US 20250257602A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2025/0257602 A1**

Wolf et al. (43) **Pub. Date: Aug. 14, 2025**

(54) **REMOVABLE POP OUT WINDOWS AND CORRESPONDING LATCHES, ACTUATORS, LIVING HINGES, AND MODULAR DESIGNS**

(71) Applicant: **Rivian IP Holdings, LLC**, Irvine, CA (US)

(72) Inventors: **Philipp Josef Wolf**, Dana Point, CA (US); **Mark Lennard Taylor**, Laguna Beach, CA (US); **Andres Meana**, Irvine, CA (US); **Miguel Angel Ramirez Basilio**, Aliso Viejo, CA (US); **Raghav Jaswal**, Coventry (GB); **James John Alexander Dowle**, Laguna Beach, CA (US); **Spencer Charles Curran**, Dana Point, CA (US)

(21) Appl. No.: **19/051,888**

(22) Filed: **Feb. 12, 2025**

Related U.S. Application Data

(60) Provisional application No. 63/559,595, filed on Feb. 29, 2024, provisional application No. 63/552,777, filed on Feb. 13, 2024.

Publication Classification

(51) **Int. Cl.**

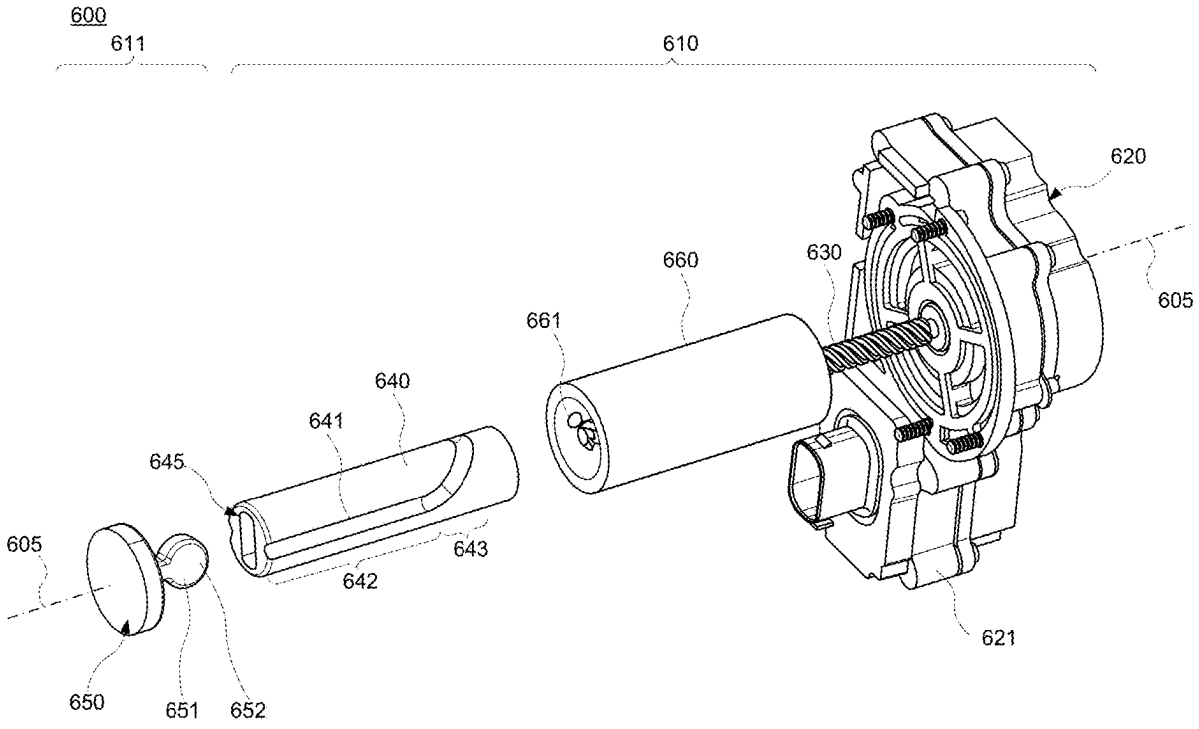
E05F 15/622	(2015.01)
B60J 1/08	(2006.01)
B60J 1/14	(2006.01)

(52) **U.S. Cl.**

CPC ***E05F 15/622*** (2015.01); ***B60J 1/085*** (2013.01); ***B60J 1/14*** (2013.01); *E05Y 2201/214* (2013.01); *E05Y 2201/638* (2013.01); *E05Y 2900/55* (2013.01)

(57) **ABSTRACT**

A removable pop out window provides a modular design. The window is configurable for multiple positions, including closed, vented, removable (e.g., pop out) positions, and combination thereof. The window may include latches, actuators, living hinges, or a combination thereof to allow for the multiple positions. The window may be modular, configured to be installed either as fixed of removable in a vehicle.



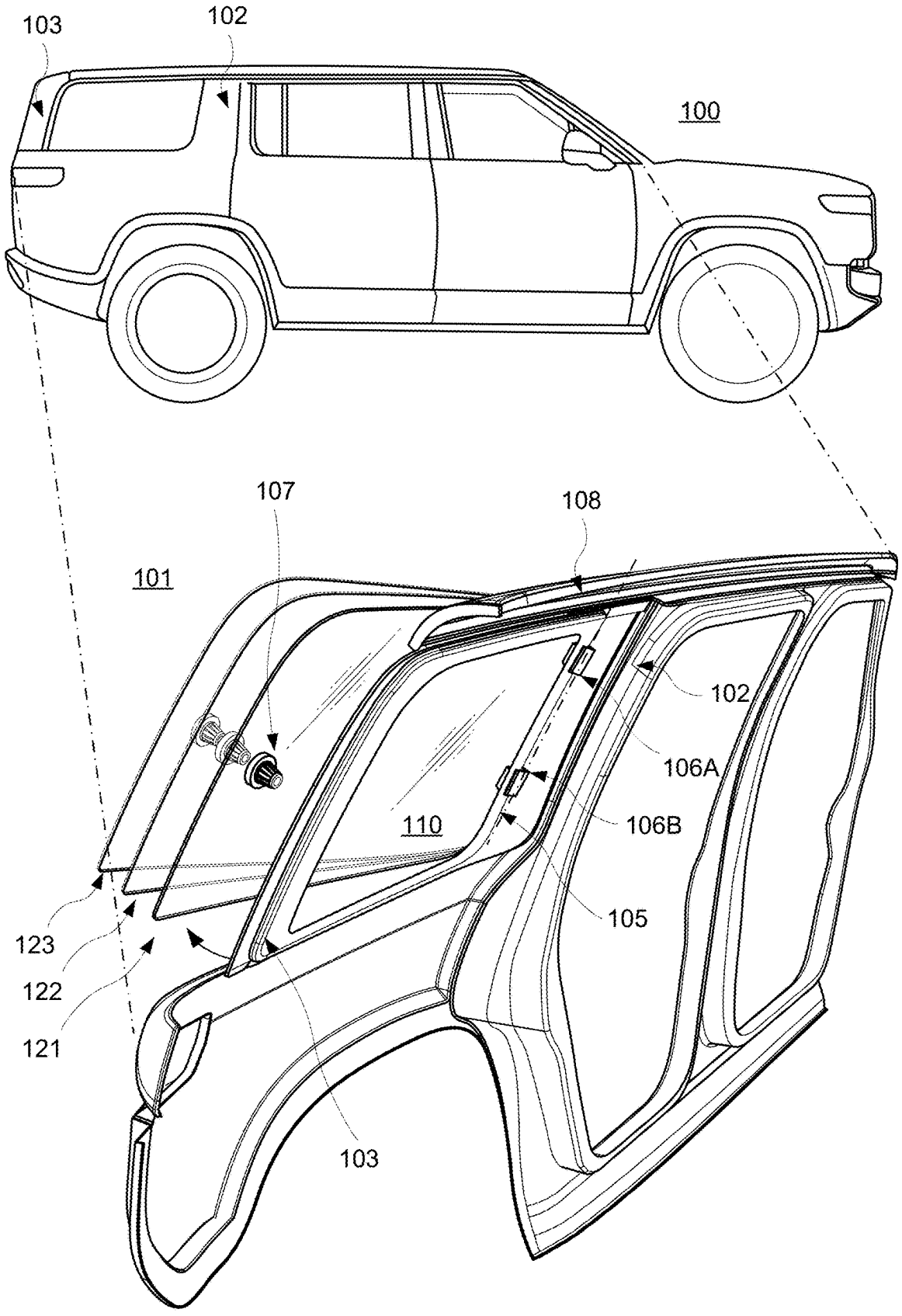


FIG. 1

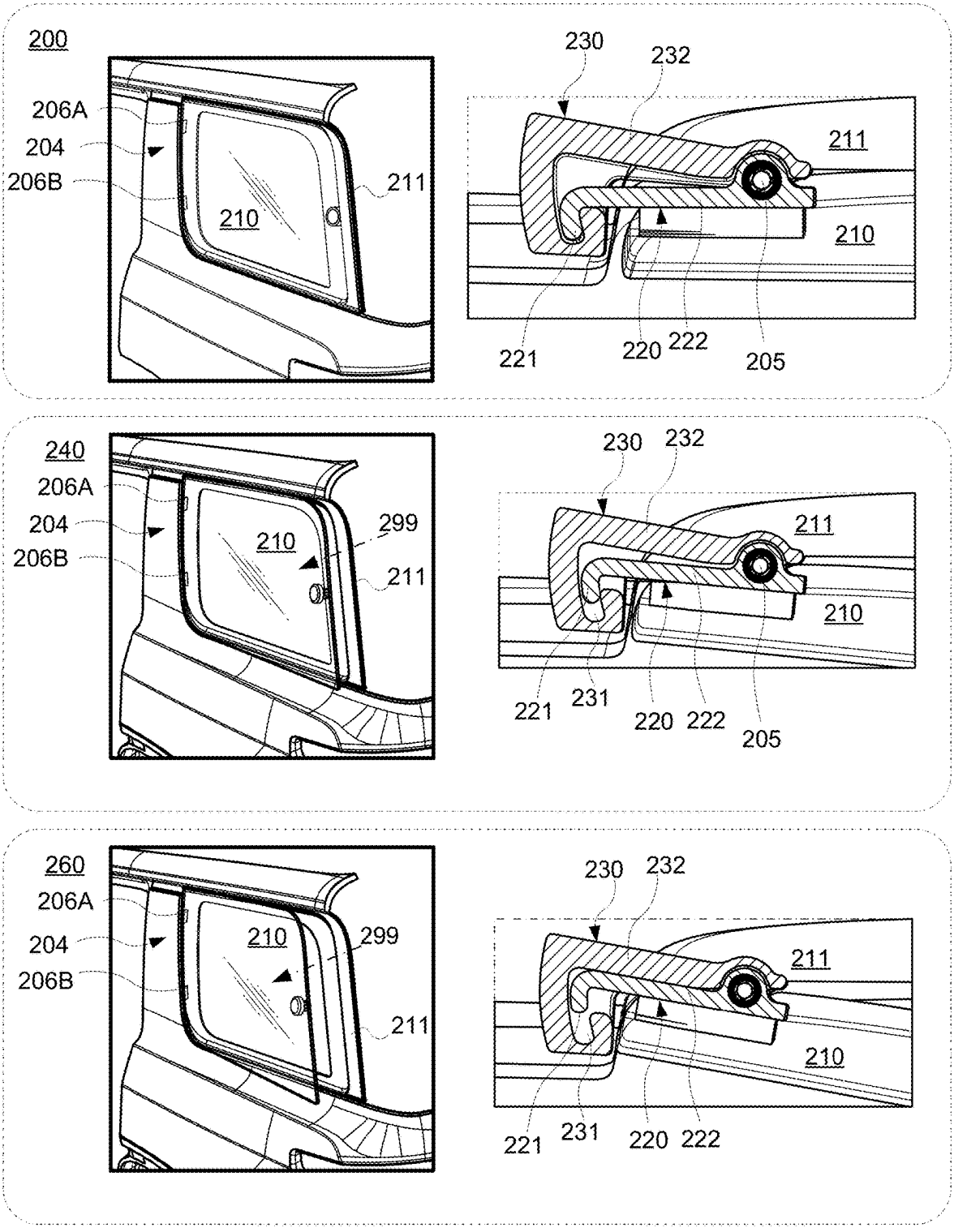

200
206A
204
206B
210
211
230
232
211
210
221
220
222
205
240
206A
204
206B
210
299
211
230
232
211
210
221
231
220
222
205
260
206A
204
206B
210
299
211
230
232
211
210
221
231
220
222

FIG. 2

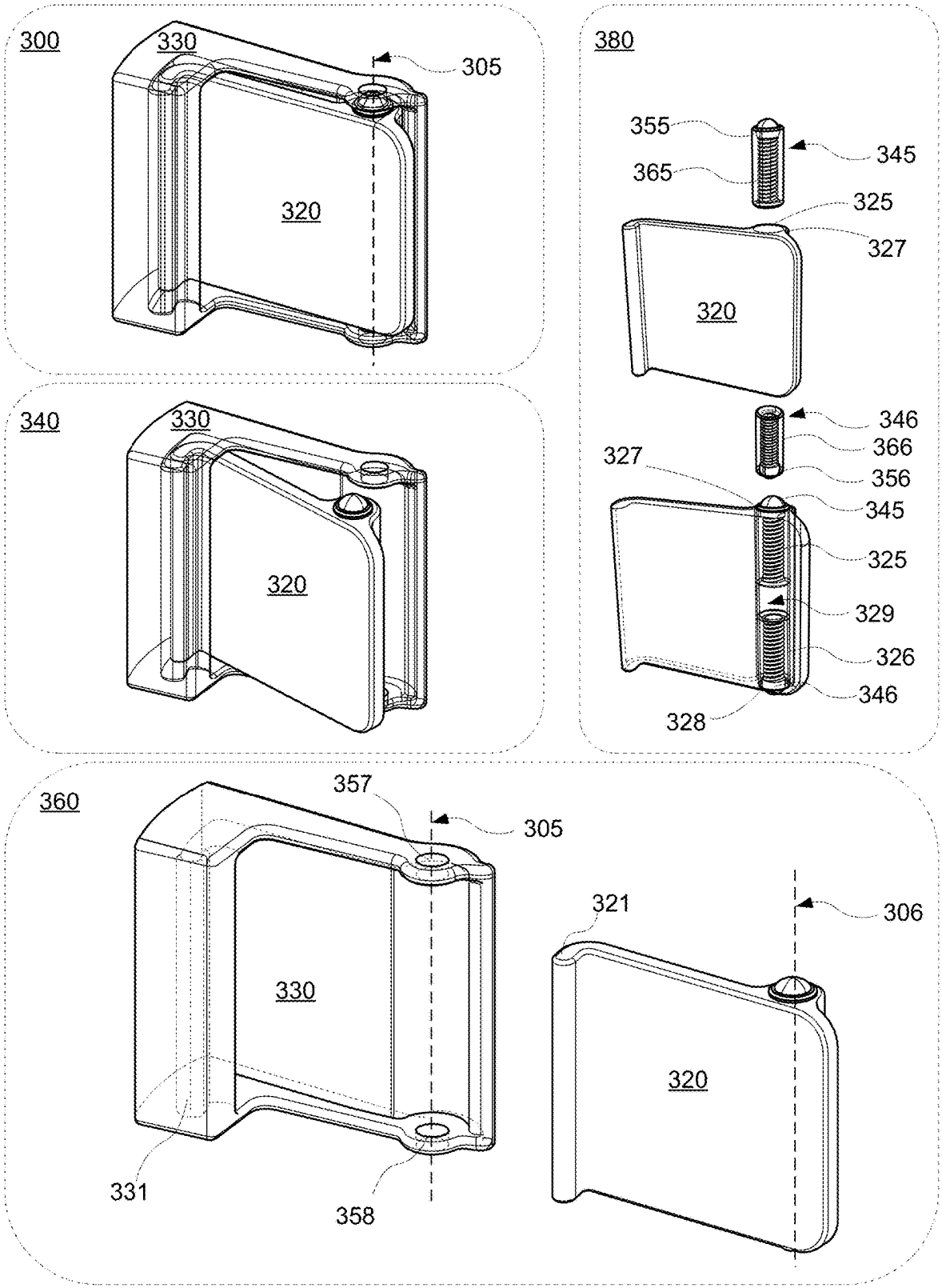

300
330
305
320
340
330
320
380
355
345
365
325
327
320
346
366
327
356
345
325
329
326
346
328
360
357
305
330
331
358
321
306
320

FIG. 3

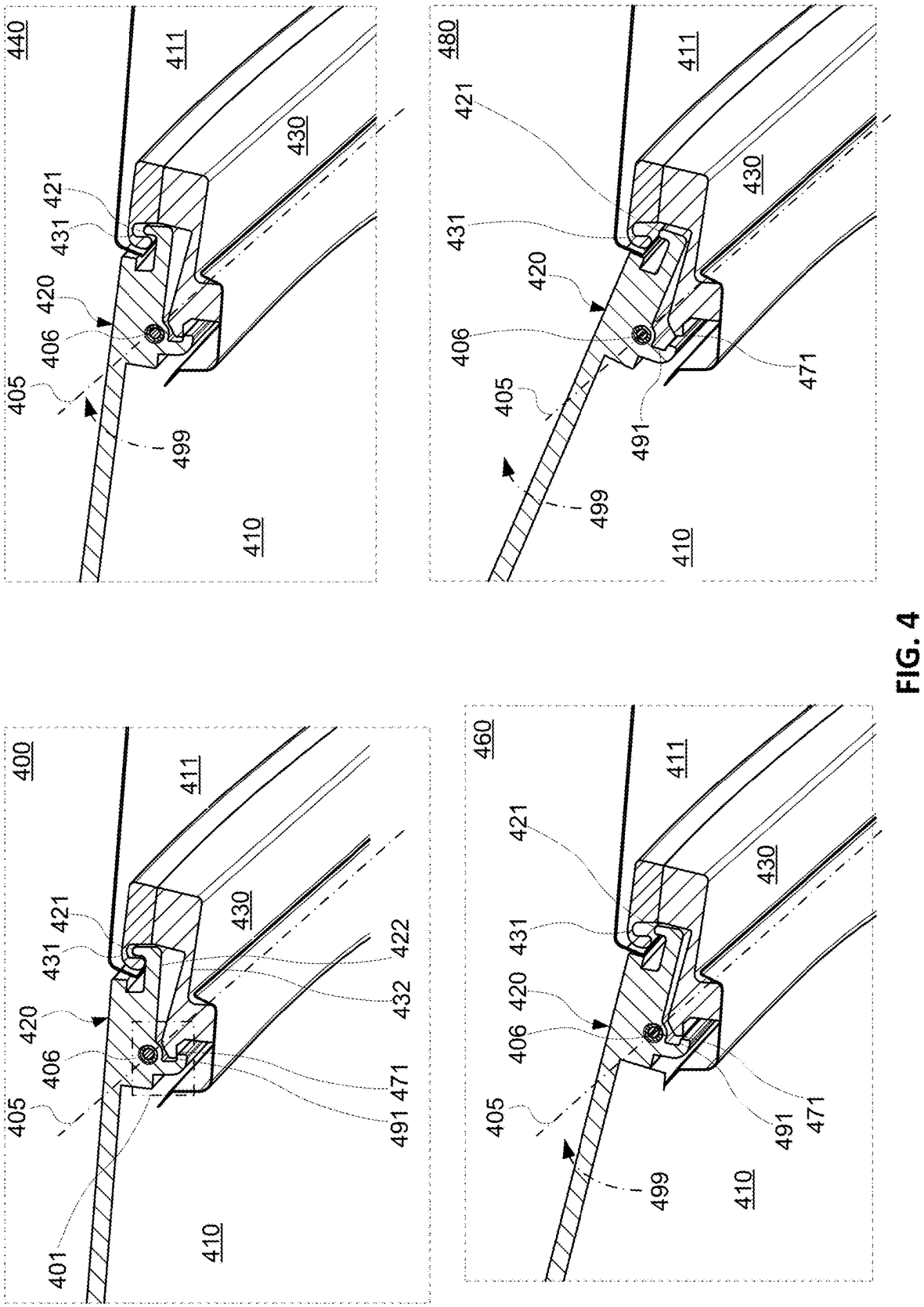

440
411
430
421
431
420
406
405
499
410
480
411
421
430
431
420
406
471
405
491
499
410
400
411
421
430
431
422
420
432
406
471
405
491
401
410
460
411
421
430
431
420
406
405
491
471
499
410

FIG. 4

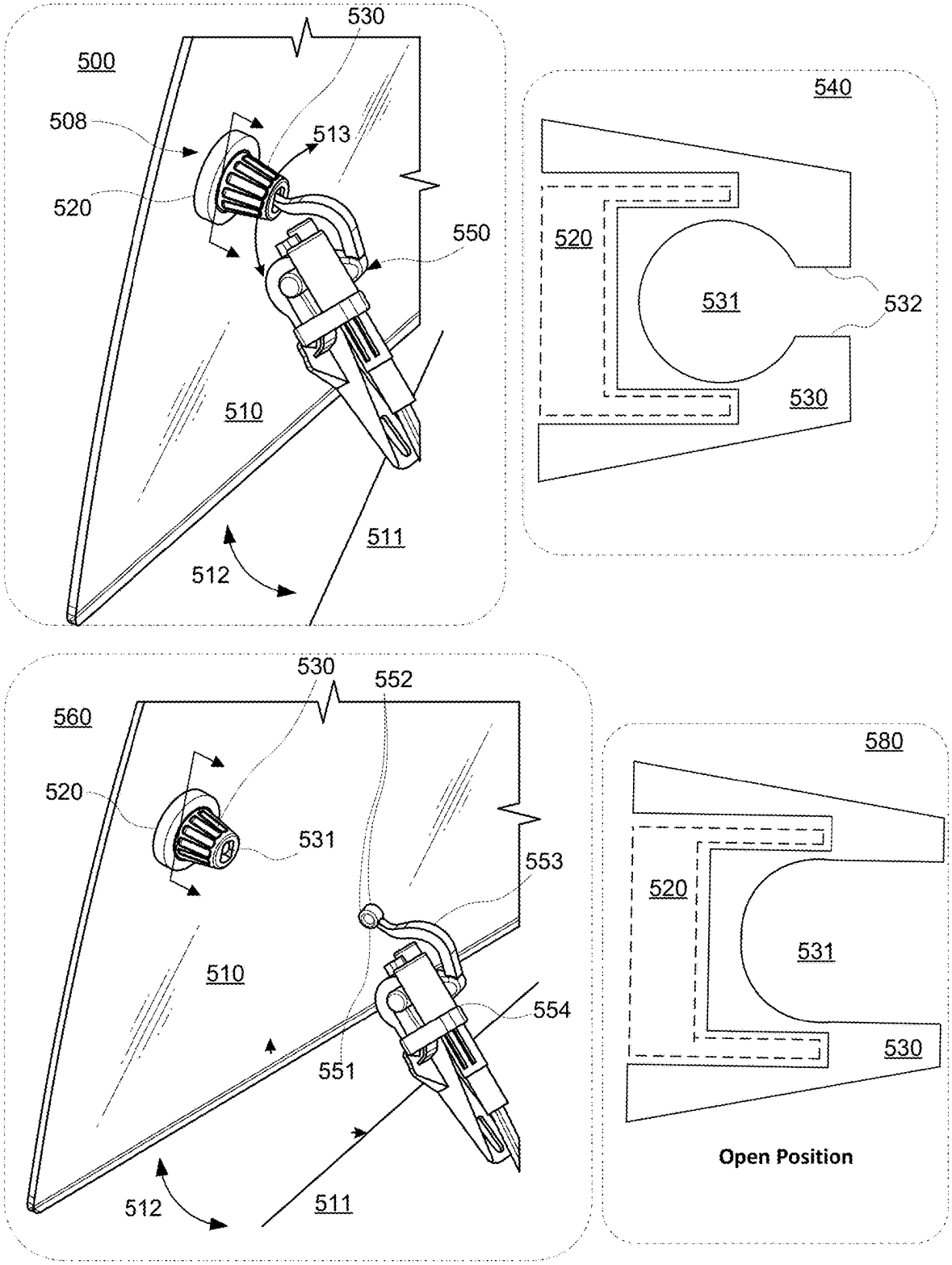

500
508
520
530
513
550
510
511
512
540
520
531
532
530
560
520
530
552
531
553
510
554
551
512
511
580
520
531
530
Open Position

