United States Patent Application Publication	20250257786
Kind Code	A1
Publication Date	August 14, 2025
Inventor(s)	Morgan-Willson; Terec Lloyd et al.

ISOLATORS FOR PANEL ASSEMBLIES AND OTHER STRUCTURES

Abstract

Example isolators for panel assemblies and other structures are disclosed herein. An example apparatus disclose herein includes a panel, a frame, and an isolator coupling the panel and the frame, the isolator including a first flange including a first side coupled to the panel, and a second side opposite the first side, a second flange including a third side coupled to the frame, and a fourth side opposite the first side, and a flexible bellows positioned between the first flange and the second flange, the flexible bellows including a first end coupled to the second side, and a second end coupled to the fourth side.

Inventors: **Morgan-Willson; Terec Lloyd (Overland, MO), Griffin; Steven F. (Kihei, HI)**

Applicant: **The Boeing Company** (Arlington, VA)

Family ID: **1000007710904**

Appl. No.: **18/439232**

Filed: **February 12, 2024**

Publication Classification

Int. Cl.: **F16F15/04** (20060101)

U.S. Cl.:

CPC **F16F15/046** (20130101);

Background/Summary

FIELD OF THE DISCLOSURE

[0001] This disclosure relates generally to isolation devices and, more particularly, to isolators for panel assemblies and other structures.

BACKGROUND

[0002] Mechanical assemblies, such as aviation systems, include vibration-sensitive devices (e.g., optics, sensors, fragile components, passenger compartments, etc.), and/or devices that generate vibration and/or noise (e.g., powerplants, aerosurfaces, etc.). Elastomers, bushings, and other systems are used in such systems to damp vibration and prevent interference with vibration-sensitive components.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. **1** is a perspective view of an example aviation system having an example panel assembly implemented in accordance with teachings of this disclosure.

[0004] FIG. **2** is a perspective view of the example panel assembly of FIG. **1** including an example flexible isolator disclosed herein.

[0005] FIG. **3**A is a perspective view of the example flexible isolator of FIG. **2**.

[0006] FIG. **3**B is a cross-sectional view of the example flexible isolator of FIG. **2**.

[0007] FIG. **4** is a cross-sectional view of the example panel assembly of FIG. **2**.

[0008] FIG. **5**A is a perspective view of an example first corner of the example flexible isolator of FIGS. **2-4**.

[0009] FIG. **5**B is a perspective view of an example second corner of the example flexible isolator of FIGS. **2-4**.

[0010] FIG. **6**A is a partial, perspective view of the example flexible isolator of FIG. **2** and an example first spring disclosed herein in an example first configuration.

[0011] FIG. **6**B is a partial, perspective view of the example flexible isolator of FIG. **2** and the example first spring of FIG. **6**A in an example second configuration.

[0012] FIG. **6**C is a partial, perspective view of the example flexible isolator of FIG. **2** and the example first spring of FIG. **6**A in an example third configuration.

[0013] FIG. **7**A is a partial, perspective view of the example flexible isolator of FIG. **2** and an example second spring disclosed herein in an example first configuration.

[0014] FIG. **7**B is a partial, perspective view of the example flexible isolator of FIG. **2** and the example second spring of FIG. **7**A in an example second configuration.

[0015] FIG. **7**C is a partial, perspective view of the example flexible isolator of FIG. **2** and the example second spring of FIG. **7**A in an example third configuration.

[0016] FIG. **8**A is a partial, first perspective view of the example flexible isolator of FIG. **2** including an example auxiliary seal disclosed herein disposed in an opening of the flexible isolator of FIG. **2**.

[0017] FIG. **8**B is a partial, second perspective view of the example flexible isolator of FIG. **8**A.

[0018] FIG. **8**C is a cross-sectional view of the example flexible isolator of FIG. **8**A. FIG. **9** is a perspective view of an example aircraft including an example window panel assembly disclosed herein.

[0019] FIG. **10** is a perspective view of another example aircraft including a plurality of example panel assemblies disclosed herein.

[0020] In general, the same reference numbers will be used throughout the drawing(s) and accompanying written description to refer to the same or like parts. The figures are not necessarily to scale.

DETAILED DESCRIPTION

[0021] Many mechanical assemblies include components that are sensitive to vibration, mechanical loads, deflection relative to adjacent components, and/or components that generate comparatively large amounts of loading, deflection, and/or vibration. For example, aviation systems can include panel assemblies that are sensitive to vibration, deflections, and/or loading associated with the operation of the aviation system. Such, aviation systems can include, but not limited to, window panel assemblies, door jamb panel assemblies, and/or electrical panel assemblies. To prevent damage to such sensitive components, assemblies can include isolators, which couple the panel assemblies to a main body or frame of the aviation system. The isolators isolate sensitive components from loading, vibration, and/or displacement (e.g., edge displacement).

[0022] One type of prior isolator is elastomer pucks (also referred to as elastomer pads). The elastomer pads can be used to damp vibrations and permit relative deflection between two or more components coupled via the elastomer pucks. However, such prior elastomer puck isolators permit a comparatively small amount of relative deflection before the elastomer pucks begin to transmit significant amounts of loading between the coupled components. Other types of prior isolators include wire rope isolators, which are typically capable of supporting greater amounts of deflections than elastomer puck isolators. However, wire rope based isolators require comparatively greater amounts of packaging space (e.g., integration volume, etc.) than elastomer puck isolators. Some space launch applications employ modified isolation systems that operate similarly to the wire rope system. Such modified isolation systems are similar to the wire rope systems but have unidirectional machined materials to improve control of the isolation direction and effective spring and dampening rates of the isolators. However, such modified isolation systems suffer similar integration volume issues as the wire rope systems. Additionally, none of the aforementioned prior isolators function as environmental seals. As such, prior isolators require additional seals to be used in aviation systems that require such environmental sealing.

[0023] Examples disclosed herein overcome the above-noted deficiencies and include isolators for panel assemblies that enable comparatively large deflections between the panel assemblies and a frame or parent structure to which the panel assembly is coupled. Additionally, example isolators disclosed herein provide a seal (e.g., a tight seal) between the panel assemblies and the frame and/or parent structure. Some example isolators disclosed herein include a first flange coupled to the panel assembly, a second flange coupled to the parent structure, and flexible bellows extending between the first flange and the second flange. In some such examples disclosed herein, the flexible bellows facilitates deflection of the panel assembly relative to the parent structure, damp vibrations transmitted therethrough, and provide a seal between the panel assembly and the parent structure (e.g., to seal an interior of the parent structure from an external environment of the parent structure, etc.). Example isolators disclosed herein enable isolation of multi-panel assemblies including panels disposed in multiple geometric planes. In some examples disclosed herein, a thickness, material composition, and/or geometry of the bellows can be selected or modified to tune or adjust a spring rate of the example isolator. Additionally, example isolators disclosed herein reduce overall system weight when compared to prior systems by mitigating the need for additional dedicated seals and/or reinforcement structures to compensate for loads caused by large deflections.

[0024] FIG. **1** is a perspective view of an example aviation system **100** including an example panel assembly **102** implemented in accordance with teachings of this disclosure. The aviation system **100** includes an example body **104**, an example powerplant **106**, an example first wing **108**A, an example second wing **108**B, an example first fin **110**A, an example second fin **110**B, an example third fin **110**C, and an example fourth fin **110**D. In the illustrated example of FIG. **1**, the aviation system **100** is a cruise missile. In other examples, the aviation system **100** can include a fixed-wing aircraft (e.g., a military fixed-wing aircraft, a commercial fixed-wing aircraft, etc.), a rotary-wing aircraft (e.g., a helicopter, etc.), an aerostat (e.g., an airship, a weather balloon, etc.), an astronautical vehicle (e.g., a launch system, a spacecraft, a spaceplane, a satellite, etc.), an unmanned vehicle (e.g. a drone), and/or another type of weapon system (e.g., a ballistic missile, a tactical missile, etc.).

