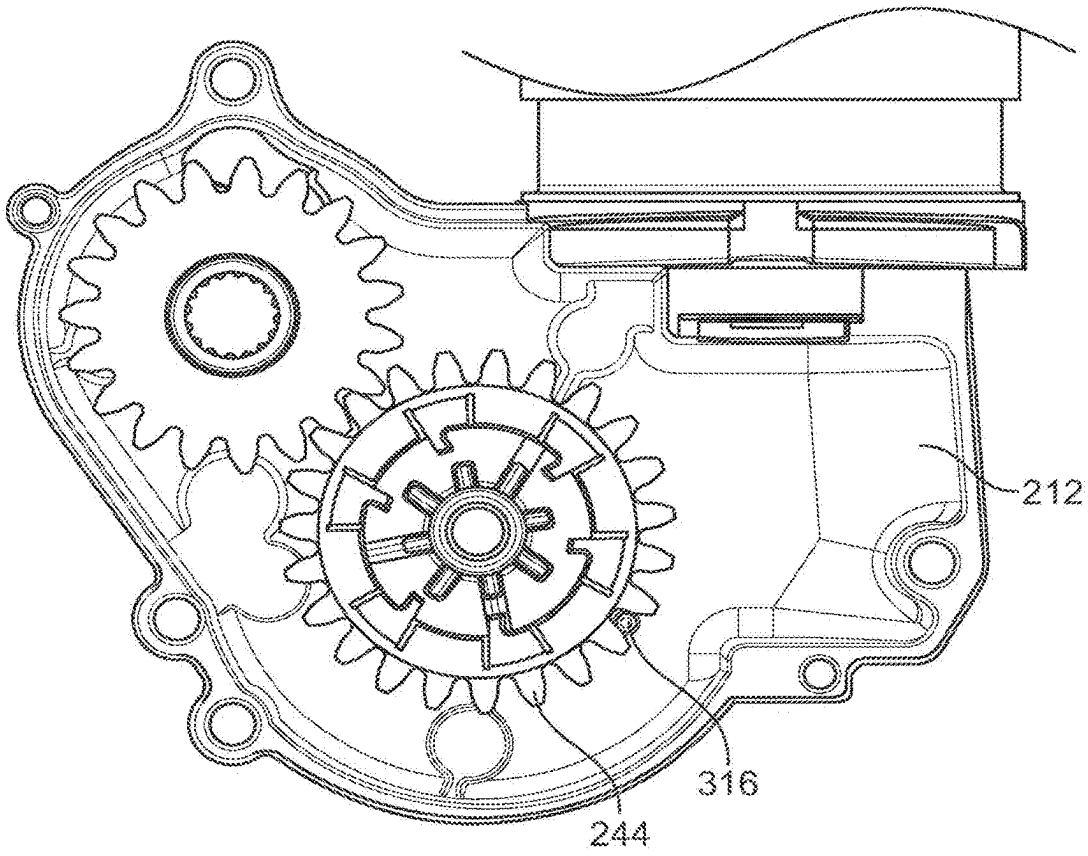


FIG. 17A

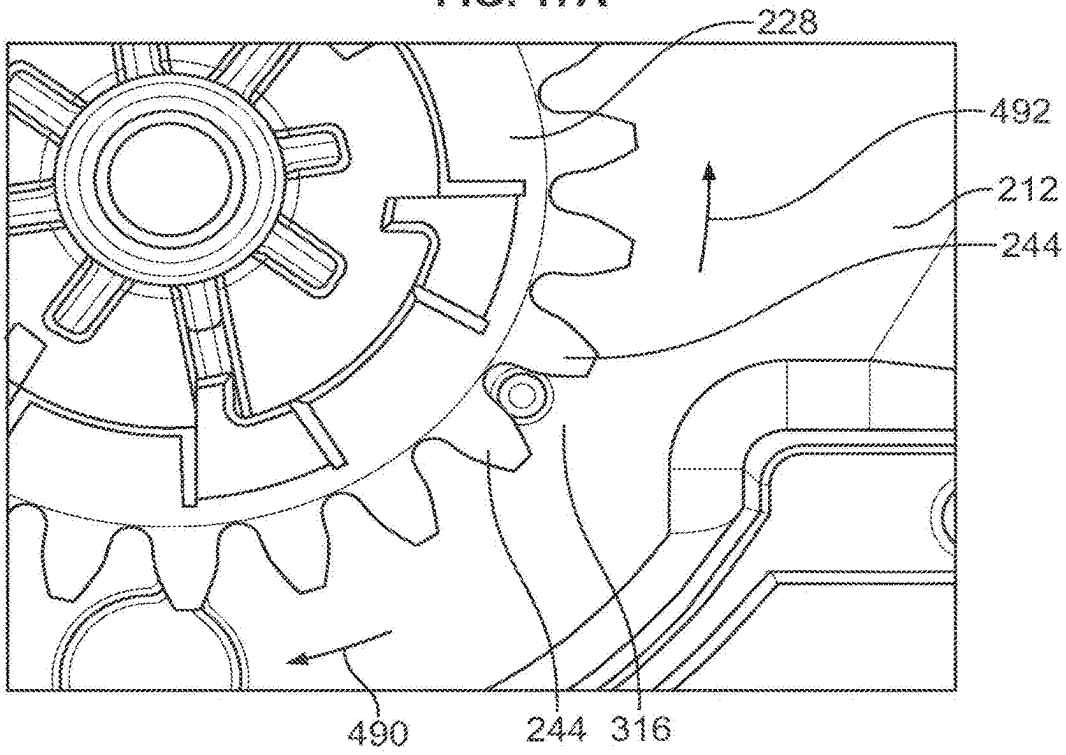
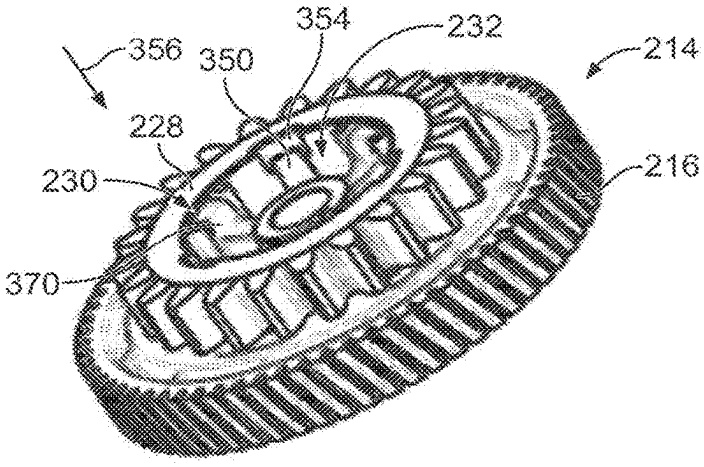


FIG. 17B



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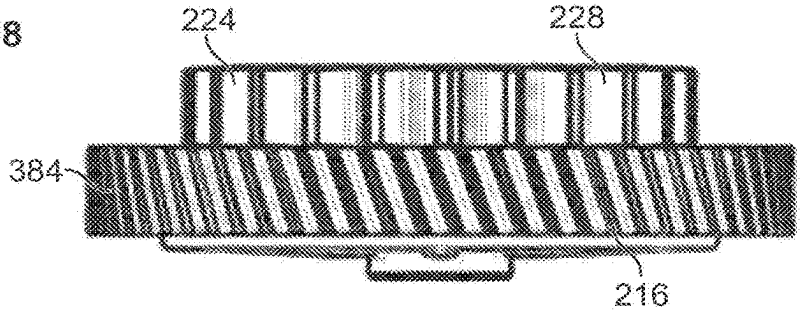


