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Pressure differential lockout system and calibration method

Abstract

A pressure differential lockout system for a door separating first and second regions comprises a piston assembly, a follower linkage, and a fluid conduit. The follower linkage is mechanically coupled with a latch release handle of the door. The piston assembly includes a piston and a piston housing collectively defining an interior chamber. The fluid conduit provides fluid communication between the first region and the interior chamber. The piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the interior chamber and the second region. The piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage. The channel inhibits rotation of the follower linkage within a first translation range of the piston and enables rotation of the follower linkage within a second translation range of the piston.

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Background/Summary

FIELD

(1) The subject disclosure relates generally to a pressure differential lockout system and calibration method for a door separating a first region from a second region, such as an exterior door of an aircraft, as an example.

BACKGROUND

(2) Pressure differential environments can be used to maintain a suitable pressure within an enclosed space, such as an aircraft cabin, as an example. Doors separating two regions can be maintained in a closed state during certain operations to maintain a pressure differential between the two regions. These doors can be opened to enable access between the two regions when the pressure differential is eliminated or reduced to below a suitable level. Technical challenges exist for inhibiting doors separating two regions from being opened when a substantial pressure differential exists between the two regions.

SUMMARY

(3) A pressure differential lockout system for a door separating a first region from a second region is disclosed. As an example, the door can take the form of an exterior door of an aircraft that separates a cabin of the aircraft from an exterior operating environment. The system comprises a follower linkage mechanically coupled with a latch release handle of a linkage assembly of the door. The system further comprises a piston assembly including a piston and a piston housing collectively defining an interior chamber of the piston assembly. The system further comprises a fluid conduit that provides fluid communication between the first region and the interior chamber of the piston assembly. The piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the interior chamber of the piston assembly

and the second region in fluid communication with an exterior side of the piston from the interior chamber. The piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage. The channel defined by the piston inhibits rotation of the follower linkage within a first translation range of the piston along the translation axis and enables rotation of the follower linkage within a second translation range of the piston along the translation axis.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** depicts an example aircraft.
(2) FIG. **2** depicts an example interior of the aircraft of FIG. **1**.
(3) FIGS. **3**A and **3**B depict an example pressure differential lockout system and linkage assembly for a door of the aircraft of FIG. **1**.
(4) FIGS. **4**A, **4**B, and **4**C depict additional aspects of the pressure differential lockout system of FIGS. **3**A and **3**B.
(5) FIGS. **5**A and **5**B depict additional aspects of the pressure differential lockout system of FIGS. **3**A and **3**B.
(6) FIG. **6** schematically depicts an example door for separating a first region from a second region of different pressures.
(7) FIG. **7** is a flow diagram depicting an example method of calibrating a pressure differential lockout system for a door separating a first region from a second region.
(8) FIG. **8** depicts another example pressure differential lockout system.
DETAILED DESCRIPTION
(9) As briefly introduced above, technical challenges exist for inhibiting doors separating two regions from being opened when a substantial pressure differential exists between the two regions. Two regions separated by a door can each comprise a fluid, such as air, water, or other fluid types, including other gases and liquids. For example, in the context of a door of an aircraft, the door can separate a first region comprising air (e.g., an operating environment within which the aircraft operates) from a second region comprising air (e.g., an interior cabin of the aircraft). As another example, the door can separate a first region comprising air from a second region comprising water. As yet another example, the door can separate a first region comprising water from a second region comprising water. In each of the preceding examples, a pressure differential may be present between the first region and the second region during which the door is to remain closed, at least until the pressure differential between the two regions is equalized or reduced to below a threshold level.
(10) A pressure differential lockout system for a door separating two regions is disclosed that offers the potential to inhibit the door from being opened when a pressure differential between the two regions exceeds a threshold. The pressure differential lockout system disclosed herein can be used in connection with mobile vehicles or stationary structures (e.g., stationary pressure vessels, building structures, etc.). As an example, the pressure differential lockout system can be used in connection with an exterior door of an aircraft that separates a cabin of the aircraft from an exterior operating environment. While examples are disclosed herein within the context of an aircraft, it will be understood that the disclosed pressure differential lockout system can be used in other contexts in which a door separates two regions of different pressure.
(11) According to an example, the pressure differential lockout system comprises a follower linkage mechanically coupled with a latch release handle of a linkage assembly of the door. The system further comprises a piston assembly including a piston and a piston housing collectively defining an interior chamber of the piston assembly. The system further comprises a fluid conduit

that provides fluid communication between the first region and the interior chamber of the piston assembly. As previously described, the first region can comprise a fluid such as air, water, or other gas or liquid. Fluid communication provided by the fluid conduit enables fluid exchange and pressure equalization of a fluid such as air, water, etc. between the first region and the interior chamber of the piston assembly.

(12) The piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the interior chamber of the piston assembly and the second region in fluid communication with an exterior side of the piston from the interior chamber. The piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage. The channel defined by the piston inhibits rotation of the follower linkage within a first translation range of the piston along the translation axis and enables rotation of the follower linkage within a second translation range of the piston along the translation axis.

(13) By inhibiting rotation of the follower linkage, as well as the latch release handle mechanically coupled with the follower linkage, the pressure differential lockout system inhibits opening of the door. A threshold pressure differential, above which rotation of the follower linkage is inhibited, can be calibrated using the features and techniques disclosed in further detail herein.