[0025] The panel assembly **102** includes an example first panel **112**A and an example second panel **112**B. In the illustrated example of FIG. **1**, the panels **112**A, **112**B are windows. The panels **112**A, **112**B enable example sensors **114** to be housed within the body **104** and receive information transmitted through the panels **112**A, **112**B. For example, the sensors **114** can include one or more optical sensors and/or infrared (IR) sensors. Additionally or alternatively, the sensors **114** can include other sensors (e.g., other sensors associated with a guidance system of the aviation system **100**, etc.). The panels **112**A, **112**B can be composed of reinforced glass, sapphire, and/or polyetherimide (PEI). In other examples, the panels **112**A, **112**B can be composed of any other suitable material(s) that permits sensor information to be received by the sensors **114**.

[0026] In some examples, operation of the aviation system **100** can generate vibrations and/or loading on the components of the aviation system **100**. For example, operation of the powerplant **106** can generate vibration (e.g., from friction within the powerplant **106**, due to unbalancing within the powerplant **106**, etc.) and/or reaction loading on the body **104** from thrust produced by the powerplant **106**. In some examples, the powerplant **106** can be a gas turbine engine (e.g., a turbojet engine, etc.) and/or a rocket engine (e.g., a liquid rocket engine, a solid rocket engine, etc.). In some examples, the powerplant **106** is absent (e.g., the aviation system **100** is unpowered, etc.). Similarly, aero-loading (e.g., lift, drag, etc.) caused by the flow of air over the wings **108**A, **108**B, and/or the fins **110**A, **110**B, **110**C, **110**D can apply loads and/or cause vibrations of the body **104**. In some examples, loading and vibration associated with the powerplant **106**, the wings **108**A, **108**B, and/or the fins **110**A, **110**B, **110**C, **110**D can be transmitted from the body **104** to the panel assembly **102**. The panels **112**A, **112**B of the illustrated example are sensitive to vibrations and/or loads associated with the body **104**. For example, high amounts of vibrations and/or loads transmitted from the body **104** to the panel assembly **102** can cause the panels **112**A, **112**B to warp, crack, and/or otherwise be damaged.

[0027] To mitigate such vibrations and/or loading, the aviation system **100** of the illustrated example employs the panel assembly **102**. The panel assembly **102** of the illustrated example is structured or configured to damp vibrations transmitted from the body **104** and to deflect/deform from loading transmitted between the panel assembly **102** and the body **104** (e.g., to reduce the stress/strain bore by the panels **112**A, **112**B, etc.). The panel assembly **102** is described in further detail below in conjunction with FIGS. **2**-**5**B. As described below, the example panel assembly **102** of the illustrated example isolates the panels **112**A, **112**B from such generated loads and/or vibrations. Aviation systems including panel assemblies similar to the panel assembly **102** of FIG. **2** are described below in conjunction with FIGS. **6** and **7**.

[0028] FIG. **2** is a perspective view of the panel assembly **102** of FIG. **1**. The panel assembly **102** of the illustrated example includes an example flexible isolator **200** disclosed herein. In the illustrated example of FIG. **2**, the panel assembly **102** further includes the first panel **112**A of FIG. **1**, the second panel **112**B of FIG. **1**, and an example parent structure **202**. The parent structure **202** of the illustrated example can be a frame, a beam, a housing, and/or any other structure(s). In the illustrated example of FIG. **2**, the first panel **112**A is disposed in an example first plane **204**A (e.g., a first geometric plane, etc.), and the second panel **112**B is disposed in an example second plane **204**B (e.g., a second geometric plane, etc.). The first plane **204**A of the illustrated example is different than the second plane **204**B. For example, the first plane **204**A is at an angle (e.g., an angle less than ninety degrees) relative to the second plane **204**B. In the illustrated example of FIG. **2**, the first panel **112**A and the second panel **112**B are coupled at an example panel joint **206** (e.g., a weld, etc.). The first panel **112**A and the second panel **112**B (e.g., collectively, etc.) define an example first perimeter **207**. In the illustrated example of FIG. **2**, the flexible isolator **200** forms an example interface **208** between the panels **112**A, **112**B, and the parent structure **202**. In the illustrated example of FIG. **2**, the parent structure **202** includes an example structure joint **210** (e.g., a weld) and an example structure lip **211**. In the illustrated example of FIG. **2**, the parent structure **202** defines an example second perimeter **212**.

[0029] The parent structure **202** is the structure (e.g., a frame, etc.) to which the panels **112**A, **112**B are coupled. Specifically, in the illustrated example, the panels **112**A, **112**B are coupled to the parent structure **202** via the flexible isolator **200**. For example, the parent structure **202** can be a component (e.g., a bulkhead, a frame, a beam, etc.) of the body **104** of the aviation system **100** of FIG. **1**. In other examples, the parent structure **202** can be a discrete component that is rigidly coupled to the body **104** (e.g., via one or more fasteners, via one or more welds, etc.). The terms "parent structure" and "frame" are used interchangeably to refer to the parent structure **202**. In the illustrated example of FIG. **2**, the parent structure **202** includes the structure joint **210**, which aligns with the panel joint **206** of the panels **112**A, **112**B. An example configuration of the parent structure **202** is described below in conjunction with FIG. **4**.

[0030] In the illustrated example of FIG. **2**, the panels **112**A, **112**B are not coplanar and are disposed in separate planes (e.g., the first plane **204**A and the second plane **204**B, respectively, etc.). That is, in the illustrated example of FIG. **2**, the panel assembly **102** is a multi-planar assembly. In other examples, the second panel **112**B is absent or is coplanar with the first panel **112**A. In some such examples, the panel assembly **102** is a mono-planar assembly. An example aviation system including a plurality of mono-planar assemblies is described below in conjunction with FIG. **7**. Additionally or alternatively, the panel assembly **102** can include additional panels (e.g., three panels, four panels, five panels, etc.). An example aviation system including a panel assembly having more than two panels is described below in conjunction with FIG. **6**. In the illustrated example of FIG. **2**, the panels **112**A, **112**B are a same size and are a same shape, which is mirrored across or relative to the panel joint **206**. In other examples, the panels **112**A, **112**B can have different size(s), different shape(s), and/or any other suitable spatial relationship.

[0031] In the illustrated example of FIG. **2**, the first panel **112**A includes an example first panel corner **214**A and an example second panel corner **214**B. In the illustrated example of FIG. **2**, the second panel **112**B includes an example third panel corner **214**C and an example fourth panel corner **214**D. In the illustrated example of FIG. **2**, the first perimeter **207** of the panels **112**A, **112**B extends along an interior of the panels **112**A, **112**B between the corners **214**A, **214**B, **214**C, **214**D adjacent to an example edge **215** of the panels **112**A, **112**B. In some examples, the panel assembly **102** can include one or more springs disposed in corresponding ones of the corners **214**A, **214**B, **214**C, **214**D. In some such examples, the springs disposed in ones of the corners **214**A, **214**B, **214**C, **214**D can be used to tune or adjust (e.g., increase) a local spring rate and/or damping rate of the panel assembly **102** at the corners **214**A, **214**B, **214**C, **214**D. Example springs that can be used in conjunction with flexible isolator **200** are described below in conjunction with FIGS. **6**A-**6**C.

[0032] As noted above, the panels **112**A, **112**B of the illustrated example are coupled (e.g., joined) at the panel joint **206**. The panel joint **206** is defined along a line at the intersection of the planes **204**A, **204**B. In some examples, the panels **112**A, **112**B are rigidly coupled at the panel joint **206** (e.g., via one or more fasteners, one or more welds, one or more interference fits, one or more chemical adhesives, etc.). Additionally or alternatively, the panels **112**A, **112**B can be coupled at the panel joint **206** via the individual coupling of the panels **112**A, **112**B to the flexible isolator **200**. In other examples, the panels **112**A, **112**B are not rigidly coupled at the panel joint **206**. In some such examples, the panel joint **206** can include one or more bushings and/or elastomers that enable the relative movement of the panels **112**A, **112**B. In some examples, the first panel **112**A is decoupled from the second panel **112**B. In some such examples, the first panel **112**A is coupled to the flexible isolator **200** independently or separately from the second panel **112**B.