FIG. 19

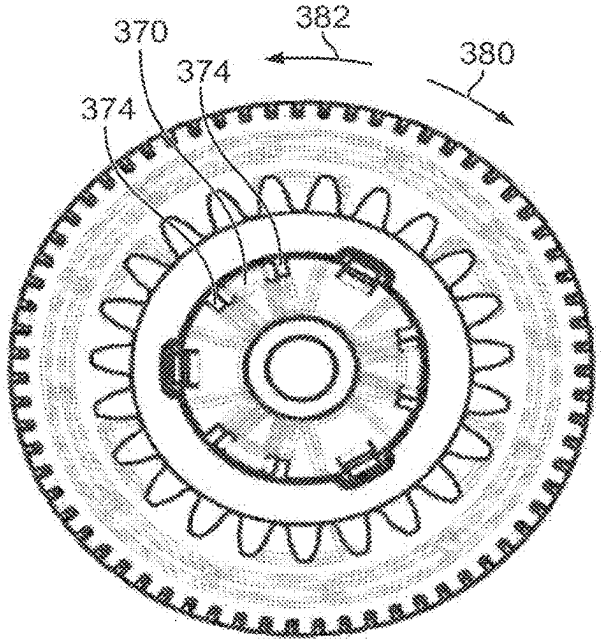


FIG. 20

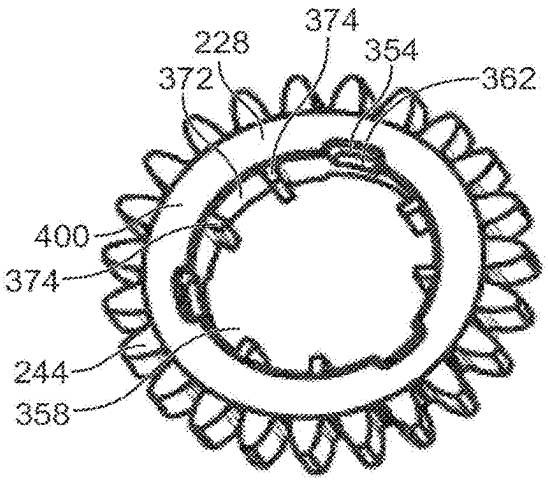


FIG. 21

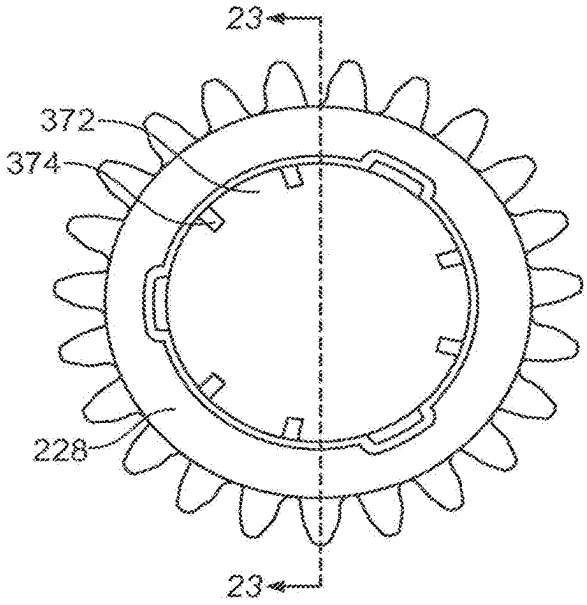


FIG. 22

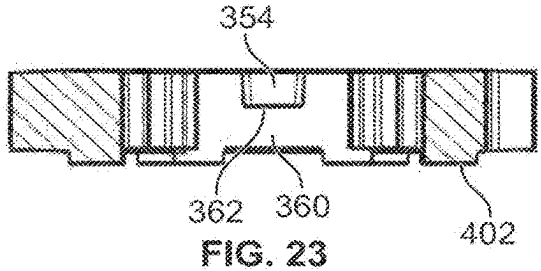


FIG. 23

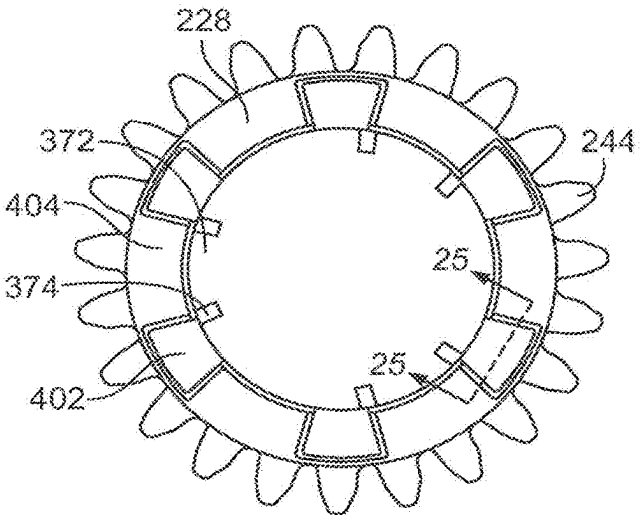


FIG. 24

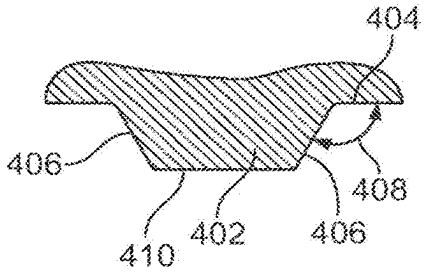


FIG. 25

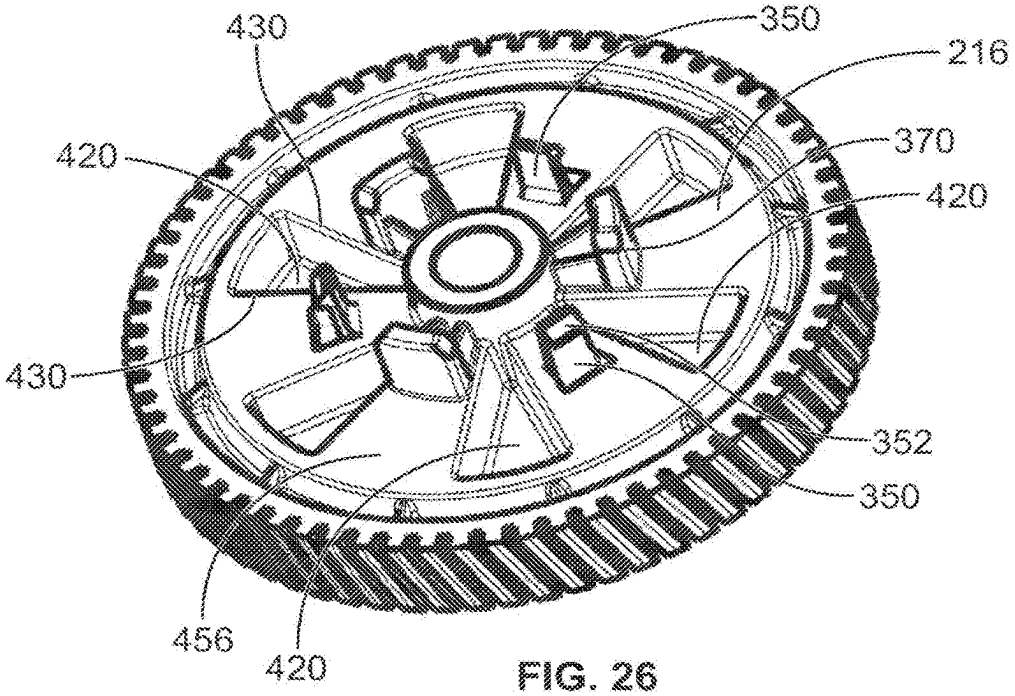


FIG. 26

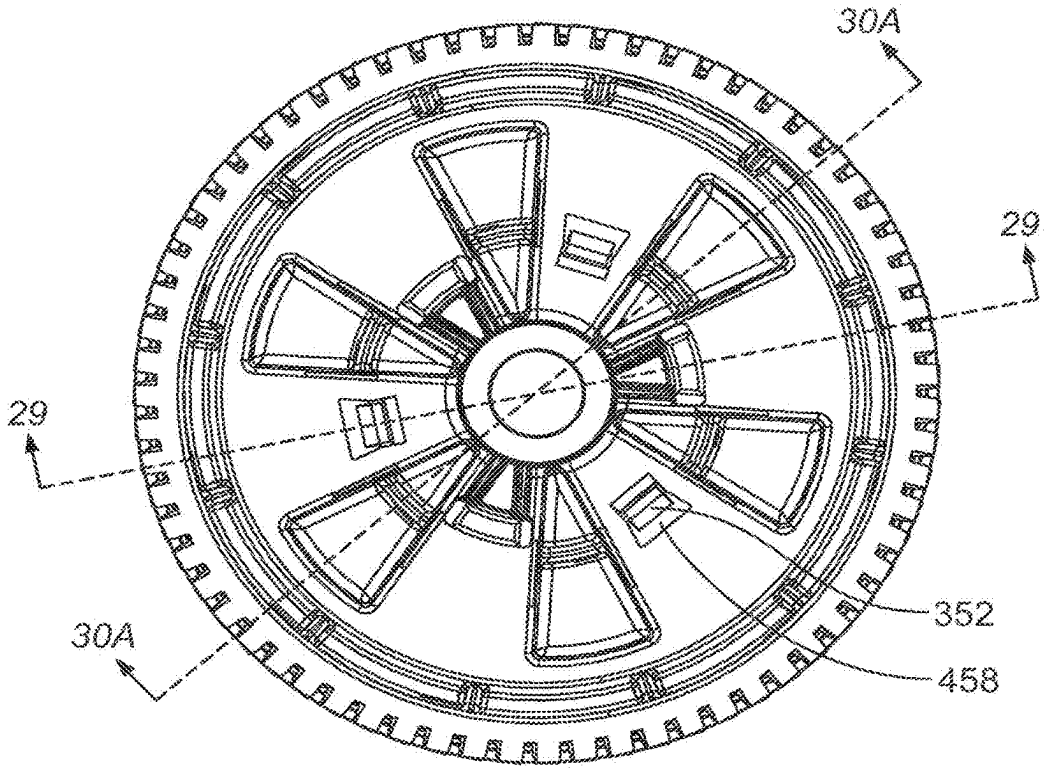


FIG. 27

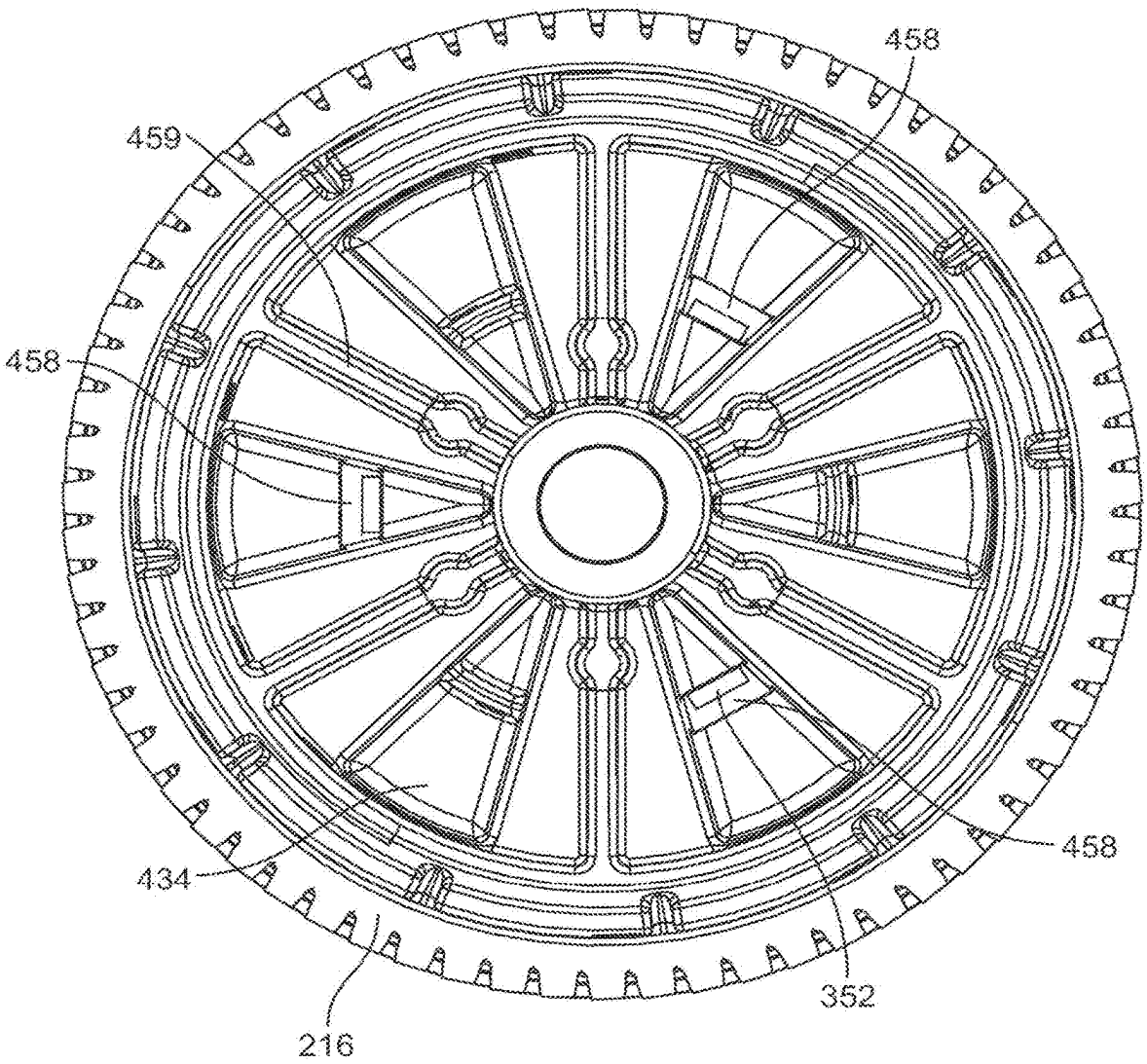


FIG. 28

