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Inventor(s)

Hall; David R. et al.

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## AUTOMATED WINDOW MECHANISM WITH COUNTER FORCE

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### Abstract

An automated window mechanism has an electric motor attached to a sliding panel of a window configured to open and close the window by moving the sliding panel. The electric motor has a locked state in which the electric motor and sliding panel are stationary. The automated window mechanism also includes a monitor configured to detect an external force applied to the sliding panel while the electric motor is in the locked state. In response to the monitor detecting the external force while the electric motor is in the locked state, the positive lead and the negative lead are grounded, rendering the electric motor an electric brake, or the electric motor opposes the external force to prevent unwanted movement of the sliding panel. A method and system for preventing unwanted movement of an automated window are also disclosed.

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**Inventors:** Hall; David R. (Provo, UT), Miles; Jerome (Spanish Fork, UT), Madsen; Mark (Provo, UT), Jones; Christopher (Spanish Fork, UT)

**Applicant:** D&D-SW, LLC (Temecula, CA)

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## **Background/Summary**

### **CROSS-REFERENCE TO RELATED PATENT APPLICATIONS**

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are incorporated by reference and made a part of this specification.

### **TECHNICAL FIELD**

[0002] This invention relates to automated window openers and mechanisms.

### **BACKGROUND**

[0003] Many improvements and developments have been made in the field of Smart Home devices. However, many devices, especially existing devices in a residence or business (such as sliding windows and window openings, for example), simply were not designed or configured to be smart.

[0004] Traditionally, windows are opened and closed manually for ventilation, energy or security or safety needs. For example, a window may be closed and locked while the owners are away from home to protect the home from entry by an intruder. A window may be opened in order to vent noxious gases from the interior of the home to the outside. When the inside of the house is hot, a window may be opened to allow cooler outside air to enter the house.

[0005] In order to enable these traditional functions to be carried out in an automated smart system, motorized devices are needed to open and close the windows.

[0006] Automatic opening and closing of sliding windows generally may require planning ahead along with using frames that are designed specifically for automatic sliding windows. However, when automation of an existing installation is desired, a complete replacement of the existing frame is costly and requires more construction skill than the typical homeowner possesses.

[0007] Therefore, a retrofit mechanism is needed to allow a simple installation of a system that provides motorized control of an existing sliding window, allowing a controller to open and close the window. A mechanism that is retrofittably attached to an existing window would be cost effective and require minimal construction skill.

### **SUMMARY**

[0008] Embodiments of the present disclosure are directed to an automated window mechanism having an electric motor attached to a sliding panel of a window configured to open and close the window by moving the sliding panel. The electric motor has a locked state in which the electric motor and sliding panel are stationary. The automated window mechanism also includes a monitor configured to observe an external force applied to the sliding panel while the electric motor is in the locked state. In response to the monitor identifying the external force while the electric motor is in the locked state the electric motor grounds the positive lead and the negative lead to a same electric potential thereby rendering the electric motor an electric brake impeding the external force from moving the sliding panel.

[0009] Further embodiments of the present disclosure are directed to a method of preventing

unwanted movement of a sliding panel of a window with an automated window mechanism having an electric motor with a positive lead and a negative lead. The method includes placing the automated window mechanism into a locked state in which the electric motor and sliding panel are stationary, and while the automated window mechanism is in the locked state, monitoring for an external force applied to the sliding panel. The method also includes grounding the positive lead and the negative lead of the electric motor to a same electric potential in response to the external force, thereby rendering the electric motor an impediment to the external force.

[0010] Further embodiments of the present disclosure are directed to a system including an automated window mechanism having an electric motor and being attached to a sliding panel of a window and being configured to open and close the sliding panel of the window. The electric motor has a positive lead and a negative lead. The automated window mechanism has a locked state in which the electric motor and sliding panel are stationary. The system also includes a monitor for an external force applied to the sliding panel while the automated window mechanism is in the locked state. The system also includes a processor and a memory storing computer-readable instructions that cause the processor to enable the automated window mechanism to, in response to the external force, ground the positive lead and negative lead to the same electric potential, thereby impeding the external force from moving the sliding panel.

[0011] Embodiments of the present disclosure are directed to an automated window mechanism including an electric motor attached to a sliding panel of a window configured to open and close the window by moving the sliding panel. The electric motor has a locked state in which the electric motor and sliding panel are stationary. The mechanism also includes a monitor configured to detect an external force applied to the sliding panel and a direction of the external force while the electric motor is in the locked state. In response to the monitor identifying the external force while the electric motor is in the locked state the electric motor applies a counter force in a direction opposite the external force to counteract the external force.

[0012] Other embodiments of the present disclosure are directed to a method of preventing unwanted movement of a sliding panel of a window with an automated window mechanism having an electric motor. The method includes placing the automated window mechanism into a locked state in which the electric motor and sliding panel are stationary. While the automated window mechanism is in the locked state, monitoring for an external force applied to the sliding panel. The method also includes, in response to the external force, opposing the external force by applying power to the electric motor.

[0013] Further embodiments of the present disclosure are directed to a system including an automated window mechanism having an electric motor and being attached to a sliding panel of a window and being configured to open and close the sliding panel of the window, the automated window mechanism having a locked state in which the electric motor and sliding panel are stationary. The system also includes a monitor for an external force applied to the sliding panel while the automated window mechanism is in the locked state. The system also includes a processor and a memory storing computer-readable instructions that cause the processor to, in response to the external force, apply a counter force to the sliding panel to oppose the external force.

[0014] Further aspects and embodiments are provided in the foregoing drawings, detailed description and claims.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The following drawings are provided to illustrate certain embodiments described herein. The drawings are merely illustrative and are not intended to limit the scope of claimed inventions

and are not intended to show every potential feature or embodiment of the claimed inventions. The drawings are not necessarily drawn to scale; in some instances, certain elements of the drawing may be enlarged with respect to other elements of the drawing for purposes of illustration.

[0016] FIG. 1A is an isometric view of an automated window mechanism with telescoping arms extended.

[0017] FIG. 1B is an isometric view of an automated window mechanism with telescoping arms not extended.

[0018] FIG. 2A is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arms not extended.

[0019] FIG. 2B is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arms fully extended.

[0020] FIG. 3A is a side view of a gear on the end of a drive shaft engaging with a rack.

[0021] FIG. 3B is a side view of a gear on the end of a drive shaft engaging with a chain.

[0022] FIG. 3C is a side view of a gear on the end of a drive shaft engaging with a pulley belt.

[0023] FIG. 3D is a side view of a gear on the end of a drive shaft engaging with a toothed belt.

[0024] FIG. 3E is a side view of a helical gear on the end of a drive shaft engaging with a worm gear drive.

[0025] FIG. 3F is a side view of a gear on the end of a drive shaft engaging with a flexible drive shaft.

[0026] FIG. 4A is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arms fully extended.

[0027] FIG. 4B is an enlarged view of the end of an extended arm in a window frame where it interfaces with a rack.

[0028] FIG. 4C is a top view of a rack and a window assembly according to embodiments of the present disclosure.

[0029] FIG. 5A is an isometric view an automated window mechanism.

[0030] FIG. 5B is an isometric view an automated window mechanism with rack teeth facing away from a user's view.

[0031] FIG. 5C is an isometric view an automated window mechanism with rack teeth facing towards a user's view.

[0032] FIG. 6 is a section view of the arm extension of FIG. 5A.

[0033] FIG. 7A is a close-up isometric view of an actuator assembly with a manual release mechanism in an open position.

[0034] FIG. 7B is a close-up isometric view of an actuator assembly with a manual release mechanism in a closed position.

[0035] FIG. 8 is a close-up isometric view a gearbox gear interfacing with a drive shaft gear.

[0036] FIG. 9A is an isometric view of an automated window mechanism with telescoping arm extensions extended.

[0037] FIG. 9B is an isometric view of an automated window mechanism with telescoping arm extensions partially retracted.

[0038] FIG. 9C is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arm extensions fully extended.

[0039] FIG. 9D is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arm extensions partially retracted.

[0040] FIG. 10 is an isometric view of an extension arm assembly separated into the three components of: stationary arm, telescoping arm extension and interface arm.

[0041] FIG. 11 is an isometric view of an extension arm assembly separated into the three components of stationary arm, telescoping arm extension and interface arm.

[0042] FIG. 12 is an isometric view of a telescoping arm extension with three sections.

[0043] FIG. 13A is an isometric view of a window assembly with an automated window

mechanism mounted to a window frame with extension arm assembly fully extended.

[0044] FIG. **13B** is an enlarged view of the end of an interface arm in a window frame where it interfaces with a rotational force transfer mechanism.

[0045] FIG. **14A** is an isometric view an automated window mechanism.

[0046] FIG. **14B** is a section view of the extension arm assembly of FIG. **14A**.

[0047] FIG. **15** is an isometric view of an automated window mechanism including anchors according to further embodiments of the present disclosure.

[0048] FIG. **16** shows the anchors of FIG. **15** according to embodiments of the present disclosure.

[0049] FIG. **17** is an exploded view of an anchor according to embodiments of the present disclosure.

[0050] FIG. **18** shows an exploded end view of the anchor according to embodiments of the present disclosure.

[0051] FIG. **19** is an exploded view of a tongue-and-groove track and anchor according to embodiments of the present disclosure.

[0052] FIG. **20** shows a ratchet portion of the anchor according to embodiments of the present disclosure.

[0053] FIG. **21** shows a center alignment member according to embodiments of the present disclosure.

[0054] FIG. **22** is an isometric view of the center alignment member according to embodiments of the present disclosure.

[0055] FIG. **23** illustrates a window for use with an automated window mechanism according to the present disclosure.

[0056] FIG. **24** is a schematic depiction of a linear path for a moving portion of a window.

[0057] FIG. **25** is a schematic illustration of a force map according to embodiments of the present disclosure.

[0058] FIG. **26** shows the force map of FIG. **25** reproduced, and a second force map, which represents a deviation from the force map accounting for the different conditions according to embodiments of the present disclosure.

[0059] FIG. **27** is an isometric view of a coupled axial clutch that can be used with the automated window mechanisms shown and described herein.

[0060] FIG. **28** shows another embodiment of an axial clutch having first component and second component which each have teeth and without a coupler.

[0061] FIG. **29** is a side view of an axial clutch according to embodiments of the present disclosure.

[0062] FIG. **30** shows the axial clutch of FIG. **29** after axial movement causes engagement between teeth and teeth according to embodiments of the present disclosure.

[0063] FIG. **31** shows one component of an axial clutch according to further embodiments of the present disclosure in which the teeth are tapered to allow for engagement with corresponding teeth on the other component.

[0064] FIG. **32** shows one component of an axial clutch according to embodiments of the present disclosure.

[0065] FIG. **33** is an illustration of an axial clutch and clutch switch assembly according to embodiments of the present disclosure.