[0033] The flexible isolator **200** couples the panels **112**A, **112**B to the parent structure **202**. That is, the flexible isolator **200** forms the interface **208** with the parent structure **202**, enables the relative deflection of the panels **112**A, **112**B and the parent structure **202**, and damps vibrations associated with parent structure **202**. In the illustrated example of FIG. **2**, the flexible isolator **200** is omnidirectionally flexible and facilitates the deflection of the panels **112**A, **112**B relative to the parent structure **202**. That is, the flexible isolator **200** is elastically deformable and enables the relative deflection of the panels **112**A, **112**B within the planes **204**A, **204**B (e.g., toward the structure lip **211** of the parent structure **202** along the planes **204**A, **204**B, etc.), the relative deflection of the panels **112**A, **112**B toward the parent structure **202** (e.g., the compression of the flexible isolator **200**, compressive strain of the flexible isolator **200**, etc.), and/or the relative the deflection of the panels **112**A, **112**B away from the parent structure **202** (e.g., elongation of the flexible isolator **200**, tensile strain of the flexible isolator **200**, etc.). The movement of the panels **112**A, **112**B relative to the parent structure **202** can be laterally rectilinearly, vertically, diagonally, and/or any other direction.

[0034] In the illustrated example of FIG. **2**, the flexible isolator **200** extends between the panels **112**A, **112**B (e.g., a surface of the panels **112**A, **112**B oriented toward the parent structure **202**) and the parent structure **202** (e.g., a surface of the parent structure **202** oriented toward the panels **112**A, **112**B). For example, the flexible isolator **200** of the illustrated example extends between the first perimeter **207** of the panels **112**A, **112**B (e.g., an interior perimeter of the panels **112**A, **112**B, etc.) and the second perimeter **212** of the parent structure **202** (e.g., an exterior perimeter of the parent structure **202**, etc.). In the illustrated example of FIG. **2**, the flexible isolator **200** extends along an entirety of the perimeters **207**, **212**. In other examples, the flexible isolator **200** can be disposed at another location on the panels **112**A, **112**B (e.g., an interior of the panels **112**A, **112**B, etc.) and/or another location on the parent structure **202** (e.g., an interior of the parent structure **202**, etc.).

[0035] In some examples, if the flexible isolator **200** does not include openings, the flexible isolator **200** seals an interior of the parent structure **202** from an exterior of the panels **112**A, **112**B (e.g., an external environment of the parent structure **202** and/or the aviation system **100**). In some such examples, the flexible isolator **200** prevents gas flow, liquid flow, debris, and/or other gases, fluids or materials from passing through the panel assembly **102** into an interior of the aviation system **100** via the interface **208**. Accordingly, in such examples, the flexible isolator **200** provides a seal for the interface **208** and mitigates the need for the interface **208** to include a separate seal. In other examples, the flexible isolator **200** can include one or more gaps and/or is only disposed on portions of the perimeters **207**, **212**. In some examples, the gaps can include one or more holes (e.g., circular holes, polygonal holes, etc.). Additionally or alternatively, the gaps can segment the flexible isolator **200** into a plurality of discrete segments (e.g., two discrete segments, three discrete segments, ten discrete segments, etc.) that are independently coupled to panels **112**A, **112**B and the parent structure **202**. In some such examples, positioning of the gaps of the flexible isolator **200** can be determined to tune the flexibility (e.g., damping rate, elasticity, etc.) at portions along the perimeters **207**, **212**, and/or the damping rate of the flexible isolator **200**. An example opening in the flexible isolator **200** is described below in conjunction with FIGS. **6**A, **7**A, and **8**A-**8**C.

[0036] FIG. **3**A is a perspective view of the flexible isolator **200** of FIG. **2**. The flexible isolator **200** of the illustrated example includes an example first portion **301**A and an example second portion **301**B. In the illustrated example of FIG. **3**A, the flexible isolator **200** includes an example first flange **302**, an example second flange **304**, and example bellows **306**. In the illustrated example of FIG. **3**A, the flexible isolator **200** includes an example first intraplanar corner **310**A, an example second intraplanar corner **310**B, an example third intraplanar corner **310**C, and an example fourth intraplanar corner **310**D. In the illustrated example of FIG. **3**A, the flexible isolator **200** includes an example first interplanar corner **312**A and an example second interplanar corner **312**B, which are disposed at, or aligned with, an example joint **308**.

[0037] In the illustrated example of FIG. **3**A, the first portion **301**A of the flexible isolator **200** aligns with or is disposed in the first plane **204**A and the second portion **301**B of the flexible isolator **200** aligns with or is disposed in the second plane **204**B. In the panel assembly **102** of FIGS. **1** and **2**, the first portion **301**A is coupled to and abutting the first panel **112**A and the second portion **301**B is coupled to and abutting the second panel **112**B. For example, the first intraplanar corner **310**A can be aligned with the first panel corner **214**A of FIG. **2**, the second intraplanar corner **310**B can be aligned with the second panel corner **214**B of FIG. **2**, the third intraplanar corner **310**C can be aligned with the third panel corner **214**C of FIG. **2**, and the fourth intraplanar corner **310**D can be aligned with the fourth panel corner **214**D of FIG. **2**. In the illustrated example of FIG. **3**A, the interplanar corner **312**A, **312**B are disposed at, or align with, the joint **308** (e.g., a longitudinal axis of the joint **308**). In some examples, the interplanar corners **312**A, **312**B and the joint **308** can be aligned with the panel joint **206** of the panels **112**A, **112**B of FIG. **2**. In some such examples, the joint **308** is coupled to and/or abutting the panel joint **206**.

[0038] In other examples, if the panel assembly **102** includes additional panels, the flexible isolator **200** can include additional portions that correspond to the additional panels. In the illustrated example of FIG. **3**A, the first portion **301**A and the second portion **301**B of the flexible isolator **200** are integral components. In other examples, the first portion **301**A and the second portion **301**B can be coupled via one or more fasteners, one or more welds, one or more chemical adhesives, and/or any other suitable fastener(s). In the illustrated example of FIG. **3**A, the portions **301**A, **301**B form an example internal angle **315** relative to the joint **308**. In the illustrated example of FIG. **3**A, the internal angle **315** is less than **180** degrees (e.g., between 25 degrees and 70 degrees). In other examples, the internal angle **315** can be greater than 180 degrees.

[0039] The intraplanar corners **310**A, **310**B, **310**C, **310**D are the corners of the flexible isolator **200** that are disposed entirely within a single or first common plane (e.g., the intraplanar corners **310**A, **310**B, **310**C, **310**D are in-plane corners, are located in a same plane, a first vertical plane, etc.). For example, the first intraplanar corner **310**A and the second intraplanar corner **310**B associated with the first portion **301**A and the third intraplanar corner **310**C and the fourth intraplanar corner **310**D associated with the second portion **301**B fall within a common plane (e.g., a vertical plane) taken through the corners **310**A-**310**D (i.e., taken through all four corners), and the first interplanar corner **312**A and the second interplanar corner **312**B are positioned outside of this common plane in which the corners **310**A-**310**D are located. An example implementation of the intraplanar corners **310**A, **310**B, **310**C, **310**D are described below in conjunction with FIG. **5**A.

[0040] The interplanar corners **312**A, **312**B are corners of the flexible isolator **200** transition the first plane **204**A and the second plane **204**B. That is, the interplanar corners **312**A, **312**B are formed between the first portion **301**A and the second portion **301**B. Thus, the first plane **204**A and the second plane **204**B share the interplanar corners **312**A, **312**B. The interplanar corners **312**A and **312**B are located in a second common plane (e.g., a second vertical plane) that is different from or spaced from the common plane (e.g., the first vertical plane) in which the intraplanar corners **310**A-**310**D are positioned. Thus, the interplanar corners **312**A and **312**B are spaced laterally from the first common plane in which the intraplanar corners **310**A-**310**D lie. An example implementation of the interplanar corners **312**A, **312**B is described below in conjunction with FIG. **5**B.