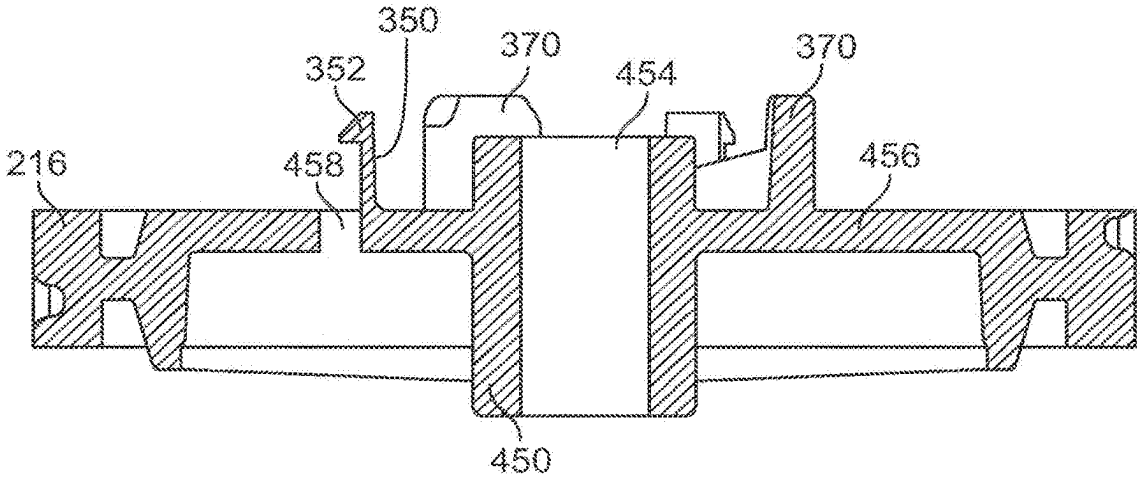


FIG. 29

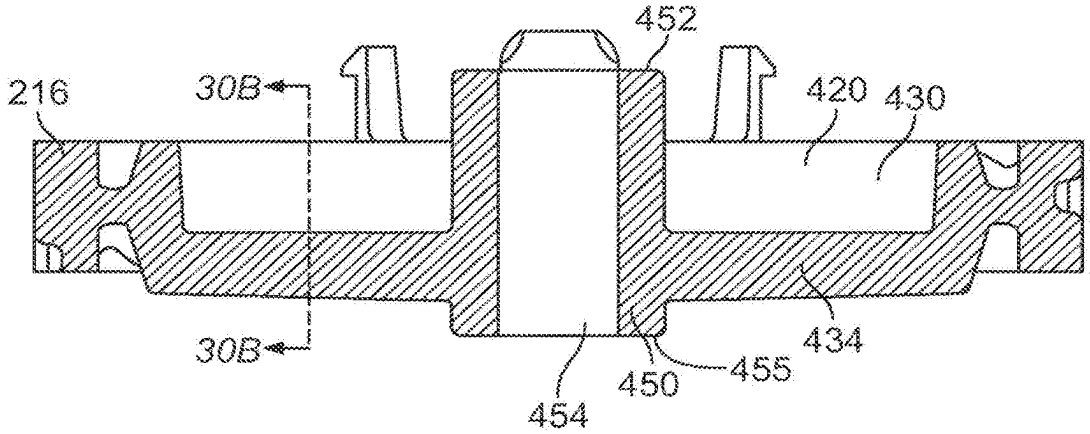


FIG. 30A

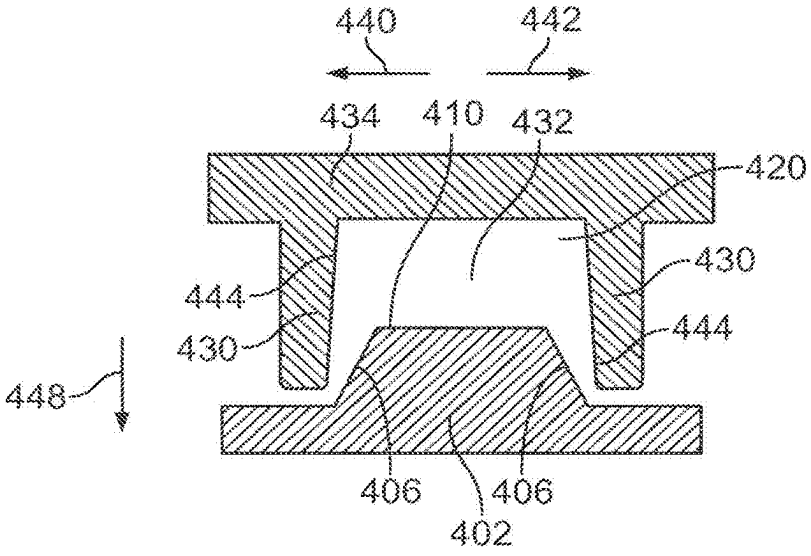


FIG. 30B

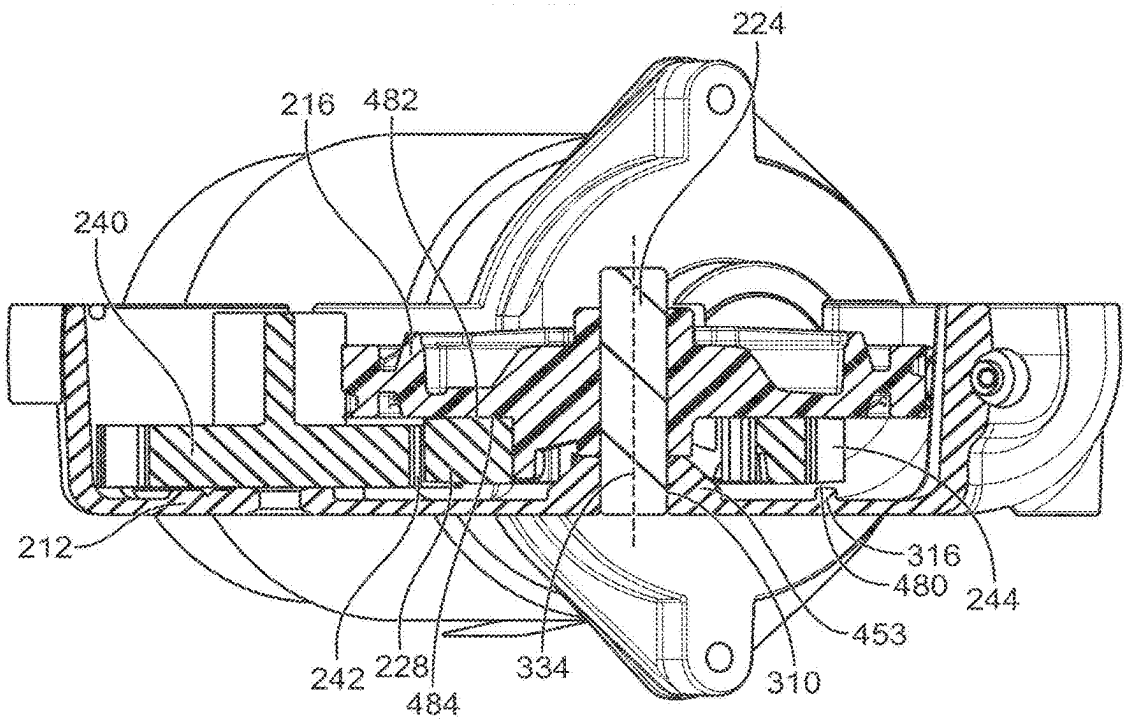


FIG. 31A

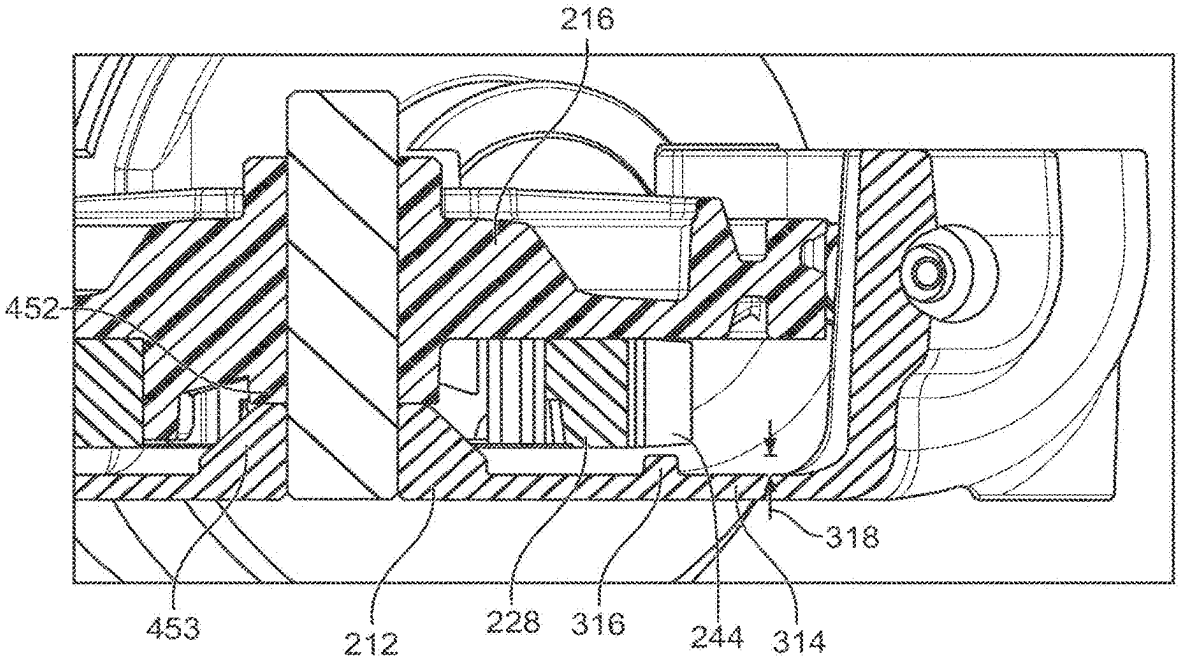
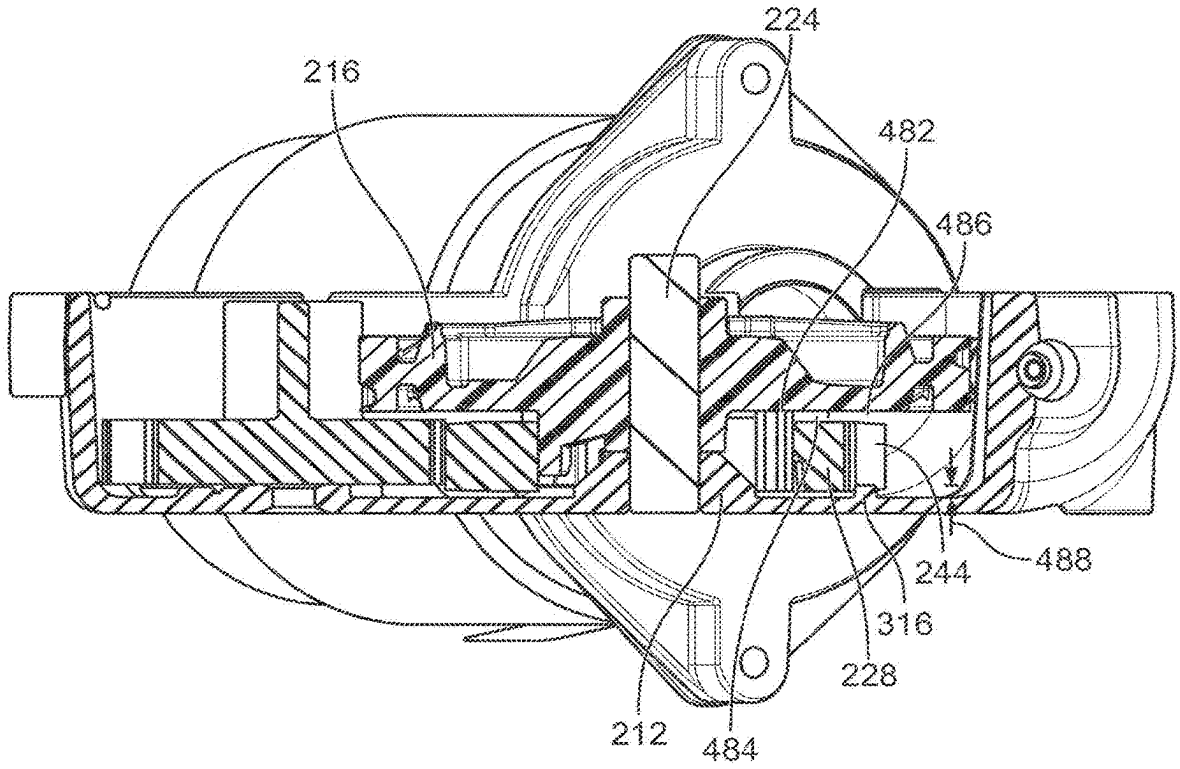


FIG. 31B



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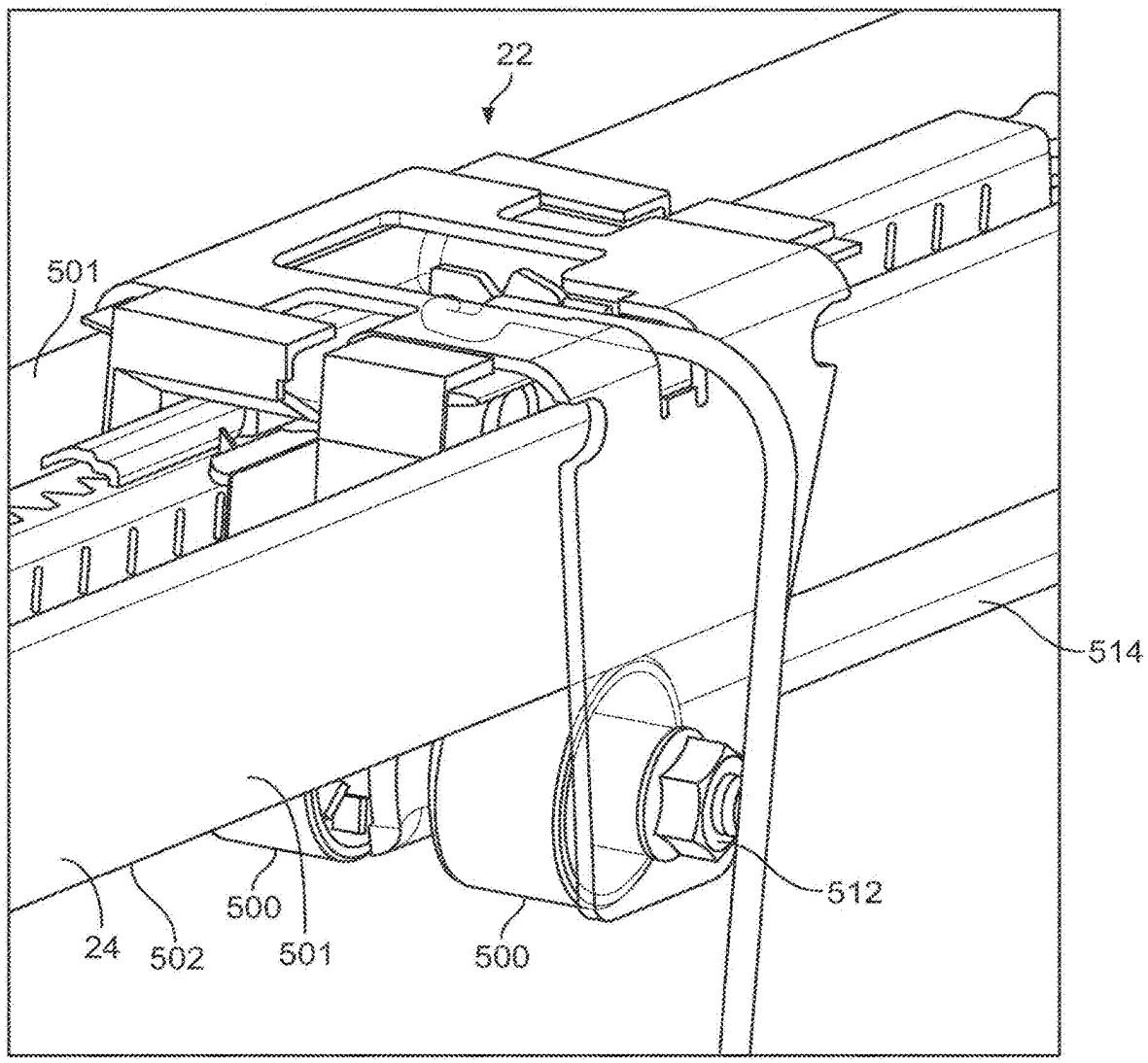

FIG. 33

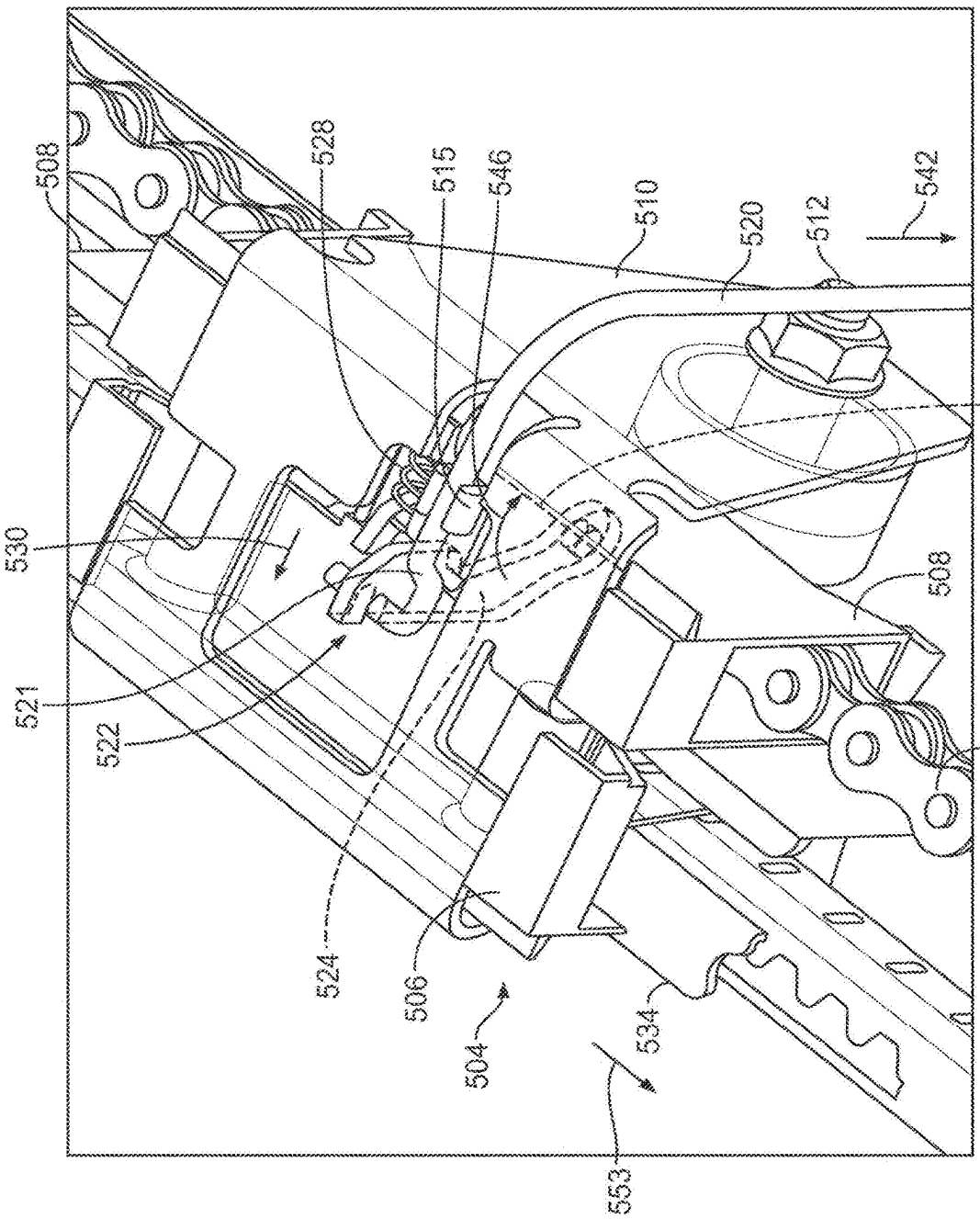
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FIG. 34