FIG. 5

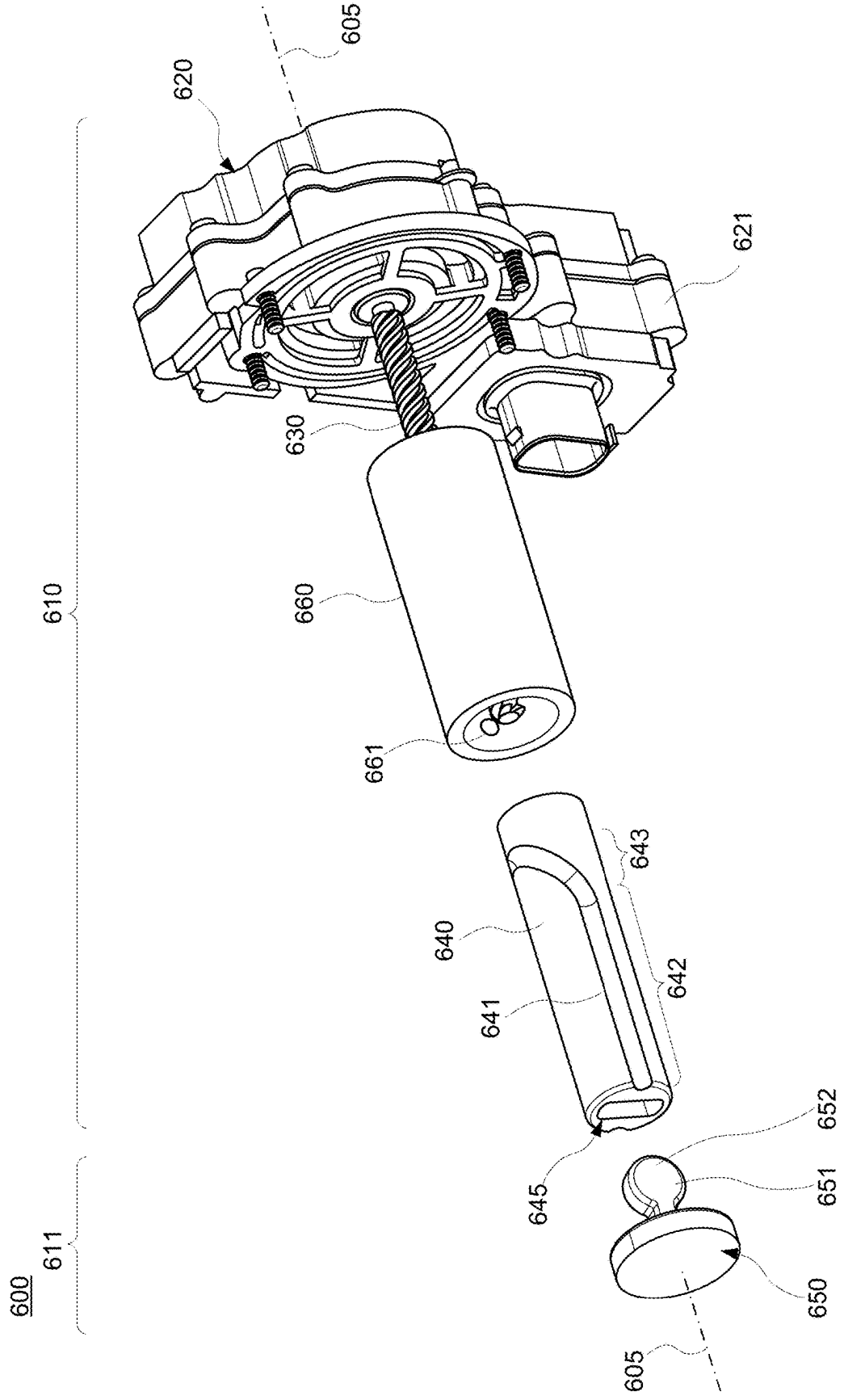

600
610
611
605
620
621
630
660
661
640
641
642
643
645
650
651
652
605

FIG. 6

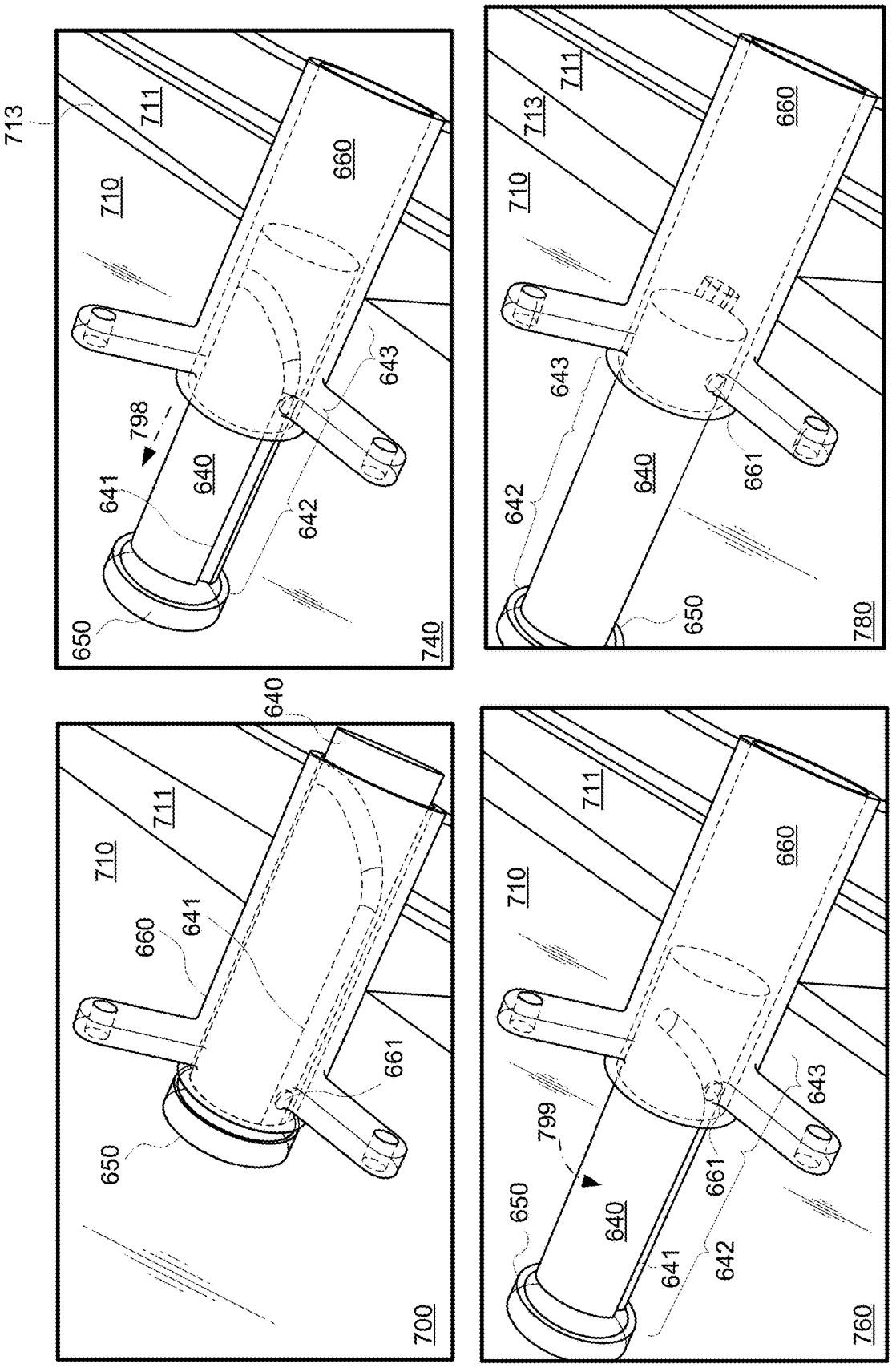

713
711
710
660
643
798
641
640
642
650
740
640
711
710
660
641
643
661
650
700
713
711
710
660
643
642
640
661
650
780
711
710
660
799
643
650
640
661
641
642
760

FIG. 7

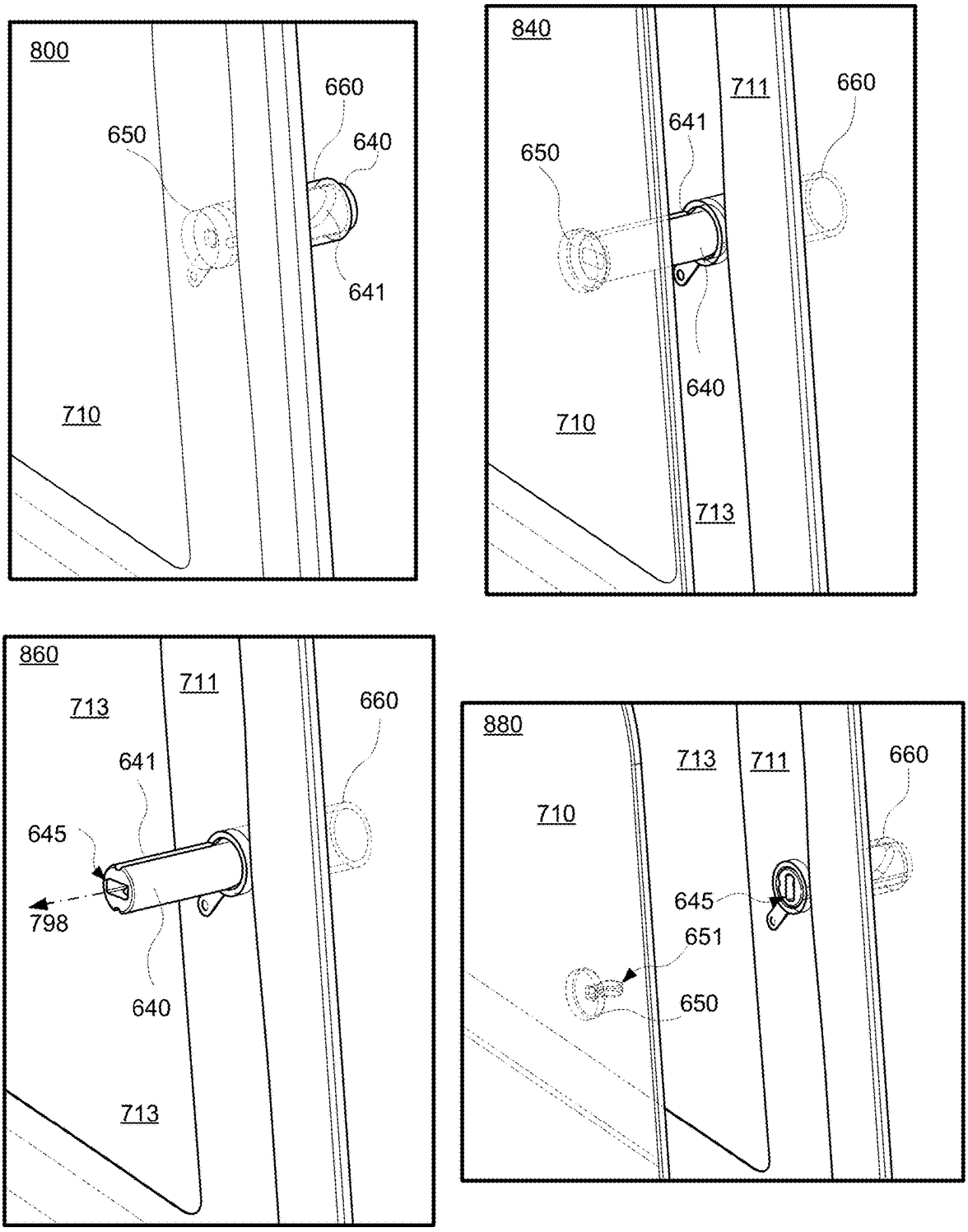

800
660
650
640
641
710
840
711
660
641
650
640
710
713
860
711
713
660
641
645
798
640
713
880
713
711
660
710
645
651
650

FIG. 8

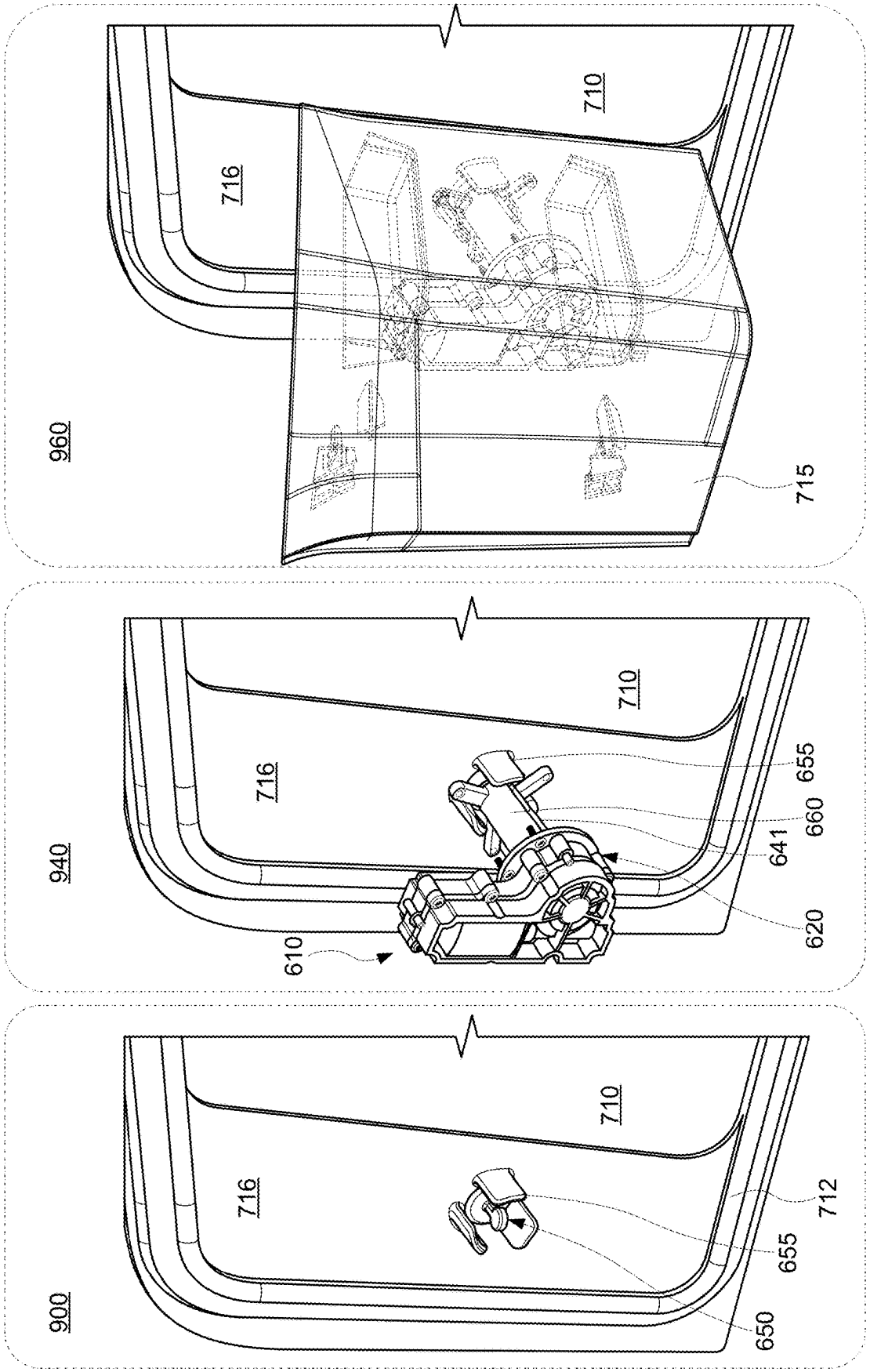

900
710
716
712
655
650
940
710
716
655
660
641
620
610
960
710
716
715

FIG. 9

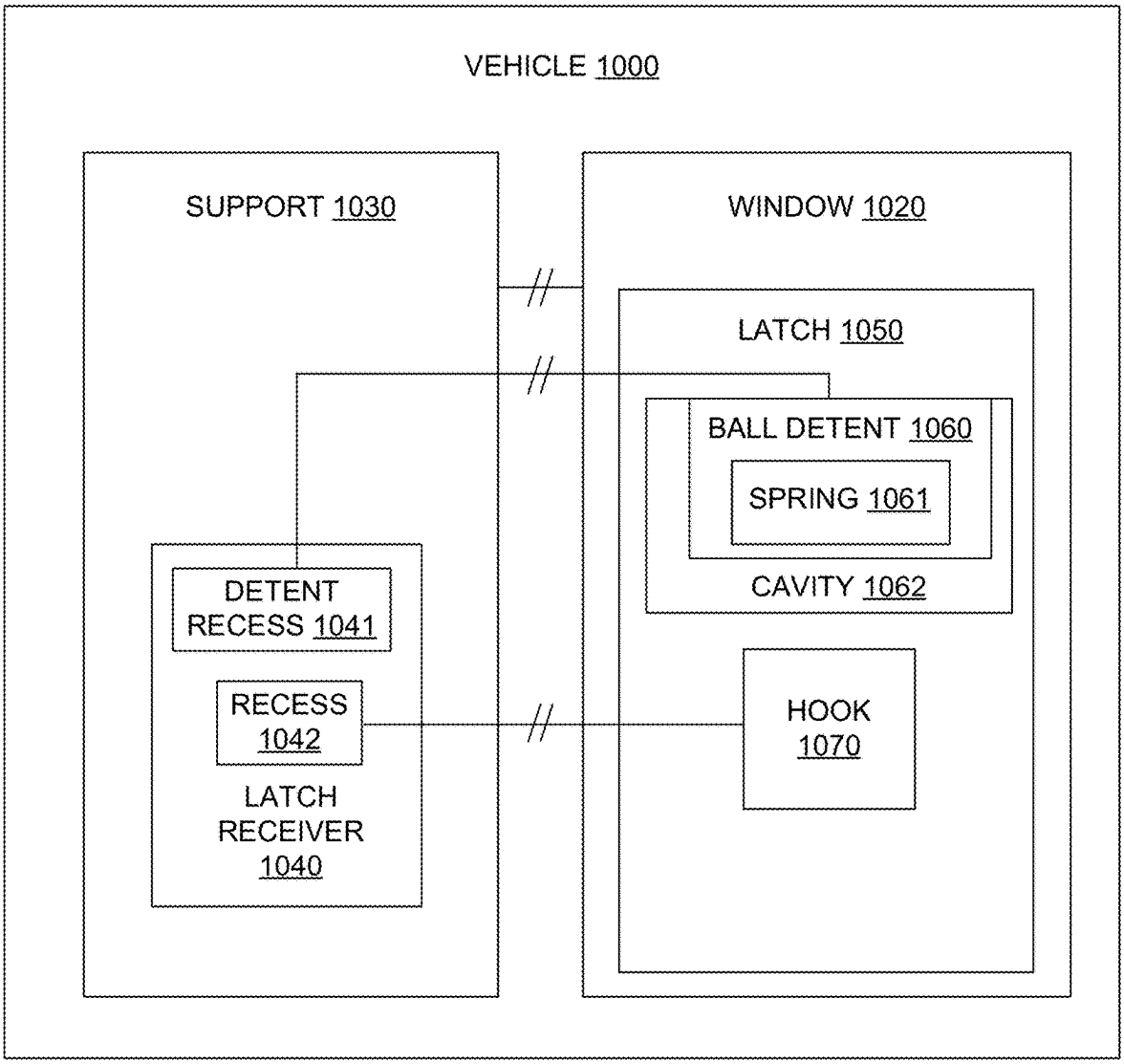

VEHICLE 1000
SUPPORT 1030
WINDOW 1020
LATCH 1050
BALL DETENT 1060
SPRING 1061
CAVITY 1062
DETENT RECESS 1041
RECESS 1042
LATCH RECEIVER 1040
HOOK 1070

FIG. 10

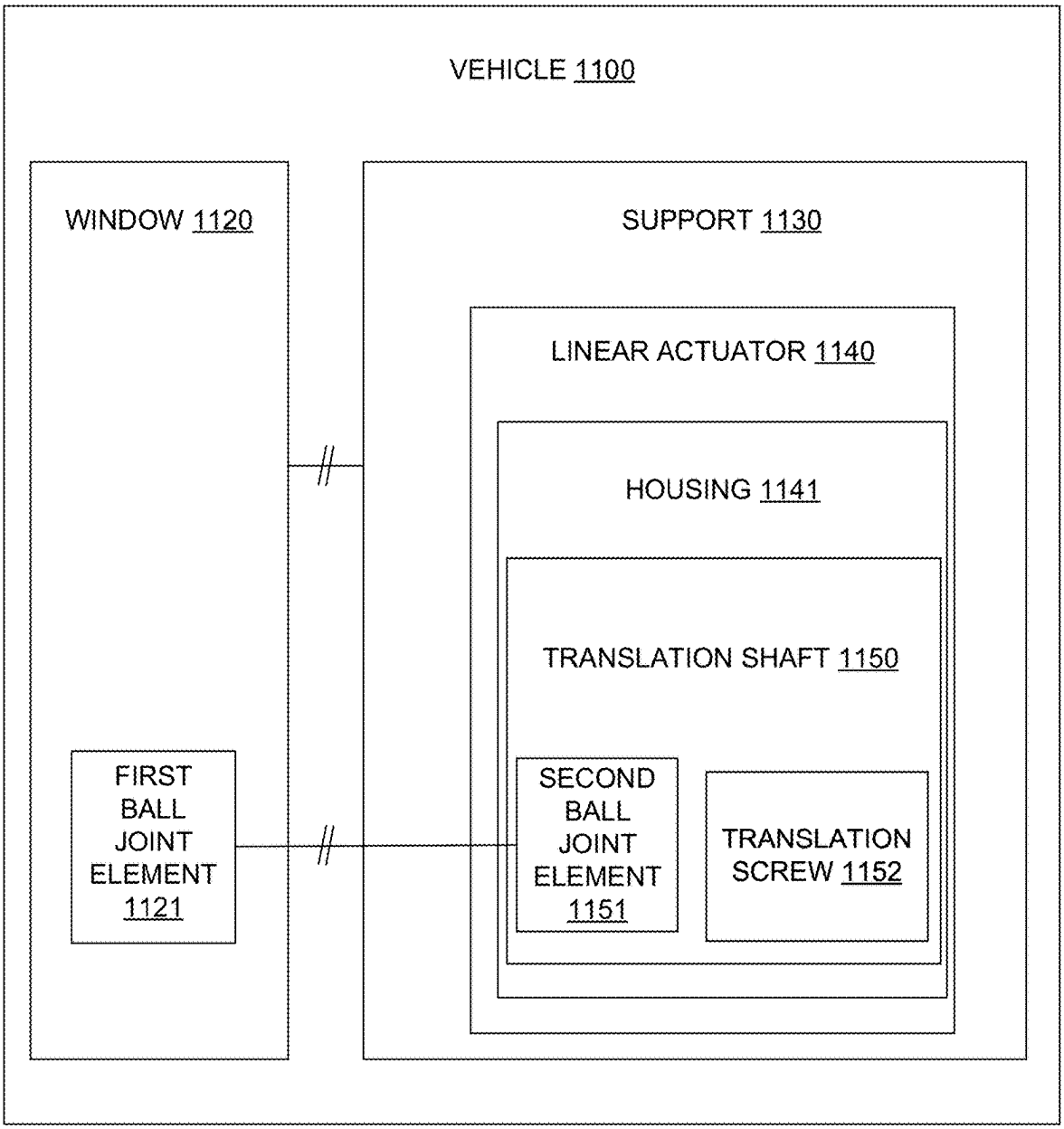

VEHICLE 1100
WINDOW 1120
SUPPORT 1130
LINEAR ACTUATOR 1140
HOUSING 1141
TRANSLATION SHAFT 1150
FIRST BALL JOINT ELEMENT 1121
SECOND BALL JOINT ELEMENT 1151
TRANSLATION SCREW 1152