[0066] FIG. **34** is an illustration of an axial clutch and clutch switch assembly according to embodiments of the present disclosure.

[0067] FIG. **35** is a plot of window position according to embodiments of the present disclosure.

[0068] FIG. **36** is a flow chart diagram of a method for determining and implementing an automatic, intelligent duty cycle according to embodiments of the present disclosure.

[0069] FIG. **37** illustrates a transmission assembly including an axial clutch formed of a first component and a second component and including a ratchet unit according to embodiments of the

present disclosure.

[0070] FIG. **38** shows an alignment tool according to embodiments of the present disclosure.

[0071] FIG. **39** is a block diagram of a method for executing a window motor lockdown according to embodiments of the present disclosure.

[0072] FIG. **40** is a block diagram of a method according to further embodiments of the present disclosure in which an unauthorized movement of a window causes a motor response.

[0073] FIG. **41** shows a method for managing unauthorized window movement according to embodiments of the present disclosure.

#### DETAILED DESCRIPTION

[0074] The following description recites various aspects and embodiments of the inventions disclosed herein. No particular embodiment is intended to define the scope of the invention. Rather, the embodiments provide non-limiting examples of various compositions, and methods that are included within the scope of the claimed inventions. The description is to be read from the perspective of one of ordinary skill in the art. Therefore, information that is well known to the ordinarily skilled artisan is not necessarily included.

[0075] Reference throughout this specification to “one embodiment,” “an embodiment,” or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases “in one embodiment,” “in an embodiment,” and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment, but mean “one or more but not all embodiments” unless expressly specified otherwise. The terms “including,” “comprising,” “having,” and variations thereof mean “including but not limited to” unless expressly specified otherwise. An enumerated listing of items does not imply that any or all of the items are mutually exclusive and/or mutually inclusive, unless expressly specified otherwise. The terms “a,” “an,” and “the” also refer to “one or more” unless expressly specified otherwise.

#### Definitions

[0076] The following terms and phrases have the meanings indicated below, unless otherwise provided herein. This disclosure may employ other terms and phrases not expressly defined herein. Such other terms and phrases shall have the meanings that they would possess within the context of this disclosure to those of ordinary skill in the art. In some instances, a term or phrase may be defined in the singular or plural. In such instances, it is understood that any term in the singular may include its plural counterpart and vice versa, unless expressly indicated to the contrary.

[0077] As used herein, the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise. For example, reference to “a substituent” encompasses a single substituent as well as two or more substituents, and the like.

[0078] As used herein, “for example,” “for instance,” “such as,” or “including” are meant to introduce examples that further clarify more general subject matter. Unless otherwise expressly indicated, such examples are provided only as an aid for understanding embodiments illustrated in the present disclosure and are not meant to be limiting in any fashion. Nor do these phrases indicate any kind of preference for the disclosed embodiment.

[0079] FIG. **1A** is an isometric view of an automated window mechanism **100** with telescoping arms **120** extended. Mounting assembly **110** is shown with telescoping arms **120** that slide on stationary arm extensions **122** that are extended out from the main body of the mounting assembly **110**. Actuator assembly **112** is located at the center of the mechanism in this embodiment, and both telescoping arms **120** extend out from the actuator assembly **112** as shown. An actuator inside the actuator assembly **112** rotates main gear **118** that is attached to a first section **116** of the drive shaft **132**. Each end of the drive shaft **132** slide in to an end of a telescoping drive shaft **131** as shown. Each of the two telescoping drive shafts **131** extend out to interface gears **134** at one end of each drive shaft as shown. Each one end is extended out with the telescoping arms **120** to fit a window opening as required. The gear teeth of interface gear **134** engage with the rack teeth (not shown)

that are adhesively attached to the window frame. The shape of the cross section of the drive shaft **132** may be an octagon, hexagon or some other shape that matches and mates with the cross section of the telescoping drive shaft **131**, allowing the telescoping drive shaft to slide out to extend to the window frame as required. The unique shape prevents the drive shaft **132** from rotating inside of the telescoping drive shaft **131**. In this way, as the main gear rotates it transfers that rotational force to the interface gears **134**.

[0080] In alternative embodiments, the telescoping drive shaft fits within the drive shaft. In still other embodiments the drive shaft and the telescoping drive shaft are not configured to rest one within the other, but instead a configured so as to mate and be connected side by side.

[0081] The mounting assembly **110** has slot openings **136** on the end of the telescoping arms **120** as shown to allow the teeth of the interface gears **134** to mesh with rack teeth. The mounting assembly **110** may also have a latching device that mates to a latching receiver attached to the slidable window, wherein mating prevents movement of the slidable window. Gears within the gearbox may release the gearbox and actuator from the window mechanism so that a user may have full control of the window to slide it open or close it. This provides a way for a user to open the window in an emergency situation. The manual release **114** operates even when the power is off and allows the window to operate completely independently from the automated window mechanism. A user may engage or disengage the manual release **114** in order to have manual control of the window, enabling the user to have full control of the opening and closing mechanism of the window, thus overriding the control system and actuator in case of an emergency.

[0082] The components of the automated window mechanism **100** that convey power through drive shafts **132**, telescoping arms **120**, any gears, or any other mechanism can be collectively referred to as transmission components. The transmission components may vary in different embodiments and include some or all of the features disclosed herein and shown in the figures.

[0083] The latching receiver may also include a communication device that generates a signal when the latching device is mated and transmits that signal to the controller, which generates a control signal that deactivates the motor. The latching device may also have a release mechanism configured to automatically release a first gear from a first gear track, thereby allowing the slidable frame to be moved to an open position by the user, in response to an emergency condition as detected by at least one of the one or more sensors.

[0084] FIG. **1B** is an isometric view of an automated window mechanism with telescoping arms not extended. The position of the telescoping arms **120** in this example embodiment are in a retracted **140** position. The telescoping arms are retracted **140** before the mounting assembly **110** is installed or retrofitted to an existing window assembly. In this example, each end of the drive shaft **132** is partially retracted inside of each of the telescoping drive shafts **131** as shown. The telescoping arms **120** are also slid in further, thus overlapping sections of the stationary arm extensions **122** as shown in this embodiment.

[0085] FIG. **2A** is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arms **120** not extended. Window assembly **210** is shown with stationary window **240** and sliding window **230**. Mounting assembly **110** is shown with telescoping arms **120** in a retracted position, prior to being fully installed or retrofitted to the window frame. In this embodiment, the mounting assembly **110** has already been attached to top of the frame of the sliding window **130** as shown. The telescoping arms are ready to be extended **212** out to fit the window opening. Racks **220** have already been adhesively attached to the frame of the window assembly **210** as shown. Each of the ends of the telescoping arms **120** align with the racks **220**, allowing the interface gears to align with the rack teeth once the telescoping arms **120** have been fully extended to fit the window opening. Slot openings **136** are shown on the ends of the telescoping arms.

[0086] FIG. **2B** is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arms fully extended. In this embodiment, window

assembly **210** is shown with stationary window **240** and sliding window **230**. Mounting assembly **110** is shown with telescoping arms **120** in a fully extended position, having been fully installed or retrofitted to the window frame. In this embodiment, the telescoping arms **120** are extended out to fit the window opening. Each of the ends of the telescoping arms **120** have been fully extended to align with the racks **220**, engaging the interface gears with the rack teeth. In this example, the system is now completely installed and ready to be controlled by a controller.

[0087] FIG. 3A is a side view of a gear on the end of a drive shaft engaging with a rack. Mounting assembly **110** is shown with gearbox **310**. Rack **220** is shown, along with interface gear **134**.

Interface gear **134** is further shown with gear teeth **312** meshing with rack teeth **320**. The end of the drive shaft is attached **316** to interface gear **314** as shown. In this embodiment, as the actuator rotates the drive shaft, interface gear **314** is rotated by the actuator and causes the mounting assembly to either up or down along the rack **220**, thus opening or closing the sliding window the mounting assembly is attached to. In this example embodiment, rotating the interface gear **134** clockwise may open the window, and rotating the interface gear **134** counterclockwise may close the window.

[0088] FIG. 3B is a side view of a gear on the end of a drive shaft engaging with a chain. Drive shaft **316** is attached to transfer gear **330**. Transfer gear **330** engages with interface chain **331** and rotates chain **331** around gear **332** supported by bracket **333** which is attached to a frame component of the window assembly. Bracket **336** is attached **337** to the chain **331** as shown, and slides **338** the window open and closed as the drive shaft **316** rotates.

[0089] FIG. 3C is a side view of a gear on the end of a drive shaft engaging with a pulley belt. Drive shaft **316** is attached to interface pulley **341**. Interface pulley **341** engages with interface belt **345** and rotates belt **343** around pulley **343** supported by bracket **344** which is attached to a frame component of the window assembly. Bracket **346** is attached **347** to the belt **345** as shown, and slides **348** the window open and closed as the drive shaft **316** rotates.

[0090] FIG. 3D is a side view of a gear on the end of a drive shaft engaging with a toothed belt. Drive shaft **316** is attached to interface pulley **350**. Interface pulley **350** engages with toothed belt **352** and rotates belt **352** around pulley **354** supported by bracket **355** which is attached to a frame component of the window assembly. Bracket **356** is attached **357** to the toothed belt **352** as shown, and slides **358** the window open and closed as the drive shaft **316** rotates.

[0091] FIG. 3E is a side view of a helical gear on the end of a drive shaft engaging with a worm gear drive. Drive shaft **316** is attached to helical gear **360**. Helical gear **360** engages with worm gear **362** and rotates threaded shaft **364**. Threaded shaft **364** rotates inside threaded sleeve **368** of bracket **366**. Bracket **366** is attached to the frame of the sliding window in this embodiment, and slides **361** the window open and closed as the drive shaft **316** rotates.

[0092] FIG. 3F is a side view of a gear on the end of a drive shaft engaging with a flexible drive shaft. Drive shaft **316** is attached **370** to flexible drive shaft **372**. Flexible drive shaft **372** is attached **376** to threaded shaft **378**. Threaded shaft **378** is supported by bracket **374**, and rotates inside threaded sleeve **388** of bracket **380**. Bracket **380** is attached to the frame of the sliding window in this embodiment, and slides **381** the window open and closed as the drive shaft **316** rotates.

[0093] FIG. 4A is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arms fully extended. In this embodiment, window assembly **210** is shown along with mounting assembly **110** is shown with telescoping arms in a fully extended position, having been fully installed or retrofitted to the window frame. Interface view **410** of the mounting assembly **110** with the rack **220** is further detailed in an enlarged view as shown in FIG. 4B.

[0094] FIG. 4B is an enlarged view of the end of an extended arm in a window frame where it interfaces with a rack. This enlarged view details the interface between the telescoping arm **120** which is fully extended to fit the window frame, with rack **220** shown along with rack teeth **320**.