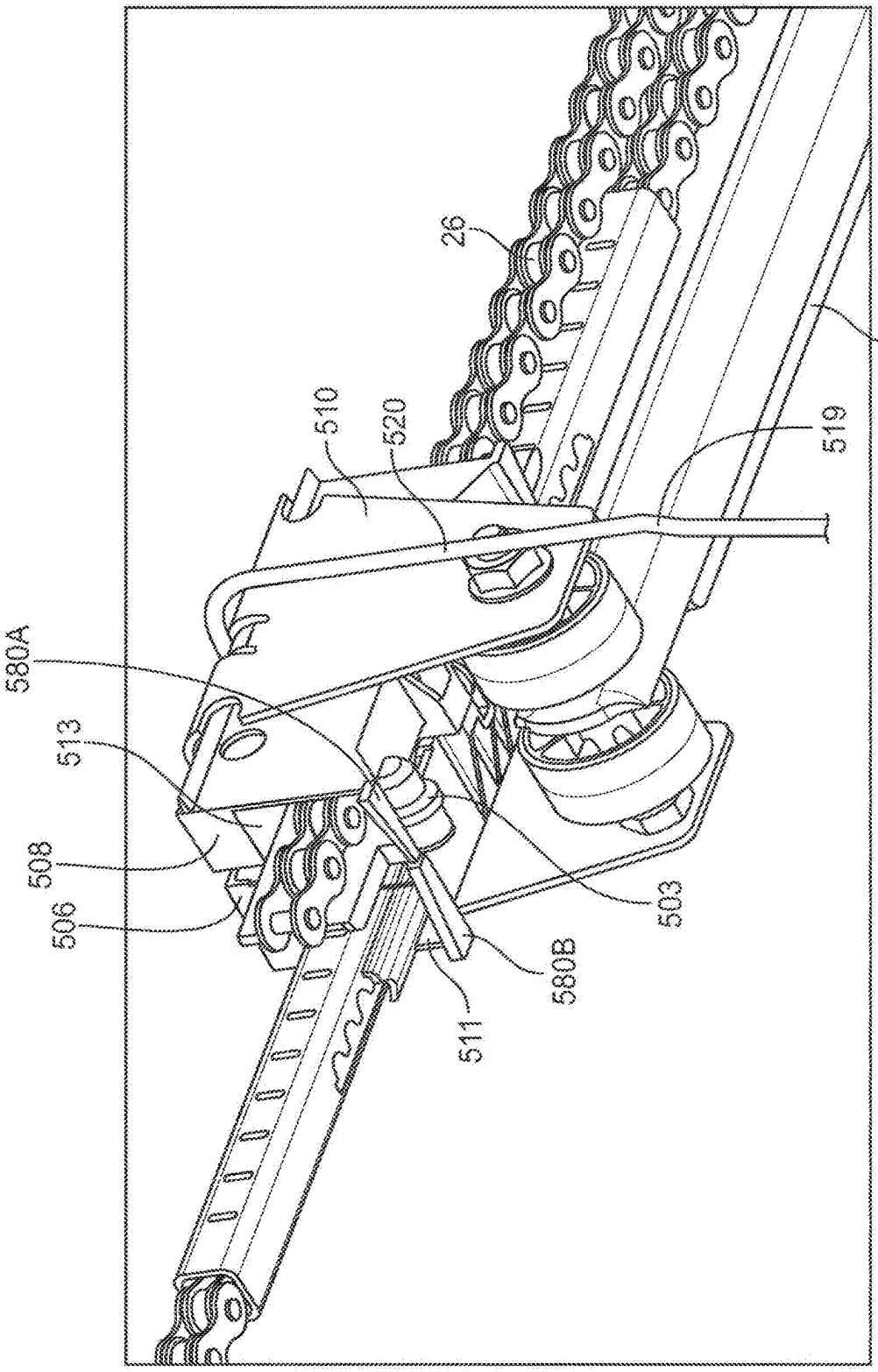

FIG. 35

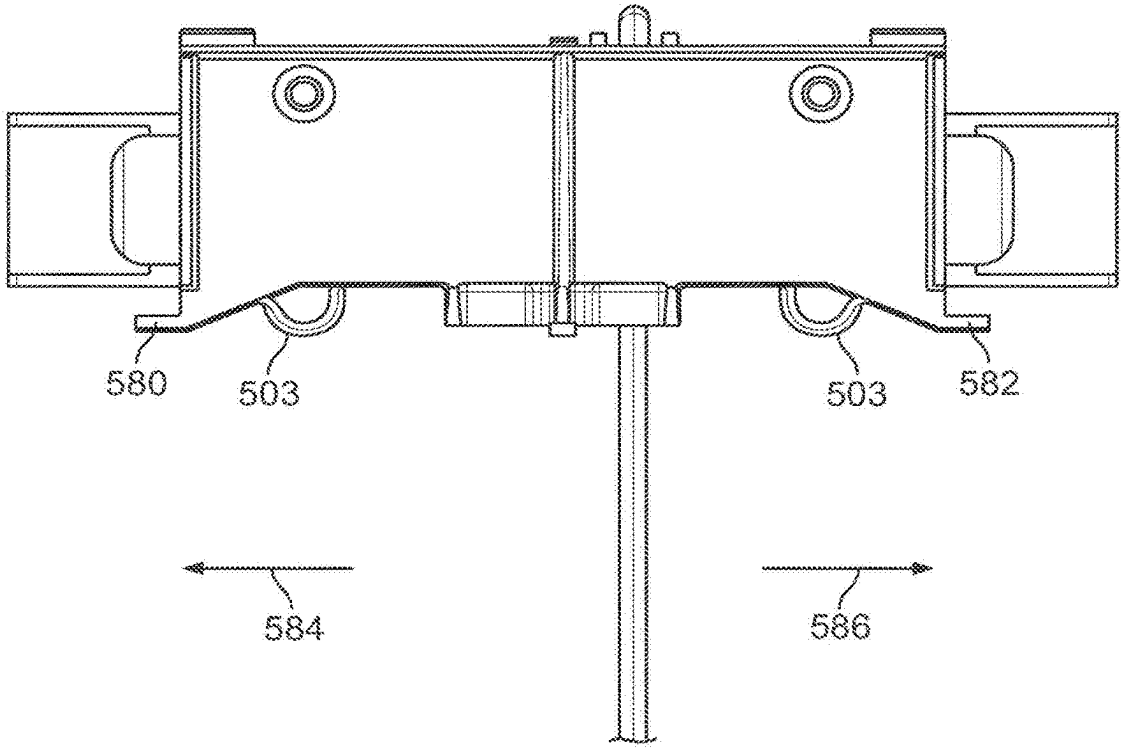

FIG. 36A

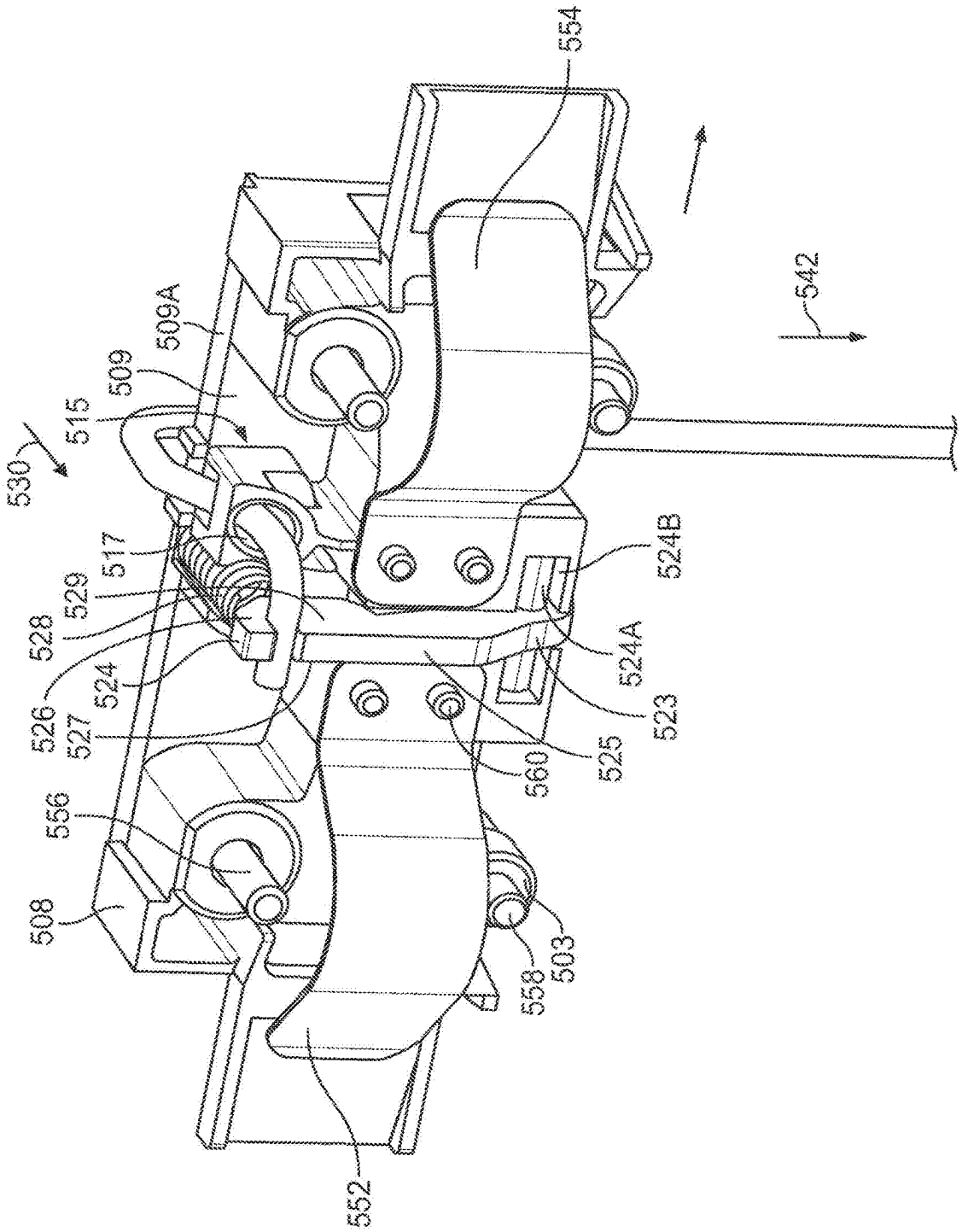
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FIG. 36B