(14) FIG. **1** depicts an example aircraft **100** that includes a fuselage **110** and one or more doors, such as doors **112**, **114**, **116** located at example locations along a first side of the fuselage. In this example, aircraft **100** takes the form of a commercial passenger airliner that includes a forward door (e.g., **112**), an over-wing door (e.g., **114**), and an aft door (e.g., **116**) located on each side of fuselage **110**. While aircraft **100** is described with reference to a commercial passenger airliner, it will be understood that aircraft **100** can take other forms, including other types of fixed wing aircraft, rotary wing aircraft, passenger aircraft, cargo aircraft, etc.

(15) Fuselage **110** in combination with the various doors of aircraft **100** (e.g., **112**, **114**, and **116**) separate a first region **120** that forms an operating environment of the aircraft from a second region **122** that forms an interior environment of the aircraft. Second region **122** is represented schematically by dotted lines in FIG. **1** in a vicinity of door **114**. It will be understood that second region **122** can further include the remaining portions of the interior cabin of the aircraft.

(16) Each door of aircraft **100** separating first region **120** from second region **122** can incorporate or otherwise be associated with a pressure differential lockout system. A general location of an example pressure differential lockout system **130** for door **114** is represented schematically in FIG. **1**, aspects of which are described in further detail with reference to FIG. **2**. As an example, system **130** can be integrated with door **114**, such as being located within or mounted to a body of the door.

(17) Each pressure differential lockout system (e.g., **130**) can inhibit opening of a respective door (e.g., **114**) of aircraft **100** while a pressure differential between first region **120** and second region **122** exceeds a threshold level. As an example, pressure differential lockout system **130** can inhibit door **114** from being opened by passengers located within second region **122** while a pressure of second region **122** exceeds a pressure of first region **120** by a threshold level.

(18) FIG. **2** depicts an example interior of aircraft **100** of FIG. **1**, corresponding to second region **122** in the vicinity of door **114**. In this example, second region **122** includes a cabin of aircraft **100**, and door **114** takes the form of an over-wing door accessible to passengers located within the cabin. It will be understood that door **114** can instead refer to a forward door (e.g., **112** of FIG. **1**), an aft door (e.g., **116** of FIG. **1**), or other suitable door location of an aircraft.

(19) Door **114** is depicted in a closed state in FIG. **2**. Door **114** includes a linkage assembly **210**, represented schematically in FIG. **2**. Linkage assembly **210** secures door **114** in the closed state with respect to a door frame **220** of fuselage **110** via one or more door latches of the linkage assembly. Linkage assembly **210** is operable via a latch release handle **212** to release door **114** from being secured by the door latches in the closed state to enable the door to be opened. As an example, latch release handle **212** can be rotated or otherwise manipulated by hand to disengage

the door latches that secure door **114** in the closed state.

(20) FIG. **2** schematically depicts pressure differential lockout system **130** integrated with door **114**, aspects of which are described in further detail herein. System **130** inhibits linkage assembly **210** from being operable via latch release handle **212** to release door **114** from being secured in the closed state when the pressure differential between first region **120** and second region **122** exceeds a threshold level.

(21) FIGS. **3**A and **3**B depict aspects of pressure differential lockout system **130** and linkage assembly **210** in further detail.

(22) In FIG. **3**A, pressure differential lockout system **130** inhibits latch release handle **212** from being rotated to release a door (e.g., **114** of FIGS. **1** and **2**) from a closed state, thereby inhibiting the door from being opened.

(23) System **130** comprises a follower linkage **310** mechanically coupled with latch release handle **212** of linkage assembly **210**. In this example, follower linkage **310** and latch release handle **212** are mechanically coupled with each other by each being mounted to a shaft **312** at a fixed position, thereby coordinating rotation of the follower linkage and the latch release handle with each other. In another example, follower linkage **310** can be coupled to another shaft of linkage assembly **210** that is mechanically coupled with handle **212** via one or more additional components of the linkage assembly.

(24) System **130** further comprises a piston assembly **320** including a piston **322** and a piston housing **324** collectively defining an interior chamber **326** of the piston assembly.

(25) System **130** further comprises a fluid conduit **330** that provides fluid communication between first region **120** and interior chamber **326** of piston assembly **320**. In this example, fluid conduit **330** is fluidically coupled to piston housing **324**. Fluid conduit **330** can be formed from one or more sections of flexible conduit material and/or rigid conduit material. Fluid conduit **330** can be formed from one or more straight, curved, or circuitous sections.

(26) Piston **322** is translatable along a translation axis **340** relative to piston housing **324** responsive to a pressure differential between interior chamber **326** of piston assembly **320** and second region **122** in fluid communication with an exterior side **328** of the piston from the interior chamber.

(27) Piston **322** defines a channel **342** that is parallel to translation axis **340**. Channel **342** accommodates a follower component **344** of follower linkage **310**. As piston **322** translates along translation axis **340**, follower component **344** translates relative to piston **322** along channel **342**. Channel **342** defined by piston **322** inhibits rotation of follower linkage **310** within a first translation range of the piston along translation axis **340** (e.g., as depicted in FIG. **3**A) and enables rotation of the follower linkage within a second translation range of the piston along the translation axis (e.g., as depicted in FIG. **3**B).

(28) In FIG. **3**B, pressure differential lockout system **130** enables latch release handle **212** to be rotated to release the door (e.g., **114** of FIGS. **1** and **2**) from the closed state, enabling the door to be opened. Within the example of FIG. **3**B, a pressure differential between first region **120** and second region **122** has be reduced as compared to the example of FIG. **3**A, which in turn reduces the pressure differential between interior chamber **326** and second region **122** due to fluid communication provided by fluid conduit **330** between the interior chamber and the first region. Within the context of aircraft **100** of FIG. **1**, as an example, movement of the aircraft to an operating environment (e.g., lower elevation) in which a pressure of first region **120** increases to or toward a pressure of second region **122** results in a reduction in a pressure differential between interior chamber **326** and the second region.