[0041] Additionally, the flexible isolator **200** of the illustrated example includes an opening **317** to enable visual access between an external area of the flexible isolator **200** and an internal area of the flexible isolator **200**. The opening **317** of the illustrated example is formed within the perimeter of the flexible isolator **200**. Thus, the flexible isolator **200** of the illustrated example includes a thickness **319** defined between an outer perimeter edge **321**A and an inner perimeter edge **321**B.

[0042] FIG. **3**B is a cross-sectional view of the flexible isolator **200** taken along the line **3**B-**3**B of FIG. **3**A. In the illustrated example of FIG. **3**B, the bellows **306** is positioned between the first flange **302** and the second flange **304**. The bellows **306** of the illustrated example include an example first crest **314**A, an example second crest **314**B, an example first root **316**A, and an example second root **316**B. In the illustrated example of FIG. **3**B, the bellows **306** has an example first end **318**A adjacent to the first flange **302** and an example second end **318**B adjacent to the second flange **304**. In the illustrated example of FIG. **3**B, the first flange **302** includes an example first side **320**A and an example second side **320**B. In the illustrated example of FIG. **3**B, the second flange **304** includes an example third side **320**C (e.g., a first side of the second flange **304**, etc.) and an example fourth side **320**D (e.g., a second side of the second flange **304**, etc.). In the illustrated example of FIG. **3**B, the first side **320**A of the first flange **302** is opposite the second side **320**B of the first flange **302**. In the illustrated example of FIG. **3**B, the third side **320**C of the second flange **304** is opposite the fourth side **320**D of the second flange **304**. In the illustrated example of FIG. **3**A and **3**B, the first flange **302** and the second flange **304** have a same thickness, which is uniform along the perimeter of the flexible isolator **200**. In other examples, the first flange **302** and the second flange **304** can have different thickness(es), which can be variable along the length and/or perimeter of the flexible isolator **200**. The coupling of the flanges **302**, **304** to the panels **112**A, **112**B and the parent structure **202** is described below in greater detail in conjunction with FIG. **4**.

[0043] The bellows **306** of the illustrated example extends between the first flange **302** and the second flange **304**. In the illustrated example of FIG. **3**B, the bellows **306** is corrugated. In other examples, the bellows **306** can be U-shaped, trapezoidal, half-circular, and/or triangular. In the illustrated example of FIG. **3**B, the bellows **306** includes two convolutions. That is, the bellows **306** includes two crests (e.g., the crests **314**A, **314**B, etc.) and two roots (e.g., the roots **316**A, **316**B, etc.). In other examples, the bellows **306** can include any other suitable number of convolutions (e.g., a single convolution, three convolutions, ten convolutions, etc.). In the illustrated example of FIG. **3**B, the configuration of the convolutions of the bellows **306** (e.g., a zig-zag configuration of the bellows **306**, etc.) facilitates expansion and compression of the flexible isolator **200** between the panels **112**A, **112**B and the parent structure **202** and/or the bending of the flexible isolator **200** within the planes **204**A, **204**B. In the illustrated example of FIG. **3**B, the bellows **306** has a uniform thickness. In other examples, the bellows **306** can have a non-uniform thickness profile (e.g., thicker near the first end **318**A, thicker near the second end **318**B, thicker near the crests **314**A, **314**B and roots **316**A, **316**B, etc.). In some examples, a spring rate of the bellows **306** can be tuned via an example thickness **322** of the bellows **306**, a thickness profile of the bellows **306**, a shape of the convolutions of the bellows **306** (e.g., a shape of the convolutions, a height of the convolutions, a pitch of the convolutions, etc.), and/or a number of convolutions of the bellows **306**. The bellows **306** can be manufactured by coupling multiple strips of material (e.g., a metal, a composite, an elastomer, etc.) via folding, forming, welding, adhesive, additive manufacturing and/or any other suitable manufacturing process(es) and/or technique(s). In other examples, the bellows **306** can be an integral component that is shaped via bending, pressing, folding, etc. In some examples, if the bellows **306** is composed of a thermally conductive material and/or electrically conductive material (e.g., aluminum, copper, steel, etc.), the flexible isolator **200** can thermally conduct electricity and/or heat between the panels **112**A, **112**B and the parent structure **202**.

[0044] In the illustrated example of FIGS. **3**A and **3**B, the bellows **306** does not include openings (e.g., between the outer perimeter edge **321**A and the inner perimeter edge **321**B, etc.). In some such examples, the bellows **306** is a seal (e.g., an environmental seal, etc.), which inhibits the flow of material (e.g., air, liquids, debris, etc.) through the flexible isolator **200**. In other examples, the bellows **306** can include openings to facilitate the flow of material through the flexible isolator **200**. Additionally or alternatively, the bellows **306** can be composed or formed of a permeable material (e.g., a mesh, etc.), which can similarly permit the flow of fluids and/or other material(s) through the bellows **306**. Thus, in the illustrated example, the flexible isolator **200** has a shape that is complementary to the shape the panels **112**A, **112**B and/or the parent structure **202**.

[0045] In the illustrated example of FIG. **3**B, the first end **318**A extends from and is coupled to second side **320**B of the first flange **302** and the second end **318**B extends from and is coupled to fourth side **320**D of the second flange **304**. In some examples, the first side **320**A of the first flange **302** and the third side **320**C of the second flange **304** can be coupled to panels (e.g., the panels **112**A, **112**B, etc.) of a panel assembly (e.g., the panel assembly **102**), and a parent structure (e.g., the parent structure **202**, etc.) of a panel assembly.

[0046] In the illustrated example of FIGS. **3**A and **3**B, the flexible isolator **200** is an integral component (e.g., composed of a unitary piece of material, etc.). In other examples, the flexible isolator **200** can be composed of multiple discrete segments. For example, the first flange **302**, the second flange **304**, and the bellows **306** can be discrete components, which are coupled via one or more suitable fasteners. In some examples, the first end **318**A of the bellows **306** can be coupled to the first flange **302** via one or more fasteners, one or more welds, one or more chemical adhesives, and/or an interference fit. Additionally or alternatively, the second end **318**B of the bellows **306** can be coupled to the second flange **304** via one or more fasteners, one or more welds, one or more chemical adhesives, and/or an interference fit.

[0047] FIG. **4** is a cross-sectional view of the panel assembly **102** taken along line **4-4** of FIG. **2**. In the illustrated example of FIG. **4**, the panel assembly **102** includes the flexible isolator **200**, the first panel **112**A, and the parent structure **202**. In the illustrated example of FIG. **4**, the parent structure **202** includes the example structure lip **211** and an example plate **402**, which includes an example recessed portion **404**. In the illustrated example of FIG. **2**, the structure lip **211** includes an example tapered surface **406** and an example first outer surface **407**. In the illustrated example of FIG. **4**, the first panel **112**A includes an example panel lip **408**, an example second outer surface **409**, and an example inner surface **410**. While FIG. **4** is described with reference to the coupling of the first panel **112**A and the parent structure **202**, it should be appreciated the second panel **112**B is also coupled to the parent structure **202** via the interface **208**.

[0048] In the illustrated example of FIG. **4**, the flexible isolator **200** separates an example interior volume **412** of the parent structure **202** from an exterior volume **414** (e.g., the ambient environment, etc.) on an exterior of the plate **402** of the parent structure **202**. As described above in conjunction with FIGS. **2-3**B, the bellows **306** functions as a seal, which prevents the flow of air, fluids, and/or debris between the exterior volume **414** and the interior volume **412**. Additionally or alternatively, the interface **208** can include one or more additional and/or separate seal(s) that seals the interior volume **412** from the exterior volume **414**. An example auxiliary seal that can be used in conjunction with the interface **208** is described below in conjunction with FIGS. **8**A-**8**C.

[0049] In the illustrated example of FIG. **4**, the first panel **112**A is generally L-shaped (e.g., the panel lip **408** extends from the second outer surface **409** toward the plate **402**, etc.). In other examples, the first panel **112**A can have any other suitable shape (e.g., generally planar, T-shaped, U-shaped, etc.). In some such examples, the panel lip **408** is absent. That is, the flexible isolator **200** is compatible with a panel assembly of any shape and/or arrangement. In the illustrated example of FIG. **4**, the parent structure **202** is generally L-shaped (e.g., the structure lip **211** extends from the plate **402**, etc.)