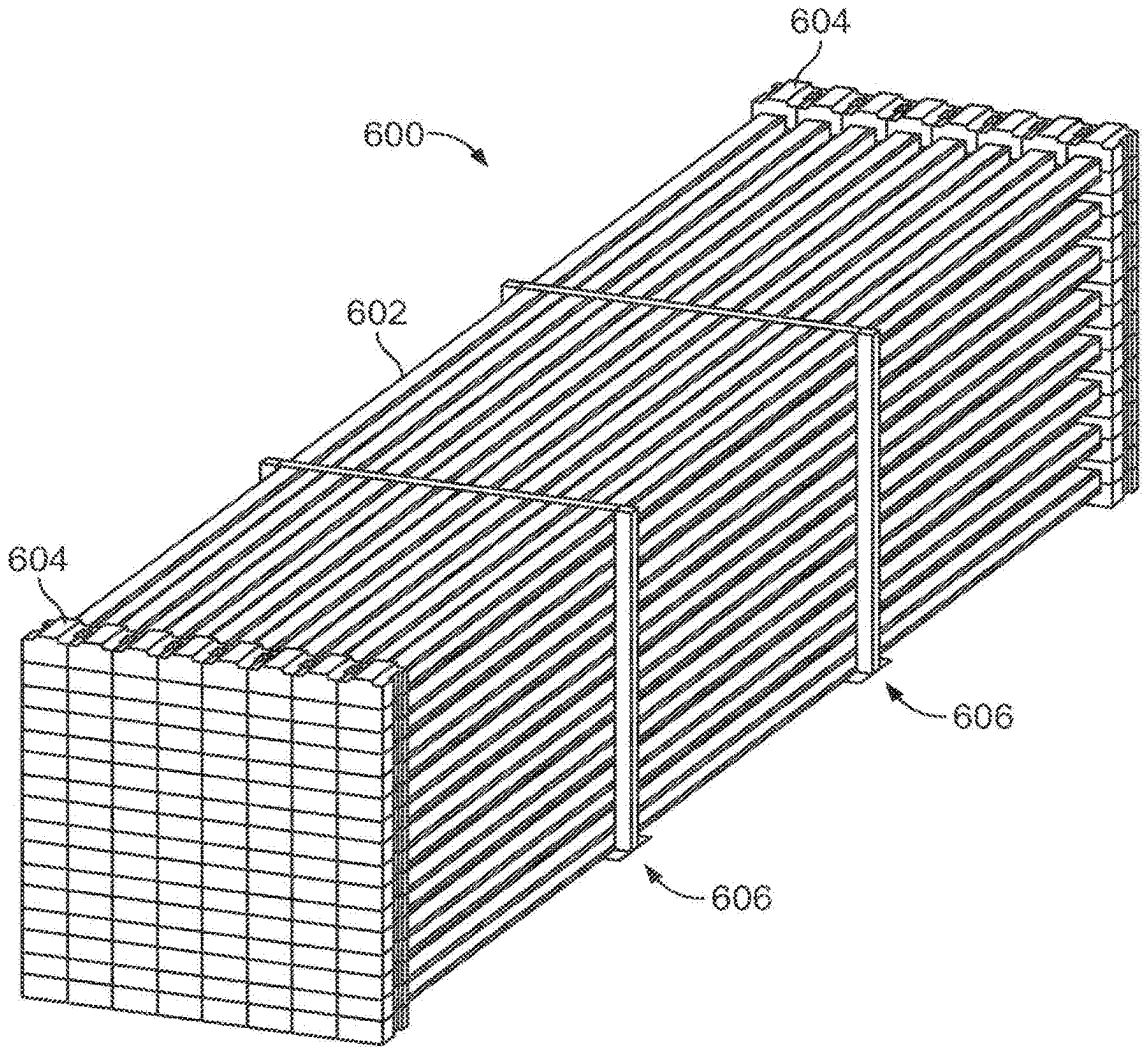

FIG. 37

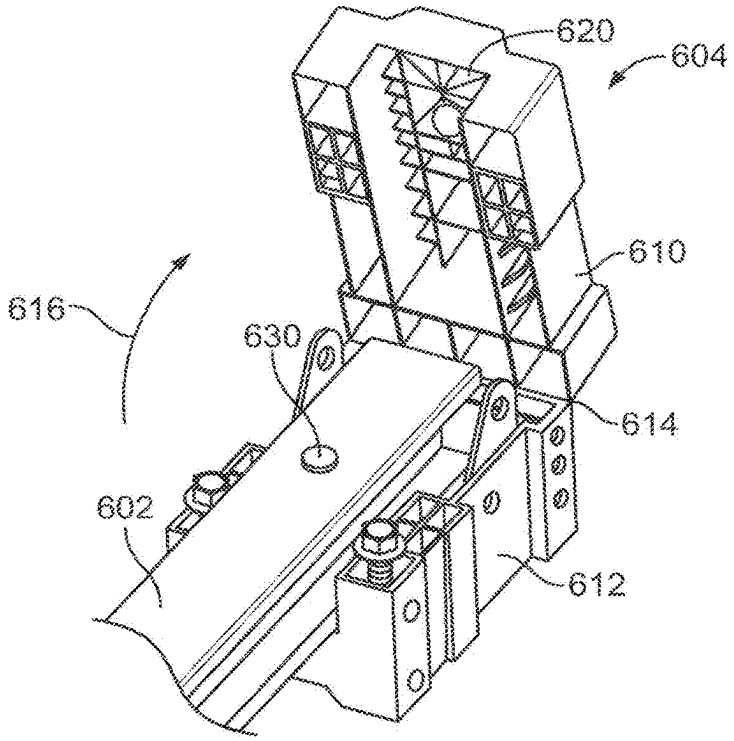

FIG. 38

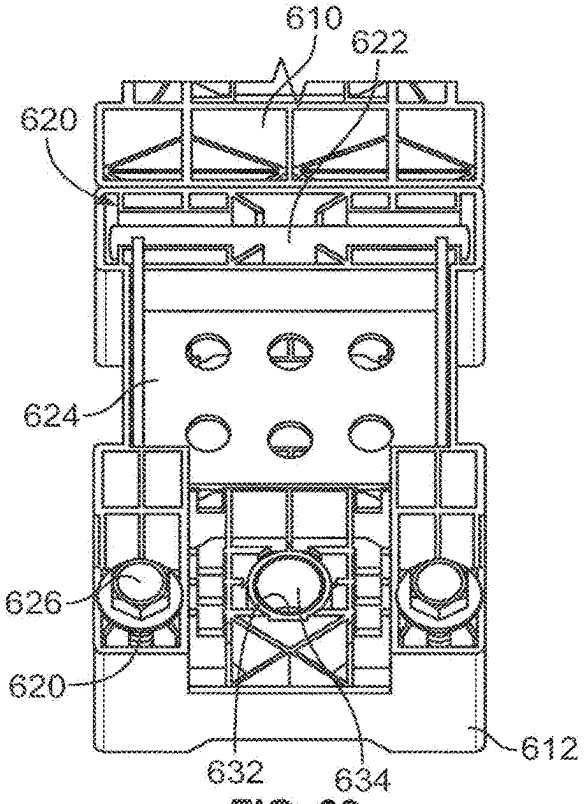

FIG. 39

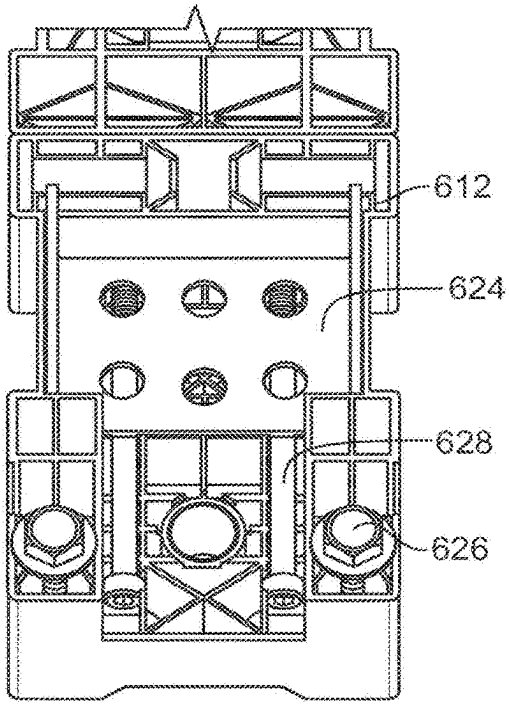

FIG. 40

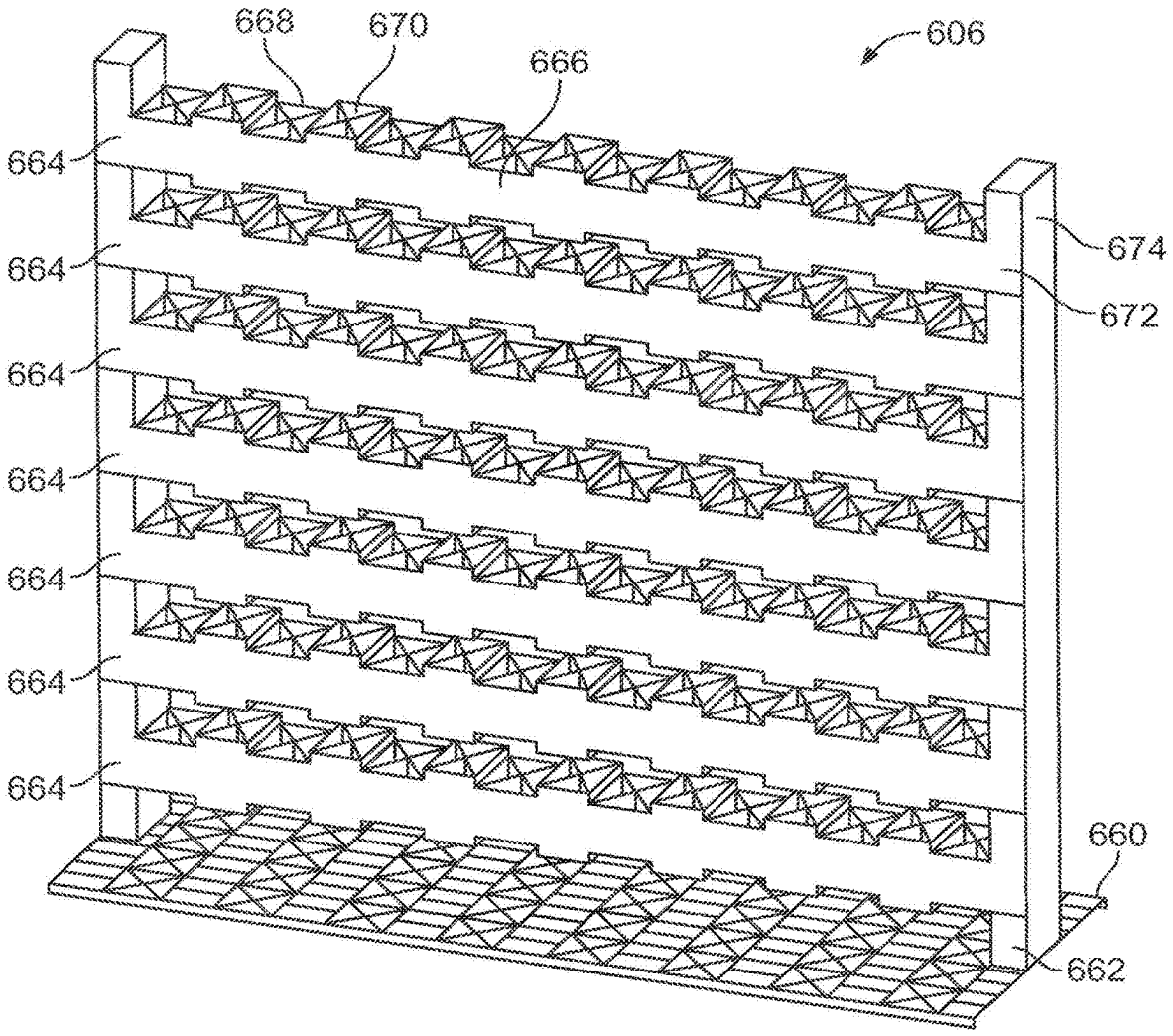
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FIG. 41

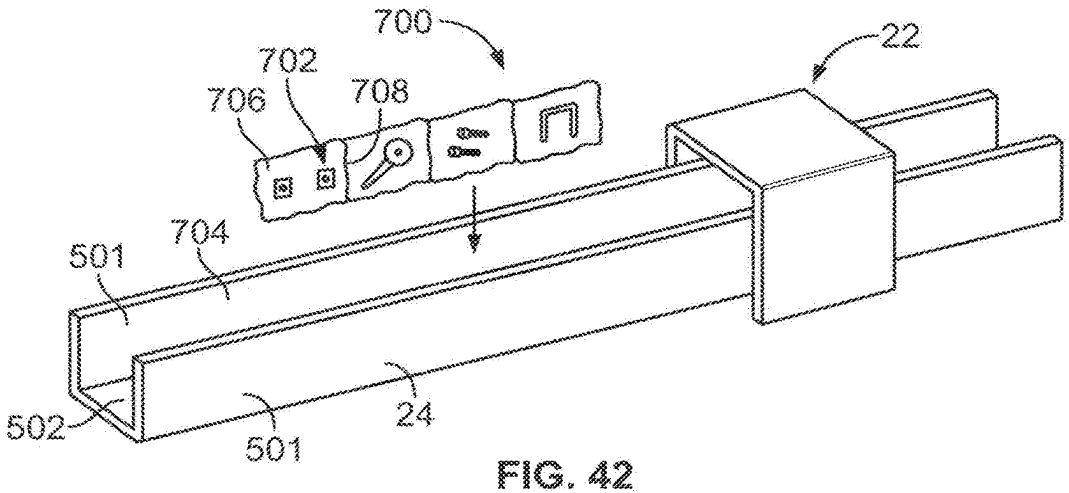
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FIG. 42

MOVABLE BARRIER OPERATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 18/233,479, filed Aug. 14, 2023, entitled MOVABLE BARRIER OPERATOR, which is a continuation of U.S. patent application Ser. No. 17/275,098, filed Mar. 10, 2021, entitled MOVABLE BARRIER OPERATOR, which is a U.S. national phase application of PCT/US2019/049265, filed Sep. 3, 2019, designating the United States, which claims the benefit of U.S. Provisional Patent App. No. 62/730,303, filed Sep. 12, 2018, which are all hereby incorporated by reference herein in their entireties.

FIELD

[0002] The field of this disclosure relates to movable barriers and, more specifically, to movable barrier operators for moving movable barriers.

BACKGROUND

[0003] Various types of movable barrier operators are known for controlling the position of movable barriers. For example, movable barrier operators may include swinging gate operators, jackshaft operators, and others. One type of movable barrier operator utilizes a head unit to move a trolley along a rail. The trolley is in turn connected to a segmented door to translate movement of the trolley into movement of the segmented door. These types of operators are commonly located in a garage of a household to move a garage door between open and closed positions. The head unit has a motor with a shaft that drives a transmission having an output such as a drive sprocket engaged with a chain. The chain is connected to the trolley so that rotation of the drive sprocket causes movement of the trolley relative to the rail.

[0004] The path of the garage door is preferably free of obstacles that could interfere with movement of the garage door between closed and open positions. However, an object may enter the path of the garage door such as a shelf installed by a homeowner in the garage. Garage doors may be heavy, such as garage doors made of wood, and may be several hundred pounds. If the garage door is traveling at full speed from the closed position toward the open position and impacts the shelf, the garage door may be brought to a sudden stop while the motor of the head unit continues to try to drive the garage door to the open position. The jarring impact of the garage door may break the motor or a transmission component of the head unit. The drive sprocket could then rotate freely and the garage door may be free to travel back toward its closed position and may damage the garage floor and/or the garage door.

[0005] Some garage door opener systems are provided to an installer with a rail having a predetermined length. The rail is packaged with the associated components, such as a chain, the gears for driving and guiding the chain along the rail, and hardware for installing the rail. The rail is packaged in a cardboard box with the components packaged in plastic bags. The cardboard box provides protection for the rail since the rail may be provided in an assembly of rails that are moved about by forklift trucks in warehouses during manufacture and shipping. One problem with the use of a cardboard box and plastic bands is the potential waste associated with disposing of the cardboard box and plastic bags. Another problem with the cardboard box/plastic bag approach is that an installer has to open the cardboard box and plastic bags and keep track of the components while the installer installs the rail.

SUMMARY

[0006] In accordance with one aspect of the present disclosure, a movable barrier operator is provided that includes a body, a motor supported by the body, and a rotatable drive supported by the body and configured to be connected to an elongate driven member. The movable barrier operator further includes a lockable transmission connecting the motor and the rotatable drive. The lockable transmission has an unlocked configuration that permits the rotatable drive to rotate relative to the body to drive the driven member and a locked configuration that secures the rotatable drive against rotation relative to the body. The lockable transmission also has a locked configuration that fixes the rotatable drive against rotation relative to the body. The lockable transmission is configured to shift from the unlocked configuration to the locked configuration in response to a torque applied to the rotatable drive exceeding a predetermined threshold. In this manner, the lockable transmission provides a safety mechanism to inhibit rotation of the rotatable drive if there is a significant torque applied to the rotatable drive, such as the associated movable barrier impacting a shelf or other object. Inhibiting rotation of the rotatable drive allows the movable barrier operator to prevent uncontrolled movement of the movable barrier post-impact.

[0007] In another aspect, a method is provided for operating a movable barrier operator. The method includes rotating a rotatable drive of the movable barrier operator to drive an elongate, flexible member and move a movable barrier connected to the flexible member. The method further includes receiving a torque at a rotatable drive of the movable barrier operator that exceeds a predetermined threshold torque. The method also includes locking a transmission of the movable barrier operator in response to receiving the torque at the rotatable drive thereof to secure the rotatable drive to a body of the movable barrier operator and fix the rotatable drive against rotation relative to the body. By fixing the rotatable drive against rotation relative to the body of the movable barrier operator, the movable barrier may be held in position against unintentional movement despite a large impact that may have damaged the movable barrier operator.

[0008] A movable barrier operator is also provided that includes a body, a motor supported by the body and having a rotatable drive shaft, and a rotatable drive supported by the body and configured to be connected to an elongate driven member. The movable barrier operator includes a shaft supported by the body and a compound gear mounted on the shaft. The compound gear includes a first gear operably coupled to the motor drive shaft and a second gear operably coupled to the rotatable drive, the first and second gears connected such that turning of the first gear causes turning of the second gear. The first and second gears may have different sizes and different numbers of teeth to provide a desired gear ratio and a desired speed of a movable barrier operator. This permits the manufacturer, installer, or repairer of the movable barrier operator to select the speed (or speeds) the movable barrier operator moves the associated

movable barrier by utilizing a compound gear with a particular gear ratio. Further, the compound gear permits the first and second gears to be made of different materials so that each gear may provide different operability in use.

[0009] In one embodiment, the compound gear assembly includes a plurality of raised ridges that each include a pair of ramp portions. The compound gear assembly further includes a plurality of recesses that receive the raised ridges and a pair of walls associated with each recess. One of the ramp portions of each of the raised ridges is configured to cammingly engage one of the pair of walls with turning of the second gear relative to the first gear caused by a torque applied to the rotatable drive. The camming engagement causes one of the first and second gears to shift along the shaft away from the other of the first and second gears. This shifting decouples the first and second gears and permits one of the gears to turn freely relative to the other gear.

[0010] In accordance with another aspect of the present disclosure, an end cap is provided for a rail of a movable barrier operator. The end cap includes a first body, a second body, and a primary compartment formed by the first body and the second body. The compartment is configured to receive an end of a rail of a movable barrier operator. The end cap further includes at least one secondary compartment of the first body or the second body configured to receive hardware for installing the rail. The end cap protects the end of the rail during transit and, during installation, provides a convenient and organized storage system for hardware an installer will use to install the rail.

[0011] The present disclosure also provides a trolley for a garage door opener system. The trolley includes a body configured to be connected to an elongated rail of a garage door opener system and to be shifted longitudinally thereallong. The body has a receiving portion configured to receive a trolley connector of an elongated drive member. The elongated drive member may include, for example, a belt or a chain. The trolley further includes a flexible actuator extending laterally outward and downward from the body, and a hammer pivotally connected to the body about a longitudinal pivot axis. The hammer is connected to the flexible actuator and is configured to pivot in response to downward movement of the flexible actuator, wherein the hammer pivots from an engaged position in which the hammer secures the trolley connector relative to the body, to a release position in which the hammer is spaced from the trolley connector and permits the trolley connector to shift relative to the body. In attempts to gain unauthorized entry to garages, intruders have been known to insert a coat hanger between the garage door and the header above the garage door to try to pull the emergency release handle of conventional garage door opener trolleys in a longitudinal direction generally along the rail of the garage door opener (toward the door) to thereby disengage the trolley and garage door from the chain or belt of the garage door opener. However, the hammer of the trolley disclosed herein is pivotally connected to the body about a longitudinal axis and the flexible actuator extends laterally outward and downward from the body. An intruder's attempt to pull the flexible actuator longitudinally toward the garage door using a coat hanger would be unlikely to pivot the hammer to the release position because the pull force would be directed generally parallel to the pivot axis of the hammer. The garage door opener system incorporating the trolley is therefore more secure against unauthorized entry into the garage.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] FIG. **1** is a perspective view of a movable barrier operator system installed in a garage, the movable barrier operator system including a head unit mounted to a ceiling of the garage;

[0013] FIG. **2** is a schematic representation of the head unit of the movable barrier operator system of FIG. **1**;

[0014] FIG. **3** is an exploded view of the head unit of FIG. **1**;

[0015] FIG. **4** is perspective view of a portion of the head unit of FIG. **1** with a cover of the head unit removed, FIG. **4** showing a motor mounted to a chassis of the head unit and a transformer mounted to a lockable transmission of the head unit;

[0016] FIG. **5** is a perspective view of the chassis of FIG. **4** and a power cord of the head unit;

[0017] FIG. **6** is a perspective view similar to FIG. **5** showing the power cord connected to the chassis;

[0018] FIG. **7** is a perspective view of a battery of the head unit secured between the chassis and a printed circuit board support of the head unit;

[0019] FIG. **8** is a perspective view of the head unit showing the printed circuit board mounted to an underside of the printed circuit board support;

[0020] FIGS. **9**, **10**, and **11** are side elevational views of a locking arm of the battery pivoting and engaging the chassis and the printed circuit board support as the battery is advanced into an operating position;

[0021] FIG. **12** is a perspective view of a portion of the head unit showing a cover of the transmission removed to illustrate the engagement between a worm driven by the motor and a worm wheel of the transmission;

[0022] FIG. **13** is a perspective view of a portion of the head unit showing a rotatable drive of the head unit that is configured to drive either a chain or a belt;

[0023] FIG. **14** is a cross-sectional view of the motor and transmission showing a primary spur gear mounted to the worm wheel and engaged with a secondary spur gear;

[0024] FIG. **15** is an exploded view of the motor and transmission of FIG. **12**;

[0025] FIG. **16** is a plan view of an interior of a housing of the transmission of FIG. **15**;

[0026] FIG. **17**A is a plan view of the housing of FIG. **17** showing the primary and secondary spur gears within the housing;

[0027] FIG. **17**B is an enlarged portion of FIG. **17**A showing a protrusion of the housing sized to fit between teeth of the primary spur gear once the primary gear has been shifted into the page;

[0028] FIG. **18** is a perspective view of a compound gear of the lockable transmission which includes the worm wheel and the primary spur gear of FIG. **14**;

[0029] FIG. **19** is an elevational view of the compound gear of FIG. **18** showing the different teeth spacing of the worm wheel and the primary spur gear;

[0030] FIG. **20** is a plan view of the compound gear of FIG. **18** showing snap-fit tabs of the worm wheel engaged with pockets of the primary spur gear;

[0031] FIG. **21** is a perspective view of the primary spur gear of FIG. **18** showing radially extending projections of the primary spur gear that receive therebetween alignment tabs of the worm wheel;

[0032] FIG. **22** is a plan view of the primary spur gear of FIG. **21** showing a central opening of the spur gear;

[0033] FIG. **23** is a cross-sectional view taken across line **23-23** in FIG. **22** showing one of the pockets of the primary spur gear;

[0034] FIG. **24** is a bottom plan view of the primary spur gear of FIG. **21** showing ridges spaced circumferentially about the primary spur gear configured to engage recesses of the worm wheel and drive the primary spur gear with rotation of the worm wheel;

[0035] FIG. **25** is a cross-sectional view taken across line **25-25** in FIG. **24** showing ramp surfaces of one of the ridges;

[0036] FIG. **26** is a perspective view of the worm wheel of FIG. **18** showing the upstanding snap-fit tabs and alignment tabs of the worm wheel;

[0037] FIG. **27** is a top plan view of the worm wheel of FIG. **26** showing generally triangular recesses separating the snap-fit tabs and the alignment tabs, the recesses being sized to receive the drive ridges of the spur gear;