(29) As depicted in FIG. **3**B, piston **322** further defines an opening **346** in a side wall **348** of channel **342** that accommodates rotation of follower component **344** of follower linkage **310** out of the channel along a path of rotation **350** that is orthogonal to translation axis **340**. As follower component **344** is no longer constrained by channel **342** in the example of FIG. **3**B, handle **212** can be rotated along a path of rotation **360** to a position **362** corresponding to disengagement of the

door latches. As handle **212** is mechanically coupled with follower linkage **310** by shaft **312**, rotation of handle **212** to position **362** about an axis of the shaft results in rotation of shaft **312** as indicated by arrows **370**, which in turn results in rotation of follower linkage **310** about the axis of the shaft along path of rotation **350** to a position **352**.

(30) FIGS. **4**A, **4**B, and **4**C depict additional aspects of pressure differential lockout system **130**, including interior features of piston assembly **320**. Within FIGS. **4**A, **4**B, and **4**C, a wall portion of piston housing **324** has been removed to reveal features of piston **322** and internal chamber **326** of piston assembly **320**.

(31) FIG. **4**A depicts pressure differential lockout system **130** in which follower component **344** of follower linkage **310** is located at a first position relative to piston **322**, corresponding to FIG. **3**A. In the example of FIG. **4**A, follower component **344** is accommodated by channel **342** and is out of alignment with opening **346** to inhibit rotation of follower linkage **310**. A floor surface of channel **342** and opening **346** are represented by a first type of crosshatching in FIGS. **4**A, **4**B, and **4**C for purposes of illustration. Interior chamber **326** of piston assembly **320** is depicted in FIG. **4**A having a first volume corresponding to a first position of piston **322** along translation axis **340**. As an example, second region **122** has a greater pressure than first region **120**, such as a pressure differential between the first region and the second region that exceeds a threshold at which the door is inhibited from being opened via the latch release handle.

(32) As depicted schematically in FIG. **4**A, channel **342** defined by piston **322** inhibits rotation of the follower linkage within a first translation range **480** of the piston along translation axis **340** due to follower component **344** being out of alignment with opening **346**, and enables rotation of the follower linkage within a second translation range **482** of the piston along the translation axis due to alignment of follower component **344** with opening **346**, as described with reference to FIGS. **4**B and **4**C.

(33) Furthermore, in this example, piston **322** includes one or more annular seals **410** to inhibit or reduce fluid communication (e.g., air leakage) between internal region **326** and second region **122**. Furthermore, in this example, fluid conduit **330** is fluidically coupled to a port **412** defined by a wall of piston body **324** and to a port **422** defined by a wall **414** of the door or of fuselage **110** of aircraft **100** of FIG. **1** to provide fluid communication between first region **120** and interior chamber **326**. In at least some examples, fluid conduit **330** and/or port **422** can be heated by a heating element **420** to inhibit or reduce freezing of the fluid conduit and/or port. As an example, heating element **420** can take the form of an electric resistive heating coil that surrounds an exterior of fluid conduit **330** and/or port **422**. In at least some examples, heating element **420** can be provided along a portion or an entire length of fluid conduit **330**. For example, heating element **420** can be provided along segments of fluid conduit **330** that are exposed to temperatures that can result in freezing of water vapor within the fluid conduit, particularly in scenarios where the fluid conduit is of substantial length.

(34) FIG. **4**B depicts pressure differential lockout system **130** in which follower component **344** of following linkage **310** is located at a second position relative to piston **322**, corresponding to FIG. **3**B. In the example of FIG. **4**B, follower component **344** of follower linkage **310** is in alignment with opening **346** and is enabled to rotate out of channel **342** through opening **346**. Interior chamber **326** of piston assembly **320** is depicted in FIG. **4**B having a second volume, greater than the first volume of FIG. **4**A, which corresponds to a second position of piston **322** along translation axis **340**. In the example of FIG. **4**B, piston **322** projects outward from piston body **324** by a greater distance as compared to FIG. **4**A due to a lower pressure differential between second region **122** and first region **120**. As an example, first region **120** and second region **122** have equivalent pressure in the example of FIG. **4**B. Alternatively, the example of FIG. **4**B can correspond to a non-zero pressure differential between first region **120** and second region **122** that is less than the pressure differential of FIG. **4**A.

(35) FIG. **4**C depicts pressure differential lockout system **130** in which follower component **344**

has been rotated out of channel **342** through opening **346** along path of rotation **350**, responsive to the latch release handle being rotated to open the door.

(36) In at least some examples, pressure differential lockout system **130** further comprises a spring that urges piston **322** toward second translation range **482** in which follower component **344** is in alignment with opening **346**. Use of a spring to urge piston **322** toward second translation range **482** can assist in returning follower component **344** into alignment with opening **346** when the pressure differential between first region **120** and second region **122** is below a threshold. Referring to FIG. **4**C, as an example, a spring **490** is schematically depicted within interior chamber **326** of the piston assembly. In this example, spring **490** exerts a spring force between piston housing **324** and piston **322**.

(37) FIGS. **5**A and **5**B depict additional aspects of the pressure differential lockout system of FIGS. **3**A and **3**B as viewed along translation axis **340**. In this example, piston **322** has a circular cross section and piston housing **324** defines a circular bore that accommodates the piston. It will be understood that piston **322** can have a cross section of other suitable shapes including oval or polygonal, as examples. In each of these examples, piston housing **324** has a bore that accommodates the shape of piston **322**.