[0050] The flexible isolator **200** extends between the first panel **112**A and the parent structure **202**. For example, the flexible isolator **200** of the illustrated example extends between the inner surface **410** of the panel **112**A and the plate **402** of the parent structure **202**. In the illustrated example of FIG. **4**, the first side **320**A of the first flange **302** is coupled to the first panel **112**A (e.g., the inner surface **410** of the first panel **112**A, etc.) and the third side **320**C of the second flange **304** is coupled to the parent structure **202** (e.g., the recessed portion **404** of the plate **402** of the parent structure **202**). In the illustrated example of FIG. **4**, the recessed portion **404** enables the first outer surface **407** and the second outer surface **409** to be substantially flush when the bellows **306** is unstressed (e.g., not strained by a load transmitted via the interface **208**, etc.). In other examples, the recessed portion **404** can be absent. In some such examples, the outer surfaces **407**, **409** are not flush. In the illustrated example of FIG. **4**, the structure lip **211** of the parent structure **202** includes the tapered surface **406**. In other examples, the tapered surface **406** is absent.

[0051] During operation, vibrations generated by the parent structure **202** are damped via the flexible isolator **200**. That is, vibration generated by the parent structure **202** is absorbed and/or dissipated by the bellows **306**, which can prevent potential damage to the first panel **112**A. Similarly, during operation, loads generated by the parent structure **202** (e.g., from thrust of a powerplant associated with the parent structure **202**, from aero-effects associated with the parent structure **202**, etc.) can cause deflection of the flexible isolator **200**. That is, reflective deflection of the parent structure **202** toward the first panel **112**A causes the compression of the bellows **306** (e.g., the inner surface **410** of the first panel **112**A is relatively displaced toward the plate **402**, etc.). Similarly, the relative deflection of the parent structure **202** away from the first panel **112**A causes the expansion of the bellows **306** (e.g., the inner surface **410** of the first panel **112**A is relatively displaced away the plate **402**, etc.) In the illustrated example of FIG. **4**, the first panel **112**A has an example distance **415** from the structure lip **211** of the parent structure **202**. In some examples, the distance **415** facilitates the displacement of the first panel **112**A toward the structure lip **211** and away from the structure lip **211** (e.g., via the deformation of the flexible isolator **200**, etc.). By tuning a spring rate of the bellows **306** of the flexible isolator **200**, stiffness and/or displacement behavior or characteristics of the flexible isolator **200** can be tuned or adjusted based on aviation systems associated with the panel assembly **102**.

[0052] FIG. **5**A is a perspective, partial view of an example first corner **500** of the flexible isolator **200** of FIGS. **2-4**. For example, the first corner **500** can correspond to one of the intraplanar corners of FIG. **3**A (e.g., one of the intraplanar corners **310**A, **310**B, **310**C, **310**D of FIG. **3**A, etc.). In the illustrated example of FIG. **5**A, the first corner **500** includes an example first joint **502** in the bellows **306** between an example first side **504** and an example second side **506**. In the illustrated example of FIG. **5**A, on the first side **504**, the bellows **306** includes an example first crest **508**A and an example second crest **508**B, which correspond to the crests **314**A, **314**B of FIG. **3**A, respectively. In the illustrated example of FIG. **5**A, on the second side **506**, the bellows **306** includes an example third crest **508**C and an example fourth crest **508**D, which also correspond to the crests **314**A, **314**B of FIG. **3**A, respectively. In the illustrated example of FIG. **5**A, an example first outer edge portion **510**A extends between the first crest **508**A and the third crest **508**C, an example second outer edge portion **510**B extends between the first crest **508**A and the fourth crest **508**D, and an example third outer edge portion **510**C extends between the second crest **508**B and the fourth crest **508**D. In the illustrated example of FIG. **5**A, the outer edge portions **510**A, **510**B, **510**C are not parallel. That is, the first crest **508**A is not aligned with the second crest **508**B and the third crest **508**C is not aligned with the fourth crest **508**D. In the illustrated example of FIG. **5**A, the joint **502** has generally the same shape as the cross-section of the bellows depicted in FIG. **3**B.

[0053] FIG. **5**B is a perspective view of an example second corner **512** of the flexible isolator **200** of FIGS. **2-4**. For example, the second corner **512** can correspond to one of the intraplanar corners of FIG. **3**B (e.g., one of the interplanar corners **312**A, **312**B of FIG. **3**B, etc.). In the illustrated example of FIG. **5**B, the second corner **512** is formed at the joint **308** of FIG. **3**A (e.g., at an interface between the first panel **112**A and the second panel **112**B, etc.). In the illustrated example of FIG. **5**B, the bellows **306** includes an example second joint **514** between an example third side **516** and an example fourth side **518**. In the illustrated example of FIG. **5**B, on the third side **516**, the bellows **306** includes an example first crest **520**A and an example second crest **520**B, which correspond to the crests **314**A, **314**B of FIG. **3**A, respectively. In the illustrated example of FIG. **5**B, on the fourth side **518**, the bellows **306** includes an example third crest **520**C and an example fourth crest **520**D, which also correspond to the crests **314**A, **314**B of FIG. **3**A, respectively. In the illustrated example of FIG. **5**B, unlike in the first corner **500** of FIG. **5**A, the first crest **520**A is contiguous and aligned with the third crest **520**C (e.g., the first crest **520**A directly intersects with and continues as the third crest **520**C at the joint **514**, etc.) and the second crest **520**B is contiguous and aligned with the fourth crest **520**D (e.g., the second crest **520**B directly intersects with and continues as the fourth crest **520**D at the joint **514**, etc.). In other words, the joint **514** provides a transition between the first crest **520**A and the third crest **520**C so that the first crest **520**A is continuous with and/or aligns with the third crest **520**C. The joint **514** provides a transition between the second crest **520**B and the fourth crest **520**D so that the second crest **520**B is continuous with and/or aligns with the fourth crest **520**D.

[0054] FIG. **6**A is a partial, perspective view of the flexible isolator **200** of FIGS. **2-4** including an example first spring **600** disclosed herein. The flexible isolator **200** and the example first spring