FIG. 11

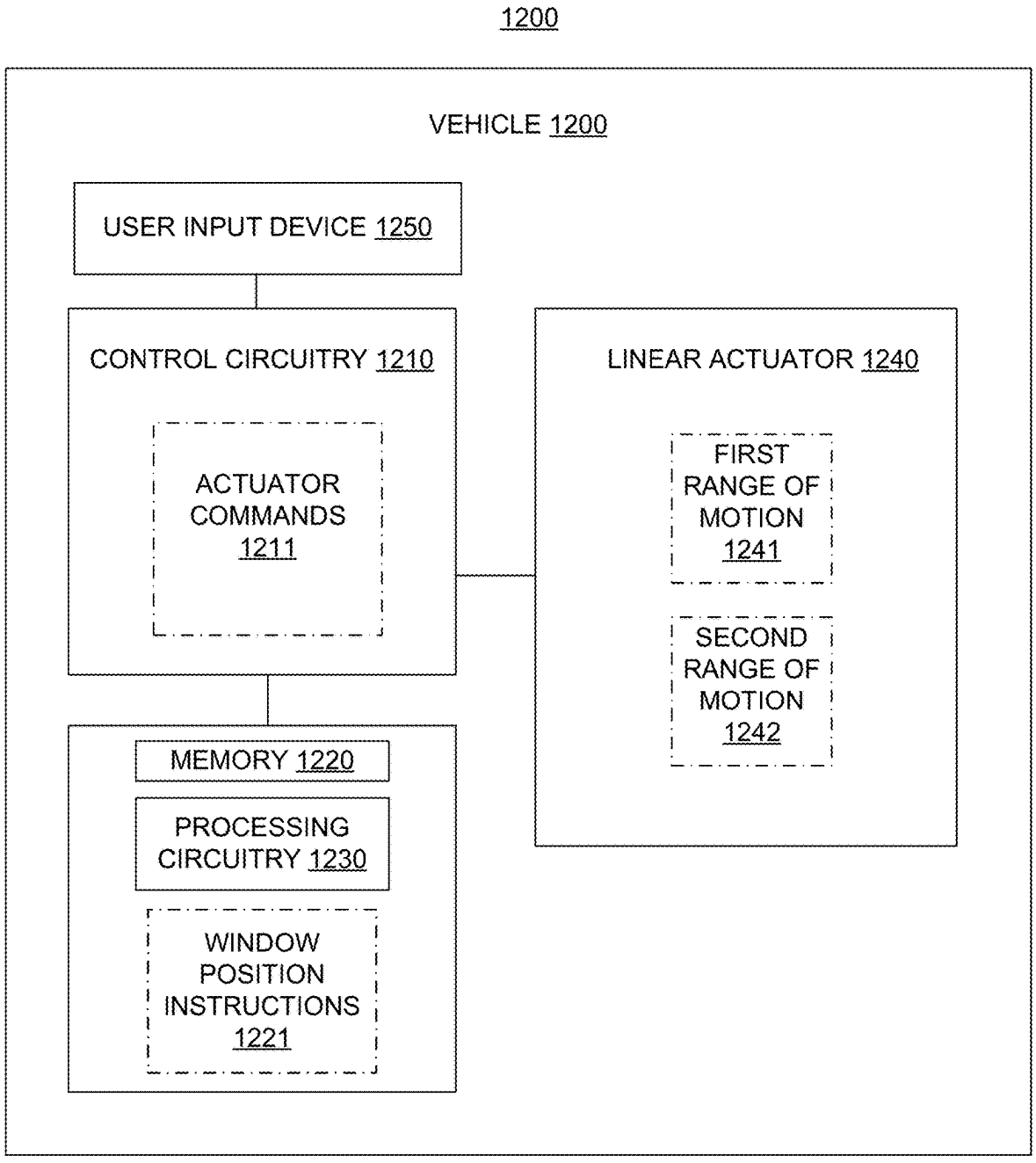

1200
VEHICLE 1200
USER INPUT DEVICE 1250
CONTROL CIRCUITRY 1210
ACTUATOR COMMANDS 1211
LINEAR ACTUATOR 1240
FIRST RANGE OF MOTION 1241
SECOND RANGE OF MOTION 1242
MEMORY 1220
PROCESSING CIRCUITRY 1230
WINDOW POSITION INSTRUCTIONS 1221

FIG. 12

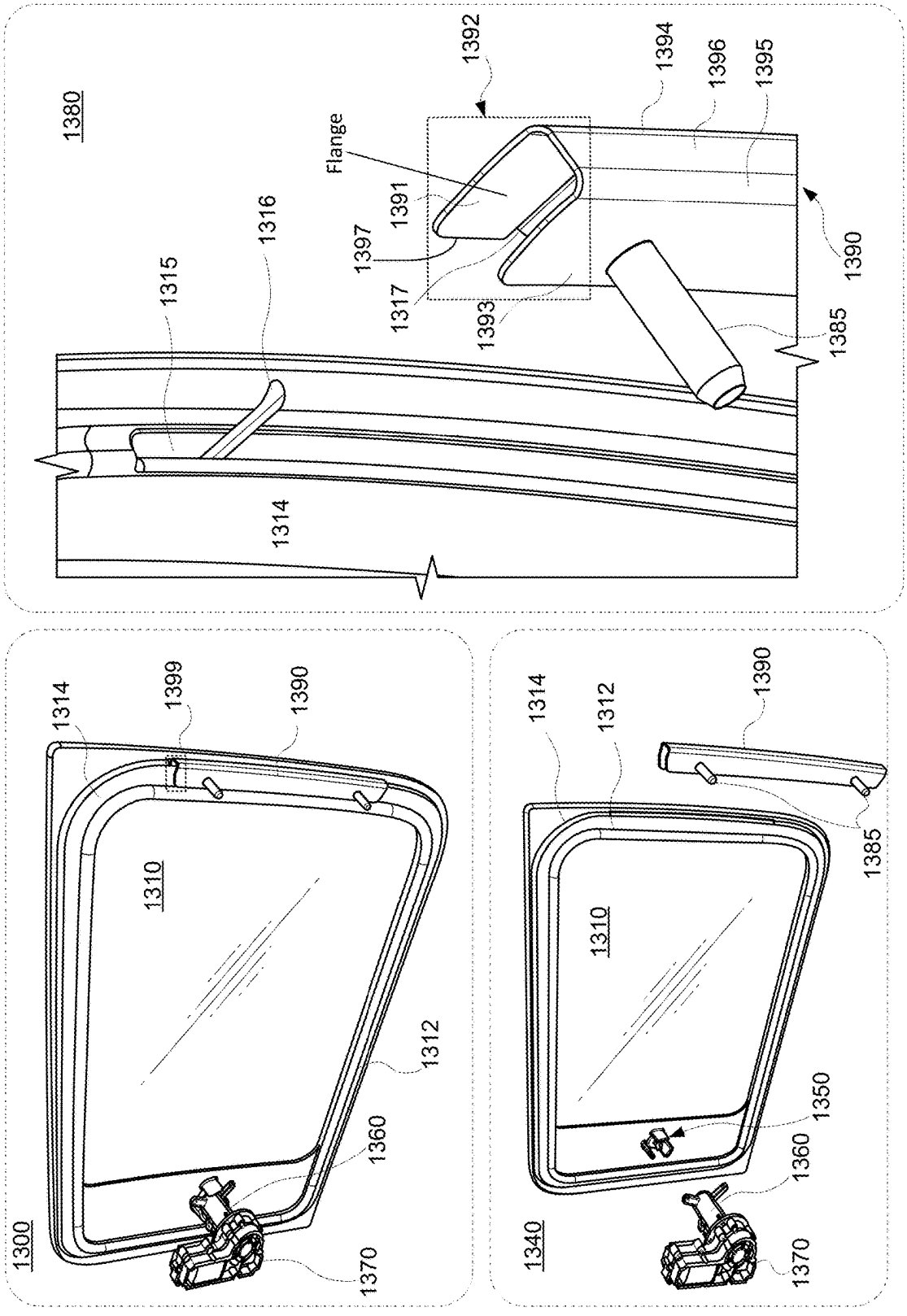

1380
1392
1394
1396
1395
Flange
1391
1316
1315
1397
1317
1393
1390
1385
1314
1399
1310
1312
1360
1370
1300
1340
1350

FIG. 13

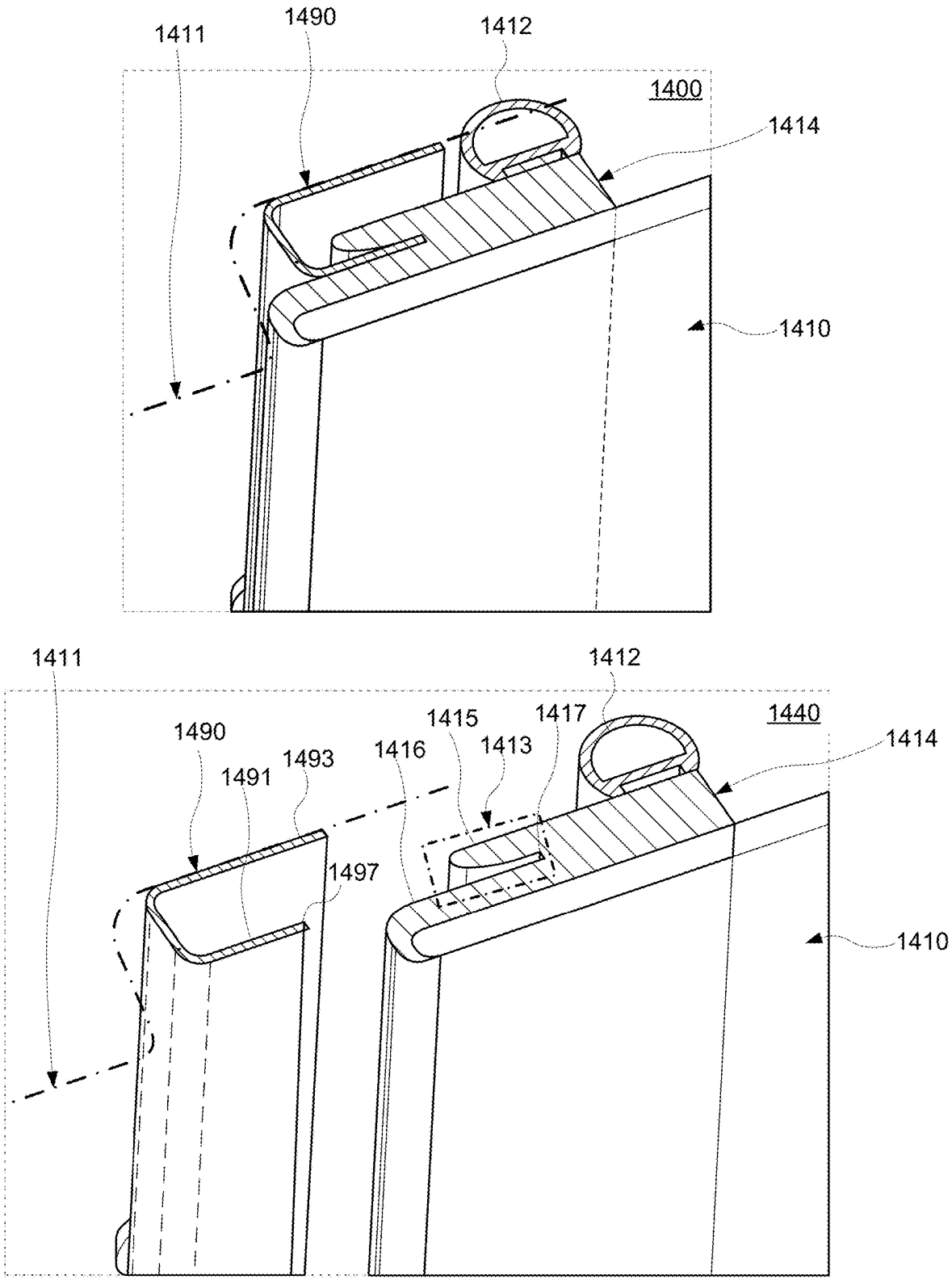

1411
1490
1412
1400
1414
1410
1411
1412
1490
1491
1493
1415
1417
1416
1413
1440
1414
1497
1410

FIG. 14

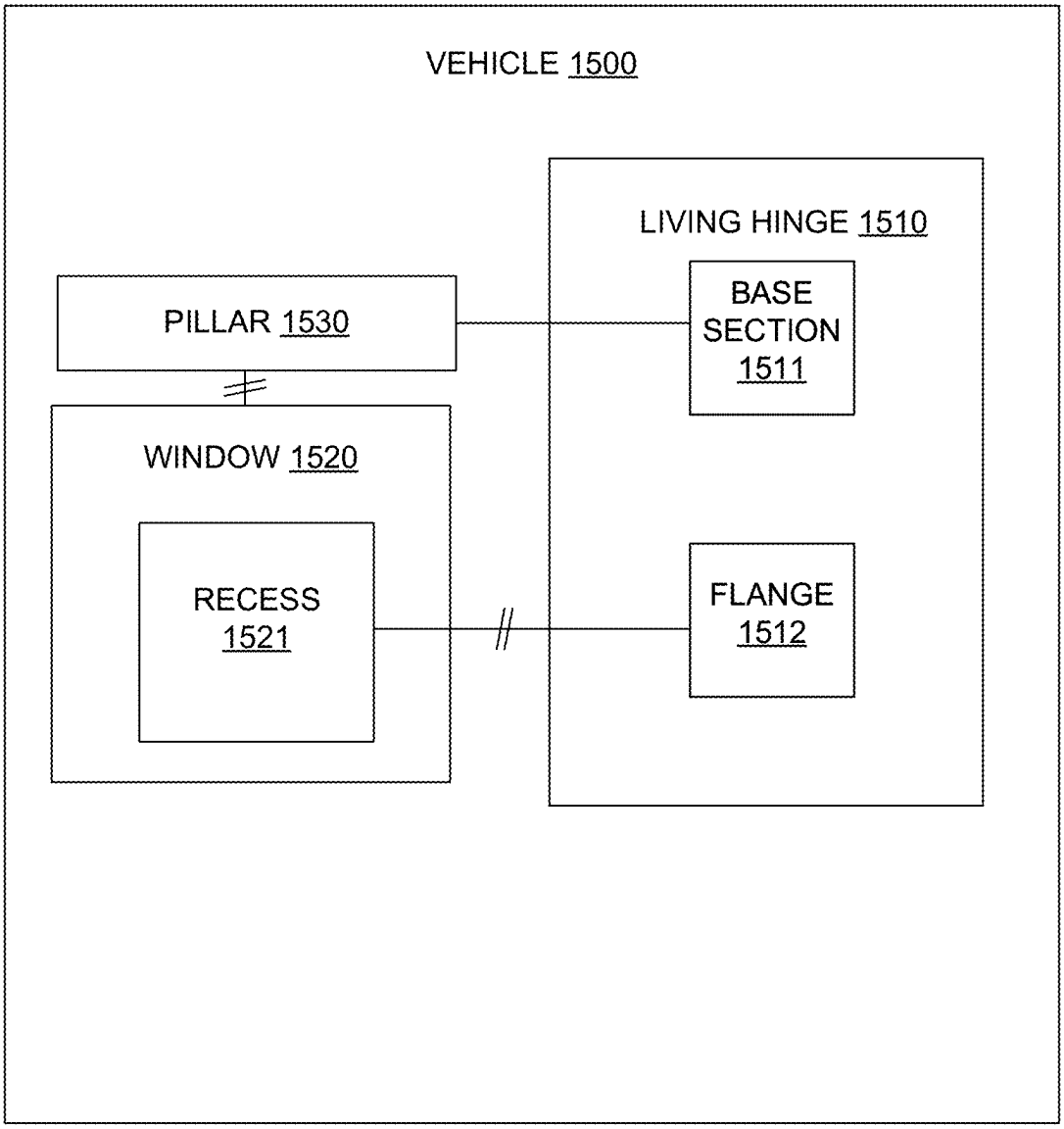

VEHICLE 1500
LIVING HINGE 1510
BASE SECTION 1511
PILLAR 1530
WINDOW 1520
RECESS 1521
FLANGE 1512

FIG. 15

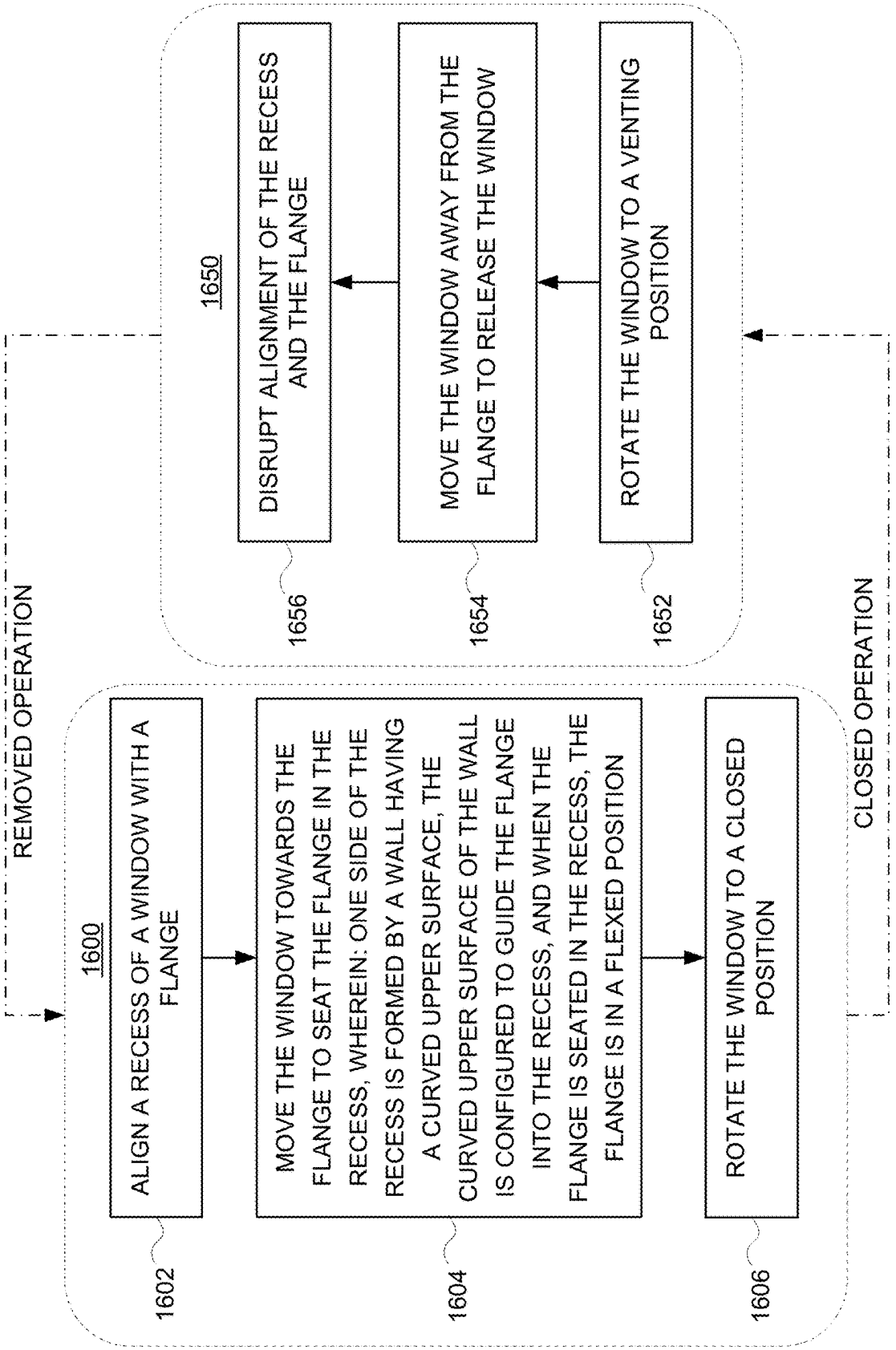
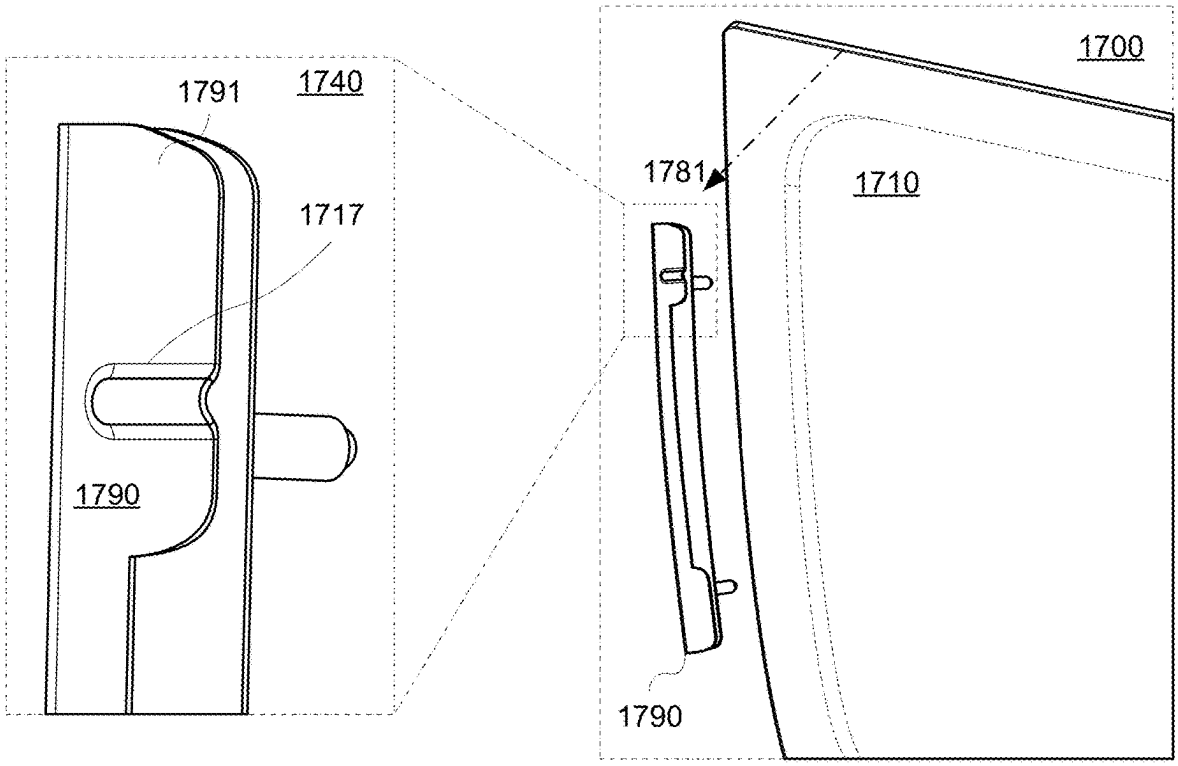

REMOVED OPERATION
1600
ALIGN A RECESS OF A WINDOW WITH A FLANGE
1602
MOVE THE WINDOW TOWARDS THE FLANGE TO SEAT THE FLANGE IN THE RECESS, WHEREIN: ONE SIDE OF THE RECESS IS FORMED BY A WALL HAVING A CURVED UPPER SURFACE, THE CURVED UPPER SURFACE OF THE WALL IS CONFIGURED TO GUIDE THE FLANGE INTO THE RECESS, AND WHEN THE FLANGE IS SEATED IN THE RECESS, THE FLANGE IS IN A FLEXED POSITION
1604
ROTATE THE WINDOW TO A CLOSED POSITION
1606
CLOSED OPERATION
1650
DISRUPT ALIGNMENT OF THE RECESS AND THE FLANGE
1656
MOVE THE WINDOW AWAY FROM THE FLANGE TO RELEASE THE WINDOW
1654
ROTATE THE WINDOW TO A VENTING POSITION
1652