(38) Furthermore, in at least some examples, piston **322** and piston housing **324** can define a keyway **500** that inhibits rotation of the piston within the bore of the piston housing. Additionally, the keyway can ensure that piston **322** and piston housing **324** are assembled correctly with the piston positioned accurately with respect to the follower linkage and other components of the linkage assembly. A keyway, such as example keyway **500** can be provided in examples in which piston **322** has a circular shape and piston housing **324** has a circular bore, but can be excluded in at least some examples where noncircular cross sections are used.

(39) FIG. **5**A depicts follower component **344** out of alignment with opening **346** of channel **342** to inhibit rotation of follower linkage **310**, such as previously described with reference to FIGS. **3**A and **4**A.

(40) FIG. **5**B depicts follower component **344** in alignment with opening **346** of channel **342** to enable rotation of follower linkage **310** out of channel **342** along path of rotation **350** to position **352**, such as previously described with reference to FIGS. **3**B, **4**B, and **4**C.

(41) In at least some examples, follower linkage **310** can be secured to shaft **312** via one or more threaded set screws, an example of which is depicted schematically in FIGS. **5**A and **5**B as set screw **510**. The set screws can be loosened to enable follower linkage **310** to be repositioned at various locations along shaft **312**, and retightened to secure the follower linkage to the shaft at a desired location. In another example, follower linkage **310** can include an annular clamp that applies a compressive force onto shaft **312** to secure the follower linkage to the shaft. The annular clamp can be loosed (e.g., via one or more clamp screws) to enable follower linkage **310** to be repositioned at various locations along shaft **312**, and retightened (e.g., via the one or more clamp screws) to secure the follower linkage to the shaft at a desired location.

(42) FIG. **6** schematically depicts a section view of example of door **114** for separating first region **120** from second region **122** of different pressures. In this example, door **114** comprises a body **610**, linkage assembly **210**, and pressure differential lockout system **130**, as previously described. While door **114** is described within the context of a door of an aircraft, such as aircraft **100** of FIG. **1**, it will be understood that door **114** can be used in other contexts to separate a first region from a second region of different pressures.

(43) In this example, linkage assembly **210** is mounted to body **610** of door **114** via a bracket **612** through which shaft **312** is rotatably mounted. Linkage assembly **210** includes latch release handle **212** and one or more door latches mechanically coupled with the latch release handle via one or more components, including shaft **312**. An example door latch **614** is depicted in FIG. **6** for a first side of door **114**. It will be understood that another door latch can be provided on a second side of door **114**. In the example of FIG. **6**, linkage assembly **210** further includes an additional linkage

616 that mechanically couples door latch **614** with shaft **312**, enabling rotation of latch release handle **212** to induce movement (e.g., rotation) of latch **614**. It will be understood that latch **614** can be mounted directly to shaft **312** in other examples, or additional components of linkage assembly **210** can be provided to coordinate rotation of latch release handle **212** with movement of each of the one or more latches of linkage assembly **210**. Such components can include linkages, gears, shafts, etc., as examples.

(44) Furthermore, in this example, piston housing **324** of pressure differential lockout system **130** is mounted to body **610** of door **114**. As an example, piston housing **324** can be mounted to body **610** of door **114** via a bracket **620**. As previously described, pressure differential lockout system **130** inhibits latch release handle **212** from being operable via follower linkage **310** to thereby inhibit operation of latches (e.g., **614**) that are mechanically coupled with the latch release handle. As previously described, channel **342** defined by piston **322** of system **130** inhibits rotation of follower linkage **310** that is mechanically coupled with latch release handle **212** via shaft **312** within a first translation range (e.g., **480**) of the piston along translation axis **340** and enables rotation of the follower linkage within a second translation range (e.g., **482**) of the piston along the translation axis. Furthermore, in this example, fluid conduit **330**, represented schematically in FIG. **6**, interfaces with first region **120** at an exterior side of door **114**. In other examples, fluid conduit **330** can traverse a hinge of the door to interface with first region **120** at an exterior side of a fuselage or other wall that separates the first and second regions.

(45) In at least some examples, door **114** can include an access panel **630** that enables technicians to access components of pressure differential lockout system **130**, such as during calibration or maintenance of the pressure lockout system as described in further detail with reference to FIG. **7**. In other examples, access panel **630** can be omitted, and components of pressure differential lockout system **130** can be accessed by removing door linings or other components of the door.

(46) In at least some examples, door **114** can include a vent **640** that provides fluid communication of second region **122** with piston **322** of pressure differential lockout system **130**. It will be understood that vent **640** can be omitted in some configurations, including configurations in which a fluid conduit provides fluid communication between the second region and piston, for example, as described in further detail with reference to FIG. **8**.

(47) FIG. **7** is a flow diagram depicting an example method **700** of calibrating a pressure differential lockout system for a door separating a first region from a second region. As an example, pressure differential lockout system **130** can be calibrated by performing method **700**. Within the context of aircraft **100** of FIG. **1**, as an example, the first region can correspond to an environment outside of the fuselage of the aircraft (e.g., first region **120**), and the second region can correspond to an interior of the fuselage (e.g., second region **122**).