[0095] FIG. 4C is a top view of a rack **220** and a window assembly **210** according to embodiments of the present disclosure. The window assembly **210** has a parallel surface **222** that is parallel to a direction of movement of the window relative to the window assembly. The rack **220** has a concave right-angle profile **224** with an adhesive **226** that fastens to the parallel surface **222**. Fastening mechanisms other than adhesives can be used. The parallel surface **222** is a convex right-angle profile. Many window assemblies have such a profile on a portion of a frame of a metal support feature to which the rack **220** can be fastened. The rack **220** has a uniform thickness which makes for convenient injection molding during manufacture. The rack **220** can be considered two plates: a first plate **245** carrying the adhesive **226**, and a second plate **247** connected to the first plate **245**. A union between the first plate **245** and second plate **247** forms the concave right-angle profile **224**. The second plate **247** has teeth **320** protruding therefrom. The shape of the rack **220** accordingly allows installation without measuring and guesswork.

[0096] FIG. 5A is an isometric view an automated window mechanism. Mounting assembly **110** is shown with telescoping arms **120** extended out from the main body of the mounting assembly **110**. In this embodiment, telescoping arms **120** are locked into place by frictional protrusions **520** on an interior surface of the telescoping arms **120**. In addition to these frictional protrusions, there are also locking mechanisms **522** that may be activated by a user in order to further lock the arms in place. These locking mechanisms **522** may also include a mechanical release allowing the user to release the lock if needed to reposition the telescoping arms **120**, or to remove the mounting assembly **110** in order to uninstall the system if needed. Slot openings **136** on the end of the telescoping arms **120** are shown ready to be aligned with a rack. Section view **510** is further detailed in FIG. 6.

[0097] FIG. 5B is an isometric view an automated window mechanism with rack teeth facing away from a user's view. Mounting assembly **110** is shown with telescoping arms **120** extended out from the main body of the mounting assembly **110**. A user interface device is shown in this embodiment as three buttons **532** on the front (user facing side) of the mounting assembly **110**. Each of the buttons **532** may cause the actuator to open or close the window or activate other actions as needed. The manual release **114** is also shown. In this embodiment, racks **220** are facing away from the window and away from the user. At distal ends of the telescoping arms **120** there are guidance panels **121** that extend from the telescoping arms **120** and engage with a base of the rack **220** opposite the teeth **320** of the rack **220**. The guide panels **121** help to maintain the gear in a meshed engagement with the rack **220**.

[0098] FIG. 5C is an isometric view an automated window mechanism with rack teeth facing towards a user's view. Mounting assembly **110** is shown with telescoping arms **120** extended out from the main body of the mounting assembly **110**. A user interface device is shown in this embodiment as touch screen **540** on the front (user facing side) of the mounting assembly **110**. In this embodiment, racks **220** are facing towards the window and towards the user.

[0099] FIG. 6 is a section view of the arm extension of FIG. 5A. This cross section of telescoping arms **120** shows stationary arm extensions **122** with interfacing protrusions **620** locking in with frictional protrusions **610** on an interior surface of the telescoping arms **120**.

[0100] FIG. 7A is a close-up isometric view of an actuator assembly with a manual release mechanism in an open position. A close-up view of mounting assembly **110** is shown. Motor actuator **710** drives gears within gearbox **712** that in turn cause position gear **724** to engage with main gear **118**, thus rotating drive shaft **132**. Rotary position encoder **730** aligns with magnetic position indicator **732** as shown. The rotary position encoder **730** may inform the control system regarding the current rotational position of the drive shaft **132**. As the window opens and closes, the end points of the fully open and fully closed positions may be determined by the rotary position encoder **730**. In addition to these end points, the rotary position encoder **730** may further communicate specific positions of the drive shaft **132** that have more friction or a potential obstruction. Any changes to a default window travel model may be discovered by the sensors and

control system in real time. A default window travel model may be established when the system is first installed on the window assembly. This model may be referred to by the control system to determine any real-time departures from the model that may indicate a problem. An alert may be sent to the user indicating this aberration or departure from the established model. The user may then indicate that this is OK (no obstruction was found) to update the default model. The user may alternatively remove an obstruction, then indicate that the obstruction has been cleared by entering an “OK” button on an app—indicating that the obstruction has been clear and it is now “OK” to return to the original model and to now re-engage the control system.

[0101] A user may also partially open a window and enter that as a desired position for ventilating a room for example. The user may select this window position by setting a position name (for example “ventilation”) in the app. The control system may then control the opening of the window to this specific position when called on by a preset for “ventilation” in the app. Other positions such as “morning cooling” may also be identified either as factory presets, or as defined by a user for a schedule that is adhered to by the control system. For example, the control system may be programmed to open several windows in the morning according to the preprogrammed position of “morning cooling” in order to allow a whole house fan to bring in cool morning air in the early morning hours in the summer.

[0102] The manual release **114** is shown in this embodiment in an engaged position wherein the control system has full control of the operation of the window. Position indicator **742** is not aligned with position sensor **740** in this example. Position sensor **740** indicates to the control system that the system is fully engaged and may control the opening and closing of the window.

[0103] FIG. 7B is a close-up isometric view of an actuator assembly with a manual release mechanism in a closed position. A close-up view of mounting assembly **110** is shown. In this embodiment, a user has slid **738** to the right, thus activating the manual release **114** into a manual over-ride position, allowing the user to fully control the opening and closing of the window. The manual release **114** is shown in this embodiment in a dis-engaged position wherein the control system does not have control of the operation of the window. Position indicator **742** is aligned with position sensor **740** in this example. Position sensor **740** indicates to the control system that the system is dis-engaged and may not control the opening and closing of the window. The user now has full control of the window.

[0104] In FIG. 7B, the control system has now been disengaged by disengaging a gear connected to the motor actuator **710** from one or more gears inside the gearbox **712**. With the gearbox **712** in this condition (disengaged), it is still necessary for the system to keep track of the window position after the user has slid it open or closed or partially open). Once the system is re-engaged and takes control of the window in the future, it may not know the position the window was left in by the user. In order to communicate the user selected position to the control system, the user selected window position is indicated to the control system by the rotary position encoder **730**. While the gears are disengaged within the gearbox **712**, the position of the window may still be communicated to the control system via the rotary position encoder **730** since the drive shaft **132** will still rotate as the window is slid open and closed by the user.

[0105] FIG. 8 is a close-up isometric view a gearbox gear interfacing with a drive shaft gear. Position gear **724** is shown engaged with main gear **118**, thus rotating drive shaft **132**. Rotary position encoder **730** aligns with magnetic position indicator **732** as shown. Sensor **810** may send a signal to the control system indicating the current rotational position of drive shaft **132**.

[0106] FIG. 9A is an isometric view of an automated window mechanism with telescoping arm extensions extended. Mounting assembly **900** is shown with extension arm assemblies on either side of the main body **910** of the actuator assembly with stationary arms **922** extending out to telescoping arm extensions **915** and on to interface arms **920** as shown. Main drive shaft **932** is connected to telescoping drive shaft **925**. Telescoping drive shaft **925** is connected to interface drive shaft **930** as shown. Main drive shaft **932** is rotated by the actuator, and in turns rotates both

telescoping drive shaft **925** along with interface drive shaft **930**. All of the drive shafts have a similar keyed configuration that allows for them to be slid together and operate together as a single drive shaft.

[0107] FIG. **9B** is an isometric view of an automated window mechanism with telescoping arm extensions partially retracted. The position of the telescoping arm extensions **915** in this example embodiment are in a retracted **940** position. The telescoping arm extensions **915** are retracted **940** before the mounting assembly is installed or retrofitted to an existing window assembly. In certain embodiments, a window may be too wide for the stationary arms **922** together with the interface arms **920** to reach. In this case, the assembly is extended by adding the telescoping arm extensions **915** to extend the arms out far enough to reach the width of the larger window. The telescoping feature allows the assembly to be adjusted to fit the larger size as needed.

[0108] FIG. **9C** is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arm extensions fully extended. Window assembly **210** is shown with the mounting assembly telescoping arm extensions **915** fully extended to fit the window as required.

[0109] FIG. **9D** is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with telescoping arm extensions partially retracted. In this embodiment, the telescoping arm extensions **915** are partially retracted **912** to allow the mounting assembly to be placed in position prior to installation. Interface arms **920** are ready to be extended out towards the window frame as needed for installation.

[0110] FIG. **10** is an isometric view of an extension arm assembly separated into the three components of: stationary arm, telescoping arm extension and interface arm. In this example embodiment, the three components of the extension arm assembly have not been connected together yet. In some cases, the window size may be too large for the stationary arm **922** together with the interface arm **920** to reach. Telescoping arm extension **915** is shown placed between the stationary arm **922** and the interface arm **920** in order to extend out the arm assembly to reach to the wide width of a larger window opening. The length of the telescoping arm extension **915** is adjustable and held in place, once adjusted to fit the opening as required, by a locking mechanism.

[0111] FIG. **11** is an isometric view of an extension arm assembly separated into the three components of stationary arm, telescoping arm extension and interface arm, with drive shafts and connection fittings shown. Interface arm **920** is shown with interface drive shaft **930**. Interface drive shaft **930** has a male keyed connector **1117** that mates with female keyed connector **1115** of telescoping drive shaft **925**. Sliding section **1110** of drive shaft **925** allows the length of the telescoping drive shaft **925** to be adjusted as needed. Telescoping drive shaft **925** connects via male connector **1125** to female connector **1127** of main drive shaft **932** in stationary arm **922** as shown.

[0112] FIG. **12** is an isometric view of a telescoping arm extension with three sections. In this example embodiment, telescoping drive shaft **925** is illustrated with three sections. In some cases, two sections may not be long enough to accommodate a very large window. In this case 3 or more sections may be needed to reach. Section **1210** slides into section **1212**. Section **1211** slides into section **1214**. All of these sections function as one assembly to extend out the arm as required.

[0113] FIG. **13A** is an isometric view of a window assembly with an automated window mechanism mounted to a window frame with extension arm assembly fully extended. In this embodiment, main body **910** of the mounting assembly is shown mounted in window assembly **210**. telescoping arm extensions **915** are shown partially extended to interface arms **920** in order to retrofit the assembly to the window frame. Interface view **1305** of rack **1310** is further detailed in an enlarged view as shown in FIG. **13B**.

[0114] FIG. **13B** is an enlarged view of the end of an interface arm in a window frame where it interfaces with a rotational force transfer mechanism. This enlarged view details the interface between the interface arm **920** which is fully extended to fit the window frame, with rack **1310** shown along with rack teeth **1320**. The rotational force transfer mechanism in this example

embodiment is the rack type assembly. Other embodiments of the rotational force transfer mechanism are shown in FIGS. 3B, 3C, 3D, 3E, and 3F.