[0038] FIG. **28** is a bottom plan view of the worm wheel of FIG. **27** showing through openings in the worm wheel;

[0039] FIG. **29** is a cross-sectional view taken across line **29-29** in FIG. **27** showing a snap-fit tab and an alignment tab upstanding from an upper wall of the worm wheel;

[0040] FIG. **30**A is a cross-sectional view taken across line **30**A-**30**A in FIG. **27** showing the sleeve of the worm wheel that receives a shaft;

[0041] FIG. **30**B is a cross-sectional view of the worm wheel taken generally across line **30**B-**30**B in FIG. **30**A, FIG. **30**B showing the worm wheel inverted and above the primary spur gear of FIG. **21** and one of the drive ridges of the primary spur gear received in one of the recesses of the worm wheel and the ramp surfaces of the drive ridge positioned to cam against walls of the worm wheel on either side of the recess;

[0042] FIG. **31**A is a cross-sectional view of the compound gear of FIG. **18** in the transmission housing with the primary spur gear of the compound gear in an unlocked position that permits the primary spur gear and secondary spur gear to rotate with rotation of the worm wheel;

[0043] FIG. **31**B is an enlarged portion of FIG. **31**A showing a gap between the primary spur gear and the protrusion of the transmission housing;

[0044] FIG. **32** is a cross-sectional view similar to FIG. **31**A showing the primary spur gear in a locked position that fixes the primary spur gear relative to the transmission housing and inhibits rotation of the primary spur gear and the secondary spur gear;

[0045] FIG. **33** is a perspective view of the trolley of the movable barrier operator system of FIG. **1**;

[0046] FIG. **34** is a perspective view of the trolley of FIG. **33** showing a release mechanism of the trolley;

[0047] FIG. **35** is a perspective view of the trolley of FIG. **33** showing lower wheels of the trolley;

[0048] FIG. **36**A is a side elevational view of a body of the trolley of FIG. **33** showing a lower pilot at each end of the trolley body for removing debris from the rail, and rollers of the trolley that travel along an inner surface of the rail;

[0049] FIG. **36**B is a perspective view of the trolley body of FIG. **36** with one half of the body removed to show components of the release mechanism and leaf springs for guiding a belt within the trolley body if a belt is used with the trolley instead of a chain;

[0050] FIG. **37** is a perspective view of an assembly of rails for movable barrier operators, each rail having end caps at the ends of the rail to protect the rail and assist in stacking of the rails;

[0051] FIG. **38** is a perspective view of one of the rail end caps of FIG. **37** with the end cap opened to show the rail and mounting hardware for the rail;

[0052] FIG. **39** is a perspective view of a lower portion of the cap of FIG. **38** with the rail removed to show fasteners and a header bracket for the rail that are contained in the cap lower portion;

[0053] FIG. **40** is a view similar to FIG. **39** of another configuration of mounting hardware in the lower portion;

[0054] FIG. **41** is a rail bridge of the assembly of rails of FIG. **37** that supports and separates the rails; and

[0055] FIG. **42** is a schematic view of a container for movable barrier operator hardware that may be received in the rail of FIG. **33**.

DETAILED DESCRIPTION

[0056] With reference to FIG. **1**, a movable barrier operator system **10** is installed in a secured area such as a garage **12**. The movable barrier operator system **10** controls the position of a movable barrier, such as a segmented garage door **14**. The garage door **14** includes wheels received in tracks **16** that guide the garage door **14** from a lower, closed position to an upper, open position. The movable barrier operator system includes one or more counterbalance torsion springs **52** that assist in moving the garage door **14**. The movable barrier operator system **10** includes a movable barrier operator, such as a head unit **20**, operable to drive a trolley **22** along a rail **24**. The trolley **22** is connected to the head unit **20** by an elongate driven member, such as a belt or chain **26** (see FIG. **34**). The movable barrier operator system **10** of FIG. **1** includes a release mechanism **25** configured to disengage the trolley **22** from the chain **26** to thereby permit the garage door **14** to move independently of the head unit **20**. The movable barrier operator system **10** includes one or more sensors **30**, such as an obstacle detector **32** and a door position sensor **34**. The obstacle detector **32** may be connected by wired or wireless approaches to the head unit **20** to detect whether there is an object in the path of the garage door **14**. The door position sensor **34** detects whether the garage door **14** is in a closed position, an open position, or moving between the open and closed positions. The movable barrier operator system **10** includes one or more remote controls, such as radio frequency transmitters **40** and a wall-mounted switch **42**.

[0057] With reference to FIG. **2**, the head unit **20** includes a motor **44** that causes rotation of a rotatable drive **46** (see FIG. **13**) via a lockable transmission **48** connecting the motor **44** and the rotatable drive **46**. As discussed in greater detail below, the lockable transmission **48** has an unlocked configuration that permits the rotatable drive **46** to turn relative to a body **50** (see FIG. **1**) of the head unit **20** and a locked configuration that secures the rotatable drive **46** to the body **50** and inhibits turning of the rotatable drive **46** relative to the body **50**. The lockable transmission **48** shifts from the unlocked configuration to the locked configuration in response to a torque applied to the rotatable drive **46** exceeding a predetermined threshold. In one embodiment, the lockable transmission **48** shifts from the unlocked configuration to the locked configuration when a torque is applied to the rotatable drive **46** which causes the rotatable

drive **46** to apply a torque to a spur gear **228** (see FIGS. **14** and **18**) of the lockable transmission **48** in the range of approximately 80 N·m to approximately 110 N·m, such as approximately 96 N·m.

[0058] For example, when the garage door **14** is closed, a user may install a shelf or other structure or object in the garage **12** too close to a path of the garage door **14**. When the user causes the head unit **20** to open the garage door **14**, the garage door **14** may contact the shelf or structure/object when the garage door is traveling at full speed such that the garage door may be suddenly stopped. The jarring impact of the garage door **14** stopping while at full speed causes the lockable transmission **48** to shift from the unlocked configuration to the locked configuration to thereby fix the rotatable drive **46** against rotation relative to the body **50**. Because the rotatable drive **46** is fixed, the rotatable drive **46** resists movement of the chain **26** and keeps the garage door **14** from moving downward without control by the motor **44**. In one embodiment, the lockable transmission **48** is internal to the head unit **20** and provides an efficient, space-saving safety mechanism for the movable barrier operator system **10**.

[0059] Regarding FIG. **2**, the head unit **20** includes a controller **56** that controls operation of the motor **44** and includes a memory **58** and a processor **60**. Memory **58** may include or may be a non-transitory computer readable medium comprising instructions that when performed by the processor **60** cause operation of the motor **44** and/or other components of the head unit **20**. The head unit **20** includes one or more lights **62** for illuminating the garage **12**. The head unit **20** includes one or more indicators **64** for making indications to a person in the garage **12**. The one or more indicators **64** may be a speaker and/or a laser identifying a location for parking, or a user interface configured to display faults, error codes, or maintenance reminders as some examples.

[0060] The head unit **20** further includes communication circuitry **70** for communicating with other devices and users of the movable barrier operator system **10**. For example, the communication circuitry **70** may include a short-range (e.g. Bluetooth) transceiver **72**, a medium-range (e.g. Wi-Fi) transceiver **74**, a long-range radio frequency (e.g. cellular) transmitter or transceiver **76**, and an input-output module **77**. The input-output module **77** may receive electrical signals from the wall-mounted switch **42** as well as the obstacle detectors **32**. The head unit **20** further includes a removable battery **80** and a battery charger **83**. The head unit **20** includes a power cord **82** (see FIG. **3**) for connecting to an AC electrical socket. The battery **80** may be used to power the head unit **20** when there is an AC power outage. Regarding FIGS. **2** and **3**, the head unit **20** includes one or more on-board sensors **84**, such as one or more rotary encoders **86** and a motion sensor for detecting movement in the garage **12**.

[0061] With reference to FIG. **3**, the body **50** includes a chassis **90**, a transmission **92** mounted to the chassis **90**, a printed circuit board (PCB) support **94** mounted to the chassis **90**, and an outer housing **96** releasably mounted to the chassis **90**. The outer housing **96** has connected thereto a shell **98** and transparent or translucent light covers **100**. The shell **98** may be a different color than the outer housing **96** and contribute to the overall appearance of the head unit **20**. To move the garage door **14**, the head unit **20** includes a motor assembly **45** which includes the motor **44** and the transmission **92**.

[0062] With reference to FIGS. **3** and **4**, the head unit **20** includes a transformer **102** mounted to the transmission **92** and a PCB assembly **104** that is mounted to the PCB support **94**. The transformer **102** includes power connectors **105** that are in direct contact with power connectors **106** of the PCB assembly **104**. The direct connection between the connectors **105** of the transformer **102** and the power connectors **106** of the PCB assembly **104** permits the transformer **102** and the printed circuit board assembly **104** to be electrically connected during assembly of the head unit **20**. More specifically, during assembly the transmission **92** and PCB support **94** are first mounted to the chassis **90**. The transformer **102** is then mounted to the transmission **92**. Next, the PCB assembly **104** is positioned so that the power connectors **105**, **106** are aligned and the PCB assembly **104** is mounted to the PCB support **94**. Because the connectors **105**, **106** are directly connected to each other, the head unit **20** does not need to include wire or cable connectors which add manufacturing complexity and cost in order to transfer electricity from the transformer to the PCB assembly **104**.

[0063] With reference to FIG. **5**, the chassis **90** had a raised portion **110** that forms a portion of a battery-receiving recess **112**. The raised portion **110** includes an opening **114** having a curved, narrow portion **116** and a rectangular, wide portion **118**. The power cord **82** includes a jacketed wire or wires **120** and a plug **122**. The power cord **82** further includes a retainer **124** sized to fit in the opening **114** and resist pull-through of the power cord **82** from the chassis **90**. The retainer **124** includes a pair of flanges **126**, **128** and a groove **130** therebetween.

[0064] Regarding FIGS. **5** and **6**, the power cord **82** is connected to the chassis **90** by advancing a leading end portion of the power cord **82**, such as wires **134**, in direction **136** into the wide portion **118** of the opening **114**. The power cord **82** is advanced in direction **136** until the retainer **124** enters the opening **114** and the groove **130** thereof is vertically aligned with an edge **140** of the chassis **90** that extends about the opening **114**. Next, the retainer **124** is shifted in direction **142** which causes engagement of the groove **130** of the retainer **124** with the edge **140** of the chassis **90**. To keep the retainer **124** in the narrow portion **116**, the PCB support **94** includes a wall **150** (see FIG. **4**) that is positioned against the flanges **126** and **128**. Thus, once the PCB support **94** has been mounted to the chassis **90**, the wall **150** keeps the retainer **124** from shifting in a direction opposite direction **142** to the wide portion **118** of the opening **114** and thereby keeps the power cord **82** secured to the chassis **90**.

[0065] With reference to FIG. **3**, the battery **80** includes a pair of locking arms **160** pivotally connected to opposite sides of a battery housing **162** of the battery **80**. The PCB support **94** includes a floor **164** and a post **166** upstanding from the floor **164** and spaced from the wall **150**. The PCB support **94** receives the battery **80** in a recess **168** (see FIG. **1**) between the wall **150** and the post **166**. Turning to FIG. **7**, the battery **80** has been advanced in direction **170** into a battery compartment **172** formed by the raised portion **110** of the chassis **90**, the floor **164** of the PCB support **94**, the wall **150** of the PCB support **94**, and the post **166** of the PCB support **94**. When the battery **80** is in the installed position in the compartment **172**, each of the locking arms **160** has

a hook portion **174** that extends through a slot **176** of the raised portion **110** and engages a portion **178** of the chassis **90** near the slot **176**. The locking arm **160** also includes a base portion **180** with a bottom edge **182** that abuts against an upper surface **184** of the PCB support **94**. With reference to FIG. **8**, once the battery **80** has been installed, the battery **80** includes contacts **190** that are engaged with contacts of the PCB assembly **104** to provide power to the PCB assembly **104** during power outage situations.

[0066] With reference to FIGS. **9-11**, a side elevational view of the battery **80** and one of the locking arms **160** is provided to illustrate a method of installing the battery **80** in the battery compartment **172**. Although only one locking arm **160** is shown, both locking arms **160** undergo similar movements as the battery **80** is installed in the battery compartment **172**. The locking arms **160** may be connected by a member such as a rigid bar or tube so that the locking arms **160** move together during the battery installation process.

[0067] With reference to FIG. **9**, each locking arm **160** is connected to the battery housing **162** at a pivot connection **194**. Initially, the locking arm **160** is in an initial clearance position whereby the battery housing **162** may be advanced into the battery compartment **172** without the hook portion **174** interfering with the raised portion **110** of the chassis **90**.

[0068] Regarding FIG. **10**, the battery **80** has been advanced sufficiently far into the battery compartment **172** that the hook portion **174** can enter the slot **176** of the raised portion **110**. As the hook portion **174** enters the slot **176**, the locking arm **160** may pivot in direction **192**. Regarding FIG. **11**, the battery **80** is advanced in direction **170** due to pivoting of the locking arms **160** until the battery **80** reaches the installed position in the battery compartment **172**. The person installing the battery **80** pivots the locking arm **160** in direction **192** to pivot the hook portion **174** into engagement with the raised portion **110** of the chassis **90**. The locking arm **160** includes a vertical portion **200** and a base portion **180** that extend transversely to one another, such as at a right angle to each other. The base portion **180** includes a bottom edge **182** that engages the upper surface **184** of the PCB support **94**. The locking arm **160** may have a distance **204** from a center of the pivot connection **194** to the bottom edge **182** of the base portion **180** that is greater than a distance **206** from the center of pivot connection **194** to a bottom **208** of the battery housing **162**. Thus, the oversized locking arm **160** when pivoted to the installed position of FIG. **11** urges the battery **80** against the chassis **90** and maintains a firm connection of the battery **80** to the chassis **90** and the PCB assembly **104** mounted thereto.

[0069] With reference to FIG. **12**, the transmission **92** is shown with a cover **210** (see FIG. **15**) removed from a housing **212** of the transmission **92**. With reference to FIGS. **12** and **13**, the lockable transmission **48** of the head unit **20** includes a rotatable transmission component such as a compound gear **214** that includes a first gear, such as a worm wheel **216**, driven by a worm **218** associated with a drive shaft **220** (see FIG. **14**) of the motor **44**. With reference to FIG. **18**, the compound gear **214** includes a second gear, such as the spur gear **228**, secured to the worm wheel **216** by way of mating portions **230** and one or more snap-fit connections **232**. The compound gear **214** is rotatably mounted to a shaft **224** supported by the housing **212** as shown by FIG. **12**.

[0070] With reference to FIG. **14**, the lockable transmission **48** includes a third gear, such as a spur gear **240**, having teeth **242** engaged with teeth **244** of the spur gear **228**. The spur gear **228** may be referred to herein as a primary spur gear and the spur gear **240** may be referred to a secondary spur gear since the spur gear **240** is driven by the spur gear **228**. To engage the belt or chain **26**, the rotatable drive **46** includes a rotatable member, such as a gear and pulley assembly **252**, which includes a sprocket **254** and a drive pulley **256** mounted to an output shaft **250** (or integral therewith) as shown in FIG. **13**. In other embodiments, the rotatable drive **46** includes only one of the sprocket **254** or the drive pulley **256** as desired for a particular application.