(48) Calibration of the pressure differential lockout system by method **700** can be performed to account for variations in pressure differential introduced by the fluid conduit of the pressure differential lockout system, which can vary due to length and/or configuration of the fluid conduit being utilized. For example, some installations may permit longer or shorter fluid conduits and/or fluid conduits of different cross sections and/or routing (e.g., linear vs. circuitous). Additionally or alternatively, calibration of the pressure differential lockout system by method **700** can be performed to account for friction variations within the system and/or variations in target pressure differentials at which the pressure differential lockout system inhibits or enables the door to be opened via the latch release handle. For example, variations in a length of the fluid conduit can result in variation in operation of the pressure differential lockout system that can be accommodated through calibration. As another example, some applications can be calibrated to permit the door to be opened at a pressure differential between the first region and the second region that is below a target threshold, but greater than zero pressure differential.

(49) At **710**, the method comprises installing the pressure differential lockout system for the door separating the first region from the second region. In at least some examples, installing the pressure

differential lockout system at **710** includes one or more operations, such as described with reference to operations **712**, **714**, and **716**.

(50) At **712**, the method comprises mounting a piston housing of a piston assembly of the pressure differential lockout system to a body of the door. As described with reference to example piston assembly **320**, piston housing **324** and piston **322** of the piston assembly collectively define an interior chamber **326** of the piston assembly. As described with reference to FIG. **6**, piston housing **324** can mounted to the body of the door, such as within an exterior shell of the door that is in fluid communication with the second region.

(51) At **714**, the method comprises mounting a follower linkage of the pressure differential lockout system to a shaft that mechanically couples the follower linkage with a latch release handle of a linkage assembly of the door. As described with reference to example pressure differential lockout system **130**, follower linkage **310** can be mounted to shaft **312** that mechanically couples the follower linkage to latch release handle **212** of linkage assembly **210** such that rotation of the latch release handle causes rotation of follower linkage **310** via the mechanical coupling provided by the shaft.

(52) At **716**, the method comprises installing a fluid conduit of the pressure lockout system that provides fluid communication between the internal region of the piston assembly and the first region. As described with reference to example pressure differential lockout system **130**, fluid conduit **330** can be fluidically coupled to port **412** defined by a wall of piston body **324** and to a port **422** defined by a wall **414** (e.g., of fuselage **110** of aircraft **100**) to provide fluid communication between first region **120** and interior chamber **326** of piston assembly **320**.

(53) Upon installation performed at operation **710**, as described with reference to example pressure differential lockout system **130**, the piston housing and the piston of the piston assembly collectively define the interior chamber of the piston assembly; the fluid conduit of the pressure differential lockout system provides fluid communication between the first region and the interior chamber of the piston assembly; the piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the interior chamber of the piston assembly and the second region in fluid communication with an exterior side of the piston from the interior chamber; the piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage; and the piston further defines an opening in a side wall of the channel that accommodates rotation of the follower component of the follower linkage out of the channel along a path of rotation that is orthogonal to the translation axis. In this configuration, the channel defined by the piston inhibits rotation of the follower linkage within a first translation range of the piston along the translation axis and enables rotation of the follower linkage within a second translation range of the piston along the translation axis, such as previously described with reference to FIGS. **3**A and **3**B.

(54) At **718**, the method comprises varying a position at which the follower linkage is mounted to the shaft to locate the follower component at a suitable location for operation.

(55) Varying the position of the follower linkage at operation **718** can include moving the follower linkage along the shaft to locate the follower component in alignment with the opening in the side wall of the channel, at operation **720**, during a first condition in which the first region and the second region have equivalent pressure to enable rotation of the follower linkage out of the channel along the path of rotation (e.g., as shown in FIGS. **3**B and **4**B). While an example of the first condition is provided in which the first region and the second region have equivalent pressure, it will be understood that for applications in which the door is enabled to be opened at a non-zero pressure differential of less than a threshold, the first condition can instead correspond to a non-zero target pressure differential between the first region and the second region that is at or below the threshold.

(56) Additionally or alternatively, varying the position of the follower linkage at operation **718** can include moving the follower linkage along the shaft to locate the follower component out of

alignment with the opening in the side wall of the channel, at operation **722**, during a second condition in which the second region has a different pressure than the first region to inhibit rotation of the follower linkage (e.g., as shown in FIGS. **3**A and **4**A).

(57) As part of operation **720**, the method at **724** comprises establishing the first condition in which the first region and the second region have equivalent pressure or some other non-zero target pressure differential at which the door is enabled to be opened. Within the context of aircraft **100** of FIG. **1**, as an example, the first condition can be established when the aircraft is grounded and the pressure within the fuselage has been equalized with the surrounding environment outside of the fuselage. Where a non-zero target pressure differential is used, the first region or the second region can be pressurized or depressurized to achieve the non-zero target pressure differential.

(58) As part of operation **722**, the method at **726** comprises establishing the second condition in which the second region has a different pressure (e.g., a higher pressure) than the first region. Within the context of aircraft **100** of FIG. **1**, as an example, the second condition can be established when the interior of the fuselage is pressurized during a test flight of the aircraft at an altitude having lower pressure than the interior of the fuselage. As another example, the second condition can be established by applying a vacuum to the port at which the fluid conduit interfaces with the first region to simulate a pressure differential that occurs during operation of the aircraft. As yet another example, the interior of the fuselage of the aircraft can be pressurized to above the pressure of the environment outside of the fuselage to simulate a pressure differential that occurs during operation of the aircraft.

(59) It will be understood that for applications where the first condition corresponds to a non-zero target pressure differential, the second condition corresponds to a pressure differential that is greater than the non-zero target pressure differential at which the door is inhibited from being opened.

(60) Operations **718**, **720**, **722**, **724**, and **726** can be iteratively performed over two or more cycles of the first condition, and two or more cycles of the second condition to ensure that the follower component is in alignment with the opening in the side wall of the channel during the first condition and that the follower component is out of alignment with the opening in the side wall of the channel during the second condition. At each iteration, the location at which the follower linkage is mounted to the shaft can be adjusted to converge on a location at which the follower component is in alignment with the opening in the side wall of the channel during the first condition and that the follower component is out of alignment with the opening in the side wall of the channel during the second condition.