[0115] FIG. 14A is an isometric view of an automated window mechanism. Main body 910 of the mounting assembly is shown with telescoping arm extensions 915 mostly compressed and extending out from the main body 910. In this embodiment, telescoping arm extensions 915 are locked into place by frictional protrusions 1420 on an interior surface of the telescoping arm extensions 915. In addition to these frictional protrusions 1420, there are also locking mechanisms 1422 that may be activated by a user in order to further lock the arms in place. These locking mechanisms 1422 may also include a mechanical release allowing the user to release the lock if needed to reposition the telescoping arm extensions 915, or to remove the mounting assembly in order to uninstall the system if needed. Section view 1410 is further detailed in FIG. 14B.

[0116] FIG. 14B is a section view of the extension arm assembly of FIG. 14A. This cross section of the extension arm assembly shows two telescoping arm extensions 915 interlocking to each other via locking mechanism 1432. Stationary arm 922 is shown with interfacing protrusions 1430 locking in with frictional protrusions on an interior surface of the telescoping arm extensions 915. Interface arm 920 locks in via similar locking mechanism 1434 with telescoping arm extension 915 as shown.

[0117] FIG. 15 is an isometric view of an automated window mechanism 1500 including anchors 1501 according to further embodiments of the present disclosure. The automated window mechanism 1500 includes a housing 1504 that surrounds components of the automated window mechanism 1500. The anchors 1501 secure the automated window mechanism 1500 to the window 130. The window 130 has an outer face 1503 that is perpendicular to the glass portion of the window and is a leading surface as the window is slid relative to the frame to open and close the window.

[0118] FIG. 16 shows the anchors 1501 of FIG. 15 according to embodiments of the present disclosure. In the shown embodiment there are two anchors 1501: one on each side of the assembly. In other embodiments there may be a different number of anchors including two or more on each side, or one side with no anchoring. The anchors 1501 have an L-shaped profile that will be shown in greater detail below. The L-shaped profile allows the anchors 1501 to be located on the surface of the window with a small lip on the front side and the larger portion on the upward-facing surface. The anchors 1501 can be flat, having no L-shaped component and can be secured to the outer face 1503 of the window 130. The anchors 1501 can be secured using glue, screws, adhesive, or using any suitable attachment mechanism.

[0119] FIG. 17 is an exploded view of an anchor 1501 according to embodiments of the present disclosure. The anchor 1501 comprises a mechanism piece 1508 and a window piece 1510. The mechanism piece 1508 attaches to the automated window mechanism 1500 shown in FIG. 15. The window piece 1510 attaches to the window 130. The window piece 1510 and mechanism piece 1508 interlock together to form the anchor 1501. The window piece 1510 includes a base member 1511, a first tongue-and-groove protrusion 1512a, and a second tongue-and-groove protrusion 1512b that each have an interlocking surface. The shape of the interlocking surfaces may vary and can include a trapezoidal shape or any other suitable interlocking shape. The mechanism piece 1508 includes a base member 1514, a first tongue-and-groove protrusion 1516a, a second tongue-and-groove protrusion 1516b, and a third tongue-and-groove protrusion 1516c extending downward from the base member 1514. The tongue-and-groove protrusions of the mechanism piece 1508 and the window piece 1510 interlock with one another to allow the anchor 1501 to slide in a transverse direction toward and away from the viewer. The transverse direction is defined in this context as a direction perpendicular to the plane of the window. The tongue-and-groove protrusions 1512a-b and 1516a-c allow the window piece 1510 to slide relative to the mechanism piece 1508 in the transverse direction, but prevents sliding in other directions. The shape of the tongue-and-groove protrusions can vary and still accomplish the desired effect. This motion allows

the automated window mechanism **1500** to be installed and aligned properly in the transverse direction.

[0120] FIG. **18** shows an exploded end view of the anchor **1501** according to embodiments of the present disclosure. The window piece **1510** is shown in this view revealing the L-shaped profile mentioned above. The window piece **1510** includes a lip **1518** and a base member **1511**. The lip **1518** is smaller than the base member **1511** and helps align the anchor **1501** to the window.

[0121] The mechanism piece **1508** has a tongue-and-groove profile defined by protrusions **1520** that extend outwardly at an upper region. The precise shape of the keyed profile may vary and need not be equal to the shown angle and may have a more complex shape. The tongue-and-groove profile of the protrusions **1520** allows the mechanism piece **1508** to move relative to the automated window mechanism **1500** as will be shown in FIG. **19**. The sliding permitted in a direction perpendicular to the transverse direction mentioned above, and perpendicular to the direction the window travels as it opens and closes.

[0122] FIG. **19** is an exploded view of a tongue-and-groove track **1522** (also referred to herein as “track **1522**”) and anchor **1501** according to embodiments of the present disclosure. The track **1522** can be found on an underside of the automated window mechanism **100**. In some embodiments the track **1522** is integral to the mechanism. In other embodiments the track **1522** is a separate piece that is attached to the mechanism. The track **1522** comprises a toothed region **1526** and interlocking protrusions **1528**. The interlocking **1528** complement the protrusions **1520** of the mechanism piece **1508** and allow the track **1522** to slide along the window frame. The length of the track **1522** can depend on the size of the automated window mechanism relative to the window into which it will be installed. In the shown embodiment the track **1522** is approximately as long as the anchor **1501**.

[0123] FIG. **20** shows a ratchet portion **1530** of the anchor **1501** according to embodiments of the present disclosure. The ratchet portion **1530** comprises a detent **1532** supported by a flexible arm **1534**. When the anchor **1501** is installed between a window and an automated window mechanism the detent **1532** interacts with the toothed region **1526** shown in FIG. **19**. The flexible arm **1534** allows the detent **1532** to deflect when it is moved along the toothed region **1526**. The detent **1532** and toothed region **1526** provides some resistance to movement of the track **1522** relative to the anchor **1501**. In some embodiments the profile of the detent **1532** and toothed region **1526** allow one-way movement only, similar to a zip tie. In other embodiments the detent **1532** allows the keyed anchor to move back and forth, but providing some resistance allows the keyed anchor to hold the components in place unless a sufficient force is applied to move them. In some embodiments the toothed region **1526** and detent **1532** require five pounds of pressure before moving.

[0124] The flexible arm **1534** and detent **1532** can be integral to the mechanism piece **1508** which can be made of a flexible material such as plastic. The mechanism piece **1508** can be molded or otherwise formed to define a three-sided perimeter around the flexible arm **1534**. The arrangement allows the flexible arm **1534** to move up and down as needed when the anchor **1501** slides relative to the automated window mechanism.

[0125] FIG. **21** shows a center alignment member **1540** according to embodiments of the present disclosure. The center alignment member **1540** has a base member **1542** and an interlocking protrusion **1544** that extends upward from the base member **1542** and has a keyed, interlocking profile similar to the protrusions **1520** of the mechanism piece **1508**. The automatic window mechanism **1500** of the present disclosure can include a track on an underside that can receive the interlocking protrusion **1544** and allow the automatic window mechanism **1500** to slide along the interlocking protrusion **1544** in the transverse direction to align the automatic window mechanism **1500** relative to the window.

[0126] FIG. **22** is an isometric view of the center alignment member **1540** according to embodiments of the present disclosure. The center alignment member **1540** has a lip **1546** and a base member **1542** similar to the window piece **1510** and interfaces with the window in a similar

manner as well. The anchors **1501** of the present disclosure accordingly allow the automatic window mechanism **1500** to be aligned with the window for ease of installation and use. The anchors **1501** prevent the automatic window mechanism **1500** to move upward away from the window and ensure that movement of the automatic window mechanism **1500** causes movement of the window in the frame. Furthermore, the anchors **1501** and center alignment member **1540** allow movement along the keyed protrusions of the various pieces.

[0127] The anchors **1501** and center alignment member **1540** can be used to install the automated window mechanism **1500** to a portion of the window or window frame. The anchors **1501** and center alignment member **1540** have certain dimensions and proportions that are chosen according to a certain desired placement of the automated window mechanism **1500** relative to a window and frame. Referring to FIG. 22, the center alignment member **1540** can be placed onto the window with the base member **1542** flat against a top surface of the window with the lip **1546** against a front surface of the window. Similarly, as shown to advantage in FIG. 18, the anchors **1501** can be placed against the window with a base member **1511** flat against the top of the window and a lip **1518** against the front. The same procedure can be used in a horizontally sliding window, in which case the center alignment member **1540** and anchors **1501** can be held in place using an adhesive, suction, or any other suitable temporary or permanent attachment means.

[0128] With the lips and base members of the anchors **1501** and center alignment member **1540** in place relative to the window edge, the protrusions **1520** are in a desired location for installing the automated window mechanism **100**, which can be keyed onto the protrusions on the center alignment member **1540** by moving the automated window mechanism **1500** transversely toward the window. The mechanism piece **1508** can also be keyedly engaged in a similar way. The top portion of the mechanism piece **1508** can then engage the telescoping arms of the automated window mechanism **1500** to keyedly engage in a parallel direction generally parallel with the edge of the window frame.

[0129] The anchors **1501** can include rack-engaging components **1547** that contact racks **220** (refer to FIGS. 2A and 2B). The rack-engaging components **1547** align the automated window mechanism **1500** with the racks **220**. The automated window mechanism **1500** can be keyedly secured to the center alignment member **1540** and the mechanism piece **1508** (aka the end alignment members) to ensure the transmission components of the automated window mechanism **1500** (such as a gear) are properly aligned with the racks.

[0130] Accordingly, the anchors **1501** and center alignment member **1540** provide installation guidance and alignment to the automated window mechanism **100**. The installer need not measure, cut, or align the pieces. With the anchors **1501** aligned with the telescoping arms, the automated window mechanism **1500** can operate without binding, twisting, or any other undue and unwanted torques or forces in the mechanism.

[0131] FIG. 23 illustrates a window **1600** for use with an automated window mechanism according to the present disclosure. The window **1600** includes a frame **1602**, a bottom panel **1606**, and a top panel **1604**. The window **1600** has installed an automated window mechanism **1605** that is in this embodiment coupled to an upper frame of the lower panel **1606**.

[0132] The window **1600** is shown in two states: closed, in which case the top panel **1604** and bottom panel **1606** do not overlap and each covers a portion of the window **1600**; and open in which case the bottom panel **1606** has been raised and covers a portion of the top panel **1604**. Referring to the window **1600** in the open state, the lower panel **1606** has been raised up a distance A, leaving a small remainder distance B above the window. The distance B represents a distance the lower panel **1606** may yet travel to open the window **1600** even further.

[0133] In other embodiments the window **1600** can have a different configuration, resulting in a different definition of open and closed. It is to be appreciated that features of the present disclosure described herein can be equally applied to windows having different configurations, such as a different number of panels, a horizontally moving window, etc. The window **1600** can also be

replaced by another type of sliding segment such as a sliding door or shower panel or any other suitable type of movable panel that can be used with the automated window mechanism **1605** of the present disclosure. Furthermore, in some embodiments the top panel **1604** may carry the automated window mechanism **1605**. In yet other embodiments both panels may carry an automated window mechanism that can operate independently or in concert to move the top panel **1604** and bottom panel **1606**.