FIG. 16


1791
1740
1717
1790
1700
1781
1710
1790

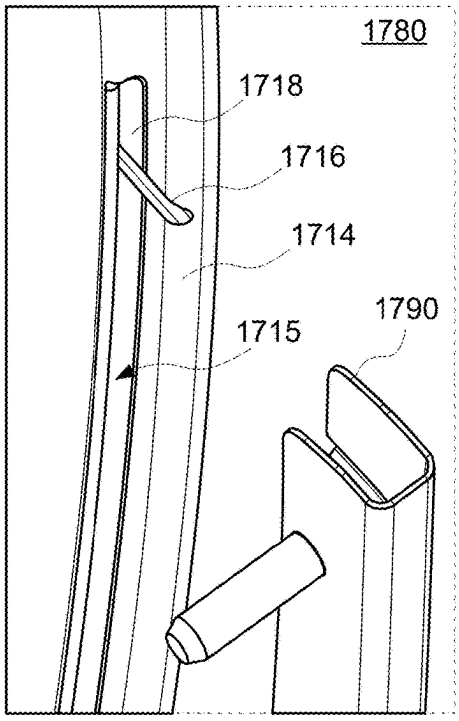

1780
1718
1716
1714
1790
1715

FIG. 17

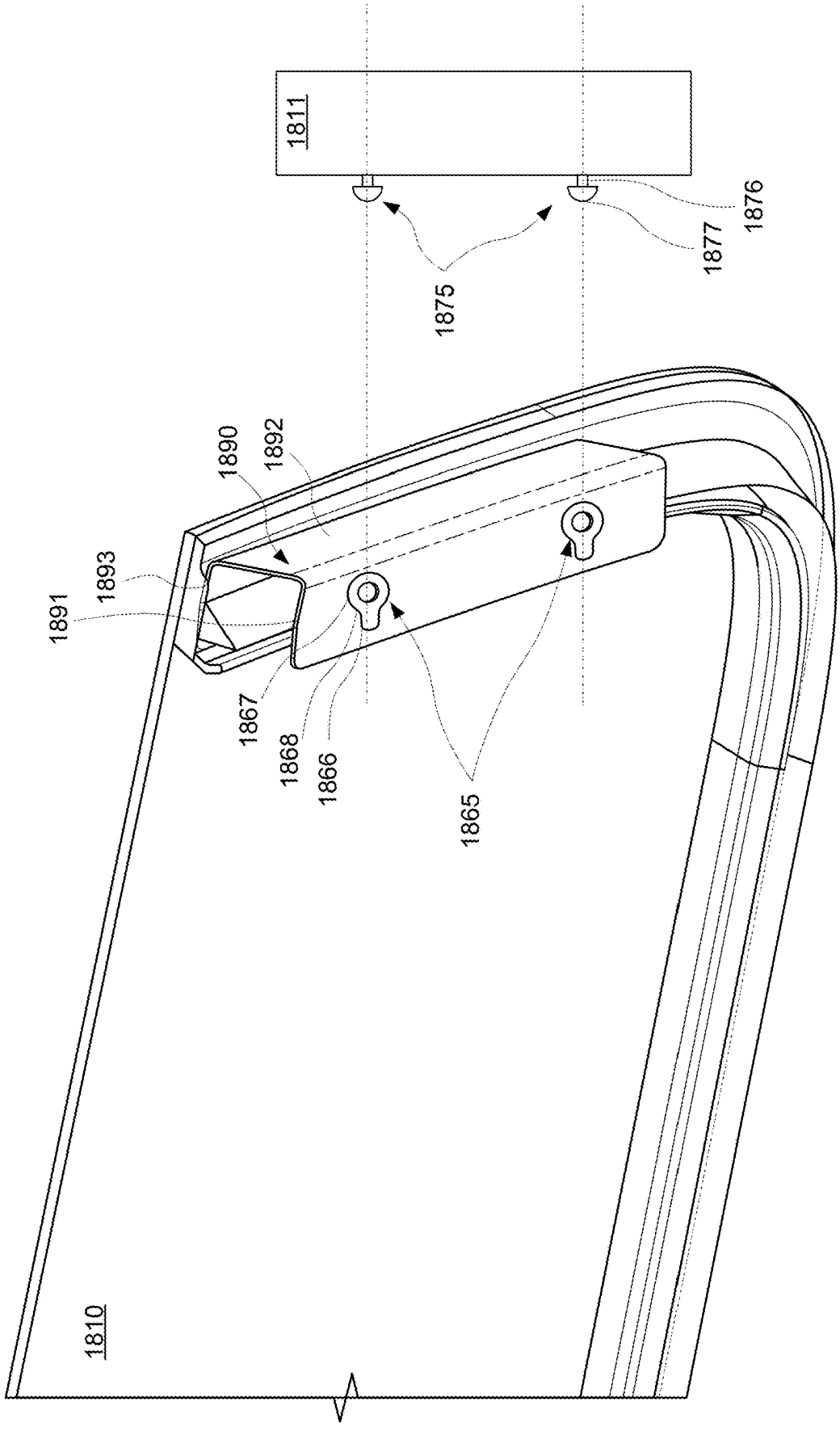

1811
1876
1877
1875
1890
1892
1893
1891
1867
1868
1866
1865
1810

FIG. 18

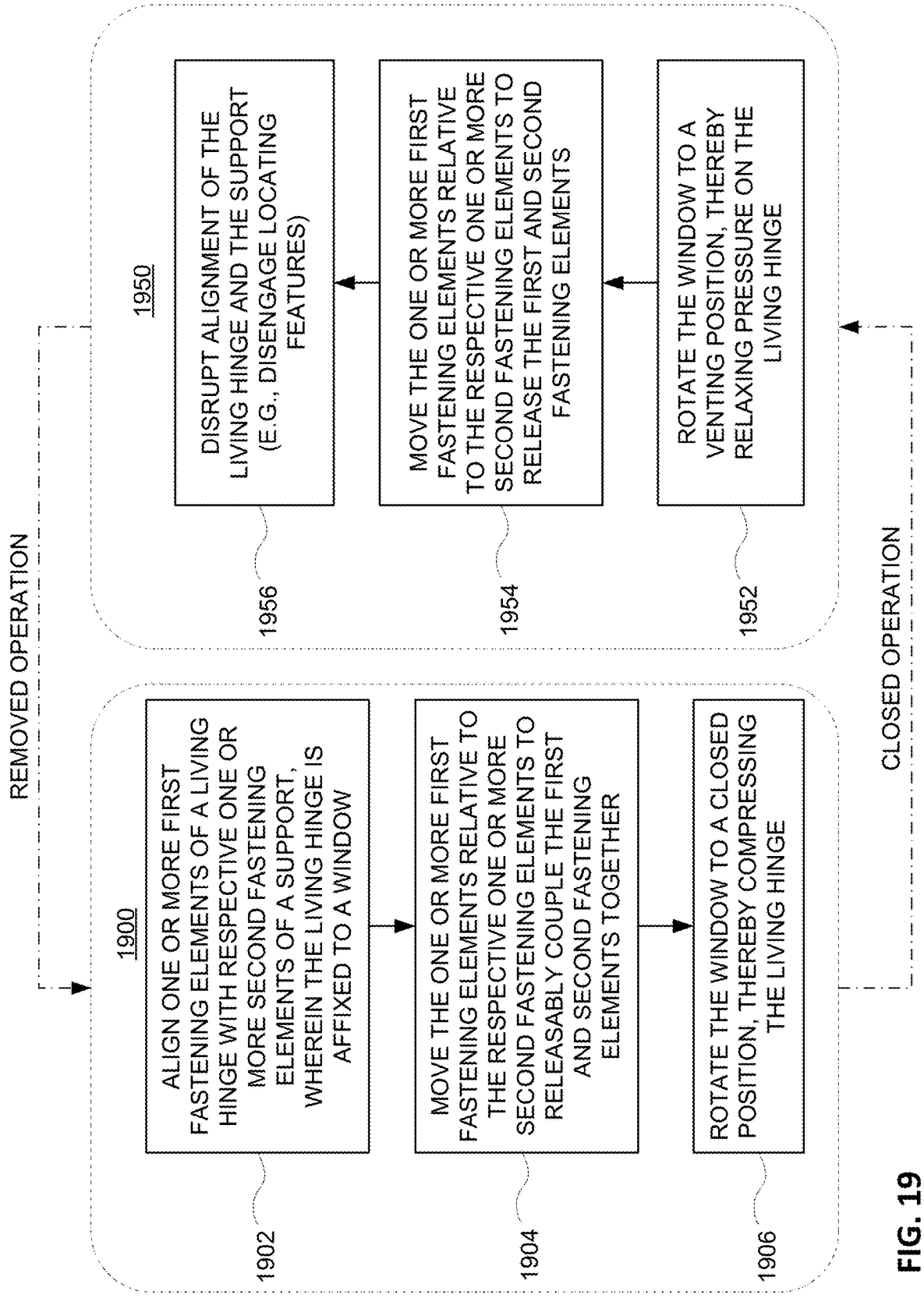

REMOVED OPERATION
1900
ALIGN ONE OR MORE FIRST FASTENING ELEMENTS OF A LIVING HINGE WITH RESPECTIVE ONE OR MORE SECOND FASTENING ELEMENTS OF A SUPPORT, WHEREIN THE LIVING HINGE IS AFFIXED TO A WINDOW
1902
MOVE THE ONE OR MORE FIRST FASTENING ELEMENTS RELATIVE TO THE RESPECTIVE ONE OR MORE SECOND FASTENING ELEMENTS TO RELEASABLY COUPLE THE FIRST AND SECOND FASTENING ELEMENTS TOGETHER
1904
ROTATE THE WINDOW TO A CLOSED POSITION, THEREBY COMPRESSING THE LIVING HINGE
1906
CLOSED OPERATION
1950
DISRUPT ALIGNMENT OF THE LIVING HINGE AND THE SUPPORT (E.G., DISENGAGE LOCATING FEATURES)
1956
MOVE THE ONE OR MORE FIRST FASTENING ELEMENTS RELATIVE TO THE RESPECTIVE ONE OR MORE SECOND FASTENING ELEMENTS TO RELEASE THE FIRST AND SECOND FASTENING ELEMENTS
1954
ROTATE THE WINDOW TO A VENTING POSITION, THEREBY RELAXING PRESSURE ON THE LIVING HINGE
1952

FIG. 19

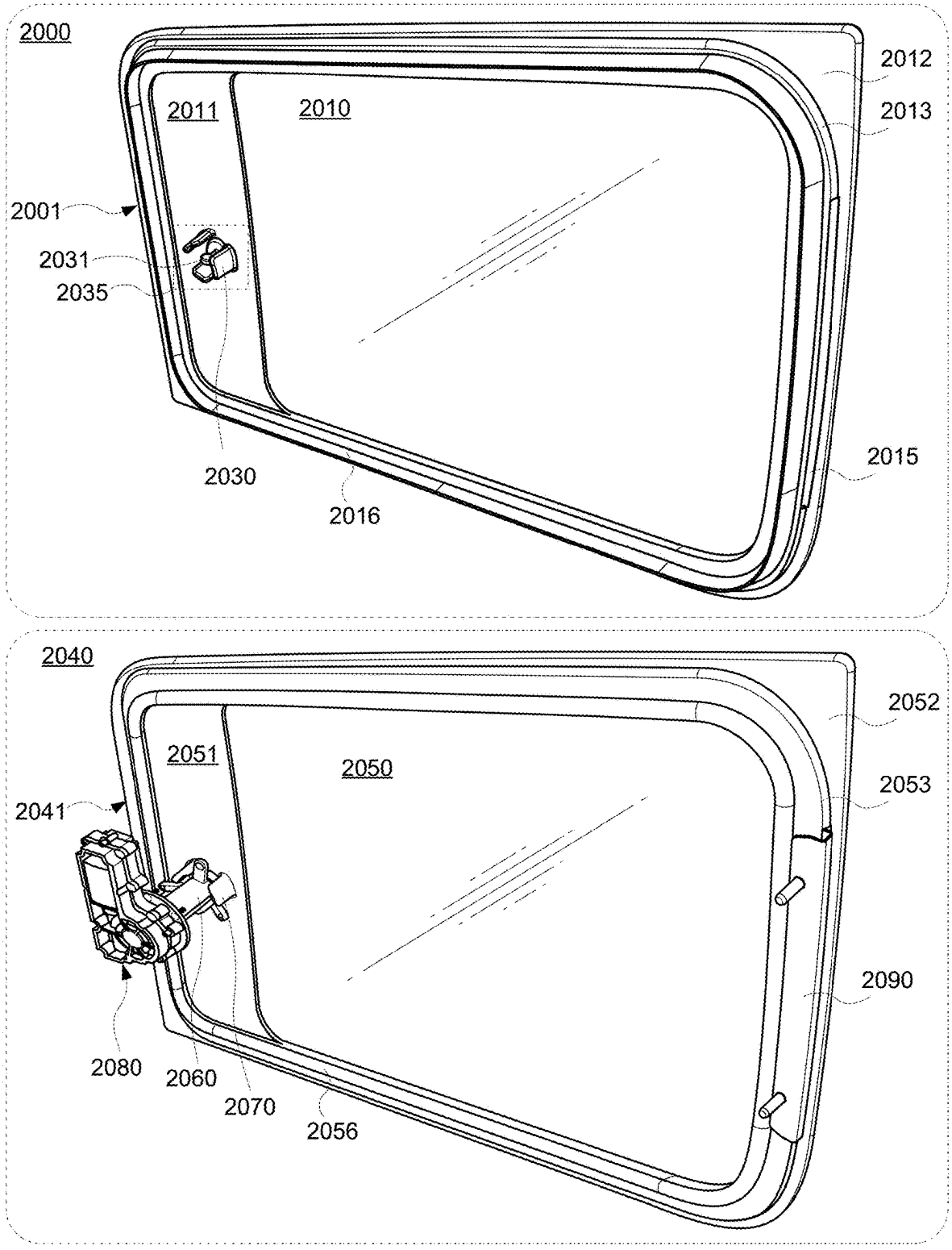

2000
2012
2011
2010
2013
2001
2031
2035
2030
2015
2016
2040
2052
2051
2050
2053
2041
2090
2080
2060
2070
2056

FIG. 20

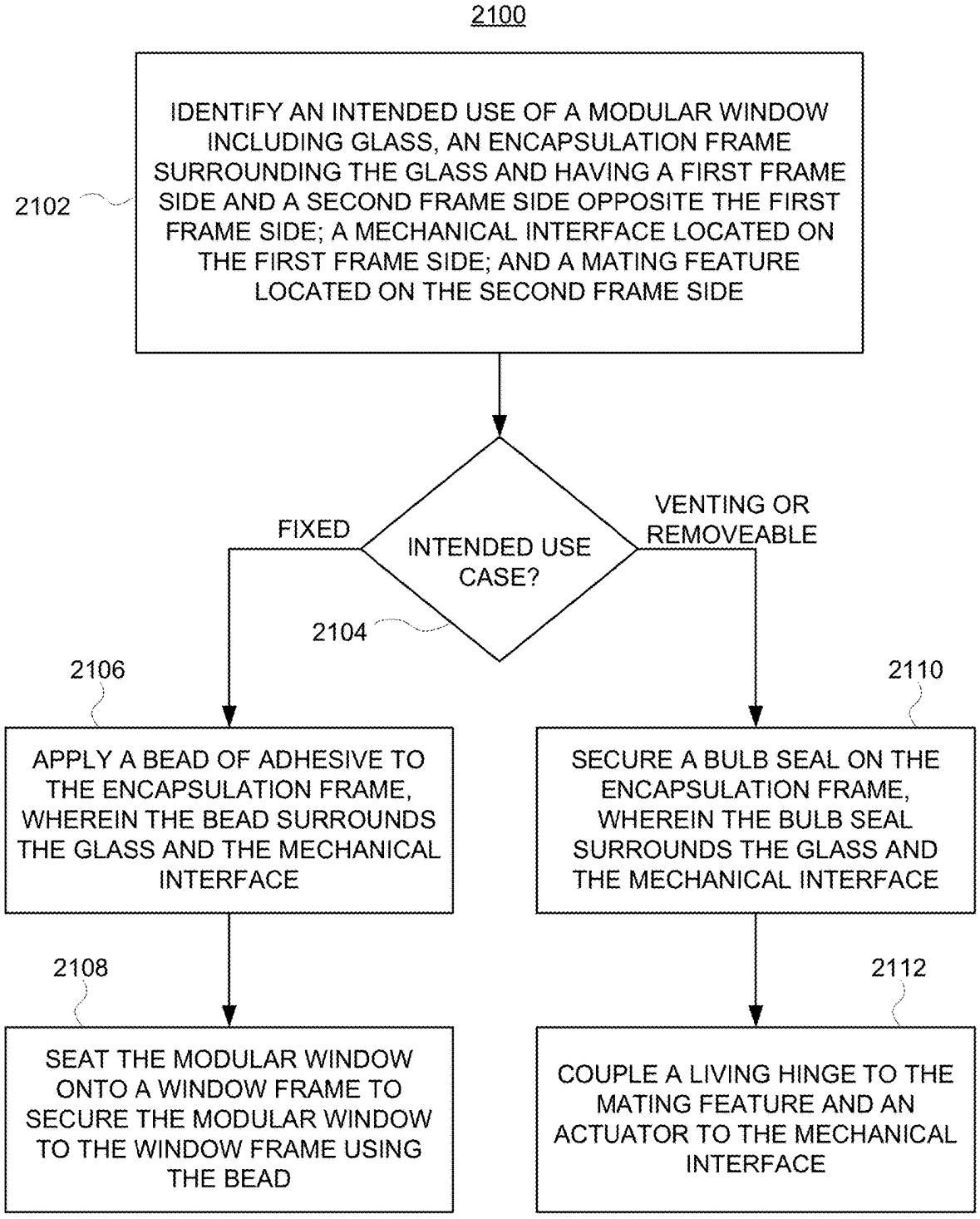

2100
IDENTIFY AN INTENDED USE OF A MODULAR WINDOW INCLUDING GLASS, AN ENCAPSULATION FRAME SURROUNDING THE GLASS AND HAVING A FIRST FRAME SIDE AND A SECOND FRAME SIDE OPPOSITE THE FIRST FRAME SIDE; A MECHANICAL INTERFACE LOCATED ON THE FIRST FRAME SIDE; AND A MATING FEATURE LOCATED ON THE SECOND FRAME SIDE
2102
INTENDED USE CASE?
2104
FIXED
VENTING OR REMOVEABLE
2106
APPLY A BEAD OF ADHESIVE TO THE ENCAPSULATION FRAME, WHEREIN THE BEAD SURROUNDS THE GLASS AND THE MECHANICAL INTERFACE
2108
SEAT THE MODULAR WINDOW ONTO A WINDOW FRAME TO SECURE THE MODULAR WINDOW TO THE WINDOW FRAME USING THE BEAD
2110
SECURE A BULB SEAL ON THE ENCAPSULATION FRAME, WHEREIN THE BULB SEAL SURROUNDS THE GLASS AND THE MECHANICAL INTERFACE
2112
COUPLE A LIVING HINGE TO THE MATING FEATURE AND AN ACTUATOR TO THE MECHANICAL INTERFACE

FIG. 21

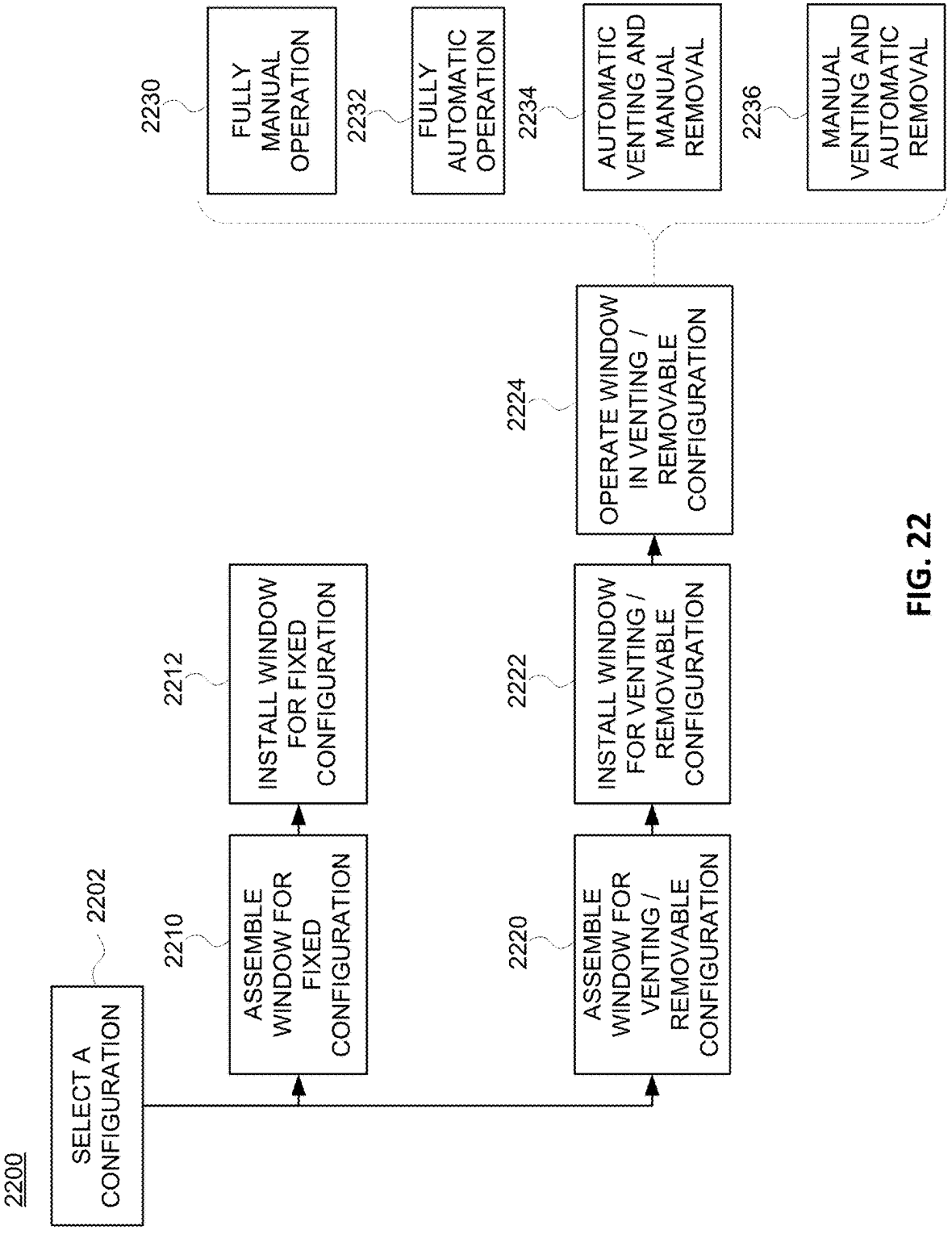

2200
SELECT A CONFIGURATION
2202
ASSEMBLE WINDOW FOR FIXED CONFIGURATION
2210
INSTALL WINDOW FOR FIXED CONFIGURATION
2212
ASSEMBLE WINDOW FOR VENTING / REMOVABLE CONFIGURATION
2220
INSTALL WINDOW FOR VENTING / REMOVABLE CONFIGURATION
2222
OPERATE WINDOW IN VENTING / REMOVABLE CONFIGURATION
2224
2230
FULLY MANUAL OPERATION
2232
FULLY AUTOMATIC OPERATION
2234
AUTOMATIC VENTING AND MANUAL REMOVAL
2236
MANUAL VENTING AND AUTOMATIC REMOVAL

FIG. 22

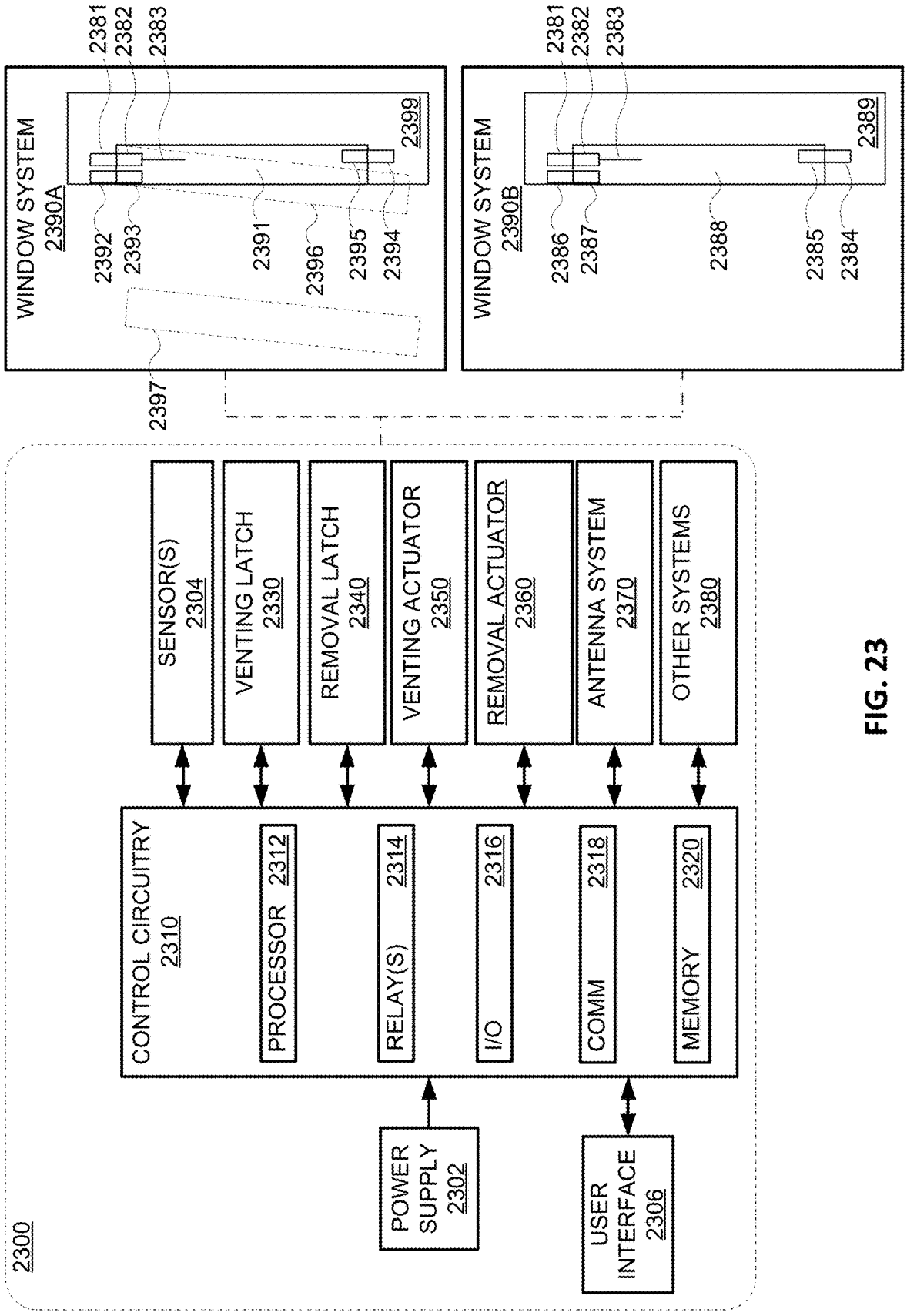

2300
CONTROL CIRCUITRY 2310
PROCESSOR 2312
RELAY(S) 2314
I/O 2316
COMM 2318
MEMORY 2320
POWER SUPPLY 2302
USER INTERFACE 2306
SENSOR(S) 2304
VENTING LATCH 2330
REMOVAL LATCH 2340
VENTING ACTUATOR 2350
REMOVAL ACTUATOR 2360
ANTENNA SYSTEM 2370
OTHER SYSTEMS 2380
2397
WINDOW SYSTEM 2390A
2381
2382
2383
2392
2393
2391
2396
2395
2394
2399
WINDOW SYSTEM 2390B
2386
2387
2388
2385
2384
2389

FIG. 23

REMOVABLE POP OUT WINDOWS AND CORRESPONDING LATCHES, ACTUATORS, LIVING HINGES, AND MODULAR DESIGNS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/552,777, filed Feb. 13, 2024, and U.S. Provisional Patent Application No. 63/559,595, filed Feb. 29, 2024, the disclosures of which are hereby incorporated by reference herein in their entireties.