600 are configured in an example first configuration **601**. In the illustrated example, the first spring **600** is disposed in an example opening **602** of the flexible isolator **200** of FIGS. **2-4**. In the first configuration **601**, the first spring **600** is disposed in an example corner **604** of the flexible isolator **200**. In the illustrated example of FIG. **6**A, the first spring **600** includes an example first mounting boss **606**A, an example second mounting boss **606**B, an example first arm **608**A, and an example second arm **608**B. In the illustrated example of FIG. **6**A, the first mounting boss **606**A includes an example first hole **610**A and the second mounting boss **606**B includes an example second hole **610**B. In the illustrated example of FIG. **6**A, the first spring **600** includes an example opening **612**.
[0055] The first spring **600** is a spring and damper that is disposed between the first flange **302** and the second flange **304**. In the illustrated example of FIG. **6**A, each of the arms **608**A, **608**B extends (e.g., in a direction away) from the mounting bosses **606**A, **606**B. The first spring **600** can be used to modify or adjust (e.g., increase) a stiffness of the flexible isolator **200** (e.g., adjacent or at the corner **604**). For example, the first spring **600** can be employed to increase the stiffness of the flexible isolator **200** adjacent or at the corner **604** when compared to the bellows **306**, decrease a stiffness of the flexible isolator **200** adjacent or at the corner when compared to the bellows **306**, etc. In some examples, a thickness of the arms **608**A, **608**B, a size of the opening **612**, and/or a geometry of the opening **612** can be modified to tune the stiffness and/or vibration damping of the flexible isolator **200**. For example, increasing a thickness of the arms **608**A, **608**B (e.g., decreasing the thickness of the opening **612**, etc.) can increase a stiffness of the flexible isolator **200** (e.g., adjacent or at the corner **604**).
[0056] In the illustrated example of FIG. **6**A, the first spring **600** is generally L-shaped. In other examples, the first spring **600** can have any other suitable shape (e.g., depending on a shape of the opening **602**, depending on a geometry of the flanges **302**, **304**, etc.) In the illustrated example of FIG. **6**A, the first spring **600** is coupled to the second side **320**B of the first flange **302** via the first mounting boss **606**A and the fourth side **320**D of the second flange **304** via the second mounting boss **606**B. For example, one or more fastener(s) (e.g., a bolt, a rivet, a screw, a pin, etc.) can be disposed in or received by the holes **610**A, **610**B and corresponding holes formed in the flanges **302**, **304**, a panel coupled to the first flange **302** (e.g., one of the panels **112**A, **112**B of FIGS. **1-2**, etc.), a parent structure (e.g., the parent structure **202** of FIG. **2**, etc.) and/or any other frame or intervening structure or layer. Additionally or alternatively, the mounting bosses **606**A, **606**B can be coupled to the flanges **302**, **304**, respectively, via one or more welds, one or more chemical adhesives, one or more interference fits, etc. In some examples, the mounting bosses **606**A, **606**B can be integrally formed with the flanges **302**, **304**, respectively. In the illustrated example of FIG. **6**A, the mounting bosses **606**A, **606**B are disposed at the corner **604**. In other examples, the mounting bosses **606**A, **606**B can be displaced from the corner **604**. In some such examples, the mounting bosses **606**A, **606**B are absent and the first spring **600** couples to the flexible isolator **200** via the arms **608**A, **608**B.
[0057] In the illustrated example of FIG. **6**A, the opening **602** is formed in the bellows **306** between the flanges **302**, **304**. That is, the flexible isolator **200** does not include bellows **306** in the opening **602** adjacent or at the first corner **604**. The first corner **604** can correspond to one of intraplanar corners of the flexible isolator **200** (e.g., one of the intraplanar corners **310**A, **310**B, **310**C, **310**D of FIG. **3**A, one of the interplanar corners **312**A, **312**B, etc.). In other examples, the first spring **600** can be disposed along a straight segment or a non-corner location of the flexible isolator **200** (e.g., along a segment of the flexible isolator **200** between one or more of the corners **310**A, **310**B, **310**C, **310**D, **312**A, **312**B of FIG. **3**A, etc.). In some such examples, the first spring **600** can have a complementary shape with the opening **602** (e.g., linearly shaped for straight segments, etc.).
[0058] FIG. **6**B is a partial, perspective view of the flexible isolator **200** of FIG. **2** and the first spring **600** of FIG. **6**A in an example second configuration **614**. In the second configuration **614**, the first spring **600** is disposed in an example second corner **616** of the flexible isolator **200**. In the

illustrated example of FIG. **6**B, the first mounting boss **606**A of the first spring **600** is coupled to the third side **320**C of the second flange **304**. In some examples, the second mounting boss **606**B of the first spring **600** can be coupled to the parent structure associated with the panel assembly **102**. For example, the first spring **600** can be disposed within an opening (e.g., a beveled region, a hole, etc.) formed in the parent structure (e.g., the parent structure **202** of FIGS. **2** and **4**, etc.). In some such examples, the second mounting boss **606**B can be coupled to the recessed portion **404** of FIG. **4**. Similar to the first configuration **601** of FIG. **6**A, in the second configuration **614**, a thickness, shape and/or size of the opening **612** in the first spring **600** can be selected to adjust or tune (e.g., increase, decrease, etc.) the damping and/or stiffness of the flexible isolator **200** at the second corner **616**.

[0059] FIG. **6**C is a partial, perspective view of the flexible isolator **200** of FIG. **2** and the first spring **600** of FIGS. **6**A and **6**B in an example third configuration **618**. In the third configuration **618**, the first spring **600** is disposed in an example corner **620** of the flexible isolator **200**. In the illustrated example of FIG. **6**C, the first spring **600** extends (e.g., or is positioned) between the first flange **302** and the second flange **304**. In the illustrated example of FIG. **6**C, the first mounting boss **606**A of the first spring **600** is coupled to the second side **320**B of the first flange **302** and the second mounting boss **606**B is coupled to the fourth side **320**D of the second flange **304**. Unlike the first configuration **601** of FIG. **6**A, the first spring **600** is not disposed in or adjacent an opening in the bellows **306**. Instead, the first spring **600** is disposed next to the bellows **306**. In the third configuration **618**, the bellows **306** does not have an opening (e.g., the opening **602**). Similar to the first configuration **601** of FIG. **6**A and the second configuration **614** of FIG. **6**B, in the third configuration **618**, a thickness, shape and/or size of the opening **612** in the first spring **600** can be selected to adjust or tune (e.g., increase, decrease, etc.) the damping and/or stiffness of the flexible isolator **200** (e.g., adjacent or at the third corner **620**).

[0060] FIG. **7**A is a partial, perspective view of the flexible isolator **200** of FIGS. **2-4** and an example second spring **700** disclosed herein. The second spring **700** of the illustrated example is disposed in the opening **602** of FIG. **6**A similar to the first configuration **601** of FIG. **6**A. The second spring **700** of the illustrated example is a coil spring (e.g., a helical spring, etc.). In other examples, the second spring **700** can be implemented by more than one coil spring, one or more volute spring(s), one or more bow spring(s), one or more flat spring(s), one or more air spring(s), one or more leaf spring(s), one or more disc spring(s), one or more Belleville springs, etc. In the illustrated example of FIG. **7**A, the second spring **700** extends (e.g., is positioned) between the first flange **302** and the second flange **304**. That is, the second spring **700** is coupled to or engages the second side **320**B of the first flange **302** and the fourth side **320**D of the second flange **304**. Thus, the first flange **302** and the second flange **304** provide respective spring seats for the second spring **700**. The second spring **700** can be used to modify (e.g., adjust, increase, decrease, etc.) a stiffness of the flexible isolator **200** (e.g., adjacent or at the corner **604**). For example, the second spring **700** can be sued to increase the stiffness of the flexible isolator **200** adjacent or at the corner **604** when compared to the bellows **306**, decrease a stiffness of the flexible isolator **200** adjacent or at the corner when compared to the bellows **306**, etc.). In some examples, a thickness of example coils **702** of the second spring **700**, a number of the coils **702**, a geometry of the coils **702**, a spring rate of the second spring **700**, and/or a length of the second spring **700** can be modified to adjust or tune (e.g., increase, decrease, etc.) a stiffness and/or vibration damping of the flexible isolator **200**. For example, increasing a thickness and/or a number of the coils **702** (e.g., decreasing the thickness of the opening **612**, etc.) can increase a stiffness of the flexible isolator **200** (e.g., adjacent or at the corner **604**).

[0061] FIG. **7**B is a partial, perspective view of the flexible isolator **200** of FIG. **2** and the second spring **700** of FIG. **7**A in an example second configuration **614**. In the second configuration **614**, the second spring **700** is disposed adjacent or at the second corner **616** of the flexible isolator **200**. In the illustrated example of FIG. **6**B, the second spring **700** is coupled to the third side **320**C of the second flange **304**. For example, the second spring **700** can be supported by, and/or disposed within an opening (e.g., a beveled region, a hole, etc.) formed in, the parent structure (e.g., the parent structure **202** of FIGS. **2** and **4**, etc.). Similar to the first configuration **601** of FIG. **7**A, in the second configuration **614**, a thickness of example coils **702** of the second spring **700**, a number of the coils **702**, a geometry of the coils **702**, a length of the second spring **700**, a spring rate of the second spring **700** can be selected to adjust or tune (e.g., increase, decrease) the damping and/or stiffness of the flexible isolator **200** at the second corner **616**.