[0134] FIG. **24** is a schematic depiction of a linear path **1609** for a moving portion of a window **1600**. In the embodiment shown in FIG. **23**, the moving portion is the bottom panel **1606** without loss of generality. The bottom panel **1606** has an automated window mechanism **1605** attached that moves the bottom panel **1606** along the path **1609**. The path **1609** is defined by a fully closed position **1608** and a fully open position at **1621**, defining the limits of possible movement of the bottom panel **1606** along the path **1609** as defined by the geometry of the frame itself. Windows are irregular, however, and may or may not be able to move from the fully open position **1621** to the fully closed position **1618**. The path **1609** includes first end point **1619** and second end point **1620** which are defined as the actually movable path for the bottom panel **1606** to move along the path **1609**. In some embodiments the bottom panel **1606** will be able to reach the fully open position **1621** and the fully closed position **1618** in which case the first end point **1619** coincides with the fully closed position **1618** and the second end point **1620** coincides with the fully open position **1621**. Once the first end point **1619** and second end point **1620** have been identified, the actual path of motion **1610** for the bottom panel **1606** is defined. The automated window mechanism **1605** can therefore be calibrated to use the actual path of motion **1610** to define when the bottom panel **1606** is fully open and fully closed.

[0135] In order to determine the first end point **1619** and the second end point **1620**, the following procedure can be executed. The automated window mechanism **1605** comprises a motor **1614** with a positive lead **2001** and a negative lead **2003** and comprises an encoder **1616**. The encoder **1616** can record the position of the automated window mechanism **1605** by recording movement of the automated window mechanism **1605**. Upon installing the automated window mechanism **1605**, a calibration operation can be initiated using digital controls which may be initiated using a remote device or by a button or switch on the automated window mechanism **1605** itself. Initiating the calibration operation can cause a processor and non-volatile memory on the automated window mechanism **1605** to begin the calibration operation which includes monitoring values noted by the encoder **1616** and/or motor **1614**.

[0136] In some embodiments the calibration operation is executed by disengaging the motor **1614** while the encoder **1616** remains engaged. Accordingly, the bottom panel **1606** with attached automated window mechanism **1605** can be manually moved along the path **1609**. While the bottom panel **1606** is being moved, the encoder **1616** can record two values defining extreme values which correspond to the first end point **1619** and the second end point **1620**. Once the user is satisfied that the bottom panel **1606** has been moved as far up and down as desired or possible, the user can instruct the automated window mechanism **1605** that the calibration operation is complete. In response to this instruction the automated window mechanism **1605** can engage the motor **1614** and use the two values as the first end point **1619** and second end point **1620** for purposes of defining the actual path of motion **1610** for the bottom panel **1606**. Armed with this information, when requested to open or close the window, the automated window mechanism **1605** actuates the motor **1614** until reaching the first end point **1619** or second end point **1620** at which point the motor **1614** is stopped because the bottom panel **1606** has reached the end of the actual path of motion **1610**.

[0137] The calibration operation can be executed at any desired time, such as to define new open and closed positions. For example, suppose the user has a pet who is prone to escape through an open window. The user can calibrate the window to open only a small amount to prevent escape.

[0138] In other embodiments the calibration operation can be executed using the motor **1614** to

move the bottom panel **1606** along the path **1609** in order to define the first end point **1619** and second end point **1620**. Upon receiving an instruction to calibrate, the motor **1614** can be used to move the bottom panel **1606** up and down. The limit of movement can be defined at points at which the motor **1614** meets sufficient resistance to conclude that the extent has been reached. In some embodiments the motor **1614** can have a predetermined current level and if the motor begins to draw more than the predetermined current level the extent has been reached. In some embodiments the encoder **1616** can also be used in addition to motor parameters to define the end points. For example, in order to conclude that the end point (first or second) has been reached, the encoder **1616** would report the bottom panel **1606** is no longer moving. This information in addition to the motor parameter (which may include current or any other motor parameter) is used to conclude that the end point has been reached.

[0139] In some embodiments the motor **1614** of the automated window mechanism **1605** can be used to execute the calibration. In this case the end points are defined according to physical limits of movement of the window. The user can give an instruction to the automated window mechanism **1605** to calibrate using the motor **1614**. The motor **1614** can move in a first direction until it encounters sufficient resistance to conclude that a first physical limit has been reached. The automated window mechanism **1605** can record the current position using the encoder **1616** and set it as the first end point **1619**. Then the motor **1614** moves in the opposite direction until it encounters sufficient resistance to conclude that a second physical limit has been reached. The automated window mechanism **1605** can record the current position using the encoder **1616** and set it as the second end point **1620**. The automated window mechanism **1605** can alert the user that the calibration is complete by emitting a sound, a light, or other notification.

[0140] The resistance that defines physical limits can be determined using motor parameters such as current drawn, wattage, or any other suitable motor parameter. In other embodiments the resistance is measured using physical measurements such as stress and strain on components in a transmission between the motor **1614** and a rack or other such mechanism used to move the window. The amount of resistance can be set low enough to avoid injury to persons or objects.

[0141] FIG. 25 is a schematic illustration of a force map **1630** according to embodiments of the present disclosure. The force map **1630** comprises a plot of force required to move the bottom panel **1606** between the first end point **1619** and second end point **1620**. The force map **1630** can be used with the actual path of motion **1610**, or it can be used between the fully closed position **1618** and fully open position **1621** without calibrating.

[0142] An automated window mechanism **1605** can plot the force map **1630** using the following procedure. The automated window mechanism **1605** can move between the endpoints (whether defined by a fully closed or open position, or by a calibrated end point) and as it moves, the automated window mechanism **1605** records the force required to move as a function of position along the path **1609** (or the actual path of motion **1610** if calibrated and using end points). The force can be plotted using any desired number of discrete points along the path **1609**. In some embodiments there are a sufficiently high number of points that the force map **1630** is effectively a continuous line. The force map **1630** pictured in FIG. 25 is shown as one of infinitely many example plots. This force map **1630** has a first peak **1632** and a second peak **1634**, and valleys between. It is to be understood that windows differ greatly in an amount of force required to move and that a force map **1630** for each window may be unique.

[0143] The automated window mechanism **1605** stores this force map **1630** and employs the force map **1630** to raise and lower the bottom panel **1606**. That is, when an instruction is given to the automated window mechanism **1605** to raise or lower the bottom panel **1606**, the automated window mechanism **1605** can identify its position along the path **1609**, access in memory the force map **1603**, and accordingly instruct a motor (**1614** in FIG. 24) to exert a proportional amount of energy to move the bottom panel **1606**.

[0144] In some embodiments if a sufficiently high slope of the force map **1630** is detected the



automated window mechanism **1605** can cause the motor to create momentum by increasing the speed of movement of the bottom panel **1606** to assist with conquering the high peak. In other embodiments the automated window mechanism **1605** can exert pulses of intermittent impact to help overcome a high peak in the force map **1630**. In some embodiments the automated window mechanism **1605** can include an impulse motor which can be a setting of the standard motor, or a separate device. The impulse motor can be configured to exert short, high energy pulses to overcome a high peak which may represent a sticking point in the path of the window.

[0145] In some embodiments the force map **1630** can be updated from time to time such that the force map **1630** remains accurate. To update the force map **1630** the automated window mechanism **1605** can be instructed manually to make the movements and calculations again. In other embodiments the updates can be on a schedule such as a weekly schedule. In other embodiments an update can be initiated by the automated window mechanism **1605** automatically upon detecting certain motor parameters. For example, if the automated window mechanism **1605** detects that the speed at which an open or close instruction is executed has become slower or faster than it has been in the past, the force map **1630** can be updated accordingly. Other motor parameters include current, temperature, etc. that can be used to conclude that the force map **1630** needs to be updated.

[0146] In other embodiments a condition sensor **1640** can be used in connection with the automated window mechanism **1605** to improve the force map **1630**. The condition sensor **1640** can be part of the automated window mechanism **1605**, or separate. The condition sensor **1640** can represent a plurality of such condition sensors. The condition sensors **1640** can represent temperature sensors, humidity sensors, weather sensors such as rain sensors, and any other condition-identifying sensor that may have a bearing on the force map **1630**.

[0147] As conditions change, so may the force map **1630**. FIG. 26 shows the force map **1630** of FIG. 25 reproduced, and a second force map **1630a**; which represents a deviation from the force map **1630** accounting for the different conditions. For example, in cold weather it is more likely that more energy is required to move the automated window mechanism **1605** along the path **1609**. Peaks **1632a** and **1634a** are higher and further to the right toward the second end point **1620**. It is to be appreciated that there is an infinite number of possible force maps and those shown here are for purposes of illustration and not limitation.

[0148] In some embodiments the condition sensors **1640** can determine that a sufficiently high change in conditions has occurred and therefore can initiate an update to the force map **1630**. The automated window mechanism **1605** can record force maps according to the measured conditions and can employ the force map pertaining to a given set of conditions if and when the conditions arise again. To illustrate an example, consider a simple example of a summer force map and a winter force map. The automated window mechanism **1605** can select which force map to employ based on information from the condition sensors **1640**. There may be any suitable number of force maps stored in memory that can be retrieved and employed as often as desired. In some embodiments each time the automated window mechanism **1605** is instructed to move in any way a proper force map can be identified and employed. In some embodiments a closest force map can be identified and employed. If a sufficient deviation between the current conditions based on the conditions sensors **1640** is identified, a new force map can be recorded during movement of the automated window mechanism **1605**.

[0149] FIG. 27 is an isometric view of a coupled axial clutch **1700** that can be used with the automated window mechanisms shown and described herein. The coupled axial clutch **1700** can be placed at any point on a shaft used by the automated window mechanism **1605** to transmit torque to the gears, pulleys, or other mechanisms used to move windows according to embodiments shown and described herein. The coupled axial clutch **1700** can be selectively engaged or disengaged by axial movement of portions of the coupled axial clutch **1700**. In some embodiments the coupled axial clutch **1700** comprises a first component **1702**, a second component **1704**, and a coupler **1706** shaped to fit between the first component **1702** and second component **1704**. The first component

**1702** and second components **1704** each have teeth **1708** protruding axially toward one another. The coupler **1706** also has teeth and are shaped to engage the teeth **1708** such that moving the first component **1702** and second component toward one another causes the teeth to engage and torque to be transmitted along the coupled axial clutch **1700**.

[0150] FIG. **28** shows another embodiment of an axial clutch **1720** having first component **1722** and second component **1724** which each have teeth **1728**, but there is no coupler. The teeth **1728** of the axial clutch **1720** engage directly with one another. The systems, devices, and methods of the present disclosure can be applied to either type of axial clutch: coupled or uncoupled. For purposes of brevity and conciseness, reference will be made to the axial clutch **1720** without loss of generality.