INTRODUCTION

[0002] The present disclosure is directed to a removable pop out window and corresponding latches and actuators. In some embodiments, the present disclosure is directed to apparatuses, assemblies, systems, and methods for implementing a window that is configurable for multiple positions, including closed, vented, removable (e.g., pop out) positions, and combination thereof.

[0003] The present disclosure is also directed to living hinges and modular designs for removable pop out windows. In some embodiments, the present disclosure is directed to living hinges, modular designs, and related apparatuses, assemblies, systems, and methods for implementing a living hinge or a modular window that may, but need not, include the living hinge.

SUMMARY

[0004] In accordance with the present disclosure, apparatuses, assemblies, linear actuators, and related methods of operation are disclosed for implementing a window that is configurable for multiple positions including closed, vented, and removable positions. In some embodiments, a vehicle includes a window that is coupled to one or more of the abovementioned apparatuses, assemblies, and linear actuators. For example, users or drivers of the vehicle may configure the window to be in the closed position (e.g., for security, quiet driving, intra-vehicle climate control, any other suitable purpose, or any combination thereof), in the vented position (e.g., for letting air into the cabin without exposing a large volume of the vehicle, any other suitable purpose, or any combination thereof), or in the removable position (e.g., for recreation, maximizing airflow into the cabin, adventure sporting, convertible-like driving, any other suitable purpose, or any combination thereof).

[0005] In accordance with the present disclosure, living hinges, modular designs, and related apparatuses, assemblies, systems, and methods for implementing a living hinge or a modular window that may, but need not, include the living hinge are disclosed. In some embodiments, a vehicle includes a living hinge that releasably couples a window to a frame and/or support of the vehicle. For example, the living hinge may attach or detach from a frame or support and may similarly attach or detach from a window, such that the window is releasably coupled to the vehicle. In some embodiments, the living hinge includes a flange section that interfaces with a recess of a window or includes fasteners configured for releasable mating with a support, and the living hinge includes a base section that is affixed to a window or support. Therefore, the living hinge is releasably mated with at least one of the window or the support. In some embodiments, a modular window is configurable to be incorporated in a fixed installation (e.g., the window cannot be removed from a support structure without undue burden) and a removable installation (e.g., the window can be readily attached or detached from a support structure). Therefore, manufacturers of the vehicle can use the single modular window to serve multiple customer preferences (e.g., a fixed or a removable window installation).

[0006] In some embodiments, the present disclosure is directed to a modular window that includes glass, an encapsulation frame, a mechanical interface, and a mating feature. In some embodiments, the encapsulation frame surrounds the glass and has a first frame side and a second frame side opposite the first frame side, the mechanical interface is located on the first frame side, and the mating feature is located on the second frame side. In some embodiments, the encapsulation frame includes a region surrounding the glass and the mechanical interface. In some such embodiments, when the modular window is installed in a fixed installation, the region is configured to receive a glue bead, and when the modular window is installed in a venting or removable installation, the region is configured to receive a bulb seal. In some embodiments, the mating feature is located outside of the region. In some embodiments, the mechanical interface includes a ball of a ball joint and a plurality of protrusions surrounding the ball that extend away from the first frame side a greater amount than the ball. In some embodiments, the plurality of protrusions includes three protrusions. In some embodiments, the mating feature includes a slot configured to receive a flange. In some embodiments, the slot includes at least one location feature configured to mate with at least one corresponding locating feature of the flange. In some embodiments, the slot includes at least one recess in a sidewall of the slot, the flange includes at least one ridge, and the at least one ridge prevents the flange from entering the slot unless the at least one ridge is aligned with the at least one recess. In some embodiments, when the modular window is installed in a fixed installation, the mechanical interface does not interface with any corresponding structure, and when the modular window is installed in a vented or removable installation, the mechanical interface is coupled to an actuator.

[0007] In some embodiments, the present disclosure is directed to a modular window including glass, an encapsulation frame, a mechanical interface, a mating feature, and a glue bead. In some embodiments, the encapsulation frame surrounds the glass and has a first frame side and a second frame side opposite the first frame side, the mechanical interface is located on the first frame side, the mating feature is located on the second frame side, and the glue bead on the encapsulation frame surrounds the glass and the mechanical interface and secures the modular window to a frame. In some embodiments, the mechanical interface includes a ball joint feature and a plurality of protrusions that surround the ball joint feature. In some such embodiments, the plurality of protrusions extends away from the first frame side a greater amount than the ball joint feature, and the plurality of protrusions extend into corresponding recesses of the frame. In some embodiments, the mating feature is arranged outside the glue bead. In some embodiments, the mating feature includes a slot. In some embodiments, the slot includes at least one recess in a sidewall of the slot.

[0008] In some embodiments, the present disclosure is directed to a modular window that includes glass, an encapsulation frame, a mechanical interface, a bulb seal, an

actuator, and a living hinge. In some embodiments, the encapsulation frame surrounds the glass and has a first frame side and a second frame side opposite the first frame side, the mechanical interface is located on the first frame side, the bulb seal is secured to the encapsulation frame (e.g., seated against such that it does not move independently when secured), the bulb seal surrounds the glass and the mechanical interface, the actuator is configured to be releasably secured to the mechanical interface, and the living hinge is coupled to the second frame side. In some embodiments, the second frame side includes a mating feature. In some embodiments, the mating feature is located outside of the bulb seal and includes a slot configured to receive a flange of the living hinge. In some embodiments, the mechanical interface includes a first ball joint feature of a ball joint and the actuator includes a second ball joint feature of the ball joint.

[0009] In some embodiments, the present disclosure is directed to a method of assembling modular window that includes glass, an encapsulation frame, a mechanical interface, a mating feature, and a glue bead. In some embodiments, the method includes identifying an intended use of the modular window, applying a bead of glue to the encapsulation frame that surrounds the glass and the mechanical interface, and seating the modular window onto a frame to secure the modular window to the frame using the bead of glue.

[0010] In some embodiments, the present disclosure is directed to a method of assembling modular window that includes glass, an encapsulation frame, a mechanical interface, a mating feature, a bulb seal, a living hinge, and an actuator. In some embodiments, the method includes identifying an intended use of the modular window, and in response to the intended use being one of venting or removable, securing a bulb seal on the encapsulation frame, coupling a living hinge to the mating feature, and coupling an actuator to the mechanical interface.

[0011] In some embodiments, the present disclosure is directed to an apparatus that includes a latch receiver having a first main body and a recess, and a latch having a second main body rotatably coupled to the latch receiver about a hinge axis and a hook at an end of the second main body. In some embodiments, when the second main body is rotated against the first main body, the hook is clear of the recess such that the latch is detachable from the latch receiver. In some embodiments, as the second main body is rotated away from the first main body, the hook enters the recess. In some embodiments, the apparatus includes at least one detent feature that couples the latch to the latch receiver to form a rotatable coupling about the hinge axis. In some embodiments, the latch includes a first cavity along a first edge and a second cavity along a second edge opposite the first edge. In some embodiments, the apparatus includes a first ball detent positioned in the first cavity and a second ball detent positioned in the second cavity, where the hinge axis passes through the first ball detent and the second ball detent. In some such embodiments, the latch receiver includes first and second detent recess features configured to respectively receive the first and second ball detents. In some such embodiments, the first ball detent has a first spring applying a force on a first ball, the second ball detent has a second spring applying a force on a second ball, and when a lateral force is applied to the latch, opposing forces are applied by the first and second recesses on the first and second balls, which cause the first and second balls to respectively compress the first and second springs, thereby enabling the latch to detach from the latch receiver. In some embodiments, the latch receiver is configured to be coupled to a support, and the latch is configured to be coupled to a window and to enable rotation of the window from a closed position to a vented position. In some embodiments, when the window is in the closed position, the second main body is rotated away from the first main body and the hook is positioned in the recess. In some embodiments, when the window is in the vented position, the second main body is rotated closer to the first main body and the hook is at least partially positioned in the recess. In some such embodiments, the latch is configured to enable rotation of the window from the vented position to a removable position, and when the window is in the removable position, the second main body is rotated against the first main body and the hook is clear of the recess of the latch receiver. In some embodiments, the latch receiver includes a protrusion, the latch includes a recess proximate a second end of the second main body, and when the second main body is rotated away from the first main body, the protrusion of the latch receiver enters the recess of the latch such that an interface between the protrusion of the latch receiver and the recess of the latch prevents a lateral force from detaching the latch from the latch receiver.

[0012] In some embodiments, the present disclosure is directed to an assembly having a window, a window frame against which the window is configured to close, a latch receiver, and a latch. For example, the latch receiver has a first main body and a recess, and is coupled to the window frame. In a further example, the latch has a second main body rotatably coupled to the latch receiver about a hinge axis and a hook at an end of the second main body, and is coupled to the window. In some embodiments, when the second main body is rotated against the first main body, the hook is clear of the recess such that the latch is detachable from the latch receiver and the window is detachable from the window frame. In some embodiments, as the second main body is rotated away from the first main body, the hook enters the recess. In some embodiments, when the second main body is rotated away from the first main body and the hook is positioned in the recess, the window is in a closed position and an interface between the latch receiver and the hook prevents the latch from being detached from the latch receiver. In some embodiments, when the second main body is rotated against the first main body and a lateral force is applied to the latch, the latch detaches from the latch receiver. In some embodiments, the assembly includes a first ball detent and a second ball detent, respectively positioned in first and second cavities of the latch, where the first cavity of the latch is along a first edge and the second cavity of the latch is along a second edge opposite the first edge, and where the hinge axis passes through the first ball detent and the second ball detent. In some embodiments, the first ball detent has a first spring applying a force on a first ball, the second ball detent has a second spring applying a force on a second ball, and when the lateral force is applied to the latch, opposing forces are applied by the first and second recesses on the first and second balls, which cause the first and second balls to respectively compress the first and second springs, thereby enabling the latch to detach from the latch body. In some embodiments, when the window is in a closed position, the second main body is rotated away from the first main body and the hook is positioned in the recess

of the latch receiver. In some embodiments, when the window is in the vented position, the second main body is rotated closer to the first main body and the hook is at least partially positioned in the recess of the latch receiver. In some embodiments, the present disclosure is directed to a window for a vehicle having an encapsulation frame and a latch coupled to the encapsulation frame. The encapsulation frame is configured to interface to a support arranged between pillars of the vehicle, for example. In some embodiments, in a closed configuration of the window, the latch is fully engaged with a latch receiver coupled to the support. In some embodiments, in a vented configuration of the window, the latch is partially engaged with the latch receiver. In some embodiments, in a removal configuration of the window, the latch is removable from the latch receiver. In some embodiments, the latch has a hook; the latch receiver has a recess; in the closed configuration, the hook is arranged fully in the recess; in the vented configuration, the hook is arranged partially in the recess; and in the removal configuration, the hook is clear of the recess. In some embodiments, the latch is detachably coupled to the latch receiver about a hinge axis, and the latch is configured to rotate relative to the latch receiver about the hinge axis. In some embodiments, the latch is configured to interface with a latch receiver or with a latch mount, and when engaged to the latch mount, the window remains in a closed configuration.

[0013] In some embodiments, the present disclosure is directed to a window disconnect having a keyed ball and a keyed socket configured to engage and disengage the keyed ball. In a first rotational orientation of the keyed socket, the keyed ball is locked in the keyed socket such that a window is locked. In a second rotational orientation of the keyed socket, the keyed ball is unlocked and removable from the keyed socket such that the window is removable. In some embodiments, the first rotational orientation and the second rotational orientation are between 80 and 100 degrees apart. In some embodiments, the keyed socket has a slot and the keyed ball has a ball having flats on opposite sides. In some such embodiments, in a first rotational orientation of the keyed socket, the flats are parallel with the sides of the slot such that the keyed ball can translate into and out of the keyed socket. Further, in a second rotational orientation of the keyed socket, the flats are misaligned with the sides of the slot such that the keyed ball cannot translate into or out of the keyed socket. In some embodiments, the window disconnect includes a base affixed to the window, and a collar rotatably coupled to the base, where the keyed socket is arranged at an end of the collar such that the keyed socket rotates with the collar. In some embodiments, the window disconnect includes an actuator coupled to the collar and configured to rotate the collar based on a control signal. In some embodiments, the window disconnect an arm coupled to the keyed ball, and an actuator that is coupled to the arm and configured to move the arm based on a control signal to cause the window to move relative to the support when the keyed ball is locked in the keyed socket. In some embodiments, the keyed ball is affixed to the window, and the keyed socket is coupled to a support. In some embodiments, the keyed ball is affixed to the window and the window disconnect includes an actuator coupled to the keyed socket and a support and that is configured to cause the keyed socket to translate and rotate. In some embodiments, the actuator is a linear actuator having a translation screw configured to rotate about an axis, a translation shaft configured to translate based on rotation of the translation screw, and a housing configured to control a rotational orientation of the translation shaft during translation. The translation shaft includes the keyed socket.

[0014] In some embodiments, the present disclosure is directed to a linear actuator having a translation screw configured to rotate about an axis, a translation shaft configured to translate based on rotation of the translation screw and having a ball joint element at an end, and a housing configured to control a rotational orientation of the translation shaft during translation. In some embodiments, during a first range of motion of the translation shaft, the rotational orientation is substantially constant, and during a second range of motion of the translation shaft, the rotational orientation varies. In some embodiments, the translation shaft has a groove along an exterior surface, and the housing has a boss that extends into the groove and controls the rotational orientation of the translation shaft. In some embodiments, the groove has a linear portion and a curved portion. During the first range of motion, the boss traverses the linear portion of the groove, and during the second range of motion, the boss traverses the curved portion of the groove. In some embodiments, the curved portion of the groove wraps at least 80 degrees around the translation shaft, and during the second range of motion, the translation shaft rotates at least 80 degrees while translating. In some embodiments, the ball joint element has a keyed socket configured to receive a keyed ball. During the first range of motion, the rotational orientation of the translation shaft maintains the keyed socket in a locked configuration relative to the keyed ball, and during the second range of motion, the translation shaft rotates the keyed socket into an unlocked configuration relative to the keyed ball. In some embodiments, the keyed ball is coupled to a window, and the first range of motion of the translation shaft causes the window to move from a closed position to a vented position. In some embodiments, the second range of motion of the translation shaft causes the window to move from the vented position to a removal position. In some embodiments, the present disclosure is directed to an apparatus having a window, a keyed ball coupled to the window, and a linear actuator. In some embodiments, the apparatus includes a hinge coupled to a first end of the window, and the first ball joint element is coupled proximate to a second end of the window opposite the first end. In some embodiments, the translation shaft has a groove having a linear portion and a curved portion, and the housing has a boss that extends into the groove and controls the rotational orientation of the translation shaft. During the first range of motion, the rotational orientation of the translation shaft maintains the keyed socket in a locked configuration relative to the keyed ball, during the second range of motion, the translation shaft rotates the keyed socket into an unlocked configuration relative to the keyed ball.

[0015] In some embodiments, the present disclosure is directed to a living hinge having a flange, one or more hinge sections connected to (e.g., in contact with such as abutting, including portions of a continuous component) the flange, and a base section connected to the one or more hinge sections (e.g., in contact with such as abutting, including portions of a continuous component). For example, the one or more hinge sections are configured to allow a window to move relative to a support, and the flange is configured to

allow removal of the window from the support. In some embodiments, the one or more hinge sections include a first curved hinge section, a second curved hinge section, and a planar section between the first curved hinge section and the second curved hinged section. For example, the flange, the one or more hinge sections, and the base section form a u-shape. In some embodiments, the flange has an end surface configured to interface to the window, and the base section is configured to be affixed to the support. In some embodiments, the window has a recess formed from two walls and a bottom, and the flange is configured to interface with the recess such that the end surface of the flange interfaces with the bottom of the recess and opposite sides of the flange interface with the two walls of the recess. In some embodiments, a first wall of the two walls is positioned between the flange and the base section, and a second wall of the two walls is taller than the first wall and extends beyond the one or more curved hinge sections. In some embodiments, the recess is located along an edge of the window. In some embodiments, the window includes an encapsulation frame surrounding glass and wherein the recess located in the encapsulation frame. In some embodiments, the flange is configured to be affixed to the support, and the base section is configured to be affixed to the window. In some embodiments, the flange has one or more first fastening elements each having a large opening and a small opening, and the one or more second fastening elements each has a protrusion having a head and a neck coupling the head to the support. The large opening is sized to receive the head, and the small opening is sized to retain the head. In some embodiments, the one or more first fastening elements each further includes a choke point between the large opening and the small opening, and each choke point provides a snap-fit connection (e.g., a contact interface where a force is applied to lock the components together past some resistance to secure the interface) with the neck of a respective mushroom-head protrusion. In some embodiments, the window frame includes an encapsulation frame surrounding glass and the base section of the living hinge is affixed to a side of the encapsulation frame.

[0016] In some embodiments, the present disclosure is directed to a window having glass, an encapsulation frame affixed to the glass, and a living hinge. The living hinge includes a flange configured to be affixed to a support, and a base section coupled to the flange and configured to be affixed to the encapsulation frame, for example. The flange is capable of flexing relative to the base section. In some embodiments, the flange includes one or more first fastening elements each having a large opening and a small opening, and the one or more second fastening elements each has a protrusion comprising a head and a neck coupling the head to the support. The large opening is sized to receive the head, and the small opening is sized to retain the head. In some embodiments, the one or more first fastening elements each further includes a choke point between the large opening and the small opening, and each choke point provides a snap-fit connection with the neck of a respective mushroom-head protrusion. In some embodiments, the present disclosure is directed to a vehicle having a support and a window configured to interface with the support. The window includes a living hinge configured to couple the window to the support. The living hinge includes a flange, one or more hinge sections affixed to the flange, and a base section affixed to the one or more hinge sections opposite the flange. The flange is capable of flexing relative to the base section to allow the window to move relative to the support. In some embodiments, the flange has one or more first fastening elements each having a large opening and a small opening, and the one or more second fastening elements each has a protrusion having a head and a neck coupling the head to the support. The large opening is sized to receive the head, and the small opening is sized to retain the head. In some embodiments, the one or more first fastening elements each further includes a choke point between the large opening and the small opening, and each choke point provides a snap-fit connection with the neck of a respective mushroom-head protrusion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The above and other objects and advantages of the disclosure will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

[0018] FIG. **1** is an illustrative depiction of a window that is configurable for multiple positions based on a latch apparatus, in accordance with some embodiments of the present disclosure;

[0019] FIG. **2** is an illustrative depiction showing configurable states of a window and corresponding states of a latch apparatus, in accordance with some embodiments of the present disclosure;

[0020] FIG. **3** is an illustrative depiction of configurable coupling between a latch and a latch receiver, in accordance with some embodiments of the present disclosure;

[0021] FIG. **4** is an illustrative depiction of a configurable interface including a window, a support, and a latch apparatus, in accordance with some embodiments of the present disclosure;

[0022] FIG. **5** is an illustrative depiction of a window disconnect, in accordance with some embodiments of the present disclosure;

[0023] FIG. **6** shows a perspective, exploded view of the illustrative linear actuator of FIG. **6** having multiple modes of translation, in accordance with some embodiments of the present disclosure;

[0024] FIG. **7** is an illustrative depiction of multiple modes of translation of the illustrative linear actuator of FIG. **6**, in accordance with some embodiments of the present disclosure;

[0025] FIG. **8** is an illustrative depiction of configurable window positions based on positions of the illustrative linear actuator of FIG. **6**, in accordance with some embodiments of the present disclosure;

[0026] FIG. **9** is an illustrative vehicle window including a ball joint element and the illustrative linear actuator of FIG. **6**, in accordance with some embodiments of the present disclosure;

[0027] FIG. **10** is an illustrative block diagram of a vehicle including a window support, a window, and a latch apparatus that is configured to implement multiple states of the window, in accordance with some embodiments of the present disclosure;

[0028] FIG. **11** is an illustrative block diagram of a vehicle including a window support, a window, and a linear actuator that is configured to implement multiple states of the window, in accordance with some embodiments of the present disclosure;

[0029] FIG. **12** is an illustrative block diagram of a vehicle including a linear actuator and corresponding control circuitry and memory and processing circuitry, in accordance with some embodiments of the present disclosure;

[0030] FIG. **13** shows an illustrative window and living hinge in closed and moved positions, in accordance with some embodiments of the present disclosure;

[0031] FIG. **14** is an illustrative depiction of a living hinge releasably interfacing with a recess of a window, in accordance with some embodiments of the present disclosure;

[0032] FIG. **15** is an illustrative block diagram of a vehicle including a pillar, a window, and a living hinge, in accordance with some embodiments of the present disclosure;

[0033] FIG. **16** is a flowchart of an illustrative process for installing a window, in accordance with some embodiments of the present disclosure;

[0034] FIG. **17** is an illustrative depiction of aspects of a living hinge for releasable mating with a corresponding support, in accordance with some embodiments of the present disclosure;

[0035] FIG. **18** is an illustrative depiction of another window and living hinge having fastening elements and a corresponding support, in accordance with some embodiments of the present disclosure;

[0036] FIG. **19** is a flowchart of an illustrative process for installing a removable window, in accordance with some embodiments of the present disclosure;

[0037] FIG. **20** is an illustrative depiction of a modular window that is configurable for fixed, venting, or removable installations, in accordance with some embodiments of the present disclosure;

[0038] FIG. **21** is a flowchart of an illustrative process for installing a modular window, in accordance with some embodiments of the present disclosure;

[0039] FIG. **22** is a flowchart of an illustrative process for assembling, installing, and operating a modular window, in accordance with some embodiments of the present disclosure; and

[0040] FIG. **23** shows a block diagram of an illustrative system for controlling a window of a vehicle, in accordance with some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0041] Windows may be permanently affixed to support structures (e.g., window frames). In some circumstances, where a window can slide or pop out to be partially open (e.g., into a venting position), the window may still be permanently affixed to a support structure in at least one location or region (e.g., the window cannot be removed from the structure without at least some disassembly or undue burden). However, it may be desirable to have a window that is configurable to be in a closed position (e.g., the window forms a substantially air-tight seal with the support structure), to be in a vented position (e.g., the window is partially separated from the support structure, such that air may flow through an opening between the window and the support structure), or to be in a removed or a removable position (e.g., the window may be completely popped out and removed from the support structure).

[0042] FIG. **1** is an illustrative depiction of vehicle **100** including window **110** having configurable positions (e.g., closed, vented, and removable positions), a window disconnect, a latch apparatus, a hinge axis, and C and D pillars (e.g., respective pillars **102** and **103**), in accordance with some embodiments of the present disclosure. In some embodiments, vehicle **100** may have three windows on each main side (e.g., driver side and passenger side), as shown in FIG. **1**, although other window configurations (e.g., one, two, or four windows on each main side of the vehicle) are also contemplated and suitable for use with the teachings of the present disclosure.

[0043] In some embodiments, at least one window of the vehicle (e.g., window **110** between the C pillar **102** and D pillar **103**, as shown in enlargement **101**, or any other suitable window) is arranged such that window **110** is configurable for multiple positions (e.g., closed, vented, and removable positions). Enlargement **101** shows a cutaway view of the left side (e.g., driver's side) as viewed from an inside, rear position (e.g., behind a liftgate and laterally between D-pillars of vehicle **100**). For example, window **110** may hinge around the hinge axis **105** (e.g., which may be parallel and proximate to C pillar **102**, as shown, or any other suitable pillar) and may separate from support **108** (e.g., which may include at least some of D pillar **103**, as shown) based on a force or translation applied by window disconnect **107** or an actuator and a corresponding configuration of one or more fastening apparatuses (e.g., latches such as latches **106**, joints, ball joints, hinges, detents, sockets, receivers, screws, threads, shafts, any other suitable fastening apparatus, or any combination thereof).

[0044] As illustrated, window **110** may be configured to realize at least three configurable positions. In some embodiments, one of these configurable positions is the closed position, in which window **110** may be flush (e.g., substantially air-tight) with support **108** (e.g., a frame of vehicle **100**). Support **108** may include the portions of the frame extending around the entire window (e.g., along the perimeter of window **110**, also referred to as "window frame"), and may include one or more frame elements (e.g., pillars, roofline, sill, or other structures). For example, support **108** may include an entire window frame, or a portion thereof to which components of window **110** interface (e.g., abut, contact, fit against, or otherwise meet at a boundary). The closed position may be desirable for keeping the interior cabin of the vehicle secure, quiet, at a particular climate, any other suitable benefit, or any combination thereof.