[0062] FIG. **7**C is a partial, perspective view of the flexible isolator **200** of FIG. **2** and the first spring **700** of FIGS. **7**A and **7**B in the third configuration **618** of FIG. **6**C. In the third configuration **618**, the first spring **700** is disposed at the third corner **620** of the flexible isolator **200**. In the illustrated example of FIG. **7**C, the second spring **700** extends between the first flange **302** and the second flange **304**. Thus, the first flange **302** and the second flange **304** provide. Unlike the first configuration **601** of FIG. **7**A, the second spring **700** is not disposed in an opening in the bellows **306** and is disposed next to the bellows **306**. Thus, the bellows **306** does not include an opening. Similar to the first configuration **601** of FIG. **7**A and the second configuration **614** of FIG. **7**B, in the third configuration **618**, a thickness of example coils **702** of the second spring **700**, a number of the coils **702**, a geometry of the coils **702**, a length of the second spring **700**, and/or a spring rate of the second spring **700** can be selected to adjust or tune (e.g., increase or decrease) the damping and/or stiffness of the flexible isolator **200** adjacent or at the second corner **616**.

[0063] FIG. **8**A is a partial, exterior perspective view of the example flexible isolator **200** of FIG. **2** implemented with an example auxiliary seal **800** disclosed herein. The auxiliary seal **800** of the illustrated example is positioned or disposed adjacent or at the first corner **604** of FIGS. **6**A and **7**A. For example, the auxiliary seal **800** of the illustrated example covers and/or seals (e.g. fluidly seals) the opening **602** of the flexible isolator **200** of FIG. **6**A. FIG. **8**B is a partial, interior perspective view of the flexible isolator **200** and the auxiliary seal **800** of FIG. **8**B. Referring to FIGS. **8**A and **8**B, the auxiliary seal **800** of the illustrated example includes an example first seal flange **802**, an example second seal flange **804**, and example seal bellows **806**. In the illustrated example of FIGS. **8**A and **8**B, the auxiliary seal **800** includes an example first seal end **808**A and an example second seal end **808**B.

[0064] In the illustrated example of FIGS. **8**A-**8**B, the auxiliary seal **800** extends (e.g., positioned vertically) between the first flange **302** and the second flange **804**. The example first seal flange **802** is coupled to the flange **302** and the example second seal flange **804** is coupled to the second flange **804**. The first seal end **808**A and the second seal end **808**B of the illustrated example are coupled the bellows **306**. That is, the auxiliary seal **800** extends over and/or completely covers the opening **602** (FIG. **6**A) in the bellows **306**. In the illustrated example of FIG. **8**A, the auxiliary seal **800** includes an example seal joint **809** at the corner **604**. In the illustrated example of FIG. **8**A, because the corner **604** is an intraplanar corner (e.g., one of the corners **310**A, **310**B, **310**C, **310**C of FIG. **3**A, etc.), the seal joint **802** is similar to the joint **502** of FIG. **5**A. In other examples, if an auxiliary seal is coupled to a corner that is an interplanar corner (e.g., one of the corners **312**A, **312**B of FIG. **3**A, etc.), the seal joint **802** can be similar to the joint **514** of FIG. **5**B. In other examples, if the opening **602** is disposed at a non-corner location of the flexible isolator **200**, the seal joint **809** is absent.

[0065] The auxiliary seal **800** inhibits (e.g., prevents, reduces, etc.) the flow of fluids, debris, and/or other materials through the opening **602**. Unlike the bellows **306** of the flexible isolator **200**, the auxiliary seal **800** does not substantially increase a stiffness of the flexible isolator **200** (e.g., at or near the opening **602** or the corner **604**). As such, the example auxiliary seal **800** disclosed herein can enable example flexible isolators disclosed herein to employ openings (e.g., the opening **602**) located at one or more locations along the flexible isolator **200** to adjust or tune a stiffness and/or damping of the flexible isolator **200** without compromising a sealing function of the flexible isolator **200**. While one auxiliary seal **800** is depicted in the illustrated examples of FIGS. **8**A-**8**B, it should be appreciated the flexible isolator **200** can include any suitable number of similar seals (e.g., a seal in each gap formed in the bellows **306**, etc.). The auxiliary seal **800** can be composed of any compliant flexible material, such as an elastomer (e.g., natural rubber, synthetic rubber, a thermoplastic elastomer, etc.) and/or any other suitable material (e.g., a flexible mesh, one or more natural fibers, one or more flexible plastics, etc.). FIG. **8**C is a cross-sectional view of the flexible isolator **200** and the auxiliary seal **800** taken along line **8**C-**8**C of FIG. **8**A. In the illustrated example of FIG. **8**C, the flexible isolator **200** includes an example first surface **810** that extends (e.g., continuously) along at least a portion of the first flange **302**, the bellows **306**, and the second flange **304**. In the illustrated example, the auxiliary seal **800** faces the interior volume **412** of FIG. **4**. In the illustrated example of FIG. **8**C, the flexible isolator **200** defines an example second surface **812** that extends (e.g., continuously) along at least a portion of the first flange **302**, the bellows **306**, and the second flange **304**, and faces the interior volume **414** of FIG. **4**. In some examples, the auxiliary seal **800** is complementary to a shape of the first surface **810** of the flexible isolator **200**.

[0066] In the illustrated example of FIGS. **8**C, the auxiliary seal **800** is coupled to the first surface **810**. In the illustrated example of FIG. **8**C, the auxiliary seal **800** extends over the roots **316**A, **316**B and extends into the crests **314**A, **314**B. In some examples, the auxiliary seal **800** can be coupled to the first surface **810** via one or more chemical adhesives, one or more mechanical fasteners, and/or any other suitable fastening method. In some examples, an additional seal can be coupled to the second side **812** to bolster the seal provided by the auxiliary seal **800**. In some examples, the auxiliary seal **800** can be integrally formed with the flexible isolator **200** via injection molding, three-dimensional printing, welding, and/or any other manufacturing techniques.

[0067] FIG. **9** is a perspective, partial view of an example aircraft **900** including an example multi-panel assembly **902** disclosed herein. In the illustrated example of FIG. **9**, the aircraft **900** is an aviation system and includes an example body **904**. In the illustrated example of FIG. **9**, the multi-panel assembly **902** houses an example sensor **906**. In some examples, the sensor **906** and the multi-panel assembly **902** can be components of an electro-optical targeting system (EOTS). The multi-panel assembly **902** can be coupled to the body **904** via a flexible isolator similar to the flexible isolator **200** described in conjunction with FIGS. **2**A-**4**, which (1) damps vibrations transmitted between body **904** and the multi-panel assembly **902**, (2) environmental seals the interior of the multi-panel assembly **902** (e.g., the sensor, etc.), and (3) permits the relative displacement of the multi-panel assembly **902** from the body **904**. In the illustrated example of FIG. **9**, the multi-panel assembly **902** includes **9** panels (e.g., windowpanes, windows, window panels, etc.), which permit optical signals to be received by the sensor **906**. In other words, the isolator permits optical signals to pass therethrough and does not interfere or reduce a strength of the signals. In other examples, the multi-panel assembly **902** can include any other suitable number of panels. In some examples, the multi-panel assembly **902** can include the first spring **600** in one or more of the configuration(s) of FIGS. **6**A-**6**C, the second spring **700** in one or more of the configuration(s) of FIGS. **7**A-**7**C, and/or the auxiliary seal **800** of FIGS. **8**A-**8**C.