(61) In the preceding examples describe with reference to pressure differential lockout system **130**, channel **342** defined by the piston **322** inhibits rotation of follower linkage **310** (and hence latch release handle **212** coupled to shaft **312**) within a first translation range of the piston along the translation axis, and enables rotation of the follower linkage (and hence latch release handle **212** coupled to shaft **312**) within a second translation range of the piston along the translation axis. FIG. **8** schematically depicts another example of a pressure differential lockout system **130-8** for a door separating first region **120** from second region **122**. System **130-8** inhibits rotation of a follower linkage **310-8** (and hence latch release handle **212** coupled to shaft **312**) within a first translation range of a piston **322-8** along a translation axis **340-8**, and enables rotation of the follower linkage (and hence latch release handle **212** coupled to shaft **312**) within a second translation range of the piston along the translation axis. Pressure differential lockout system **130-8** can replace pressure differential lockout system **130-8** in any of the preceding examples, including within aircraft **100** of FIG. **1**, the door-integrated configuration of FIG. **6**, and the calibration method of FIG. **7**.

(62) Referring to FIG. **8**, pressure differential lockout system **130-8** comprises follower linkage **310-8** mechanically coupled with latch release handle **312** of linkage assembly **210** of a door (e.g., as shown in FIG. **3**A).

(63) System **130-8** further comprises a piston assembly **320-8** including piston **322-8** and a piston

housing **324-8** collectively defining a first interior chamber **326-8** of the piston assembly. In this example, first interior chamber **326-8** is further defined by a first flexible seal **810** of system **130-8**. Piston **322-8** and piston housing **324-8** collectively define a second interior chamber **826** of the piston assembly that is located on an opposite side of the piston from the first interior chamber **326-8**. In this example, second interior chamber **826** is further defined by a second flexible seal **812** of system **130-8**.

(64) System **130-8** further comprises a first fluid conduit **330-8** that provides fluid communication between first region **120** and first interior chamber **326-8** of piston assembly **320-8**. System **130-8** further comprises a second fluid conduit **830** that provides fluid communication between second region **122** and second interior chamber **826** of piston assembly **320-8**. As previously described with reference to fluid conduit **330**, first fluid conduit **330-8** and second fluid conduit **830** can each be formed from one or more sections of flexible conduit material and/or rigid conduit material, and can each be formed from one or more straight, curved, or circuitous sections of any suitable length.

(65) The configuration of system **130-8** enables piston housing **324-8** to be positioned at various locations, including locations residing outside of the body of the door, as well as locations that are not in fluid communication with second region **122**.

(66) Piston **322-8** is translatable along translation axis **340-8** relative to piston housing **324-8** responsive to a pressure differential between first interior chamber **326-8** of the piston assembly and second region **122** that is in fluid communication, via second fluid conduit **830**, with an exterior or opposite side of the piston (that interfaces with second interior chamber **826**) from the first interior chamber. Furthermore, in this example, piston housing **324-8** defines a channel **842** that constrains movement of piston **322-8** along translation axis **340-8**, such as previously described with reference to keyway **500** of FIG. **5**.

(67) FIG. **8** schematically depicts piston **322-8** at a first location along translation axis **340-8** that does not inhibit rotation of follower linkage **310-8**. FIG. **8** further depicts piston **322-8** at a second location represented by broken lines and identified by reference numeral **322-8**′ following translation of piston **322-8** along translation axis **340-8**. In this example, such translation is responsive to a pressure of second region **122** exceeding a pressure of first region **120**. At the location indicated at **322-8**′, piston **322-8** inhibits rotation of follower linkage **310-8**, thereby inhibiting rotation of the latch release handle mechanically coupled with the follower linkage via shaft **312**. Translation of piston **322-8** along translation axis **340-8** results in the opposite direction responsive to a pressure of first region **120** exceeding a pressure of second region **122**. Alternatively or additionally, a spring (e.g., **490** of FIG. **4**C) can be included that urges piston **322-8** out of alignment with follower linkage **310-8** when the pressures of first region **120** and second region **122** are the same or below a non-zero target pressure differential.

(68) As previously described with reference to calibration of system **130** according to method **700** of FIG. **7**, system **130-8** can be calibrated at operations **720** and **722** by locating with follower component **310-8** out of alignment with piston **322-8** at operation **720**, and by locating follower component **310-8** in alignment with piston **322-8** at operation **722**. Additionally, for system **130-8**, operation **716** of method **700** instead includes connecting first fluid conduit **330-8** to provide fluid communication between first internal region **326-8** and first region **120**, and connecting second fluid conduit **380** to provide fluid communication between second internal region **826** and second region **122**.

(69) Further, the disclosure comprises configurations according to the following clauses.

(70) Clause 1. A pressure differential lockout system for a door separating a first region from a second region, the system comprising: a follower linkage mechanically coupled with a latch release handle of a linkage assembly of the door; a piston assembly including a piston and a piston housing collectively defining an interior chamber of the piston assembly; and a fluid conduit that provides fluid communication between the first region and the interior chamber of the piston assembly; wherein the piston is translatable along a translation axis relative to the piston housing responsive

to a pressure differential between the interior chamber of the piston assembly and the second region in fluid communication with an exterior side of the piston from the interior chamber; wherein the piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage; wherein the channel defined by the piston inhibits rotation of the follower linkage within a first translation range of the piston along the translation axis and enables rotation of the follower linkage within a second translation range of the piston along the translation axis.