[0151] FIG. **29** is a side view of an axial clutch **1730** according to embodiments of the present disclosure. The axial clutch **1730** includes a first component **1732** having a first shaft **1734** and first teeth **1736**. The axial clutch **1730** also includes a second component **1742** having a second shaft **1744** and second teeth **1746**. Axial movement of the first component **1732** and second component **1742** toward one another will cause the first teeth **1736** to engage with the second teeth **1746**. With the teeth engaged the axial clutch can transmit torque which is used by the automated window mechanism **1605** to open and close a window. Rotational movement and axial movement of the first component **1732** and/or the second component **1742** can be accomplished via a motor shown and described elsewhere herein. In some embodiments one of the first component **1732** and second component **1742** are capable of being rotated and/or moved axially. In other embodiments both the first component **1732** and second component **1742** are capable of being rotated and/or moved axially.

[0152] FIG. **30** shows the axial clutch **1730** of FIG. **29** after axial movement causes engagement between teeth **1736** and teeth **1746**. With the teeth so engaged the axial clutch **1730** can transmit torque to perform useful work such as raising or lowering an automated window.

[0153] The polar position of the first teeth **1736** and second teeth **1746** as measured around an axis parallel with the shafts **1734**, **1744** as shown in FIGS. **29** and **30** has the teeth aligned and the engagement can take place. If, however, the teeth are not aligned with one another, the teeth may not engage. In certain embodiments one of the first component **1732** and second component **1742** can be rotationally oscillated until the teeth are in position to engage. The oscillation can be caused by the motor (not shown) that actuates the axial clutch **1730**. In some embodiments the oscillation can be repeated, back and forth rotation of the first component **1732**, the second component **1742**, or both the first and second components. In some embodiments the magnitude of movement of the oscillation as measured in a circumferential dimension is approximately equal to or slightly greater than a circumferential dimension of the teeth **1736**, **1746**. Oscillating the teeth by a circumferential distance equal to or slightly greater than the circumferential width of the teeth ensures that the teeth **1736**, **1746** will merge. In some embodiments where both the first component **1732** and the second component **1742** are oscillated, each can be oscillated by approximately half the circumferential width of the teeth. The oscillation can be cyclical, achieving a back-and-forth rotation to encourage the front faces of the teeth **1736**, **1746** from sticking.

[0154] In some embodiments the oscillation can be executed when the axial clutch **1730** is activated without measuring for interference of the teeth. In other embodiments the axial movement can be monitored for interference, and if there is interference the oscillation can be initiated. There are many ways in which the motor can determine whether or not the axial clutch **1730** has been properly engaged, such as measuring position of the first component **1732** and second component **1742**, measuring relative rotation of the first component **1732** and second component **1742**, measuring motor parameters such as current or temperature during the axial motion to engage the first component **1732** and second component **1742** or during rotation after moving the first component **1732** and second component **1742** axially toward one another. In some embodiments the axial and oscillation can take place at the same time, causing a spiral motion to encourage

proper engagement of the teeth. In some embodiments the oscillation may comprise movement in one rotational direction, and as such may not be oscillation at all, but simply rotation.

[0155] FIG. **31** shows one component **1750** of an axial clutch according to further embodiments of the present disclosure in which the teeth **1752** are tapered to allow for engagement with corresponding teeth on the other component **1750**. The degree of taper can be slight such that the radially facing surfaces of the teeth are still able to transmit torque without slipping.

[0156] FIG. **32** shows one component **1760** of an axial clutch according to embodiments of the present disclosure. The component **1760** has one tooth **1764** that is longer than another tooth **1762**. There may be any suitable number of teeth, and any number of them may be longer than the others. In certain embodiments one tooth is longer to promote proper engagement with corresponding teeth on the other component (not shown).

[0157] FIG. **33** shows one component **1770** of an axial clutch according to further embodiments of the present disclosure. The component **1770** has teeth **1772** that each have a tapered leading surface **1774** and a flat surface **1776**. The tapered surface **1774** promotes proper engagement with the other component, and the flat surface **1776** transfers torque without slipping that may be associated with a tapered surface.

[0158] These features of the teeth shown in FIGS. **29-33** can be found in various combinations of embodiments. For example, in one embodiment there may be teeth having a tapered leading surface, and one or more of the teeth may be longer than the others. Any suitable combination of these features can be employed in various embodiments.

[0159] FIG. **34** is an illustration of an axial clutch **1780** and clutch switch assembly **1781** according to embodiments of the present disclosure. The axial clutch **1780** includes components generally similar to those of other axial clutches shown and described herein, such as first component **1782** and second component **1792**. The first component **1782** includes a shaft **1784** and teeth **1786**. The second component **1792** includes a shaft **1794** and teeth **1796**. The axial clutch **1780** operates by moving the first component **1782** and second component **1792** together to engage the teeth **1786** and **1796**. With the teeth engaged torque can be transmitted through the axial clutch **1780** to raise and lower a window to which the axial clutch **1780** is coupled.

[0160] The clutch switch assembly **1781** includes a clutch actuator **1797** coupled to the shaft **1794**. The clutch actuator **1797** is configured to move the second component **1792** toward and away from the first component **1782** to engage and disengage them. The clutch actuator **1797** may comprise a solenoid, a magnet, a motor, or any other suitable mechanism to actuate the axial clutch **1780** by axial movement. The clutch actuator **1797** may be coupled to the shaft **1794** or the second component **1792**. In some embodiments the clutch actuator **1797** may be coupled to the first component **1782**. In some embodiments each component has a clutch actuator **1797**. In some embodiments the clutch actuator **1797** is configured to execute the oscillations discussed above with respect to FIGS. **29-32**.

[0161] The clutch switch assembly **1781** also includes encoders **1799a** and **1799b** that are coupled to the one or both the first component **1782** or the second component **1792**. In some embodiments the encoder comprises a single encoder **1799a** attached to the second component **1792** on the same side as the clutch actuator **1797**. In other embodiments the encoder comprises a single encoder **1799b** attached to the first component **1782** opposite the clutch actuator **1797**. The encoders **1799a** and **1799b** may be referred to collectively herein as the encoder **1799** or the encoders **1799**. The encoders **1799** are configured to monitor axial and/or rotational movement of the components relative to one another. The encoder **1799** plays a role in calibrating the automated window mechanism shown and discussed above with respect to FIGS. **23-26**. The rotational position of the axial clutch **1780** can be mapped to the position of the window segment moved during calibration.

[0162] The clutch switch assembly **1781** also includes a switch **1798** shown here coupled to the clutch actuator **1797** and operable to engage or disengage the clutch actuator **1797** from the axial clutch **1780**. A user can manually operate the switch **1798**, or it can be operated automatically using

signals from the controller or from a remote device according to embodiments of the present disclosure. Operating the switch **1789** renders the clutch actuator **1797** unable to engage the axial clutch **1780**, so that the window may be raised and lowered without the axial clutch **1797** interfering. A user can operate the switch **1789** to move the window by hand for any desired reason. The switch **1798** can include a timer after which time the switch **1798** returns to the engaged position such that the window can be raised and lowered using the motor (not shown) and axial clutch **1780** to do so. The timer may include a schedule that the user can input or customize as desired.

[0163] The encoder **1799** remains operational regardless of the position of the switch **1798**. By so doing, the encoder **1799** maintains the calibration of the automated window mechanism regardless of the switch **1798** coupling or uncoupling the clutch actuator **1797**. A user can disengage the clutch switch **1798**, move the window up and down however they like, and upon flipping the switch **1798** again the motor is once again engaged and due to the calibration still contains end points for movement.

[0164] In some embodiments the encoder **1799b** is opposite the motor and is on the same side as the window. Rotation of the second component **1792** while the axial clutch **1780** is not engaged does not affect the position of the window and is not monitored by the encoder **1799b**, so the encoder **1799b** can remain engaged and monitoring rotational position of the first component **1782**. In other embodiments the encoder **1799a** is attached to the motor side, opposite the window side. Accordingly, the encoder **1799a** can be configured to selectively monitor position of the second component **1792**, such that the encoder **1799a** records movement for purposes of maintaining the calibration end points only when the axial clutch **1780** is engaged. If for any reason the axial clutch **1780** is not engaged the encoder **1799a** does not record movement. Accordingly, the calibration end points are maintained regardless of using the switch **1798** to render the clutch actuator **1797** inoperable.

[0165] In some embodiments the encoder **1799** can account for rotational deviation caused by the oscillations described above. In some embodiments the encoder **1799** can maintain an oscillation zero point to which the axial clutch **1780** can return after the oscillations are complete and the axial clutch **1780** is engaged. In other embodiments the encoder **1799** can monitor the position of the axial clutch **1780** throughout the oscillations and therefore no return to zero point is required.

[0166] The clutch switch assembly **1781** also operates as a lock. With the switch **1798** in the engaged position, and axial clutch **1780** engaged, the motor (not shown) will prevent the window from moving unless the motor receives specific instruction to move to raise or lower the window. It is to be appreciated that the axial clutch **1780** can be placed at any point along a power transmission mechanism between a motor and the window.

[0167] The calibration can result in any arbitrary limits on window movement which can be useful to define window movement limits. In some cases, these limits are not based on a physical limitation but rather on a desired limit. If the clutch switch assembly **1781** is used to release the motor and the window is moved manually outside of the calibration range, that is, beyond the first or second end points in either direction (refer to FIGS. **24-26**). The clutch switch assembly **1781** may be reengaged outside of the end points. In this the automated window mechanism **1605** can take one of three possible actions given in no particular order. First, the automated window mechanism **1605** can request a recalibration by issuing a signal to an electronic device, emitting a sound, a light, or a pre-recorded voice message instructing the user to recalibrate. Second, the automated window mechanism **1605** can move back into the calibration range by calculating a distance from the nearest end point, and by moving the window that distance to reach the nearest end point. This can be done upon reengaging the clutch switch assembly **1781**. Third, the current value can be redefined as the new end point, whether first or second, depending on which is the nearest end point. In this case a notice can be issued to alert the user that the calibration has been reset.

[0168] FIG. 35 is a plot **1800** of window position according to embodiments of the present disclosure. The plot **1800** can represent distance between end points along an actual path of motion as determining using calibration operations disclosed and shown elsewhere herein. The plot **1800** will be used to describe a feature called “backlash” or “backup.” As the window is moved along the path of motion and reaches one of the end points, there may be an obstacle such as the end of the frame or another object physically preventing the window from moving further. Such may be used to define end points according to the calibration. Referring back to the axial clutches shown and described above, at the end points there may be stored energy in the axial clutch between teeth of cooperating components of the clutch. In other embodiments using a different power transmission mechanism there may still be stored energy. For purposes of brevity this discussion will refer to the axial clutch. However, it is to be understood that other transmission mechanisms may be possible and will benefit from the backlash equally.