[0071] Regarding FIG. **14**, the spur gear **240** has a through bore **246** that receives the output shaft **250** of the gear and pulley assembly **252**. Thus, when the motor **44** causes turning of the worm **218**, the worm **218** produces corresponding turning of the worm wheel **216**, spur gear **228** secured thereto, spur gear **240**, output shaft **250**, and the sprocket **254** and pulley **256**. In one embodiment, the rotary encoder **86** may be an absolute positioning encoder **290** (see FIG. **12**) that interacts with a disc mounted to the output shaft **250**. Thus, as the output shaft **250** turns, the controller **56** can determine the position of the garage door **14**.

[0072] The gear and pulley assembly **252** can be connected to either a belt or a chain **26** and provides flexibility for installation of the head unit **20**. Regarding FIG. **13**, the body **50** in some instances includes a rail section **258** for being connected to the rail **24**. The rail section **258** includes an opening **260** through which the belt or chain **26** utilized with the head unit **20** can extend and engage the sprocket **254** or drive pulley **256**. The head unit **20** includes a guide **262** that is connected to the rail section **258** and guides the belt or chain **26** about the sprocket **254** or drive pulley **256**. The guide **262** includes a base portion **264** and side members **266** connected via one or more hinges **268** (e.g., living hinges) to the base portion **264**. During assembly of the head unit **20**, the base portion **264** is positioned on the rail section **258** and the side members **266** are folded downward onto opposite sides of the rail section **258**. The base portion **264** and the side members **266** are secured to the rail section **258** by one or more fasteners and/or snap-fit connections. If a belt is utilized, the side members **262** include belt backing members **270** that extend around the drive pulley **256** and resist the belt from disengaging from the drive pulley **256**. If the chain **26** is utilized, the side members **266** also include chain spacing members **272** that limit pinch points of the chain **26** near the sprocket **254**.

[0073] With reference to FIGS. **14** and **15**, the worm **218** may have a unitary, one-piece construction with the drive shaft **220** of the motor **44**. In other forms, the worm **218** is a separate component assembled to the drive shaft **220**. The motor **44** may be selected from various types known in the art including, for example direct current (DC) motors, induction motors, synchronous motors, etc. As shown, the motor **44** includes an armature assembly **300** and magnets **302**. The motor **44** includes a housing **304** mounted to the housing **212** of the transmission **92**. The motor **44** includes a circuit board **306** for controlling electrical power to the armature assembly **300**.

[0074] With reference to FIGS. **16** and **17**, housing **212** of the transmission **92** includes a through opening **310** that receives the shaft **224** of the compound gear **214** and a through opening **312** that receives the output shaft **250** of the

spur gear **240**. The housing **212** includes a base wall **314** and a stop, such as a protrusion **316**. In one form, the protrusion **316** is formed by coining the material of the base wall **314**. With reference to FIG. **31**B, the protrusion **316** has a height **318** that extends above an inner surface of the wall **314**.

[0075] Regarding FIG. **16**, the protrusion **316** is spaced a radial distance **332** away from an axis **334** of rotation of the spur gear **228**, e.g., the centerline of the shaft **224**. The distance **332** is less than a radius from the axis **334** to the radially outermost point of the teeth **244** of the gear **228**. As discussed in greater detail below, the spur gear **228** shifts axially along the shaft **224** away from the worm wheel **216** in response to a torque applied to the shaft **224** exceeding a predetermined threshold. The distance **332** as well as the size and shape of the protrusion **316** are selected so that the protrusion **316** extends into a gap between two of the teeth **244** (see FIG. **17**B) of the spur gear **228** when the spur gear **228** shifts axially along the shaft **224** away from the worm wheel **216**. Once the protrusion **316** extends into the gap between the teeth **244** of the spur gear **228**, the protrusion **316** acts as a brake to hold the spur gear **228** substantially immobile and fixed relative to the housing **212** of the transmission **92**. Although the spur gear **228** may turn a small distance due to some clearance between the teeth **244** and the protrusion **316**, the spur gear **228** is generally fixed against free rotation relative to the housing **212**. Because the spur gear **228** is fixed relative to the housing **212**, the spur gear **228** inhibits rotation of the spur gear **240** (which is engaged with the spur gear **228**), the output shaft **250**, and the gear and pulley assembly **252** mounted to (or integral with) the output shaft **250**. Further, the gear and pulley assembly **252** held by the spur gear **228** inhibits movement of the belt or chain **26** and therefore prevents associated movement of the garage door **14**. In this manner, the head unit **20** stops the garage door **14** in position after a high-torque event at the output shaft **250**.

[0076] With reference to FIG. **18**, the snap-fit connections **232** connect the spur gear **228** to the worm wheel **216** when the lockable transmission **48** is in the unlocked configuration. The snap-fit connections **232**, however, may disengage and permit the spur gear **228** to shift away from the worm wheel **216** and engage the protrusion **316** of the housing **212** of the transmission **92**. The snap-fit connections **232** include snap-fit tabs **350** having barbs **352** (see FIG. **26**) that engage pockets **354** of the spur gear **228**. During assembly of the compound gear **214**, the spur gear **228** is advanced in direction **356** (see FIG. **18**) so that the snap-fit tabs **350** enter a central opening **358** (see FIG. **21**) of the spur gear **228**. Alternatively, the spur gear **228** is stationary and the worm wheel **216** is advanced in a direction opposite to direction **356**, or the worm wheel **216** and the spur gear **228** are brought together in direction **356** and the opposite thereof.

[0077] The barbs **352** cam radially inward around walls **360** (see FIG. **23**) until the barbs **352** are vertically aligned with the pockets **354** and snap into the pockets **354**. The barbs **352** are in overlapping relation with ledges **362** of the pockets **354** and resist axial movement of the spur gear **228** away from the worm wheel **216**. Despite the spur gear **228** and the worm wheel **216** being shown and described herein as including interference features (e.g., snap-fit connections **232**), it should be appreciated that the compound gear **214** may be configured otherwise. For example, the interference features may be augmented with or replaced by a fastener (or fasteners) such as one or more of screws, bolts, glue, welds, etc. Furthermore, although the example compound gear **214** includes three snap-fit connections **232** arcuately spaced about 120° apart from each other, nevertheless the compound gear **214** may be configured with fewer or additional snap-fit connections. Furthermore, the various complementary portions of the spur gear **228** and the worm wheel **216** that facilitate alignment, joining, and power/torque transfer may be configured otherwise. Examples of alternative embodiments of the spur gear **228** and the worm wheel **216** are provided in the drawing appendix submitted herewith.

[0078] With reference to FIGS. **24** and **26**, the spur gear **228** includes a radially inner annular body **400** and the teeth **244** extending outward from the annular body **400**. The annular body **400** includes ridges **402** spaced circumferentially about the body **400** that are sized to extend into recesses **420** of the worm wheel **216**. The worm wheel **216** includes a pair of walls **430** extending along either side of each of the recesses **420**. The mating portions **230** (see FIG. **18**) of the compound gear **214** include the ridges **402** and the walls **430**. To transfer rotary movement of the worm wheel **216** to the spur gear **228** when the lockable transmission **48** is in the unlocked configuration, the ridges **402** and the walls **430** engage as the worm wheel **216** is driven by the worm **218**.

[0079] The mating portions **230** also include alignment tabs **370** (see FIG. **26**) of the worm wheel **216** that are received in gaps **372** (see FIG. **21**) between radially extending projections **374** of the spur gear **228**. The alignment tabs **370** ensure that the ridges **402** of the spur gear **228** are axially aligned with the recesses **420** of the worm wheel **216** as the spur gear **228** and worm wheel **216** are connected together. Further, each alignment tab **370** of the worm wheel **216** is held snuggly between a pair of the projections **374** of the spur gear. Thus, when the worm wheel **216** turns in direction **380** or direction **382** (see FIG. **20**), the alignment tabs **370** engage one of the projections **374** and assist in causing turning of the spur gear **228** in the same direction **380**, **382**.

[0080] The compound gear **214** permits the use of different materials for the worm wheel **216** and the spur gear **228**. In one example, the worm wheel **216** is made of a plastic material and the spur gear **228** is made of a metallic material, such as steel. The plastic material of the worm wheel **216** may be softer than the material of the worm **218**, which may be made of plastic or metal. Thus, even if the worm wheel **216** or the entire compound gear **214** binds or otherwise becomes stuck, the worm **218** may still rotate thereby causing the worm **218** to strip the worm wheel **216** without damaging the worm **218**. For example, the worm **218** may strip the worm wheel **216** when the motor **44** drives the worm **218** and the garage door **14** remains stationary such as due to the trolley **22** or chain **26** binding up. A repair person may then replace the compound gear **214** and not have to replace the worm **218** which may be a component of the motor drive shaft **220**.

[0081] Another advantage of the compound gear **214** is that the worm wheel **216** and/or spur gear **228** may be selected for a specific gear ratio to provide different speeds of the garage door **14** for different applications while utilizing the same worm **218** and gear and pulley assembly **252**. For example, for applications that specify a faster garage door **14**, a spur gear **228** may be selected that has a larger outer diameter and more teeth **244**. For applications that specify a slower garage door **14**, a smaller spur gear **228**

with a smaller number of teeth **244** than the number of teeth **384** of the worm wheel **216** may be selected (see FIG. **19**). Once the desired spur gear **228** is selected, the spur gear **228** is assembled with the worm wheel **216**. In this manner, different door speeds may be provided by tailoring the compound gear **216** to provide the desired gear ratio. Such a gear customization makes it easier for the head unit **20** to operate in a wider range of environments, contexts or applications.

[0082] With reference to FIGS. **30**A and **31**, the worm wheel **216** has a sleeve **450** with a through bore **454** that receives the shaft **224** and permits the worm wheel **216** to turn about the shaft **224**. The worm wheel **216** is constrained against axial movement along the shaft **224** because the worm wheel sleeve **450** has an end **452** at a shaft support **453** of the transmission housing base wall **314** and an end **455** at the transmission housing cover **210**. Further, with reference to FIGS. **26** and **29**, the worm wheel **216** includes walls **456** that separate the recesses **420** and from which the snap-fit tabs **350** and alignment tabs **370** are upstanding therefrom. The walls **456** may include openings **458** (see FIGS. **27** and **28**) at the base of the snap-fit tabs **350** to facilitate molding of the worm wheel. As further shown in FIG. **28**, interposed between the openings **458** the worm wheel **216** includes ribs **459** that radially extend as raised, spoke-like features from the worm wheel sleeve **450** to provide additional stiffness for resisting twisting or other deformation of the worm wheel **216**.

[0083] With reference to FIGS. **22** and **24**, the spur gear **228** includes at least one ramp portion for shifting the spur gear **228** axially away from the worm wheel **216** in response to a torque applied to the gear and pulley assembly **252** exceeding the predetermined threshold. In one example, the at least one ramp portion includes the ridges **402** of the spur gear **228**. Extending between the ridges **402** are flats **404**. With reference to FIG. **25**, each ridge **402** includes a ramp surface **406** extending on either side of the ridge **402** at an angle **408** relative to the adjacent flat **404**. Each ridge **402** also includes a flat surface **410** extending between the ramp surfaces **406**.

[0084] With reference to FIG. **26**, the ridges **402** fit into the recesses **420** that separate the alignment tabs **370** and snap-fit tabs **350**. With reference to FIG. **30**B, when each ridge **402** is in a respective recess **420**, the ramp surfaces **406** face the walls **430** of the worm wheel **216** which extend along either side of the recess **420**. In one embodiment, there is a gap **432** between the flat surface **410** and a wall **434** of the worm wheel **216**.

[0085] When a sufficiently high torque is applied to the output shaft **250** and transmitted to the spur gear **228** via the spur gear **240**, the spur gear **228** will turn in one of the directions **440**, **442** which causes a camming engagement between one of the ramp surfaces **406** and the side surface **444** of one of the walls **430**. The camming engagement shifts the spur gear **228** axially in direction **448** away from the worm wheel **216**.

[0086] With reference to FIGS. **31**A and **31**B, the worm wheel **216** and the spur gear **228** are shown with the lockable transmission **48** in the unlocked configuration. The teeth **244** of the spur gear **228** are separated from the protrusion **316** by a gap **480**. The spur gear **228** may rotate without the teeth **244** contacting the protrusion **316**. Further, the worm wheel **216** has a lower surface **482** contacting an upper surface **484** of the spur gear **228**. The teeth **244** of the spur gear **228** are engaged with the teeth **242** of the spur gear **240**. Thus, rotation of the worm wheel **216** causes turning of the spur gear **228** and turning of the spur gear **240**.

[0087] With reference to FIG. **32**, the lockable transmission **48** is shown in a locked configuration with the spur gear **228** having been shifted axially along the shaft **224** away from the worm wheel **216**. As noted above, the lockable transmission **48** may shift from the unlocked configuration to the locked configuration in response to a sufficiently large torque being applied to the gear and pulley assembly **252** such as by the garage door **14** impacting an object such as, for example, a shelf mounted to the garage ceiling at full speed. When the lockable transmission **48** is in the locked configuration, a spacing **486** is introduced between the lower surface **482** of the worm wheel **216** and the upper surface **484** of the spur gear **228**. Further, the protrusion **316** extends into a gap between two of the teeth **244** of the spur gear **228** and axially overlaps with the teeth **244** a distance **488**. The teeth **244** will contact the protrusion **316** and inhibit turning of the spur gear **228** in either direction **490**, **492** (see FIG. **17**B). Due to the presence of the protrusion **316** between the teeth **244**, the spur gear **228** cannot turn relative to the housing **212**. Further, due to the engagement between the teeth **244** of the spur gear **228** and the teeth **242** of the spur gear **240**, the spur gear **240** cannot turn relative to the housing **212** nor can the gear and pulley assembly **252**. Because the gear and pulley assembly **252** is now fixed relative to the chassis **90**, the gear and pulley assembly **252** resists movement of the belt or chain **26** and keeps the garage door **14** in position. The user (or a service person) may then remove the obstruction that caused the garage door **14** to stop suddenly, disengage the trolley **22** from the belt or chain **26**, and safely lower the garage door **14**. Once the garage door **14** has been lowered, the user or service person can fix the head unit **20** by replacing the compound gear **214**.

[0088] With reference to FIG. **33**, the rail **24** has a U-shaped cross section including a pair of spaced side walls **501** and a lower wall **502** connecting the side walls **501**. The trolley **22** includes one or more wheels **500** that roll along the lower wall **502** as the trolley **22** travels along the rail **24**. The trolley **22** also includes one or more rollers **503** (see FIGS. **35** and **36**A) that roll along an inner, flat surface of the lower wall **502**.

[0089] Regarding FIGS. **34** and **35**, the trolley **22** includes a body **504** having two halves **506**, **508** that form receiving portions, such as passageways **511**, **513**, for receiving different runs of the chain **26**. The halves **506**, **508** are secured to a bracket **510** that extends down around the rail **24** and connects the lower wheels **500** to the halves **506**, **508**. The bracket **510** includes openings on either side of the bracket **510** that receive a threaded rod or fastener such as a bolt **512** about which the wheels **500** may rotate. The bolt **512** also pivotally connects a J-arm **514** to the trolley **22**. With reference to FIG. **1**, the J-arm **514** connects the trolley **22** to the garage door **14**.