(71) Clause 2. The system of clause 1, wherein the first translation range of the piston corresponds to a higher pressure differential between the first region and the second region, and the second translation range of the piston corresponds to a lower pressure differential between the first region and the second region.

(72) Clause 3. The system of any of clauses 1-2, wherein the first translation range of the piston corresponds to the second region having a higher pressure than the first region.

(73) Clause 4. The system of any of clauses 1-3, wherein the first translation range of the piston corresponds to a lower volume of the interior chamber of the piston assembly, and the second translation range of piston corresponds to a higher volume of the interior chamber of the piston assembly.

(74) Clause 5. The system of any of clauses 1-4, wherein the piston further defines an opening in a side wall of the channel that accommodates rotation of the follower component of the follower linkage out of the channel along a path of rotation that is orthogonal to the translation axis.

(75) Clause 6. The system of clause 5, wherein alignment of the follower component with the opening in the side wall of the channel corresponds to the second translation range of the piston.

(76) Clause 7. The system of any of clauses 1-6, wherein the piston housing is mounted to a body of the door in fluid communication with the second region.

(77) Clause 8. The system of any of clauses 1-7, wherein an end of the fluid conduit is fluidically coupled to the piston housing.

(78) Clause 9. The system of clause 8, wherein another end of the fluid conduit interfaces with the first region via a port formed in a body of the door.

(79) Clause 10. The system of any of clauses 1-9, further comprising a heating element disposed at an end of the fluid conduit that interfaces with the first region.

(80) Clause 11. The system of any of clauses 1-10, further comprising a spring that urges the piston toward the second translation range from the first translation range along the translation axis.

(81) Clause 12. A door for separating a first region from a second region of different pressures, the door comprising: a body of the door; a linkage assembly mounted to the body of the door, the linkage assembly including a latch release handle and one or more door latches mechanically coupled with the latch release handle; a pressure differential lockout system, comprising: a follower linkage mechanically coupled with the latch release handle of the linkage assembly; a piston assembly including a piston and a piston housing collectively defining an interior chamber of the piston assembly; and a fluid conduit that provides fluid communication between the first region and the interior chamber of the piston assembly; wherein the piston housing is mounted to the body of the door in fluid communication with the second region; wherein the piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the interior chamber of the piston assembly and the second region in fluid communication with an exterior side of the piston from the interior chamber; wherein the piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage; wherein the channel defined by the piston inhibits rotation of the follower linkage within a first translation range of the piston along the translation axis and enables rotation of the follower linkage within a second translation range of the piston along the translation axis.

(82) Clause 13. The door of clause 12, wherein the first translation range of the piston corresponds to a higher pressure differential between the first region and the second region, and the second

translation range of the piston corresponds to a lower pressure differential between the first region and the second region.
(83) Clause 14. The door of any of clauses 12-13, wherein the first translation range of the piston corresponds to the second region having a higher pressure than the first region.
(84) Clause 15. The door of any of clauses 12-14, wherein the first translation range of the piston corresponds to a lower volume of the interior chamber of the piston assembly, and the second translation range of piston corresponds to a higher volume of the interior chamber of the piston assembly.
(85) Clause 16. The door of any of clauses 12-15, wherein the piston further defines an opening in a side wall of the channel that accommodates rotation of the follower component of the follower linkage out of the channel along a path of rotation that is orthogonal to the translation axis; and wherein alignment of the follower component with the opening in the side wall of the channel corresponds to the second translation range of the piston.
(86) Clause 17. The door of any of clauses 12-16, further comprising a heating element disposed at an end of the fluid conduit that interfaces with the first region.
(87) Clause 18. The door of any of clauses 12-17, further comprising a spring that urges the piston toward the second translation range from the first translation range along the translation axis.
(88) Clause 19. A method of calibrating a pressure differential lockout system for a door separating a first region from a second region, the method comprising: mounting a piston housing of a piston assembly of the pressure differential lockout system to a body of the door; wherein the piston housing and a piston of the piston assembly collectively define an interior chamber of the piston assembly; wherein a fluid conduit of the pressure differential lockout system provides fluid communication between the first region and the interior chamber of the piston assembly; wherein the piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the interior chamber of the piston assembly and the second region in fluid communication with an exterior side of the piston from the interior chamber; mounting a follower linkage of the pressure differential lockout system to a shaft of a linkage assembly that mechanically couples the follower linkage with a latch release handle of the door; wherein the piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage; wherein the piston further defines an opening in a side wall of the channel that accommodates rotation of the follower component of the follower linkage out of the channel along a path of rotation that is orthogonal to the translation axis; and varying a position at which the follower linkage is mounted to the shaft to locate the follower component: in alignment with the opening in the side wall of the channel during a first condition in which the first region and the second region have equivalent pressure to enable rotation of the follower linkage out of the channel along the path of rotation, and out of alignment with the opening in the side wall of the channel during a second condition in which the second region has a different pressure than the first region to inhibit rotation of the follower linkage.
(89) Clause 20. The method of clause 19, wherein the second region has a higher pressure than the first region during the second condition.
(90) It will be understood that the configurations and/or approaches described herein are exemplary in nature, and that specific examples are not to be considered in a limiting sense, because numerous variations are possible. The specific methods or operations described herein may represent one or more of any number of techniques. As such, various acts illustrated and/or described may be performed in the sequence illustrated and/or described, in other sequences, in parallel, or omitted. Likewise, the order of the above-described processes may be changed.
(91) The subject matter of the present disclosure includes all novel and non-obvious combinations and sub-combinations of the various methods, operations, systems, and configurations, and other features, functions, acts, and/or properties disclosed herein, as well as any and all equivalents thereof.