[0169] The stored energy in the axial clutch may present a problem of making it difficult or impossible to release the axial clutch because of friction between the teeth. In order to prevent this, the motor driving the automated window mechanism can be configured to retreat a certain distance, defined as the backlash, when the motor stops. Referring again to the plot **1800**, a left extreme **1802** represents the farthest point to the left; a right extreme **1810** represents the farthest point to the right. It is to be appreciated that left and right are used with respect to FIG. 35 and in an actual window the extremes may be up and down, right and left, left and right, or any other possible configuration. The left backlash is at **1804**; the right backlash **1808** is at **1808**. The path in the middle is at **1806**.

[0170] The distance of the backlash can be equal to a rotational movement that would begin to exert pressure on the axial clutch in the opposite direction. The backlash can account for any play in the axial clutch. Suppose for example that there are 4 degrees of play in the axial clutch. The backlash can be equal to a rotational movement sufficient to release the stored energy in a first direction, plus the 4 degrees of play in the axial clutch, plus an additional movement to press on the axial clutch in the opposite direction just before the window begins movement in the opposite direction. The backlash may be known in the manufacturing stage and can be built into the controller(s) operating the motor. Accordingly, a move command may include the following steps: engage (or confirm engagement of) axial clutch; operate motor to move window; reach endpoint; reverse movement for backlash. Accordingly, the axial clutch rests without stored energy, allowing for release.

[0171] In some embodiments a neutral point can be defined as equal to half the backlash. If the backlash is defined as a distance between moving the window in either direction, the neutral point is halfway between backlash end points.

[0172] In some embodiments the motor can be configured to reverse to release energy using the backlash no matter where the window stops. In these embodiments the motor may receive a command to open partway, and upon reaching the desired stopping point, whether or not the window is abutting a frame or other obstacle, the motor can release using backlash. In embodiments in which the window moves horizontally and the weight of the window does not directly bear on the axial clutch, the backlash can be equal in both directions. In embodiments in which the axial clutch bears the weight of the window, the backlash can account for this and release energy using backlash when the motor moves downward and can maintain energy if the movement is upward.

[0173] FIG. 36 is a flow chart diagram of a method **1820** for determining and implementing an automatic, intelligent duty cycle according to embodiments of the present disclosure. A duty cycle is defined as an amount of time a given machine can operate before overheating or reaching some other work-stopping condition. The automatic window mechanisms, motors, actuators, controllers, and transmission mechanisms shown and described herein generate heat when operated, and as with all machinery, too much heat can damage the machinery. One approach to duty cycle is to

build in extra capacity such that there are sufficiently heat-dissipating systems that a duty cycle is never met. This approach can lead to machinery that is overqualified and therefore more expensive than could be. This approach also depends on knowing the loads on the system and building accordingly.

[0174] The method **1820** of the present disclosure improves on conventional duty cycle methods as will be shown and described herein. At **1822** the automatic window mechanism is installed, and at **1824** it is calibrated according to the calibration operations shown and described herein. A force map may be created. At **1826** a calculation is performed of the actual work performed as a function of distance. The force map may be position-sensitive according to the force map. The higher the force on the force map, the more energy required to move along that portion of the map. By analogy, the work performed is equal to the integral of the force map. The area under the force map curve defines the work performed. At **1828** the duty cycle is set according to the work performed. At **1830** if a limit is reached, a warning can be issued, or a shutdown can be triggered.

[0175] Accordingly, the duty cycle is automatic and intelligent, being based upon an actual calculation of work performed at the specific window in question.

[0176] Referring back to FIG. **23** which shows a window **1600** in an open state and in a closed state according to embodiments of the present disclosure. The window **1600** includes a lower panel **1606** which moves up and down in response to instructions given to an automated window mechanism **1605** attached to the lower panel **1606**. In the open state the lower panel **1606** has a distance A between the lower panel and the frame or sill or another lower boundary. Referring to FIG. **24**, a first end point **1619** and second end point **1620** are shown and are defined by calibrating the automated window mechanism **1605** to move between the first and second end points.

[0177] The automated window mechanism **1605** of the present disclosure can avoid pinching fingers or any other object or obstacle in the window **1600**. The automated window mechanism **1605** can operate in a first state during normal operation and during the intermediate portion of the actual path of motion **1610**. Nearing the end points, the automated window mechanism **1605** can enter a second state in which certain precautions are taken and parameters changed to avoid pinching. The region near the end points can be referred to as a proximate closing zone. The second state can be a reduced state. Operation in the safe or reduced state can include slowing down a rate of movement of the lower panel **1606**. In some embodiments the speed of the motor of the automated window mechanism **1605** can be reduced such as by reducing actual rotations per minute of the motor, reducing the electrical current drawn by the motor, or by reducing the voltage to the motor. In embodiments the encoder **1616**, which monitors the position of the lower panel **1606** relative to the actual path of motion **1610**, can monitor position of the lower panel **1606** relative to the first or second end points. The automated window mechanism **1605** can include a pinch tolerance defined as a distance from one or the other end point at which point the automated window mechanism **1605** enters the second state. When the encoder **1616** determines that the lower panel **1606** has reached the pinch tolerance, the automated window mechanism **1605** can be configured to enter the second state.

[0178] In some embodiments another trigger to enter the second state can be any departure greater than a predetermined threshold from the force map. That is, if an unusually large or small force is exerted by the automated window mechanism **1605** that represents too large of a departure from expected, the automated window mechanism **1605** can enter the second state.

[0179] During operation, the automated window mechanism **1605** can continuously check the force map and forces. The check can be discrete check instances that can take place on a regular basis, such as every 0.1 second. More or less frequent polling rates are possible. In some embodiments the second state can be defined as a reduced speed. Maintaining the same polling rate, while slowing down movement, results in a higher resolution per unit distance. It effectively increases the resolution. In other embodiments the map can be checked at predetermined time intervals. Moving slower makes for higher resolution. In other embodiments the automated window mechanism can

maintain speed and change time intervals. In other embodiments both the speed of the window and the polling rate can be increased during the second state. In other embodiments a tolerance for deviation from the force map can be reduced in the second state. In some embodiments the tolerance for deviation from the force map is a proportional to distance from closed.

[0180] In some embodiments the size of the window is accounted for by the calibration. That is, the position of the automated window mechanism **1605** relative to the window component that it is attached to is determined by the calibration. The automated window mechanism **1605** need not know the dimensions of the window—the calibration process described above provides the information sufficient to execute pinch protection precautions. Accordingly, the window **1600** can be opened or closed without undue fear of pinching fingers or any other item in the window.

[0181] FIG. **37** illustrates a transmission assembly **1800** including an axial clutch formed of a first component **1802** and a second component **1804** and including a tattletale unit **1816** according to embodiments of the present disclosure. The axial clutch operates generally similarly to other axial clutches shown and described herein. It is also to be appreciated that in other embodiments a different form of transmission component can be employed with the tattletale unit. The transmission assembly **1800** includes a clutch switch assembly **1808** including a clutch actuator **1810** and a clutch switch **1812** that can engage or disengage the transmission assembly **1800** by manually flipping the clutch switch **1812** or by receiving an electronic instruction to do so from a remote unit. The transmission assembly **1800** may include an encoder **1815** configured to monitor movement of the transmission assembly **1800**. The encoder **1815** may be coupled to the window side of the transmission assembly **1800** as shown here. In other embodiments there may be an encoder attached to the motor side as shown in FIG. **33**. A motor **1814** is shown attached to a shaft **1806**. The motor **1814** provides power to rotate the shaft **1806** and if the transmission assembly is engaged, this will result in the window moving relative to a window frame as shown and described in detail with respect to FIGS. **1** and **2** and other herein.

[0182] The tattletale unit **1816** monitors engagement or disengagement of the clutch switch assembly **1808** to inform a user of activity relating to the clutch switch assembly **1808**. The tattletale unit **1816** includes a transmitter **1818** that is operatively coupled to the clutch switch assembly **1808** and the motor **1814** and is configured to receive information describing actions of these items. The transmitter **1818** is connected to a remote device **1820** which can include a mobile phone, a smart phone, or a remote server configured to manage such information in a useful way. The tattletale unit **1816** can record instances of movement of the clutch switch **1812**, the clutch actuator, the encoder **1815**, or the motor **1814**.

[0183] The tattletale unit **1816** may include a processor and memory to perform instructions and logic to determine how to report the information to the user. The processor and memory may reside in the transmitter **1818**, or in the remote device **1820**. The user may instruct the processor and memory to provide information how and when it is desired. In some embodiments a notification can be given any time there is movement in any of the monitored components. In other embodiments a notification can be given only if the window actually moves. In some embodiments the tattletale unit **1816** can issue loud alarm locally to the window to alert those nearby of the movement which may be from a would-be intruder or a would-be escapist. In some embodiments the tattletale unit may store information in an accessible way without providing notifications for certain observed events, so the user can use the stored information after the fact to determine what has happened with the window in a precise way. The tattletale unit **1816** accordingly operates as a security device.

[0184] FIG. **38** shows an alignment tool **1850** according to embodiments of the present disclosure. The alignment tool **1850** enables placement of a window piece **1510** shown and described above with respect to FIGS. **16-22**. The alignment tool **1850** enables placement of the window piece **1510** with respect to a window **1852**. The window **1852** has an outer face **1854**, a window front surface **1856**, and a window front edge **1858** defined as where the window front surface **1856** and front

edge **1858** meet. The alignment tool **1850** has a lip **1860** and a base **1862** similar to the window piece **1510** itself. The alignment tool **1850** may also have a back wall **1864** that extends upwardly from the base **1862**. The alignment tool **1850** also has a mounting ledge **1866** that extends outwardly from the base **1862**.

[0185] As shown and described in greater detail above, the automated window mechanisms of the present disclosure include a rack **1868** having rack teeth **1870**. The rack **1868** provides a way for the automated window mechanism to move the window **1852**. In some embodiments the alignment tool **1850** is placed onto the window **1852** onto the window front edge **1858** with the alignment tool against a side frame **1867**. The side frame **1867** has a parallel surface **1869** that in the shown embodiment is a vertical surface and the movement of the window is vertical. The parallel surface **1869** may be horizontal in a horizontally-oriented window. The lip **1860** and base **1862** can be placed onto the window front edge **1858** as shown. The rack **1868** can then be placed onto the mounting ledge **1866**. The dimensions of the alignment tool **1850** ensure that the automated window mechanism, when installed, will mate properly with the teeth **1870** of the rack **1868** both in terms of position relative to the window, and in terms of timing of the gears of the automated window mechanism. The alignment tool **1850** can have a second mounting ledge **1866a** on the opposite side that is used for installing on the other side of the window.