[0045] In some embodiments, one of the configurable positions is the vented position, which may be based on a position of at least one latch assembly, such either or both of latch assemblies **106**A and **106**B (e.g., a latch position realized in response to an actuator movement or manual movement). For example, in the vented position, there may be one edge of window **110** that remains coupled to an edge of support **108** (e.g., along C pillar **102**, as illustrated in FIG. **1**) while the other three edges of window **110** (e.g., corresponding substantially to the other side, top and bottom) may be separated from support **108**. It will be understood that a window, such as window **110**, may be coupled to the edge of a support, such as support **108**, using any suitable mechanism or interface (e.g., the coupling constrains the motion and position of window **110** relative to support **108**), but does not require a direct connection (e.g., there may be an intermediate component). It will also be understood that some edges of window **110** may be rounded or otherwise may not form a strict top, bottom, or side (e.g., such that the window may have a top portion, side portions, and a bottom portion which need not be straight or have well defined endpoints). For example, the vented position may include a

separation distance of a few millimeters (e.g., 1, 5, or 8 mm), a few centimeters (e.g., 1, 2, or 3 cm), a few inches (e.g., 0.5, 1, 2, or 3 in) or any other suitable separation distance between the window edge opposing the window edge coupled to the corresponding support (e.g., D pillar **103**, as illustrated in FIG. **1**). In some embodiments, the separation distance in the vented position is configurable (e.g., based on an input from the user, e.g., corresponding to a desired amount of air flow to permit in/out of the cabin). The vented position may be desirable for allowing fresh air into the cabin of vehicle **100** while maintaining a relatively small (e.g., compared to the area of window **110**) area of open space (e.g., to prevent excess air from flowing into the cabin, or to preclude things from falling out of window **110**). As illustrated, window **110** may achieve vented positions **121**, **122**, and **123** as window **110** is rotated about hinge axis **105** further from the closed position.

[0046] In some embodiments, one of the configurable positions is the removable position, which is also based on a position of at least one latch of latch assemblies **106**A and **106**B (e.g., the latch position realized in response to an actuator movement, e.g., where the actuator movement corresponding to the removable position is greater than that corresponding to the vented position). In the removable position, window **110** may be readily (e.g., without substantial force or damaging any structures) detached from support **108**. For example, a latch element of either or both of latch assemblies **106**A and **106**B may include a latch coupled to window **110** may be detached from a latch receiver coupled to support **108**, such that window **110** is not secured (e.g., not sealed against nor otherwise held tightly to prevent motion of window **110** or a portion thereof) to support **108** and may be fully removed from vehicle **100**. The removable position may be desirable for recreational activities, maximizing airflow into the cabin, adventure sporting, convertible-like driving, any other suitable purpose, or any combination thereof. In an illustrative example, in some embodiments, in transitioning from the vented position to the removed position, the force required to remove the window may be the same as or similar to, or less than, the weight of window **110** (e.g., such that it is lifted away from support **108**).

[0047] FIG. **2** shows illustrative depictions of the aforementioned window positions with corresponding latch and latch receiver configurations, in accordance with some embodiments of the present disclosure. As illustrated, window **210** is arranged between C pillar **204** and a D pillar (not shown), and latch assemblies **206**A and **206**B couple window **210** to support **211** (e.g., as illustrated, support **211** includes the entire window frame extending around the periphery of window **210**). Latch **220** may reside in multiple positions with respect to latch receiver **230**, where various positions of latch **220** correspond to configurable positions of window **210**. For example, the latch apparatus of FIG. **1** may include latch **220** and latch receiver **230** of FIG. **2**. In some embodiments, latch **220** rotates around hinge axis **205** to realize the various latch positions illustrated in panels **200**, **240**, and **260**. In some embodiments, latch **220** and latch receiver **230** are coupled by at least one component (e.g., a detent). In some embodiments, the coupling component may be coaxial with hinge axis **205**. As illustrated, latch **220** includes main body **222** and hook **221**. For example, main body **222** may be a relatively flat body portion or panel that extends from a pivot (e.g., at hinge axis **105**) and curves at the end (e.g., to form hook **221**). In a further example, latch receiver **230** may include a relatively flat body portion that extends away from the pivot and includes a pocket (e.g., recess **231**) at the other end. Latch **220** may include any suitable shape to act in concert with latch receiver **230** to allow a window to achieve a closed, vented, and removable configuration. Latch receiver **230** may include any suitable shape to interface with latch **220**, to capture, constrain, and release hook **221**, depending on the relative positions.

[0048] In some embodiments, window **210** may be in the closed position, as illustrated in panel **200** of FIG. **2**. In the closed position, hook **221** extending from main body **222** of latch **220** may be substantially engaged with the recess of latch receiver **230**. For example, latch **220** may engage with recess **231** of latch receiver **230** in response to an actuator translation or force (e.g., about hinge axis **205**) that rotates main body **222** away from main body **232** of latch receiver **230** and that rotates latch hook **221** toward recess **231**.

[0049] In some embodiments, the window may be in a vented position, as illustrated in panel **240** of FIG. **2**. In the vented position, hook **221** may be partially positioned in recess **231** (e.g., compared to the closed position, the vented position may include main body **222** being rotated less far away from main body **232** and hook **221** being rotated less toward recess **231**). In some embodiments, based on the separation distance between the end of hook **221** and the deepest part of recess **231**, a corresponding separation may occur between window **210** and support **211**. In some embodiments, the separation between window **210** and support **211** may be configured by translating hook **221** particular distances (e.g., based on corresponding actuator commands) with respect to recess **231**. For example, a relative angular position of latch **220** and latch receiver **230** about hinge axis **105** may determine the separation may occur between window **210** and support **211** (e.g., separation along direction **299**), and may be controllable based on this angular position. As illustrated on the right sides of panels **200**, **240**, and **260**, the cross sections are views from above looking down at latch assemblies **206**A (e.g., latch assembly **206**B may be the same), with the exterior of the vehicle at the bottom and the interior at the top. Latch assembly **206**A includes latch **220**, latch receiver **230**, any suitable detents, any other suitable components, or any suitable combination thereof.

[0050] In some embodiments, the window may be in a removable position, as illustrated in panel **260** of FIG. **2**. In the removable position, hook **221** may be positioned outside of recess **231** (e.g., compared to the vented position, the removable position may include main body **222** being rotated less far away from main body **232** and hook **221** being rotated less toward recess **231**). For example, in the removable position, main body **222** may be substantially flush with main body **232**. Based on hook **221** not being coupled to recess **231**, the apparatus (e.g., including latch **220** and latch receiver **230**) may be positioned for disassembly, such that after disassembly of the apparatus, window **210** may be fully removed from support **211**. For example, by increasing the separation along direction **299**, window **210** may transition from the vented state to the removable state. In some embodiments, as illustrated in FIG. **3**, for example, the apparatus disassembly includes removal of at least one detent feature, the detent feature coupling latch **220** to latch receiver **230** prior to its removal.

[0051] FIG. **3** shows illustrative details of an apparatus including latch **320** and latch receiver **330**, the apparatus configured to be readily assembled or disassembled, in accordance with some embodiments of the present disclosure. In an illustrative example, latch **320** and latch receiver **330** may correspond to latch **220** and latch receiver **230** shown in FIG. **2**. A window and support are not illustrated in FIG. **3**, merely for purposes of illustration. FIG. **3** illustrates an isometric view of the apparatus in various configurations (e.g., both assembled and disassembled).

[0052] Panel **380** illustrates an exploded view and assembled view of latch **320** (e.g., without detents assembled in latch **320** and with detents assembled in latch **320**, respectively). In some embodiments, latch **320** includes two cavities (e.g., cavities **325** and **326**), each with a respective edge (e.g., edges **327** and **328**) and a respective volume (e.g., volume **329** includes both) for holding a respective ball detent (e.g., ball detents **345** and **346**, which may be spring-loaded). For example, detent **345** may be configured to reside in cavity **325** of latch **320**, and ball detent **346** may be configured to reside in cavity **326** of latch **320**, opposite cavity **325**. In some embodiments, cavities **325** and **326** may be first and second regions of a through-hole of latch **320** (e.g., defining volume **329**). In some embodiments, ball detents **345** and **346** may have lips, ridges, extensions, or other features that extend beyond a diameter of edges **327** and **328**, such that ball detents **345** and **346** are configured to occupy a particular position within respective cavities **325** and **326** (e.g., or respective portions of a single cavity such as a through hole defining volume **329**). In some embodiments, the length of each of cavities **325** and **326** and the length of respective ball detents **345** and **346** are oriented coaxially with hinge axis **305**.

[0053] The progression of panels illustrated in FIG. **3**, from panel **300** to **340** to **360**, may correspond to disassembling the apparatus (e.g., for removing a window from a window support, where both the window and the support may be coupled to respective elements of the apparatus). For example, as illustrated in panel **300**, latch **320** is coupled to latch receiver **330**, capable of rotating about hinge axis **305**. In this coupled state, ball detents **345** and **346** may respectively reside in cavities **325** and **326** of latch **320**. For example, respective balls **355** and **356** of ball detents **345** and **346** may respectively occupy first and second detent recesses **357** and **358** (e.g., ball-shaped recesses) in latch receiver **330**. In some embodiments, detent recesses **357** and **358** include holes in latch receiver **330**. In some embodiments, detent recesses **357** and **358** are configured such that an inner surface of the recess couples to the top of the balls of the ball detent (ball detent **345** or **346**). While ball detents **345** and **346** are shown as being spring-loaded, this is merely illustrative, and other mechanisms for loading and unloading a ball detent may be used in accordance with the present disclosure.

[0054] In some embodiments, as shown in panel **340** of FIG. **3**, latch **320** may be partially removed from latch receiver **330**. In this partially removed state, ball detents **345** and **346** may be decoupled from latch receiver **330** (e.g., by compressing one or more ball detent springs **365** and **366**, such that ball detents **345** and **346** decouple from corresponding detent recesses **357** and **358**). In some embodiments, when one or more ball detents (e.g., ball detents **345** and **346**) are decoupled from corresponding detent recesses (e.g., detent recesses **357** and **358**), the cavity of latch **320** (e.g., centered about axis **306**) may be rotated off of hinge axis **305**. In some embodiments, not illustrated in FIG. **3**, a latch or latch receiver may include integrated detent features (e.g., ball detents) that are formed as part of the component. For example, a latch, latch receiver, or both may include a ball detent or mating indentation and a flexible/deformable portion that allows the ball detent or mating indentation to flex to fit in to position and then remain in position by spring forces in the material (e.g., arising from deformation). Accordingly, in some embodiments, springs **365** and **366** may be integrated into a latch or latch receiver, and may include a relatively thin portion of material having a lessened stiffness to deflection such that it acts as a spring (e.g., a beam spring, a coil spring, a torsion spring, or any other suitable type of spring that may be formed as part of a single piece of material) and may move in response to forces on the material (e.g., a plastic material).

[0055] In some embodiments, as shown in panel **360** of FIG. **3**, latch **320** is removed from latch receiver **330**. In some embodiments, after the cavity of latch **320** (e.g., defining volume **329**) is rotated off of hinge axis **305**, hook **321** (e.g., similar to hook **221** of FIG. **2**) may be fully removed from recess **331** (e.g., similar to recess **231** of FIG. **2**) and the proximate area, such that latch **320** and latch receiver **330** may be fully decoupled (e.g., as the window is removed from the support). In some embodiments, though not explicitly shown in FIG. **3**, removing hook **321** from recess **331** may permit or correspond to removing the window (e.g., where latch **320** may be coupled to the window) from the window support (e.g., where latch receiver **330** may be coupled to the window support).

[0056] FIG. **4** shows illustrative details of an interface between latch **420** and latch receiver **430**, in accordance with some embodiments of the present disclosure. In some embodiments, latch receiver **430** includes protrusion **471** and latch **420** includes recess **491**, where protrusion **471** is configured to couple to recess **491** (e.g., engage and disengage with). For example, panel **400** of FIG. **4** corresponds to a closed window position, where window **410** may be sealed against **411**. In the closed position, the interface (e.g., including interface **401** of protrusion **471** and recess **491**) may tightly secure latch **420** to latch receiver **430** (e.g., such that they are not easily separated). In some embodiments, latch **420** is coupled to window **410** and latch receiver **430** is coupled to a window support (e.g., support **411**), such that the tight coupling of the interface tightly secures window **410** to support **411** such that window **410** is not removable when closed (e.g., which may include a frame or at least one pillar of a vehicle). To illustrate, protrusion **471** may include a lip and recess **491** may include an open slot into which the lip fits (e.g., each extending along the axis **405** of pivot **406**).

[0057] In some embodiments, panel **440** of FIG. **4** illustrates a vented window position. In the vented position, while hook **421** may be rotated partially away from recess **431** and main body **422** may be rotated partially toward main body **432** (e.g., about pivot **406**, in direction **499**), protrusion **471** may remain coupled to recess **491**, such that interface **401** continues to tightly secure latch **420** to latch receiver **430** such that they are not detachable from each other. For example, as illustrated in panel **440**, window **410** may be partially opened to permit air flow into the vehicle while leaving only a small gap between window **410** and support **411**.

[0058] Panel **460** of FIG. **4** illustrates a removable window position. In the removable position, because hook **421** may be rotated entirely away from recess **431** and main body **422** may be rotated entirely toward main body **432** (e.g., about pivot **406**, in direction **499**), protrusion **471** may be decoupled from recess **491**, such that interface **401** no longer secures latch **420** to latch receiver **430** (e.g., they can be detached). For example, as illustrated in panel **460**, a manipulator of latch **420** (e.g., an owner or mechanic of a vehicle including the latch, or an actuator configured to operate the latch assembly) may be able to fully detach latch **420** from latch receiver **430** and therefore detach window **410** from support **411**.

[0059] Panel **480** of FIG. **4** illustrates a detached window position. In the detached position, because interface **401** no longer secures latch **420** to latch receiver **430**, latch **420** may be fully decoupled from latch receiver **430**, therefore decoupling window **410** from support **411**.

[0060] Interface **401** is disrupted, as protrusion **471** is removed from recess **491**. Decoupled window **410** may be fully detached from support **411**. To reattach detached window **410**, the manipulator of latch **420** may simply insert window **410** such that recess **491** is again coupled to protrusion **471**. As illustrated in panel **480**, in the detached state, the features of latch **420** are clear from features of latch receiver **430** such that latch **420** may be translated away from latch receiver **430** (e.g., as window **410** is removed from a vehicle, away from support **411**).

[0061] FIG. **5** shows illustrative details of window disconnect **508** (e.g., which may correspond to the window disconnect of FIG. **1**) and arm device **550** that is configured to be coupled to or decoupled from the window disconnect, in accordance with some embodiments of the present disclosure. Panel **500** of FIG. **5** corresponds to a closed configuration of window disconnect **508** (e.g., the closed or vented window positions) and the bottom-right cross-sectional perspective of FIG. **5** corresponds to an open position of window disconnect **508** (e.g., the removable window position). As shown in the isometric (left) and cross-sectional (right) perspectives of FIG. **5**, window disconnect **508** includes base **520** that is coupled to window **510** and collar **530** that is configured to rotate around base **521**. In some embodiments, arm device **550** includes keyed ball **551** (e.g., a keyed ball may be generally spherical but have flats on opposite sides) configured to engage with and rotate, or otherwise interface with, collar **530** (e.g., based on coupling of keyed ball **551** to keyed socket **531** of collar **530**). For example, keyed ball **551** of arm device **550** may be inserted into keyed socket **531** and rotated 80, 85, 90, 95, or 100 degrees (or any other suitable degree of rotation). In some embodiments, a first direction of the rotation (e.g., clockwise or counter-clockwise, as indicated by direction **513**) may adjust keyed socket **531** from the open to the closed position, and a second direction of the rotation, opposite the first direction, may adjust keyed socket **531** from the closed position to the open position. Keyed socket **531** may correspond to a recess shaped similarly as keyed ball **551**, such that relative axial displacement is only possible at some relative angles (e.g., when flats **552** line up with flats **532**). Although illustrated as being exposed (e.g., visible from the vehicle interior) in FIG. **5**, arm device **550** (e.g., including keyed ball **551**) may reside within a vehicle frame, a window support structure, or a vehicle pillar (e.g., a C pillar, D pillar, or any other suitable pillar). In some embodiments, arm device **550** includes actuator assembly **554**, which may include an electromagnetic motor, circuitry, connectors, any other suitable components, or any combination thereof.

[0062] As illustrated in panels **540** and **580** of FIG. **5**, a geometry of keyed socket **531** may be affected by the rotation of collar **530** and may thereby cause window disconnect **508** to be in the open or closed position. For example, in the closed configuration, keyed socket **531** may have a narrow (e.g., less wide than a diameter of keyed ball **551**) throat that prevents window **510** from being removed, whereas in the opened configuration, keyed socket **531** may have a wide (e.g., greater than or equal to the diameter of keyed ball **551**) throat that permits window **510** to be removed (e.g., from support **511**, as illustrated in panels **500** and **560** of FIG. **5**). Space **512** is increased when window **510** is removed from support **511**, relative to the closed position of window disconnect **508**. Any space between in window **510** and support **511** may be negligible (e.g., they may be sealed against each other) in the closed state, but may be any suitable value in a vented state (e.g., as shown in panel **500**) or a removed state (e.g., as shown in panel **560**). In some embodiments, keyed ball **551** remains in keyed socket **531** in the closed and vented window positions (e.g., with window **510** thereby mounted to the vehicle via arm **553** connected to keyed ball **551**), and keyed ball **551** remains outside of keyed socket **531** in the removable position (e.g., with window **510** thereby not mounted to the vehicle via arm **553**). In some embodiments, when window disconnect **508** is in the open position, window **510** is in the removable position and may be detached from support **511**.

[0063] FIG. **6** shows a perspective, exploded view of illustrative linear actuator **610** having multiple modes of translation, in accordance with some embodiments of the present disclosure. In some embodiments, a suitable system, assembly, architecture, apparatus, or mechanical structure for actuating a window includes linear actuator **610** (e.g., which may be coupled to a window support) and ball joint element **650** (e.g., which may be coupled to a window). In some embodiments, linear actuator **610** includes translation screw **630** (e.g., which is driven by motor assembly **620**, which may include motor, gear box, and circuitry **621**), translation shaft **640** coupled to translation screw **630**, and housing **660** coupled to translation shaft **640**. For example, a concentric arrangement of linear actuator **610** may include, from inside to outside, translation screw **630**, translation shaft **640**, and housing **660**. In some embodiments, translation screw **630** may also include a leadscrew or power screw. In some embodiments, translation shaft **640** includes threading (e.g., with suitable female threads configured to engage with the threading of translation screw **630**) on the interior of the shaft, such that the inside of translation shaft **640** may couple to the outside of translation screw **630**. In some embodiments, the outside of translation shaft **640** includes groove **641** and the inside of housing **660** includes boss **661**, such that the outside of translation shaft **640** may couple to the inside of housing **660** via boss **661** being inserted into or traversing groove **641**. In some embodiments, housing **660** controls the rotational orientation of translation shaft **640** based on how boss **661** traverses corresponding groove **641** (e.g., the rotational orientation of translation shaft **640** may depend on the axial position of translation shaft **640**, as controlled by translation screw **630**).

[0064] In some embodiments, linear actuator **610** couples to a window (or to another surface that is manipulated by the

linear actuator) via element **611** of the window or window assembly (e.g., element **611** may include ball joint element **650**). For example, ball joint element **650** (e.g., with keyed ball **651** having opposed flat faces **652** connected by a curved edge) may be coupled to the window, and translation shaft **640** may include ball joint element **645** (e.g., including a keyed socket having a slotted opening) configured to couple to ball joint element **650**. For example, the interface may be defined by a first ball joint element (e.g., ball joint element **650**) and a second ball joint element (e.g., ball joint element **645**), which are configured to engage and disengage with each other. Based on translation shaft **640** being coupled to ball joint element **650** (e.g., via the keyed socket) and translation screw **630** (e.g., via the internal female threading), and ball joint element **650** being coupled to the window (e.g., via an adhesive), the window may push out or pop out in response to linear actuator **610** driving out translation shaft **640** based on rotation of translation screw **630**.

[0065] In some embodiments, linear actuator **610** and translation screw **630** are configured for at least three states and two ranges of motion (e.g., where the first range of motion transitions between the first and second states, and the second range of motion transitions between the second and third states). In some embodiments, a first state of linear actuator **610** and translation screw **630** (e.g., in which translation screw **630** is most proximate to the motor driving translation screw **630**) corresponds to a closed position of a window. In some embodiments, linear actuator **610** drives translation shaft **640** to extend away from the motor (e.g., via rotation of translation screw **630**) through the first range of motion with a substantially constant rotational orientation. For example, translation screw **630** may drive translation shaft **640** outward, without rotating translation shaft **640** (e.g., about axis **605**). In some embodiments, groove **641** of translation shaft **640** is oriented substantially parallel to the length of translation screw **630** (e.g., along axis **605**) though the first range of motion, such that a mating (e.g., fitting together at an interface) between groove **641** of translation shaft **640** and boss **661** of housing **660** maintains translation shaft **640** at the substantially constant rotational orientation (e.g., boss **661** traverses linear portion **642** of the groove **641**). Because of the substantially constant rotational orientation in the first range of motion, the movement of translation shaft **640** may maintain ball joint element **645** (e.g., a keyed socket of translation shaft **640**) in a locked configuration relative to ball joint element **650** (e.g., keyed ball **651** thereof). In some embodiments, a second state of translation shaft **640** (e.g., corresponding to the vented position of the window) corresponds to one or more positions within or at the outermost (e.g., with respect to the actuator motor of motor assembly **620**) portion of the first range of motion. For example, the one or more positions of the second state of translation shaft **640** may correspond to a configurable separation distance between the window and the window support.

[0066] In some embodiments, a third state of translation shaft **640** corresponds to a removable position of the window. In some embodiments, through the second range of motion, linear actuator **610** drives translation shaft **640** to extend away from the motor with a varying rotational orientation (e.g., via translation screw **630**). In other words, translation screw **630** may drive translation shaft **640** outward (e.g., with respect to the actuator motor of motor assembly **620**) while rotating translation shaft **640**. For example, during the second range of motion, translation shaft **640** may rotate at least 80 degrees (e.g., 80, 85, 90, 95, or 100 degrees, or any other suitable degree of rotation). In some embodiments, the second range of motion drives translation shaft **640** such that curved portion **643** of groove **641** is mated with boss **661**. Boss **661** causes rotation of translation shaft **640** (e.g., boss **661** traverses curved portion **643** of groove **641**). Because of the resulting varying rotational orientation during the second range of motion, the movement of translation shaft **640** may rotate ball joint element **645** (e.g., the keyed socket of translation shaft **640**) about axis **605** into an unlocked configuration relative to ball joint element **650** (e.g., keyed ball **651** may be removable from the keyed socket of ball joint element **645**). To illustrate, ball joint element **645** may include a keyed socket having a spherical recess with flats to correspond to a spherical shape of keyed ball **651** having flat faces **652**.

[0067] FIG. **7** is an illustrative depiction of multiple modes of translation of linear actuator **610** of FIG. **6**, in accordance with some embodiments of the present disclosure. As mentioned above, linear actuator **610** may be configured for a first range of motion (e.g., translation without rotation), as shown in panels **700** and **740** of FIG. **7**; linear actuator **610** may also be configured for a second range of motion (e.g., translation with rotation), as shown in panels **760** and **780** of FIG. **7**. In some embodiments, panels **700**, **740**, **760**, and **780** of FIG. **7** respectively illustrate closed, venting, venting, and removable window positions (e.g., as boss **661** traverses groove **641**). As illustrated in panels **700** and **740** (e.g., closed to vented configurations), translation shaft **640** may move through some or substantially all of linear portion **642** of groove **641**, along direction **798**. In the vented position, window **710** is separated by space **713** from support **711**. As illustrated in panel **760**, translation shaft **640** has moved through at least part of curved portion **643** of groove **641**, rotating along direction **799**. As illustrated in panel **780**, translation shaft **640** has moved through substantially all of curved portion **643** of groove **641** (e.g., leaving space **713** between window **710** and support **711**). As shown in the sequence of panels **700**, **740**, **760**, and **780**, the outward movement of translation shaft **640** causes a corresponding outward movement of window **710** from support **711** (e.g., from a closed position to a vented position and then to a removal position).