Claims

1. A pressure differential lockout system for a door separating a first region from a second region, the system comprising: a follower linkage mechanically coupled with a latch release handle of a linkage assembly of the door; a piston assembly including a piston and a piston housing collectively defining an interior chamber of the piston assembly; and a fluid conduit that provides fluid communication between the first region and the interior chamber of the piston assembly; wherein the piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the interior chamber of the piston assembly and the second region in fluid communication with an exterior side of the piston from the interior chamber; wherein the piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage; wherein the channel defined by the piston inhibits rotation of the follower linkage within a first translation range of the piston along the translation axis and enables rotation of the follower linkage within a second translation range of the piston along the translation axis.
2. The system of claim 1, wherein the first translation range of the piston corresponds to a higher pressure differential between the first region and the second region, and the second translation range of the piston corresponds to a lower pressure differential between the first region and the second region.
3. The system of claim 1, wherein the first translation range of the piston corresponds to the second region having a higher pressure than the first region.
4. The system of claim 1, wherein the first translation range of the piston corresponds to a lower volume of the interior chamber of the piston assembly, and the second translation range of piston corresponds to a higher volume of the interior chamber of the piston assembly.
5. The system of claim 1, wherein the piston further defines an opening in a side wall of the channel that accommodates rotation of the follower component of the follower linkage out of the channel along a path of rotation that is orthogonal to the translation axis.
6. The system of claim 5, wherein alignment of the follower component with the opening in the side wall of the channel corresponds to the second translation range of the piston.
7. The system of claim 1, wherein the piston housing is mounted to a body of the door in fluid communication with the second region.
8. The system of claim 1, wherein an end of the fluid conduit is fluidically coupled to the piston housing.
9. The system of claim 8, wherein another end of the fluid conduit interfaces with the first region via a port formed in a body of the door.
10. The system of claim 1, further comprising a heating element disposed at an end of the fluid conduit that interfaces with the first region.
11. The system of claim 1, further comprising a spring that urges the piston toward the second translation range from the first translation range along the translation axis.
12. A door for separating a first region from a second region of different pressures, the door comprising: a body of the door; a linkage assembly mounted to the body of the door, the linkage assembly including a latch release handle and one or more door latches mechanically coupled with the latch release handle; a pressure differential lockout system, comprising: a follower linkage mechanically coupled with the latch release handle of the linkage assembly; a piston assembly including a piston and a piston housing collectively defining an interior chamber of the piston assembly; and a fluid conduit that provides fluid communication between the first region and the interior chamber of the piston assembly; wherein the piston housing is mounted to the body of the door in fluid communication with the second region; wherein the piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the

interior chamber of the piston assembly and the second region in fluid communication with an exterior side of the piston from the interior chamber; wherein the piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage; wherein the channel defined by the piston inhibits rotation of the follower linkage within a first translation range of the piston along the translation axis and enables rotation of the follower linkage within a second translation range of the piston along the translation axis.
13. The door of claim 12, wherein the first translation range of the piston corresponds to a higher pressure differential between the first region and the second region, and the second translation range of the piston corresponds to a lower pressure differential between the first region and the second region.
14. The door of claim 12, wherein the first translation range of the piston corresponds to the second region having a higher pressure than the first region.
15. The door of claim 12, wherein the first translation range of the piston corresponds to a lower volume of the interior chamber of the piston assembly, and the second translation range of piston corresponds to a higher volume of the interior chamber of the piston assembly.
16. The door of claim 12, wherein the piston further defines an opening in a side wall of the channel that accommodates rotation of the follower component of the follower linkage out of the channel along a path of rotation that is orthogonal to the translation axis; and wherein alignment of the follower component with the opening in the side wall of the channel corresponds to the second translation range of the piston.
17. The door of claim 12, further comprising a heating element disposed at an end of the fluid conduit that interfaces with the first region.
18. The door of claim 12, further comprising a spring that urges the piston toward the second translation range from the first translation range along the translation axis.
19. A method of calibrating a pressure differential lockout system for a door separating a first region from a second region, the method comprising: mounting a piston housing of a piston assembly of the pressure differential lockout system to a body of the door; wherein the piston housing and a piston of the piston assembly collectively define an interior chamber of the piston assembly; wherein a fluid conduit of the pressure differential lockout system provides fluid communication between the first region and the interior chamber of the piston assembly; wherein the piston is translatable along a translation axis relative to the piston housing responsive to a pressure differential between the interior chamber of the piston assembly and the second region in fluid communication with an exterior side of the piston from the interior chamber; mounting a follower linkage of the pressure differential lockout system to a shaft of a linkage assembly that mechanically couples the follower linkage with a latch release handle of the door; wherein the piston defines a channel that is parallel to the translation axis and that accommodates a follower component of the follower linkage; wherein the piston further defines an opening in a side wall of the channel that accommodates rotation of the follower component of the follower linkage out of the channel along a path of rotation that is orthogonal to the translation axis; and varying a position at which the follower linkage is mounted to the shaft to locate the follower component: in alignment with the opening in the side wall of the channel during a first condition in which the first region and the second region have equivalent pressure to enable rotation of the follower linkage out of the channel along the path of rotation, and out of alignment with the opening in the side wall of the channel during a second condition in which the second region has a different pressure than the first region to inhibit rotation of the follower linkage.
20. The method of claim 19, wherein the second region has a higher pressure than the first region during the second condition.