[0186] The alignment tool **1850** has a void **1872** that defines a placement guide for the window piece **1510**. The void **1872** includes one or more anchor-receiving contours. In some embodiments the void **1872** is substantially the same shape as the anchor and receives the anchor **1501** snugly within the anchor-receiving contour. The user simply places the window piece **1510** into the void **1872**. An adhesive or other fastening mechanism can secure the window piece **1510** to the window **1852**. The alignment tool **1850** can be removed once the rack **1868** and window piece **1510** are in place. The user can then install the automated window mechanism onto the center alignment member **1540** which is shown and described in greater detail in FIGS. **16-22**.

[0187] In some embodiments of the present disclosure an automated window mechanism is equipped to resist an unauthorized attempt to open the window. In some embodiments the automated window mechanism can render a motor of the automated window mechanism inoperable thereby preventing unauthorized movement of the window. In other embodiments the automated window mechanism can oppose the unauthorized movement to maintain the position of the window before the unauthorized movement began, or to close the window.

[0188] FIG. **39** is a block diagram of a method **1900** for executing a window motor lockdown according to embodiments of the present disclosure. The automated window mechanism can have the ability to monitor the status of the window and the automated window mechanism using one or more of a variety of monitors such as a rotary encoder **730**, a position indicator at **742**, a position sensor at **740**, and a sensor at **810**, shown and described herein above at least in FIGS. **7A**, **7B**, and **8**. Any one or more of these components can monitor the window at **1902** of the method **1900**. The position of the window can be monitored directly, the position of the motor or components thereof can be monitored, or both the window position and motor position can be monitored. In some embodiments the monitors comprise two or more monitor components such as a first monitor component for monitoring movement in a first direction and a second monitor component for monitoring movement in a second direction. At **1904** the window meets resistance which may be in the form of a blockage, an unexpected attempt to open the window, or any unexpected resistance to movement. The resistance may be encountered during movement or while the window is stationary. In other embodiments the automated window mechanism can be manually operated using buttons that are pressed from an inside of the window, and the absence of such a button being pressed can indicate that the movement is unauthorized. In other embodiments the window can be set to a “locked” status during which any attempts to move the window in either direction (toward open or toward closed) are considered unauthorized. In this locked state all resistances to movement can be met with a reaction. The automated window mechanism can be in motion under power from the



motor when the external force is encountered and the reaction can be the same as when the window is stationary. Accordingly the automated window mechanism in the locked state is able to react to any impediment with one or more of these actions.

[0189] At **1906** a motor lockdown is executed. The motor lockdown can be one or more of several actions. At **1908** the motor is an electric motor having a positive and a negative terminal, and grounding these two terminals to the same potential energy renders the motor inoperative. The connection of the automated window mechanism to the window and/or window frame is maintained by the gear(s) and driveshaft(s) such that the motor's inability to move renders the window incapable of opening. At **1910** the motor lockdown can comprise a physical impediment to the motor's movement and/or movement of other components of the automated window mechanism. The physical impediment can be a clutch or a brake that grasps or blocks one or more moving parts to prevent movement. At **1912** the motor lockdown includes routing power to a battery for storage. The unauthorized movement of the window can be used to turn components of the motor which can then be routed to a battery for storage and later use. Use of the battery in this way can be done in combination with other motor lockdown measures.

[0190] At **1914** an alert can be delivered to notify of the unauthorized movement of the window. The alert can be audible and/or visual and can be executed by the automated window mechanism itself, or it can be sent via electronic communication to a remote device such as a phone or a home security system. Accordingly the method **1900** can resist potential theft and burglary by these measures.

[0191] FIG. **40** is a block diagram of a method **1920** according to further embodiments of the present disclosure in which an unauthorized movement of a window causes a motor response. At **1922** the window is monitored and at **1924** the window meets resistance. At **1926** the automated window mechanism can, in response to the resistance, operate in the reverse direction. For example if window were opened by an authorized user to be open two inches. If an unauthorized movement attempt is made to open the window further, the motor can switch on and drive against the opening force to maintain the current position of the window. If the resistance is an unauthorized movement to close the window, the motor can detect this direction of movement and the motor can oppose the closing movement. At **1928** the method can include a further step of moving the window after the unauthorized movement is no longer detected. The window can be moved to return to the previous position, or it can be closed because the unauthorized opening attempt may present a threat and in a preemptive measure the window can close. At **1930** an alert can be delivered to instruct the user of the unauthorized movement, the actions taken by the automated window mechanism, and the current position and lock status of the window.

[0192] FIG. **41** shows a method **1940** for managing unauthorized window movement according to embodiments of the present disclosure. The method **1940** includes at **1942** monitoring the window and at **1944** meeting resistance. At **1946** remedial measures can be taken that may include features shown in FIG. **39** involving a motor lockdown and/or in FIG. **40** involving a counter movement of the window. At **1948** the method includes determining whether or not the resistance persists. If it has not, the method returns to **1944**. If the resistance has ceased, the method can return to **1942** where the window is monitored for the next unauthorized movement.

[0193] The gear ratios of the automated window mechanisms shown and described herein throughout can be chosen so that the mechanical advantage favors the automated window mechanism exerting an opening or closing force on the window, and disfavors the window exerting a force onto the automated window mechanism. Manually grasping and raising or lowering the window is not readily able to rotate the gears and driveshaft(s) of the automated window mechanism. This natural resistance to such an opening or closing movement enables the motor lockdown and motor opposition operations to seize the window in place in the event of an unauthorized movement from an attempted burglary.

[0194] The automated window mechanism of the present disclosure can detect an unauthorized

movement in one or more of several ways. In some embodiments the incoming instruction to move the window creates a temporary authorization window during which movement of the window and/or the automated window mechanism is not recognized as unauthorized. Any movement outside of the temporary authorization windows is considered unauthorized. In other embodiments the sensing components such as the encoder, position sensor, position indicator or sensor, can detect a movement of the window or automated window mechanism components and can query whether or not an instruction to move has been received recently within the last few seconds. If not, the movement can then be identified as unauthorized.

[0195] The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

[0196] All patents and published patent applications referred to herein are incorporated herein by reference. The invention has been described with reference to various specific and preferred embodiments and techniques. Nevertheless, it is understood that many variations and modifications may be made while remaining within the spirit and scope of the invention.

## Claims

**1-20.** (canceled)

**21.** An automated window mechanism for a window of a building, the automated window mechanism comprising: an electric motor configured to connect to a sliding panel of a window and configured to open and close the window by moving the sliding panel relative to a window frame of a building via a drive shaft connected to the electric motor, the electric motor having a locked state in which the electric motor and the sliding panel are stationary; and a monitor configured to detect an external force applied to the sliding panel and a direction of the external force while the electric motor is in the locked state, wherein, in response to the monitor detecting the external force while the electric motor is in the locked state, the electric motor applies a counter force in a direction opposite the external force to counteract the external force.

**22.** The automated window mechanism of claim 21, wherein the monitor comprises an encoder configured to monitor one or more components of the electric motor or the sliding panel.

**23.** The automated window mechanism of claim 21, wherein the monitor comprises a position sensor configured to monitor a position of one or more components of the electric motor or the sliding panel.

**24.** The automated window mechanism of claim 21, wherein the monitor comprises the electric motor itself, wherein the external force causes an electromechanical force in the electric motor that the monitor detects.

**25.** The automated window mechanism of claim 21, wherein the monitor comprises a first monitor component configured to detect a first external force in a first direction and a second monitor component configured to detect a second external force in a second direction opposite the first direction.

**26.** The automated window mechanism of claim 21, further comprising a processor and a memory storing computer-readable instructions, the processor in communication with the memory and configured to execute the computer-readable instructions to at least: store in the memory an initial position of the sliding panel at a time of the external force being applied; and after the external force is removed, cause the electric motor to move the sliding panel to the initial position.

**27.** The automated window mechanism of claim 26, wherein the processor is further configured to, after the external force is applied, cause the electric motor to close the window by moving the sliding panel to a closed position.

**28.** The automated window mechanism of claim 21, wherein, in response to the monitor detecting

the external force while the electric motor is in the locked state, the electric motor moves sliding panel to an initial position before the external force was applied.

**29.** The automated window mechanism of claim 21, further comprising a clutch or a brake configured to prevent movement of components of the electric motor, wherein, in response to the monitor detecting the external force while the electric motor is in the locked state, the clutch or the brake prevent movement of the components of the automated window mechanism to counteract the external force.

**30.** The automated window mechanism of claim 29, further comprising a processor and a memory storing computer-readable instructions, the processor in communication with the memory and configured to execute the computer-readable instructions to at least: monitor engagement or disengagement of the clutch or the brake; and store data in the memory associated with instances of engagement or disengagement of the clutch or the brake.

**31.** A method for inhibiting unwanted movement of a sliding panel of a window relative to a window frame of a building with an automated window mechanism having an electric motor connected to the sliding panel of the window, the method comprising: placing the automated window mechanism into a locked state in which the electric motor and the sliding panel are stationary; while the automated window mechanism is in the locked state, monitoring for an external force applied to the sliding panel; and in response to the external force, opposing the external force via a drive shaft connected to the electric motor by applying power to the electric motor.

**32.** The method of claim 31, wherein monitoring for the external force comprises monitoring for physical movement of the sliding panel or the electric motor.

**33.** The method of claim 31, wherein monitoring for the external force comprises monitoring an electrical characteristic in the electric motor.

**34.** The method of claim 31, wherein monitoring for the external force is performed by one or more of an encoder or a position sensor.

**35.** The method of claim 31, further comprising, in response to the external force, closing the window by moving the sliding panel to a closed position.

**36.** The method of claim 31, further comprising determining that application of the external force to the sliding panel is unauthorized based on incoming instructions not having been received within a last predetermined time period.

**37.** A system for automating a window of a building, the system comprising: an automated window mechanism comprising an electric motor, the automated window mechanism configured connect to a sliding panel of a window in a window frame of a building, the automated window mechanism configured to open and close the sliding panel of the window via a drive shaft connected to the electric motor, and the automated window mechanism having a locked state in which the electric motor and the sliding panel are stationary; a monitor configured to detect an external force applied to the sliding panel while the automated window mechanism is in the locked state; a memory storing computer-readable instructions; and a processor in communication with the memory and configured to execute the computer-readable instructions to at least: in response to the external force, cause the automated window mechanism to apply a counter force to the sliding panel to oppose the external force.

**38.** The system of claim 37, wherein the monitor comprises at least one of an encoder or a position sensor.

**39.** The system of claim 37, wherein the monitor is configured to monitor at least one of the sliding panel or the electric motor.

**40.** The system of claim 37, wherein the monitor comprises the electric motor and the external force causes an electromagnetic force in the electric motor that the monitor is configured to detect.

**41.** The system of claim 37, wherein the monitor is configured to detect a direction of the external force, and the counter force is applied in an opposite direction.

**42.** The system of claim 37, wherein the processor is further configured to, in response to the external force, cause the automated window mechanism to move the sliding panel to a closed position to close the window from an initial position.

**43.** The system of claim 37, wherein the processor is further configured to, in response to the external force, activate an alarm to notify of an unauthorized movement of the window.

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