[0068] FIG. **8** is an illustrative depiction of configurable window positions based on positions of linear actuator **610** of FIG. **6**, in accordance with some embodiments of the present disclosure. FIG. **8** illustrates window **710** as viewed from outside the vehicle (e.g., the vehicle interior is directly visible only through space **713** or otherwise through window **710**). As illustrated in panel **800** of FIG. **8**, window **710** may be in the closed position when translation shaft **640** is not substantially extended from housing **660**. In this closed position, window **710** may be mated (e.g., via suitable mating features) or otherwise coupled to support **711** (e.g., forming an airtight seal). As illustrated in panel **840** of FIG. **8**, window **710** may be in the vented position when translation shaft **640** has extended from housing **660** with a substantially constant rotational orientation. In this vented position, window **710** may be at least partially separated from support **711** (e.g., to permit airflow). As illustrated in panel **860** of FIG. **8**, window **710** may be in the removable position when translation shaft **640** has further extended

from housing **660** with a varying rotational orientation. In panel **860**, window **710** is shown as being removed from support **711** (e.g., window **710** is not visible). In panel **880**, translation shaft **640** is shown as being retracted back into housing **660** despite not being recoupled or refastened to window **710**. In some embodiments, to reattach window **710** to the support **711**, keyed ball **651** of ball joint element **650** is inserted into the keyed socket of ball joint element **645**. In some embodiments, based on the variable rotational orientation of the keyed socket of ball joint element **645** (e.g., based on at least the two rotational orientation states shown in panels **860** and **880**), keyed ball **651** may be inserted into the keyed socket of ball joint element **645** when translator shaft **640** is in the fully extended position, and keyed ball **651** may not be inserted into the keyed socket of ball joint element **645** when translator shaft **640** is in the retracted position. For example, in the retracted position, the keyed socket of ball joint element **645** may have a rotational orientation such that the fastening orientations are mismatched between the keyed socket of ball joint element **645** and the keyed ball **651**. To illustrate, in the retracted position, the keyed socket may be oriented vertically, while in the extended position, the keyed socket may be oriented horizontal (e.g., or any other suitable set of retracted and extended positions).

[0069] FIG. **9** is an illustrative vehicle window and an illustrative vehicle window support including ball joint element **650** and linear actuator **610** of FIG. **6**, in accordance with some embodiments of the present disclosure. For example, support **711** may be a D pillar or a C pillar of a vehicle frame, or another aspect of the vehicle frame, although integration with other pillars and supports is also contemplated and suitable for use with the teachings provided herein. In some embodiments, the progression of panels **900**, **940**, and **960** may correspond to a manufacturing flow of a vehicle or system to incorporate an apparatus into the vehicle, consistent with the present disclosure.

[0070] Illustrated in panel **900**, the apparatus includes window **710**, support **711**, bulb seal **712** (e.g., to realize an airtight interface between window **710** and support **711**), and ball joint element **650**. As illustrated, window **710** includes region **716** at which ball joint element **650** is arranged and attached. For example, region **716** may be transparent, translucent or tinted, or opaque, and may be the same or different material from the rest of window **710** (e.g., part of a frame of window **710**). In some embodiments, ball joint element **650** is surrounded by brackets **655** to support, or otherwise interface with, housing **715** (e.g., which may be part of, or integrated with, a pillar of the vehicle), any other suitable component, or any combination thereof. As illustrated in panel **940**, linear actuator **610** and housing **715** are added to the apparatus. As illustrated, housing **715** is coupled to linear actuator **610** and coupled to brackets **655** surrounding ball joint element **650**. In some embodiments (e.g., as shown in FIG. **6**), linear actuator **610** includes motor assembly **620** configured to drive translation screw **630** and includes translation shaft **640** coupled to translation screw **630** via mating threads, where translation shaft **640** and translation screw **630** reside within housing **660**. As similarly illustrated in FIGS. **6-8**, linear actuator **610** may be configured to push window **710** away from support **711** (e.g., into the venting position or the removal position) based on driving translation shaft **640** away from the body of linear actuator **610**. As illustrated in panel **960**, linear actuator **610** may be concealed inside a D pillar or other suitable element of a vehicle frame. In some embodiments, an input interface associated with the vehicle may provide an actuation mechanism (e.g., a button on the vehicle, an option on a vehicle console, touch screen, or other haptic input system, a selection on a mobile application coupled to the vehicle, an input on a key or key fob coupled to the vehicle, any other suitable actuation mechanism, or any combination thereof). In some embodiments, the input interface may include an audio receiver (e.g., a microphone) and may be configured to receive voice commands issued by a user (e.g., control circuitry may be configured to perform voice recognition, speech recognition, or both to identify commands spoken by a user and received at the audio interface). In some embodiments a user input may be received at the input interface, as illustrated in FIG. **12**, and the system may be configured to command linear actuator **610** (e.g., by generating one or more motor commands) to adjust window **710** into one of at least three predetermined positions (e.g., the closed, vented, and removable positions). The command may be generated by circuitry **621**, or generated by control circuitry and transmitted to circuitry **621**, which may include a motor controller. In some embodiments, for example, the command may be generated automatically based on at least one other signal such as a temperature (e.g., of an occupant compartment or a zone thereof, or an ambient temperature), a speed of the vehicle, a locked/unlocked state of the vehicle, a climate control signal (e.g., based on a user setting), any other suitable signal, any other suitable criteria, or any combination thereof.

[0071] FIG. **10** is an illustrative block diagram of vehicle **1000** including window support **1030** (support **1030** hereinafter), window **1020**, and latch apparatus (e.g., latch **1050** and latch receiver **1040**) that is configured to implement multiple states of window **1020**, in accordance with some embodiments of the present disclosure. For example, vehicle **1000** may be the same as or similar to vehicle **100** of FIG. **1**. Vehicle **1000** includes at least a window (e.g., window **1020**) and support **1030**, which are configured to be coupled to (e.g., as indicated by the connecting line) or decoupled from (e.g., as indicated by the diagonal hashmarks) each other. In other words, a connecting line with diagonal hashmarks as used herein indicates components that may be coupled or decoupled based on at least an action from a user (e.g., where the action may be to trigger one or more ranges of motion of a linear actuator).

[0072] In some embodiments, support **1030** of FIG. **10** includes latch receiver **1040** (e.g., as also illustrated in FIGS. **2-4**), latch receiver **1040** including recess **1042** (e.g., for receiving latch hook **1070**) and at least one detent recess (e.g., detent recess **1041** configured to receive at least one spring-loaded ball detent such as ball detent **1060**). As illustrated, detent recess **1041** may couple to or decouple with ball detent **1060**, and recess **1042** may couple to or decouple with hook **1070**. In some embodiments, not shown, latch receiver **1040** also includes a protrusion configured to couple to a recess of a latch. Hook **1070** may include a loop or portion of a loop (e.g., closed or open loop) that may be engaged by recess **1042** (e.g., using any suitable mechanism).

[0073] In some embodiments, window **1020** includes latch **1050** (e.g., as also illustrated in FIGS. **2-4**), latch **1050** including hook **1070** (e.g., for engaging with recess **1042** of latch receiver **1040**) and at least one cavity (e.g., cavity

1062) including ball detent **1060** (e.g., for engaging with detent recess **1041** of latch receiver **1040**), ball detent **1060** including spring **1061** configured to engage or disengage ball detent **1060** with detent recess **1041** of latch receiver **1040**. As illustrated, ball detent **1060** may couple to or decouple from detent recess **1041**, and hook **1070** may couple to or decouple from recess **1042**. In some embodiments, latch **1050** also or alternatively includes a recess, configured to receive the protrusion of latch receiver **1040**.

[0074] In some embodiments, the coupling and decoupling between window **1020** and support **1030**, between ball detent **1060** and detent recess **1041**, or between hook **1070** and recess **1042**, or a combination thereof is configurable based on a position of latch **1050**. The position of latch **1050** may be configurable based on a translation, range of motion, force, or other input from an actuator. In some embodiments, the translation or force from the actuator is configurable based on an input from a user.

[0075] FIG. **11** is an illustrative block diagram of vehicle **1100** including window support **1130** (hereinafter support **1130**), window **1120**, and linear actuator **1140** that is configured to implement multiple states of window **1120**, in accordance with some embodiments of the present disclosure. For example, vehicle **1100** may be the same as or similar to vehicle **100** of FIG. **1**. Vehicle **1100** includes at least a window and a window support (e.g., window **1120** and support **1130**), which are configured to be coupled to (e.g., as indicated by the connecting line) or decoupled from (e.g., as indicated by the diagonal hashmarks) each other.

[0076] In some embodiments, window **1120** includes first ball joint element **1121** (e.g., similar to those illustrated in FIGS. **6**, **8-9**), first ball joint element **1121** including a base (e.g., for mounting to the window) and a keyed ball (e.g., for coupling to a keyed socket). In some embodiments, the keyed ball includes a ball having flats on opposite sides. In some embodiments, first ball joint element **1121** also includes brackets surrounding the base and the keyed ball (e.g., to receive a housing of linear actuator **1140**). As illustrated, first ball joint element **1121** may couple to or decouple with second ball joint element **1151**. For example, second ball joint element **1151** may include a keyed socket (e.g., within a rotatable element), such that first and second ball joint elements **1121** and **1151** are coupled when the keyed ball is locked in the keyed socket (e.g., in response to a first rotational orientation of the rotatable element) and first and second ball joint elements **1121** and **1151** may be decoupled when the keyed ball is not locked in the keyed socket (e.g., in response to a second rotational orientation of the rotatable element).

[0077] In some embodiments, support **1130** includes linear actuator **1140** (e.g., which may be similar to those shown in FIGS. **6-9**), linear actuator **1140** including translation screw **1152** (e.g., for driving a translation of elements coupled to translation screw **1152**), translation shaft **1150** (e.g., which is coupled to translation screw **1152** via a corresponding female threading on the interior of translation shaft **1150**) with a groove along a side (e.g., where the groove has a straight portion and a curved portion, the curved portion curving at least 80 degrees about the center axis), second ball joint element **1151** (e.g., a keyed socket within translation shaft **1150**), and housing **1141** with a boss (e.g., where the boss traverses the groove of translation shaft **1150** and causes translation shaft **1150** to rotate when the boss traverses a curved region of the groove). As illustrated by the nested blocks of FIG. **11**, in some embodiments, translation screw **1152** resides within translation shaft **1150** and translation shaft **1150** resides within housing **1141** (e.g., within concentric arrangements). As illustrated, second ball joint element **1151** resides inside translation shaft **1150**, particularly at the side of translation shaft **1150** that mates with first ball joint element **1121** (e.g., have reciprocal shapes that fit together); translation screw **1152** resides behind (e.g., looking from first ball joint element **1121**) second ball joint element **1151**, toward the interior of linear actuator **1140** (e.g., the actuator motor), and within translation shaft **1150**.

[0078] In some embodiments, the coupling and decoupling between window **1120** and support **1130**, between first and second ball joint elements **1121** and **1151**, or a combination thereof, is configurable based on an actuation of linear actuator **1140** (e.g., which correspondingly positions translation screw **1152** and translation shaft **1150**). As mentioned, the actuation (e.g., an applied translation, range of motion, force, or other action) from linear actuator **1140** may occur in response to an input from a user. In some embodiments, linear actuator **1140** may include multiple ranges of motion, in which a first range of motion opens window **1120** to a vented position (e.g., without making window **1120** readily separable from support **1130**) and a second range of motion opens window **1120** to a removable position (e.g., in which window **1120** is readily separable from support **1130**).

[0079] FIG. **12** is an illustrative block diagram of vehicle **1200** including linear actuator **1240** and corresponding control circuitry **1210**, memory **1220**, and processing circuitry **1230**, in accordance with some embodiments of the present disclosure. In some embodiments, one or more of control circuitry **1210**, memory **1220**, and processing circuitry **1230** may reside within an apparatus coupled to linear actuator **1240** (e.g., to a translation screw within the motor and gear box container and/or within the circuitry container, as illustrated in FIG. **6**). Vehicle **1200** includes user input device **1250**, control circuitry **1210** configured to deliver actuator commands **1211** (e.g., corresponding to first and second ranges of motion of the actuator), linear actuator **1240** (e.g., configured to drive a translation shaft through at least first and second ranges of motion **1241** and **1242**), memory **1220**, and processing circuitry **1230** (e.g., to relate window positions, including the closed, vented, and removable positions, to corresponding actuator commands **1211**).

[0080] In some embodiments, user input device **1250** may include any one or more of a button, slider, joystick, touch screen, any other user-responsive display of the vehicle, or any combination thereof. In some embodiments, user input device **1250** may include any suitable hardware configured to operate a corresponding software application (e.g., a smart phone, smart watch, or other device configured for internet connectivity and/or telecommunication capabilities), where the software application is configured to operate control circuitry **1210**, memory **1220**, processing circuitry **1230**, or a combination thereof. In some embodiments, user input device **1250** may include a key, key fob, or any other suitable mechanical or electromechanical apparatus coupled to the vehicle (e.g., as is needed to turn on vehicle **1200**). In some embodiments, for example, actuator commands **1211** may be generated automatically by control circuitry **1210** based on at least one other signal such as a temperature (e.g., of an occupant compartment or a zone thereof, or an ambient temperature), a speed of the vehicle, a locked/unlocked state of the vehicle, a climate control signal (e.g., based on a user

setting), any other suitable signal, any other suitable criteria, or any combination thereof. For example, control circuitry **1210** may receive information from sensors or other vehicle controllers or systems and may generate actuator commands **1211** based on that information.

[0081] As shown in FIG. **12**, in some embodiments, user input device **1250** is coupled to control circuitry **1210**. In some embodiments, memory **1220** and processing circuitry **1230** are also coupled to control circuitry **1210**, and control circuitry **1210** is coupled to linear actuator **1240**. In an illustrative embodiment, a user may select a desired window removal position from various options presented or otherwise made accessible by user input device **1250**. In response, control circuitry **1210** may retrieve, from memory **1220**, processing circuitry **1230**, or both, instructions for how to translate the window removal position into an actuator command (e.g., window position instructions **1221**). In response to retrieving an actuator command, control circuitry **1210** may provide one or more actuator commands **1211** to linear actuator **1240** (e.g., to provide a certain voltage, current, or power, or schedule thereof to linear actuator **1240**). In response to receiving one or more actuator command (e.g., of actuator commands **1211**), linear actuator **1240** may move through first range of motion **1241** (e.g., if the window is transitioning from the closed position to the vented position), linear actuator may move through second range of motion **1242** (e.g., if the window is transitioning from the vented position to the removable position), or linear actuator **1240** may move through both first and second ranges of motion **1241** and **1242** (e.g., if the window is transitioning from the closed position, through the vented position, to the removable position). Therefore, the configurable window positions may be responsive to an input provided by a user of vehicle **1200** via user input device **1250**.

[0082] FIG. **13** shows illustrative window **1310** and living hinge **1390** in closed and moved positions, in accordance with some embodiments of the present disclosure. As illustrated in panel **1300**, in the closed position (also referred herein as a closed configuration), living hinge **1390** is mated to encapsulation frame **1314** based on flange **1391** of living hinge **1390**. In particular, the partially obscured end of u-shape section **1392** (e.g., end **1397** of flange **1391**) is mated with recess **1315** of encapsulation frame **1314**. As illustrated in panel **1340**, in an "after removal" configuration, window **1310** and encapsulation frame **1314** can release from living hinge **1390** and "pop out" of a support (not shown) to which living hinge **1390** may remain affixed (e.g., under normal operation is not separable). Comparing the illustrations of panels **1300** and **1340**, living hinge **1390**, linear actuator **1370**, and housing **1360** may remain in substantially fixed positions (e.g., with small possible adjustments that are made to release window **1310**). As illustrated in panel **1340**, in a removed configuration, window **1310** may be "popped out" (e.g., pushed back through an axis oriented into the surface of the page). Because window **1310** is further back in panel **1340** (e.g., after removal), it is illustrated as smaller as it would be at the same depth as compared to living hinge **1390**, linear actuator **1370**, and housing **1360**. Linear actuator **1370** and housing **1360** may be similar to those described in FIGS. **6-9**. Housing **1360** (e.g., which may be similar to housing **660** of FIG. **6**) is configured to engage and disengage from element **1350** (e.g., which may be similar to ball joint element **650** of FIG. **6**).

[0083] Panel **1380** of FIG. **13** illustrates an enlargement of living hinge **1390** and the recess in encapsulation frame **1314**. As shown, the living hinge includes flange **1391** with a flange end surface (e.g., end **1397**), base section **1393**, first curved section **1394** and second curved section **1395**, and planar section **1396** between the first and second curved sections **1394** and **1395**. Flange **1391**, curved sections **1394** and **1395**, planar section **1396**, and base section **1393** of living hinge **1390** form a u-shape indicated by u-shape section **1392**. In some embodiments, flange **1391** mates with recess **1315** of encapsulation frame **1314**. As illustrated, recess **1315** of encapsulation frame **1314** includes locating feature **1316** (e.g., a recess such as a hole or slot configured to receive locating feature **1317** of living hinge **1390**) that may be used for aligning encapsulation frame **1314** to a particular position of living hinge **1390** when coupling encapsulation frame **1314** to a support (e.g., a pillar) of a vehicle. For example, locating features **1316** and **1317** may include any suitable interfacing features such as male-female features (e.g., a boss and a recess such as ribs and slots, or pins and holes), interlocking features that may slide in one dimension (e.g., a key and slot), or any other suitable interface to constrain a relative position of living hinge **1390** and window **1310**. As illustrated, living hinge **1390** includes one or more mounting features **1385**. One or more mounting features **1385** may include one or more pins (e.g., as illustrated), one or more holes (e.g., for fasteners), detent features, locking features, keyed interfaces, snap-fit interfaces, press-fit interfaces, latched interfaces, any other suitable feature for mounting base section **1393** to a vehicle (e.g., a support thereof), or any combination thereof.

[0084] FIG. **14** shows an illustrative interface between living hinge **1490** and recess **1413** of window **1410**. In some embodiments, recess **1413** is in encapsulation frame **1414** of window **1410**, as illustrated. In some embodiments, the recess of the window may be arranged in another support of the window. As illustrated, recess **1413** is located at an edge of window **1410**. As illustrated in panel **1400** of FIG. **14**, in the closed or venting positions, flange **1491** of living hinge **1490** is configured to interface with recess **1413** of window **1410** such that end surface **1497** of flange **1491** interfaces with bottom **1417** of recess **1413** and opposite sides of the flange interface with the first and second walls of recess **1413** (e.g., walls **1415** and **1416** that define recess **1413**. Base **1493** is affixed to support **1411** (e.g., only a boundary of which is illustrated), such that window **1410** is thereby affixed to support **1411**. Bulb seal **1412** may form a substantially airtight seal between window **1410** and the interior of a vehicle (e.g., support **1411**) to which window **1410** is affixed.

[0085] As shown at the bottom of FIG. **14**, in the removal position, window **1410** slides or pops out of living hinge **1490**. In particular, window **1410** may be removed by applying a force that is oriented normal to end surface **1497** of flange **1491**. When window **1410** is removed, living hinge **1490** remains in a substantially fixed position due to being affixed (e.g., fastened using one or more fasteners) to support **1411**, and bulb seal **1412** is also removed due to being affixed (e.g., glued) to window **1410**.

[0086] FIG. **15** shows an illustrative block diagram of vehicle **1500** that includes living hinge **1510**, window **1520**,

and pillar **1530**, in accordance with some embodiments of the present disclosure. As illustrated, living hinge **1510** includes at least one base section (e.g., base section **1511**) and flange **1512**, and window **1520** includes at least one recess (e.g., recess **1521**). In some embodiments, window **1520** also includes an encapsulation frame and the recess is in an encapsulation frame of the window. In some embodiments, window **1520** or an encapsulation frame thereof and living hinge **1510** also include corresponding locating features that are used to properly align living hinge **1510** in recess **1521** of window **1520**. Base section **1511** of living hinge **1510** couples to pillar **1530** (e.g., it is fastened or otherwise affixed to the pillar) and cannot be disconnected without a relatively large force (e.g., such that it does not become inadvertently dislodged). Flange **1512** of living hinge **1510** releasably mates with recess **1521**, causing window **1520** to releasably mate with pillar **1530**. As described above, the connecting lines with two diagonal hash marks indicate releasable couplings between the elements of FIG. **15** and other block diagrams.

[0087] FIG. **16** is a flowchart of illustrative process **1600** for installing a window, in accordance with some embodiments of the present disclosure. In some embodiments, process **1600** may be used to assemble (or may be similarly used to disassemble) a living hinge and a window/encapsulation frame, such as those shown in FIGS. **13-15** and FIG. **17**. Step **1602** includes aligning a recess of a window with a flange. In some embodiments, a locating feature on the window, the flange, or both is used to align the recess of the window with the flange. Step **1604** includes moving the window towards the flange to seat the flange in the recess. For example, in some embodiments, one side of the recess is formed by a wall having a curved upper surface, the curved upper surface of the wall is configured to guide the flange into the recess, and when the flange is seated in the recess, the flange is in a flexed position. Step **1606** includes rotating the window to a closed position (e.g., about a pivot or hinge joint).

[0088] In some embodiments, removing the window is substantially similar to process **1600** but performed in reverse, or otherwise modified, order. For example, step **1652** includes rotating the window, e.g., rotated into a venting position, and step **1654** includes moving the window away from the flange (e.g., with the flange in a flexed position) to release the window. In some embodiments, the removal method does not require any operation corresponding to step **1602**. In some embodiments, step **1656** includes disrupting an alignment between the recess of the window and the flange (e.g., disengaging one or more locating feature) to fully remove the window from a support to which the flange is coupled.

[0089] FIG. **17** shows illustrative details of living hinge **1790** and window that are configured for disassembly and reassembly. As illustrated in panel **1700** of FIG. **17**, in an "After Removal" configuration, living hinge **1790** is separated from window **1710**. Although not shown in FIG. **17**, in some embodiments, living hinge **1790** remains coupled to a support (e.g., a pillar of a vehicle) after window **1710** is disconnected (e.g., living hinge **1790** may be attached more permanently to the support). As illustrated in panel **1740** of FIG. **17**, which includes an enlargement of a portion of living hinge **1790**, ridge **1717** of flange **1791** (e.g., which may be similar to locating feature **1317** of flange **1391** of FIG. **13**) may be aligned with a slot (e.g., locating feature **1716**, which may be similar to locating feature **1316** of FIG. **13**) in sidewall **1718** of recess **1715** in window **1710** (e.g., recess **1715** being in encapsulation frame **1714** or other support structure of window **1710**). Panel **1780** of FIG. **17**, taken from approximately the perspective of direction **1781** in panel **1700**, shows additional aspects of the interface (although ridge **1717** is substantially hidden due to observing the other side of living hinge **1390**). Based on the interface between locating feature **1716** and ridge **1717**, window **1710** may be readily reassembled with living hinge **1790** and be readily reconnected to a vehicle or other support to which living hinge **1490** is affixed or otherwise configured to be affixed.

[0090] FIG. **18** is an illustrative depiction of another window and living hinge having fastening elements and a corresponding support, in accordance with some embodiments of the present disclosure. Living hinge **1890** differs in some respects from living hinge **1790** of FIG. **17**. Living hinge **1890** includes base section **1893** that is affixed to window **1810** (e.g., using fasteners, adhesives, or any other suitable affixation mechanism the prevents separation). For example, when removing window **1810** from a support structure (e.g., support **1811**), living hinge **1890** detaches from the support structure (and remains affixed to window **1810**) such that window **1810** may be detached from the support structure. Living hinge **1890** also includes flange **1891** and curved hinge section **1892** that connects to base section **1893** and to flange **1891** (e.g., is part of the same continuous component, or otherwise in contact with) thus coupling base section **1893** to flange **1891**.

[0091] As shown in FIG. **18**, living hinge **1890** includes flange **1891** with one or more fastening elements **1865** (also referred to as first fastening elements **1865**) that are configured to releasably couple to respective one or more fastening elements **1875** (also referred to as second fastening elements **1875**) of support **1811** (e.g., window **1810** may also interface to a plurality of supports or otherwise be interchangeable among vehicles). For example, fastening elements **1865** may be openings in flange **1891**, where each opening includes a respective small opening **1866**, large opening **1867**, and choke point **1868**. Support **1811** to which living hinge **1890** releasably couples includes second fastening elements **1875**, each of which may correspond to a respective first fastening element of first fastening elements **1865**. For example, one or more fastening elements **1875** (e.g., second fastening elements) may be mushroom-head protrusions including mushroom head **1877** (e.g., or any other suitable cap of a sphere or ellipsoid) and neck **1876** (e.g., or any other suitable extended component with a smaller width than the head). As shown, a size of mushroom head **1877** may correspond to large openings **1867** and size of neck **1876** may correspond to small opening **1866**.