[0090] Regarding FIGS. **34** and **35**, the trolley release mechanism **25** (see FIG. **1**) includes a flexible actuator, such as a pull-cord **520**, having an end portion **521** connected to a hammer mechanism **522**. Opposite the end portion **521**, the pull-cord **520** includes a handle end portion **519** for gripping. In one embodiment, the handle end portion **519** includes an enlarged, rigid handle made of plastic. The hammer mechanism **522** includes a hammer **524** having a lower end portion, such as a connection portion **523**, piv-

otally connected to the trolley half **508** via a pin **524**A received in a slot **524**B (see FIG. **36**B) of the trolley half **508**. The hammer **524** is pivotable as indicated by arrow **546** about a pivot axis **524**C (see FIG. **34**) that extends longitudinally such as parallel to the longitudinal length of the rail **24**. The pull-cord end portion **521** may be connected to the hammer **524** by, for example, a knot, a fastener or an enlarged terminal end of the end portion **521** that limits movement of the pull-cord **520** through an opening of the hammer **524**.

[0091] Regarding FIG. **36**B, the body half **508** of trolley **22** includes a wall **509** having an upper portion **509**A and a guide **515** that directs the pull-cord **520** laterally away from the hammer **524** and up over the upper portion **509**A of the wall **509**. The guide **515** includes an opening **517** through which the pull-cord **520** extends. The hammer **524** includes side surfaces **527**, **529** and the pull-cord **520** extends along one of the side surfaces **527**, **529** toward the guide **515**.

[0092] The hammer mechanism **522** further includes a spring **528** that urges an upper portion, such as an attachment portion **526**, of the hammer **524** in direction **530** and causes an engagement member **525** of the hammer **524** to engage a groove of a trolley connector **534**. The trolley connector **534** secures the ends of the belt or chain **26** together and permits adjustment of the spacing between the ends of the belt or chain **26** to adjust the tension in the belt or chain **26**. When the hammer **524** is engaged with the trolley connector **534**, movement of the belt or chain **26** causes movement of the trolley **22** and garage door **14** connected thereto. In one embodiment, the hammer **524** is made of steel and trolley connector **534** is made of a rigid plastic.

[0093] With reference to FIG. **34**, to release the trolley **22** from the belt or chain **26**, the user pulls the pull-cord **520** downward in direction **542**. A portion of the pull-cord **520** shifts through the guide **515**, up and over the upper portion **509**A of the wall **509**, and downward. Pulling the pull-cord **520** in direction **542** pivots the hammer **524** in direction **546**. This overcomes the bias provided by the spring **528** and withdraws the engagement member **525** of the hammer **524** from the groove of the trolley connector **534**. However, if an intruder attempts to pull the pull-cord **508** in generally longitudinally in direction **553** using a coat hanger, the pull-cord **520** will be applying a force on the hammer **524** that is generally parallel to the pivot axis **524**C of the hammer **524**. Most of the force the intruder applies to the pull-cord **520** will be transferred to the guide **515** and/or the upper portion **509**A of the wall **509**. This makes it difficult for the intruder to overcome the spring **528** and move the hammer **524** toward a release position.

[0094] Regarding FIG. **36**B, the trolley **22** is shown with components removed including the half **506**. The trolley **22** includes pins **556** for connecting upper ends of the halves **506**, **508** and pins **558** for connecting lower ends of the halves **506**, **508** and capturing the rollers **503** between the halves **506**, **508**. If a belt is utilized with the trolley **22** instead of the chain **26**, the trolley **22** includes leaf springs **552**, **554** that are arranged to urge the belt toward one side of the passageway **511**. The trolley **22** includes pins **560** sized to extend through openings of the leaf springs **552**, **554** and capture the leaf springs **552**, **554** between the halves **506**, **508**.

[0095] With reference to FIG. **36**A, the trolley body **504** includes pilots **580**, **582** configured to push debris inside of the rail **24** out of the way of the rollers **503**. More specifically, when the trolley **22** moves in direction **584**, the pilot **580** pushes debris to the end of the travel of the trolley **22** within the rail **24**. When the trolley **22** moves in direction **586**, the pilot **582** pushes debris to the opposite end of the travel of the trolley **22** within the rail **24**. Each pilot **580**, **582** may be formed by pilot portions **580**A, **580**B (see FIG. **35**) of the halves **506**, **508**. In one embodiment, each pilot **580**, **582** includes a V-shaped leading edge for collecting debris as the trolley **22** moves within the rail **24**.

[0096] The head unit **20** and the rail **24** may be configured differently depending on the intended installer. With reference to FIG. **13**, for installation by a homeowner, the head unit **20** may include the rail section **258** mounted to the chassis **90** and the gear and pulley assembly **252** connected to the spur gear **240**. The rail **24** may be provided in sections that the homeowner assembles and connects to the rail section **258** during installation of the movable barrier operator system **10**.

[0097] With reference to FIG. **37**, a one-piece rail assembly **602** may be connected to the head unit **20** when the movable barrier operator system **10** is installed or intended for installation by a professional, experienced installer. Each rail assembly **602** includes the rail **24** along which the trolley **22** travels, drive and idler pulleys/gears (depending on whether a belt or chain is to be used), and hardware. In some instances, the rail assembly **602** may include the trolley **22** and chain or belt pre-installed on the rail **24**, however in other instances the trolley **22** and chain or belt may be separate from the rail **24** but included in or otherwise packaged with the rail assembly **602**. The hardware included in a rail assembly **602** may be used by the installer for mounting the rail assembly **602** within a garage **12**, connecting the rail **24** to garage header and to the head unit **20**, and connecting the trolley **22** to the garage door **14** (e.g., via J-hook **514**).

[0098] FIG. **37** illustrates a bundle, a collection, or a plurality **600** of rail assemblies **602**. The plurality **600** is configured for transport, such as from a manufacturer to a distributor. The plurality, bundle or collection **600** includes: a plurality of rail assemblies **602**, wherein each rail assembly is constituted by a pair of caps **604** with each cap **604** configured at opposite ends of each rail assembly **602**; and one or more rail bridges **606** that help maintain the plurality of rail assemblies **602** in a bundled configuration. The assembly **600** may also include one or more elongated members such as straps, chains, or bands which are secured about the caps **604** and/or the rail bridges **602** to maintain the rail assemblies **602** in the bundled configuration. Furthermore the collection **600** of rail assemblies **602** (or each rail assembly **602**) may include a cover such as a plastic wrap or film to protect the rails **24** or other contents during transportation and/or storage from intrusion by foreign objects such as fine particulate matter, liquids, insects, etc.

[0099] Regarding FIG. **38**, the caps **604** protect the ends of the rail **24** and the drive and idler pulleys/sprockets therein. Each cap **604** includes an upper portion **610**, a lower portion **612**, and a hinge portion **614** connecting the upper and lower portions **610**, **612**. In other configurations the upper portion **610** and the lower portion **612** of the caps **602** are separate without hinge portion **614**. The upper portion **610** may be connected to the lower portion **612** by means of, for

example, fasteners, a snap-fit engagement, or one or more frangible portions. To open the cap **604**, the snap-fit engagement is released, or the frangible portion is broken, and the upper portion **612** is pivoted upwardly in direction **616** to open the cap **604**. In another embodiment, the upper portion **610** and lower portion **612** are separate components and are secured together about the rail assembly **602** using a plastic band and/or fasteners such as bolts, threaded rods or screws. The caps **604** may be made from, for example, a durable, high-impact, recyclable plastic material.

[0100] With reference to FIGS. **38** and **39**, the upper and lower portions **610**, **612** include one or more compartments **620** that may be configured to receive the end of the rail **24** and/or hardware for mounting the rail **24** of the rail assembly **602**. In one embodiment, the one or more compartments **620** include separate compartments **620** for receiving a clevis pin **622**, a header bracket **624**, and bolts **626**. The rail **24** may include a shaft **630** to which a drive sprocket/pulley is mounted. The shaft **630** may include splines that engage recesses of a socket of the spur gear **240**. The cap lower portion **612** may include a through opening **632** and an annular wall **634** extending thereabout. When the rail **24** is positioned in the cap lower portion **612**, a portion of the shaft **630** may extend into the through opening **632**. The annular wall **634** extends around and protects the shaft **630**. In FIG. **40**, an alternative embodiment is provided which includes bolts **628** for mounting the header bracket **624** or for attaching the rail **24** to the head unit **20**.

[0101] In some embodiments, the caps **604** may each include indicia regarding returning the caps to the manufacturer or seller of the rails **24** and/or of the head units **20** for recycling or reuse. The indicia may be printed on or molded into the upper and lower portions **610**, **612** of the caps **604**. In an embodiment, for each cap **604** (or pair of caps **604**) returned by the installer to the manufacturer/seller, a discount or a credit may be offered to the installer for the purchase of additional product(s) including, but not limited to, rails **24**, head units **20**, and remote controls such as radio transmitters **40**. In this manner, certain installers of movable barrier operator systems who facilitate cap reuse or recycling can enjoy additional profit due to higher margins as compared to other installers who choose to dispose of the caps **604** rather than participating in environmental reuse/recycling of the caps **604**. Accordingly, professional installers of movable barrier operator systems are encouraged or incentivized to recycle the caps **604**.

[0102] Regarding FIG. **41**, each rail bridge **606** includes a base **660** and legs **662** that receive a support **664**. The rail bridge **606** includes one or more supports **664** stacked on top of each other that support the rail assemblies **602**. Each support **664** includes a horizontal member **666** having recesses **668** and walls **670** separating the recesses **668**. The rail **24** of each rail assembly **602** fits into one of the recesses **668** and the walls **670** separate the rail from nearby rails and inhibits lateral movement of each of the rail assemblies **602**. Each support **664** includes a lower portion **672** that engages an upper portion **674** of the nearby support **664**. In one example, the upper portion **674** includes a recess and the lower portion **672** includes a projection that fits into the recess of the upper portion **674** and forms an engagement therebetween.

[0103] Turning to FIG. **42**, in one embodiment the movable barrier operator system **10** may be provided with a container **700** containing hardware **702** for installation such as nuts, bolts, brackets, and pins. As shown, the rail **24** has a generally square U-shaped cross sectional shape, and the container **700** may be positioned in a recess **704** of the rail **24** during transport. During installation, the installer removes the container **700** from the rail **24** and removes the hardware **702** as needed. In one embodiment, the container **700** is a plastic bag or tube having sections or pockets **706** separated by heat seals **708**. The pockets **706** may be labeled and/or arranged to assist the installer. For example, the pockets **706** may be arranged, configured or marked with indicia (e.g., drawings and/or human-readable text) so that the installer sequentially opens the pockets **706** in a particular order so that the hardware **702** becomes accessible in a predetermined order that corresponds to installation instructions provided with the movable barrier operator system **10**.

[0104] While there have been illustrated and described particular embodiments of the present invention, it will be appreciated that numerous changes and modifications will occur to those skilled in the art, and it is intended for the present invention to cover all those changes and modifications which fall within the scope of the appended claims.

What is claimed is:

1. A trolley for a garage door opener system, the trolley comprising:

a body configured to be connected to an elongated rail of a garage door opener system and be moved longitudinally therealong;

a receiving portion of the body configured to receive a trolley connector of an elongated drive member;

a flexible actuator extending laterally outward and downward from the body; and

a hammer pivotally connected to the body about a longitudinal pivot axis, the hammer connected to the flexible actuator and configured to pivot in response to downward movement of the flexible actuator from an engaged position of the hammer wherein the hammer secures the trolley connector relative to the body to a release position of the hammer wherein the hammer is spaced from the trolley connector and permits the trolley connector to shift relative to the body.

2. The trolley of claim **1**, wherein the body comprises a wall having an inner surface and an outer surface, the hammer being pivotally connected to the inner surface of the wall and the flexible actuator extending over the wall and downward along the outer surface thereof.

3. The trolley of claim **2**, wherein the flexible actuator is connected to the hammer at an actuator portion of the hammer, and wherein a spring biases the actuator portion away from the inner surface of the wall.

4. The trolley of claim **1**, wherein the hammer comprises a first side surface for facing toward a garage door and a second side surface opposite the first surface for facing away from the garage door, and wherein the flexible actuator extends along one of the first and second side surfaces of the hammer.

5. The trolley of claim **1**, wherein the longitudinal pivot axis of the hammer is fixed relative to the body and the body limits movement of the hammer to pivotal movement about the longitudinal pivot axis.

6. The trolley of claim **1**, wherein the hammer comprises an upper end portion and a lower end portion, the hammer being pivotally connected to the body at the lower end portion and the hammer being connected to the flexible actuator at the upper end portion of the body; and

an engagement member of the hammer intermediate the upper and lower end portions and sized to fit into a recess of the trolley connector.

7. The trolley of claim **1**, wherein the body comprises a guide adjacent the hammer directing the flexible actuator laterally outward from the body.

8. The trolley of claim **7**, wherein the guide comprises a through opening and the flexible actuator is sized to extend through the guide through opening.

9. The trolley of claim **1**, wherein the receiving portion comprises an opening that permits the elongated drive member to shift along an axis that is parallel to the pivot longitudinal axis of the hammer.

10. The trolley of claim **1**, further comprising:

at least one roller rotatably mounted to the body for rolling along an inner surface of the rail;

a first pilot configured to move debris on the inner surface of the rail with shifting of the body in a first direction along the rail; and

a second pilot configured to move debris on the inner surface of the rail with shifting of the body in a second direction along the rail.

11. The trolley of claim **1**, further comprising at least one wheel for rolling along a lower surface of the rail, and a bracket connecting the at least one wheel to the body; and

a plurality of rollers rotatably mounted to the body for rolling along an upper surface of the rail.

12. The trolley of claim **1**, wherein the flexible actuator comprises a pull cord arranged on the body such that a greater force on the pull cord is required to move the hammer from the engaged position to the release position when the force is in a direction offset from the longitudinal pivot axis.

13. A trolley for a garage door opener system, the trolley comprising:

a body configured to be connected to an elongated rail of a garage door opener system and be moved longitudinally therealong;

a hammer mechanism;

a pull cord coupled to the hammer mechanism to rotate the hammer mechanism about a pivot axis; and

a spring configured to urge the hammer about the pivot axis towards a groove of a trolley connector,

wherein the hammer is configured to secure the body to a belt or chain when the pull cord is not tensioned, and wherein the hammer is configured to permit the body to shift relative to the trolley connector when the pull cord is tensioned.

14. The trolley of claim **13**, wherein the hammer mechanism comprises:

a hammer;

a connection portion extending from the hammer; and

a pin pivotally connecting the connection portion to the body such that the hammer rotates about a pivot axis.

15. The trolley of claim **13**, further comprising:

a bracket coupled to the body; and

a wheel rotatably coupled to the bracket, wherein the wheel rolls along a lower wall of the elongated rail.

16. The trolley of claim **15**, wherein the elongated rail is U-shaped, wherein the body is at least partially disposed in a recess defined by an upper surface of the elongated rail, and wherein the bracket extends external to lateral sidewalls of the elongated rail.

17. The trolley of claim **15**, wherein the wheel is coupled to the bracket through a pin, and wherein an arm that couples a garage door to the body is coupled to the body through the pin.

18. A trolley for a garage door opener system, the trolley comprising:

a body configured to be connected to a rail of a garage door opener system and be moved longitudinally therealong;

a receiving portion of the body configured to receive a trolley connector of an elongated drive member; and

a hammer pivotally connected to the body about a longitudinal pivot axis, the hammer configured to be connected to an actuator, wherein the hammer pivots about the longitudinal pivot axis between a secured position and a release position, wherein the hammer secures the trolley connector relative to the body in the secured position, and wherein the hammer permits the trolley connector to shift relative to the body in the released position.

19. The trolley of claim **18**, wherein the hammer is biased to the secured position by a spring, and wherein the actuator moves to the release position when a force is applied on the actuator to overcome the spring.

20. The trolley of claim **18**, wherein the body is coupled to a bracket having one or more wheels, and wherein the one or more wheels ride along the elongated rail.

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