[0092] In an illustrative assembly process consistent with the apparatus shown in FIG. **18**, window **1810** may be aligned with and coupled to support **1811** such that mushroom heads of second fastening elements **1875** penetrate the large openings of first fastening elements **1865**. Then, window **1810** may be maneuvered such that the necks (e.g., neck **1876**) of second fastening elements **1875** pass through the choke points of the first fastening elements (e.g., choke points **1868**) until these necks reside in the small openings of the first fastening elements (e.g., small opening **1866**). Therein, the mushroom heads of the second fastening elements (e.g., mushroom head **1877**) will not be able to release

from the small openings (e.g., small opening **1866**) unless a corresponding lateral force is applied (e.g., as occurs during disassembly) to push these necks back into the large openings of the first fastening elements (e.g., large opening **1867**). For example, as illustrated, each of first fastening elements **1865** include a respective choke point **1868** between the respective large opening and the small opening, and each choke point provides a snap-fit connection with the neck of a respective mushroom-head protrusion. To illustrate, the snap-fit connection between first fastening elements **1865** and second fastening elements **1875** is a contact interface where a force is applied to lock the components together past some resistance (i.e., choke point **1868**) to secure the interface.

[0093] FIG. **19** is a flowchart of illustrative process **1900** for installing a window, in accordance with some embodiments of the present disclosure. In some embodiments, process **1900** may be used to assemble (or may be similarly used to disassemble) the living hinge and the support/pillar as shown in FIG. **18**. Step **1902** includes aligning one or more first fastening elements of a living hinge with respective one or more second fastening elements of a support, wherein the living hinge is affixed to a window (e.g., is not detachable from the window). In some embodiments, a locating feature on the window, the flange, or both is used to align the recess of the window with the flange. Step **1904** includes moving the one or more first fastening elements relative to the respective one or more second fastening elements to releasably couple the first and second fastening elements together. Step **1906** includes rotating the window to a closed position, thereby compressing the living hinge.

[0094] In some embodiments, corresponding process **1950** to remove the window is substantially similar to that of process **1900** but performed in reverse order, or an otherwise suitably modified order. For example, step **1952** includes rotating the window into a venting position, thereby releasing some pressure on the living hinge, and step **1954** may include moving one or more first fastening elements relative to the respective one or more second fastening elements to release the first fastening elements from the second fastening elements. In some embodiments, process **1900** need not include step **1956**. In some embodiments, process **1900** includes disrupting an alignment between the living hinge and the support (e.g., disengaging one or more locating feature) to fully remove the window from a support to which the living hinge is coupled.

[0095] FIG. **20** shows illustrative implementations of a modular window that is configurable for a fixed installation (as shown in panel **2000**) or a venting/removable installation (as shown in panel **2040**), in accordance with some embodiments of the present disclosure. In both possible installations, the modular window may include glass (e.g., a window pane), an encapsulation frame with first and second slides, a slot, and a mechanical interface including a plurality of protrusions and a ball of a ball joint. Modular window **2001** is configured for a fixed installation, and the modular window additionally includes glue bead **2016**. In venting or removable installations, such as that illustrated in panel **2040**, the modular window additionally includes bulb seal **2056** and a mating feature. In some embodiments, the venting or removable installations may also include linear actuator **2080** and housing **2060** that is coupled to mechanical interface **2035** of the modular window **2001**. In some embodiments, modular window **2041** is the same (e.g., having equivalent components and manufacturing processes) when installed in either of the venting or removable positions, as illustrated in panel **2040**. In some embodiments, a setting, software update, user input, any suitable local action, any suitable remote action, or any combination thereof may configure the installed modular window **2041** to be in either of the venting or the removable states.

[0096] As shown in FIG. **20**, first side **2011** of encapsulation frame **2012** includes mechanical interface **2035**. In the fixed installation illustrated in panel **2000**, mechanical interface **2035** (ball joint element **2031** and bracket **2030**) need not be coupled to any other structures. In the venting or removable installations illustrated in panel **2040**, this mechanical interface is coupled to linear actuator **2080** and housing **2060** (e.g., to drive modular window **2041** between closed, vented, and removable positions). Second side **2013** of encapsulation frame **2012** includes mating feature **2015** (e.g., a recess, slot, or other suitable feature for interfacing to a support), where mating feature **2015** includes a slot as illustrated. In the fixed installation illustrated in panel **2000**, this mating feature need not be coupled to any other structures. In the venting or removable installations illustrated in panel **2040**, this mating feature may be coupled to living hinge **2090**, where living hinge **2090** releasably couples encapsulation frame **2052** to a vehicle or another support of modular window **2041**. When modular window **2041** is in the venting or removable installation, bulb seal **2056** forms a substantially airtight seal when modular window **2041** is in a closed position, without preventing modular window **2041** from releasing into venting or removable positions (e.g., maintains the closed position and seal). When modular window **2001** is in a fixed installation, glue bead **2016** forms a more permanent and more substantially airtight seal.

[0097] In some embodiments, a modular window such as modular windows **2001** and **2041** illustrated in FIG. **20** may be desirable to reduce manufacturing complexity and degrees of freedom while offering multiple possible end-product configurations. For example, a single modular window design may be mass produced and integrated into at least two possible assembly options. In the first assembly option (e.g., fixed installation), a glue bead is applied and the encapsulation frame is affixed to a vehicle or other suitable window support such that it is not intended as removable. In the second assembly option (e.g., the venting or removable installation), a bulb seal, living hinge, housing, and linear actuator are applied and the encapsulation frame is installed to a vehicle or other suitable window support. In some embodiments, the living hinge, housing, and linear actuator may be applied after the window (with the bulb seal) is installed in the vehicle or other suitable window support.

[0098] FIG. **21** is a flowchart of illustrative process **2100** for installing a modular window, in accordance with some embodiments of the present disclosure. In some embodiments, process **2100** or portions thereof may be used to install the modular window as shown in FIG. **20** (e.g., with a living hinge, actuator and housing). Step **2102** may include identifying an intended use of a modular window. The intended use may be one of fixed, venting, or removable, for example, as illustrated in Step **2104**. Steps **2102** and **2104** may be combined, for example, where use cases are identified at step **2102** and then selected from among those options at step **2104**. In some embodiments, the intended use may be stored in memory as part of a vehicle build file. For example, the intended use may be identified by retrieving the

intended use from memory. To illustrate, a modular window may include glass, an encapsulation frame surrounding the glass with a first encapsulation frame side and a second encapsulation frame side opposite the first side, a mechanical interface located on the first encapsulation frame side, and a mating feature located on the second encapsulation frame side. If the intended use case is identified as fixed, then process **2100** may proceed to step **2106**, which includes applying a bead of adhesive (e.g., glue) to the encapsulation frame, where the bead surrounds the glass and the mechanical interface (e.g., such that there are no gaps in adhesive). Step **2108** includes seating the modular window onto a window frame to secure the modular window to the window frame using the bead (e.g., such that the window is not removable under normal operation). Alternatively, if the intended use case was identified as venting or removable, then process **2100** proceeds to step **2110**, which includes securing a bulb seal on the encapsulation frame (e.g., or alternatively on the window frame of the support), where the bulb seal surrounds the glass and the mechanical interface. Step **2112** includes coupling a living hinge to the mating feature and an actuator to the mechanical interface.

[0099] FIG. **22** is a flowchart of illustrative process **2200** for assembling, installing, and operating a modular window, in accordance with some embodiments of the present disclosure. Step **2202** includes selecting a configuration of window such as, for example, fixed, venting, removable, or a combination thereof. For example, a window may configured as either fixed or venting/removable (e.g., there may be two selections available). In some embodiments, step **2202** may be same as either or both of steps **2102** and **2104** of FIG. **21**.

[0100] For a fixed configuration selected at step **2202**, step **2210** includes assembling the window for the fixed configuration. Step **2210** may include assembling a glass window pane and an encapsulation frame (e.g., a metal, composite, or plastic frame), hardware for venting even if not used, plugs or other components to seat recesses that would otherwise be used for venting/removal, any other suitable actions, or any combination thereof. Step **2212** includes installing the window in a vehicle in the fixed configuration (e.g., against a window frame or support thereof), which may include applying an adhesive bead, arranging the modular window in an opening of the vehicle, pressing the modular window into place, applying trim, coupling connectors for an antenna (e.g., for a radio antenna integrated into the window), any other suitable actions, or any combination thereof. In some embodiments, for example, a window may be assembled at step **2210** and include a latch, and the window may be installed at step **2212** to a support having a latch mount rather than a latch receiver. To illustrate, when installed in a vehicle having a latch mount rather than a latch receiver, the window remains in the fixed configuration. For example, the latch mount may include a recess sized to lock a hook of the latch such that it cannot rotate relative to the latch mount (e.g., the hook remains fully engaged with and within the recess).

[0101] For a venting and/or removable configuration selected at step **2202**, step **2220** includes assembling the window for the venting/removable configuration. Step **2220** may include assembling a glass windowpane and an encapsulation frame (e.g., a metal, composite, or plastic frame), hardware for venting (e.g., latches, actuators, mechanical interfaces), hardware for removal (e.g., latches, actuators, mechanical interfaces), any other suitable actions, or any combination thereof. Step **2222** includes installing the window in a vehicle in the venting/removable configuration (e.g., against a window frame or support thereof), which may include installing a bulb seal, arranging the modular window in an opening of the vehicle (e.g., a window frame), pressing the modular window into place in the window frame, applying trim, coupling latching and actuator interfaces, coupling connectors for an antenna (e.g., for a radio antenna integrated into the window), any other suitable actions, or any combination thereof.

[0102] For a venting and/or removable configuration selected at step **2202**, once installed at step **2222**, the window system may be operated at steps **2224**, using any of configurations **2230**, **2232**, **2234**, or **2236**, depending on the installation type at step **2222**. Configuration **2230** includes fully manual operation, where both venting and removal are controlled by the user (e.g., using a mechanized link and/or latches). Configuration **2232** includes fully automatic operation, where venting and removal may be governed controlled by actuators and powered latches. Configuration **2234** includes automatic venting (e.g., using a linear actuator) and manual removal (e.g., a hand operated latch or removable living hinge). Configuration **2236** includes manual venting (e.g., a crank mechanism or swing-out mechanism) and automatic removal (e.g., using powered latches and an actuator to move the window off of the support).

[0103] FIG. **23** shows a block diagram of illustrative system **2300** for controlling a window of a vehicle, in accordance with some embodiments of the present disclosure. For example, system **2300** may be included as part of vehicle **100** of FIG. **1**, having window **110**. As illustrated, system **2300** includes control circuitry **2310**, sensors **2304**, user interface **2306**, power supply **2302**, venting latch **2330**, removal latch **2340**, venting actuator **2350**, removal actuator **2360**, antenna system **2370**, and any other suitable systems (e.g., other system **380**), in accordance with some embodiments of the present disclosure. Illustrative control circuitry **310** includes processor **2312**, one or more relays **2314**, input/output **2316** (hereinafter referred to as I/O **2316**), communication hardware **2318** (hereinafter referred to as COMM **2318**), and memory **2320**. Window system **2390**A corresponds to an installation in which a window may achieve more than one configuration, while window system **2390**B corresponds to an installation where the window is fixed.

[0104] Control circuitry **2310** may include hardware, software, or both, implemented on one or more modules configured to provide control of venting, removing, latching, locking/unlocking, or otherwise manipulation of a window. In some embodiments, processor **2312** includes one or more microprocessors, microcontrollers, digital signal processors, programmable logic devices, field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), or any suitable combination thereof. In some embodiments, processor **2312** is distributed across more than one processor or processing units. In some embodiments, control circuitry **2310** executes instructions stored in memory (e.g., non-transitory computer readable media) for managing the window. In some embodiments, memory **2320** is an electronic storage device that is part of control circuitry **2310**. For example, memory may be configured to store electronic data, computer instructions, applications, firm-

ware, or any other suitable information. In some embodiments, memory **2320** includes random-access memory, read-only memory, hard drives, optical drives, solid state devices, or any other suitable memory storage devices, or any combination thereof. In some embodiments, control circuitry **2310** may be similar to, or otherwise include components of control circuitry **1210**, memory **1220**, and processing circuitry **1230** of FIG. **12**.

[0105] In some embodiments, control circuitry **2310** is powered by power supply **2302**. In some embodiments, power supply **2302** includes a car battery (e.g., a 12 V lead acid battery), a DC-DC converter, an AC power supply (e.g., generated by suitably inverting a DC power supply), any other power supply, any corresponding components (e.g., terminals, switches, fuses, and cables), or any combination thereof. In some embodiments, power supply **2302** supplies power to sensors **2304**, venting latch **2330**, removal latch **2340**, venting actuator **2350**, removal actuator **2360**, antenna system **2370**, and any other suitable systems (e.g., other system **380**), or any combination thereof.

[0106] In some embodiments, user interface **2306** includes a push button, a toggle switch, a turnable knob, a display screen (e.g., a touch screen), a key fob, a key-lock combination, any other suitable system or component for receiving input from a user or providing output to a user, or any combination thereof. In some embodiments, user interface **2306** includes a touchscreen on the dash of a vehicle, configured to receive input from the user, and provide a display to the user. In some embodiments, user interface **2306** includes one or more buttons that are selectable by a user. For example, the one or more buttons may include a button coupled to a switch, a button on a touchpad, any other suitable button that may be used by a user to make a selection, or any combination thereof. In some embodiments, user interface **2306** includes one or more turnable knobs that a user may turn to adjust a venting setting, or latch setting, for example. User interface **2306** may be the same as, or include components of, user input device **1250** of FIG. **12**.

[0107] In some embodiments, sensor(s) **2304** include one or more contact sensors (e.g., at least one set of electrical contacts wherein a voltage, current, or impedance is measured across the contracts to determine whether engaged or disengaged), position sensors (e.g., a rotary or linear encoder), proximity sensors, any other suitable sensors, or any combination thereof. For example, sensors **2304** may be used to determine whether window **2391** is in a sealed position, vented position, or removed position based on the feedback from one or more sensors. In a further example, sensors **2304** may be used to measure a relative position of window **2391** and support **2399**. In a further example, sensors **2304** may be used to measure a position of venting latch **2330**, removal latch **2340**, venting actuator **2350**, removal actuator **2360**, antenna system **2370**, or any combination thereof. Sensors **2304** may include one or more sensors of any suitable type or types.

[0108] Venting latch **2330** may include any suitable controllable latch to release a venting end of a window. For example, venting latch **2330** may include a hook-pin interface or other cinching interface controlled by an electromagnetic actuator (e.g., linear actuator **610** or any other suitable actuator). Venting actuator **2350** may be separate from, or integrated with, venting latch **2330**. For example, venting actuator **2350** may include linear actuator **610** and venting latch **2330** may include a separate cinching latch.

[0109] Removal latch **2340** may include any suitable controllable latch to release a removal end of a window (e.g., a hinged end, an end having a living hinge). For example, removal latch **2340** may include a hook-pin interface or other cinching interface controlled by an electromagnetic actuator. Removal actuator **2360** may be separate from, or integrated with, removal latch **2340**. For example, removal actuator **2360** may include an actuator for pushing window **2391** away from support **2399** in a controlled and predictable way (e.g., based on the trajectory of the actuator and any linkages), and removal latch **2340** may include a separate cinching latch.

[0110] In some embodiments, other systems **2380** may include an antenna system, for use with detecting radio waves for radio, network connectivity, or other electromagnetic signals. For example, window **2391** may include an embedded or attached antenna (e.g., antenna **2383**), which may interface to the vehicle. In some embodiments, window **2391** includes element **2382** (e.g., an electrical connector such as a plug or socket), and support **2399** includes element **2381** (e.g., a mating electrical connector such as a socket or plug) that interfaces to element **2382**. In some embodiments, removal of window **2391** may itself disconnect elements **2381** and **2382** (e.g., connectors configured to engage or disengage as the window is installed or removed), such that antenna **2383** is not electrically coupled to control circuitry **2310**. In some embodiments, a user may need to manually disconnect elements **2381** and **2382** from each other (e.g., unplug the connectors when removing the window). In some embodiments, control circuitry **2310** may detect if elements **2381** and **2382** are engaged or disengaged, and either control connecting and disconnecting them, or generate a notification to a user (e.g., on user interface **2306**) prompting the user to disengage or re-engage elements **2381** and **2382**. In some embodiments, control circuitry **2310** is configured to determine that elements **2381** and **2382** are disengaged or otherwise that antenna **2383** is unavailable, and may select another antenna of the vehicle to use for communications. In some embodiments, for example, a vehicle includes more than one antenna (e.g., permanently mounted, or mounted in more than one window), and control circuitry **2310** may select from the antennas based on availability, signal strength, or any other suitable criteria. In some embodiments, elements **2381** and **2382** need not be configured to be disconnected or otherwise be flexible. For example, as illustrated by window system **2390**B, in a fixed configuration, elements **2381** and **2382** may be connected and may remain connected because window **2390**B is fixed.

[0111] For example, control circuitry **310** may execute computer readable instructions stored on non-transitory computer readable media to select from among configurations or window actuations (e.g., based on input from user interface **2306**), retrieve reference information (e.g., from memory), generate and transmit control signals to any system of system **2300**, receive and process sensor signals, or a combination thereof. System **2300**, or control circuitry **2310** thereof, may be referred to herein as a control system (e.g., for controlling window system **2390**A of a vehicle).

[0112] In an illustrative example, window system **2390**A of a vehicle may include window **2391** and support **2399**. A vehicle may include any suitable number of window systems (e.g., any suitable number of modular windows). Window

2391 may interface to support **2399** at two distinct regions. Removal element **2393** of window **2391** may interface to removal element **2392** of support **2399**. Removal elements **2392** and **2393** may include a pivot (e.g., a hinged joint, a living hinge), an actuator, a latch, a sensor, locating features, an engageable and dis-engageable interface, any other suitable components or features, or any combination thereof. Venting element **2395** of window **2391** may interface to venting element **2394** of support **2399**. Venting elements **2394** and **2395** may include an actuator (e.g., such as linear actuator **610**), a latch, a sensor, locating features, an engageable and dis-engageable interface, any other suitable components or features, or any combination thereof. Any or all of removal elements **2392** and **2393**, and venting elements **2394** and **2395**, may be manual or otherwise controlled by control circuitry **2310** (e.g., as discussed in the context of process **2200**). In some embodiments, window **2319** may be configured to remain in place (e.g., as illustrated, in a fixed configuration) and need not be controllable. In some embodiments, window **2319** may be configured to achieve a fixed, vented (e.g., configuration **2396**), and removed configuration (e.g., configuration **2397**).

[0113] In an illustrative example, window system **2390**B of a vehicle may include window **2388** and support **2389**. In some embodiments, a modular window may be configured to be controllable using control circuitry **2310**, manually controllable, or not controllable. As illustrated, window **2388** is not controllable, and only achieves a fixed configuration. Window **2388** may interface to support **2389**. While window **2388** may include removal element **2387** (e.g., similar to removal element **2393** of window **2391**), it may be configured to interface to mounting element **2386** of support **2389**, which does not allow removal. When installed in a vehicle having mounting element **2386** rather than removal element **2392**, window **2388** may remain fixed in place interfaced to support **2389**. Similarly, venting element **2395** of window **2391** may interface to mounting element **2384** of support **2389**, which does not allow venting or removal. When installed in a vehicle having mounting element **2384** rather than venting element **2394**, window **2388** may remain fixed in place interfaced to support **2389** (e.g., is not able to achieve a vented configuration). In some embodiments, a window may be configured to achieve a fixed, vented (e.g., configuration **2396**), and removed configuration (e.g., configuration **2397**) when installed in a first vehicle or first support type, but may only be able to achieve a fixed configuration in another vehicle or other support type. For example, windows **2391** and **2388** may be identical, but may have different functionality depending upon the type of support or vehicle they are installed in.

[0114] The processes described above are intended to be illustrative and not limiting. One skilled in the art would appreciate that the steps of the processes described herein may be omitted, modified, combined and/or rearranged, and any additional steps may be performed without departing from the scope of the invention. It will also be understood that the processes may be implemented at least in part using processing circuitry.

[0115] The foregoing is merely illustrative of the principles of this disclosure, and various modifications may be made by those skilled in the art without departing from the scope of this disclosure. The above-described embodiments are presented for purposes of illustration and not of limitation. The present disclosure also can take many forms other than those explicitly described herein. Accordingly, it is emphasized that this disclosure is not limited to the explicitly disclosed methods, systems, and apparatuses, but is intended to include variations thereto and modifications thereof, which are within the spirit of the following claims.

What is claimed is:

1. A window disconnect comprising:

a keyed ball; and

a keyed socket configured to engage and disengage the keyed ball, wherein:

in a first rotational orientation of the keyed socket, the keyed ball is locked in the keyed socket such that a window is locked; and

in a second rotational orientation of the keyed socket, the keyed ball is unlocked and removable from the keyed socket such that the window is removable.

2. The window disconnect of claim **1**, wherein the first rotational orientation and the second rotational orientation are between 80 and 100 degrees apart.

3. The window disconnect of claim **1**, wherein the keyed socket comprises a slot and the keyed ball comprises a ball having flats on opposite sides.

4. The window disconnect of claim **3**, wherein:

in a first rotational orientation of the keyed socket, the flats are parallel with the sides of the slot such that the keyed ball can translate into and out of the keyed socket; and

in a second rotational orientation of the keyed socket, the flats are misaligned with the sides of the slot such that the keyed ball cannot translate into or out of the keyed socket.

5. The window disconnect of claim **1**, further comprising:

a base affixed to the window; and

a collar rotatably coupled to the base, wherein the keyed socket is arranged at an end of the collar such that the keyed socket rotates with the collar.

6. The window disconnect of claim **5**, further comprising an actuator coupled to the collar and configured to rotate the collar based on a control signal.

7. The window disconnect of claim **1**, further comprising:

an arm coupled to the keyed ball; and

an actuator coupled to the arm and configured to move the arm based on a control signal to cause the window to move relative to a support when the keyed ball is locked in the keyed socket.

8. The window disconnect of claim **1**, wherein:

the keyed ball is affixed to the window; and

the keyed socket is coupled to a support.

9. The window disconnect of claim **1**, wherein the keyed ball is affixed to the window and wherein the window disconnect further comprises:

an actuator coupled to the keyed socket and a support and configured to cause the keyed socket to translate and rotate.

10. The window disconnect of claim **9**, wherein the actuator is a linear actuator comprising:

a translation screw configured to rotate about an axis;

a translation shaft configured to translate based on rotation of the translation screw, wherein the translation shaft comprises the keyed socket; and

a housing configured to control a rotational orientation of the translation shaft during translation.

11. A linear actuator, comprising:

a translation screw configured to rotate about an axis;

a translation shaft configured to translate based on rotation of the translation screw, wherein the translation shaft comprises a ball joint element at an end; and

a housing configured to control a rotational orientation of the translation shaft during translation, wherein:

during a first range of motion of the translation shaft, the rotational orientation is substantially constant; and

during a second range of motion of the translation shaft, the rotational orientation varies.

12. The linear actuator of claim **11**, wherein:

the translation shaft comprises a groove along an exterior surface; and

the housing comprises a boss that extends into the groove and controls the rotational orientation of the translation shaft.

13. The linear actuator of claim **12**, wherein:

the groove comprises a linear portion and a curved portion;

during the first range of motion, the boss traverses the linear portion of the groove; and

during the second range of motion, the boss traverses the curved portion of the groove.

14. The linear actuator of claim **13**, wherein:

the curved portion of the groove wraps at least 80 degrees around the translation shaft; and

during the second range of motion, the translation shaft rotates at least 80 degrees while translating.

15. The linear actuator of claim **11**, wherein:

the ball joint element comprises a keyed socket configured to receive a keyed ball;

during the first range of motion, the rotational orientation of the translation shaft maintains the keyed socket in a locked configuration relative to the keyed ball; and

during the second range of motion, the translation shaft rotates the keyed socket into an unlocked configuration relative to the keyed ball.

16. The linear actuator of claim **15**, wherein:

the keyed ball is coupled to a window; and

the first range of motion of the translation shaft causes the window to move from a closed position to a vented position.

17. The linear actuator of claim **15**, wherein the second range of motion of the translation shaft causes the window to move from a vented position to a removal position.

18. An apparatus, comprising:

a window;

a keyed ball coupled to the window; and

a linear actuator, comprising:

a translation screw configured to rotate about an axis;

a translation shaft configured to translate based on rotation of the translation screw, wherein the translation shaft comprises a keyed socket coupled to the keyed ball; and

a housing configured to control a rotational orientation of the translation shaft during translation, wherein:

during a first range of motion of the translation shaft, the rotational orientation is substantially constant at a first orientation and the window moves from a closed position to a vented position; and

during a second range of motion of the translation shaft, the rotational orientation changes from the first orientation to a second orientation and the window moves from the vented position to a removal position.

19. The apparatus of claim **18**, further comprising:

a hinge coupled to a first end of the window, wherein the keyed ball is coupled proximate to a second end of the window opposite the first end.

20. The apparatus of claim **18**, wherein:

the translation shaft comprises a groove having a linear portion and a curved portion;

the housing comprises a boss that extends into the groove and controls the rotational orientation of the translation shaft;

during the first range of motion, the rotational orientation of the translation shaft maintains the keyed socket in a locked configuration relative to the keyed ball; and

during the second range of motion, the translation shaft rotates the keyed socket into an unlocked configuration relative to the keyed ball.

* * * * *