[0068] FIG. **10** is a perspective view of an example aircraft **1000** including a plurality of example panel assemblies disclosed herein. In the illustrated example of FIG. **10**, the aircraft **1000** is an aviation system and includes an example body **1002**. In the illustrated example of FIG. **10**, the aircraft **1000** includes an example first panel assembly **1004**, an example second panel assembly **1006**, an example third panel assembly **1008**, an example fourth panel assembly **1010**, and an example fifth panel assembly **1012**. In the illustrated example of FIG. **10**, each of the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012** is a single panel assembly. In other examples, some or all of the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012** can have more than one panel (e.g., two panels, three panels, four panels, etc.). In the illustrated example of FIG. **10**, the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012** are electrical panels. In some examples, the component(s) of the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012** can be sensitive to loading and/or vibration from the body **1002**. In some examples, some or all of the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012** are coupled to the body **1002** via a flexible isolator similar to the flexible isolator **200** described in conjunction with FIGS. **2**A-**4**, which (1) damps vibrations transmitted between body **1002** and corresponding ones of the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012**, (2) environmental seals interior of the components of the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012**, and (3) permits relative displacement of the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012** from the body **1002**. For example, the first panel assembly **1004** is an electrical panel including a jammer (e.g., a radar jammer, etc.), the second panel assembly **1006** is an electrical panel including a laser warning receiver (LWR), the third panel assembly **1008** is an electrical panel including a radar warning receiver (RWR), the fourth panel assembly **1010** is an electrical panel that controls countermeasures (e.g., chaff, etc.) from the aircraft **1000**, and the fifth panel assembly **1012** is an electrical panel including an infrared sensor and a missile detection system. In other examples, the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012** can include any other suitable components. In some examples, some or all of the panel assemblies **1004**, **1006**, **1008**, **1010**, **1012** can include the first spring **600** in one or more of the configuration(s) of FIGS. **6**A-**6**C, the second spring **700** in one or more of the configuration(s) of FIGS. **7**A-**7**C, and/or the auxiliary seal of FIGS. **8**A-**8**C.

[0069] While examples disclosed herein are described with reference to aviation systems (e.g., the aviation system **100** of FIG. **1**, the aircraft **900** of FIG. **9**, the aircraft **1000** of FIG. **10**, etc.), the teachings of this disclosure are not limited to such aviation systems. Instead, the panel assembly **102** of FIGS. **1** and **2** and the flexible isolator **200** of FIG. **2** can be used in conjunction with any other assembly that includes panels with vibration and deflection-sensitive components. For example, the isolators and panel assemblies disclosed herein can be used in conjunction with other vehicles (e.g., nautical vehicles, automobiles, trains, construction vehicles, etc.), precision industrial machinery (e.g., computer numerical control (CNC) machines, additive manufacturing machines, etc.), laboratory equipment (e.g., microscopes, lasers, high-power magnets, etc.) and/or any other sensitive machinery.

[0070] It should be appreciated that the panel assembly **102** of FIGS. **1** and **2** and the flexible isolator **200** of FIG. **2** dampen vibrations associated with aviation systems, such as the aviation system **100** of FIG. **1**. For example, operations to assemble an aviation system including the panel assembly **102** of FIGS. **1** and **2** and the flexible isolator **200** of FIG. **2** and/or dampen vibrations generated by the aviation system include manufacturing the flexible isolator **200**. For example, the flexible isolator **200** of FIG. **2** can be manufactured by bending, pressing, folding, etc. Additionally or alternatively, the flexible isolator **200** can be manufactured via additive manufacturing. After the manufacturing of the flexible isolator **200**, the panels **112**A, **112**B can be coupled to the first flange **302** via one or more weld(s), one or more fastener(s), one or more interference fit(s), and/or one or more chemical adhesive(s) to form the panel assembly **102**. The panel assembly **102** can be coupled to the parent structure **202** by coupling the second flange **304** to the parent structure via one or more weld(s), one or more fastener(s), one or more interface fit(s), and/or one or more chemical adhesive(s). The coupling of the panel assembly **102** to the parent structure **202** enables the flexible isolator **200** to damped (e.g., damp, reduce vibration, etc.) transmitted between the parent structure **202** and the panels **112**A, **112**B. For example, a method of assembling a panel assembly **102** to dampen vibrations between two structures (e.g., of an aviation system) includes attaching a first flange **302** of the panel assembly **102** to a first structure and attaching a second flange **304** of the panel assembly **102** to a second structure to position a flexible isolator **200** of the panel assembly **102** between the first structure and the second structure. The flexible isolator **200** of the panel assembly **102** is structured to enable the first structure to move relative to the second structure. The flexible isolator **200** includes a plurality of bellows structured to enable the first structure to move relative to the second structure. In some examples, only the first structure moves relative to the second structure. In some examples, only the second structure moves relative to the first structure. In some examples, both the first structure and the second structure move relative to each other. The foregoing examples of the isolators and/or panel assemblies disclosed herein can be employed with aerospace systems, aviation systems, satellites, aircraft, automobiles, vehicles, structures, buildings, electrical panels, and/or any other system(s) that can benefit from vibration dampening and/or sealing. Although each of the example aviation systems, flexible isolators, panel assemblies, first spring **600**, second spring **700**, and/or the auxiliary seal **800** disclosed above have certain features, it should be understood that it is not necessary for a particular feature of one example to be used exclusively with that example. Instead, any of the features described above and/or depicted in the drawings can be combined with any of the examples, in addition to or in substitution for any of the other features of those examples. One example's features are not mutually exclusive to another example's features. Instead, the scope of this disclosure encompasses any combination of any of the features.

[0071] “Including” and “comprising” (and all forms and tenses thereof) are used herein to be open ended terms. Thus, whenever a claim employs any form of “include” or “comprise” (e.g., comprises, includes, comprising, including, having, etc.) as a preamble or within a claim recitation of any kind, it is to be understood that additional elements, terms, etc., may be present without falling outside the scope of the corresponding claim or recitation. As used herein, when the phrase “at least” is used as the transition term in, for example, a preamble of a claim, it is open-ended in the same manner as the term “comprising” and “including” are open ended. The term “and/or” when used, for example, in a form such as A, B, and/or C refers to any combination or subset of A, B, C such as (1) A alone, (2) B alone, (3) C alone, (4) A with B, (5) A with C, (6) B with C, or (7) A with B and with C. As used herein in the context of describing structures, components, items, objects and/or things, the phrase “at least one of A and B” is intended to refer to implementations including any of (1) at least one A, (2) at least one B, or (3) at least one A and at least one B. Similarly, as used herein in the context of describing structures, components, items, objects and/or things, the phrase “at least one of A or B” is intended to refer to implementations including any of (1) at least one A, (2) at least one B, or (3) at least one A and at least one B. As used herein in the context of describing the performance or execution of processes, instructions, actions, activities, etc., the phrase “at least one of A and B” is intended to refer to implementations including any of (1) at least one A, (2) at least one B, or (3) at least one A and at least one B. Similarly, as used herein in the context of describing the performance or execution of processes, instructions, actions, activities, etc., the phrase “at least one of A or B” is intended to refer to implementations including any of (1) at least one A, (2) at least one B, or (3) at least one A and at least one B.

[0072] As used herein, singular references (e.g., “a”, “an”, “first”, “second”, etc.) do not exclude a plurality. The term “a” or “an” object, as used herein, refers to one or more of that object. The terms “a” (or “an”), “one or more”, and “at least one” are used interchangeably herein. Furthermore, although individually listed, a plurality of means, elements, or actions may be implemented by, e.g., the same entity or object. Additionally, although individual features may be included in different examples or claims, these may possibly be combined, and the inclusion in different examples or claims does not imply that a combination of features is not feasible and/or advantageous.

[0073] As used herein, unless otherwise stated, the term “above” describes the relationship of two parts relative to Earth. A first part is above a second part, if the second part has at least one part between Earth and the first part. Likewise, as used herein, a first part is “below” a second part when the first part is closer to the Earth than the second part. As noted above, a first part can be above or below a second part with one or more of: other parts therebetween, without other parts therebetween, with the first and second parts touching, or without the first and second parts being in direct contact with one another.

[0074] As used in this patent, stating that any part (e.g., a layer, film, area, region, or plate) is in any way on (e.g., positioned on, located on, disposed on, or formed on, etc.) another part, indicates that the referenced part is either in contact with the other part, or that the referenced part is above the other part with one or more intermediate part(s) located therebetween.

[0075] As used herein, connection references (e.g., attached, coupled, connected, and joined) may include intermediate members between the elements referenced by the connection reference and/or relative movement between those elements unless otherwise indicated. As such, connection references do not necessarily infer that two elements are directly connected and/or in fixed relation to each other. As used herein, stating that any part is in "contact" with another part is defined to mean that there is no intermediate part between the two parts.

[0076] Unless specifically stated otherwise, descriptors such as "first," "second," "third," etc., are used herein without imputing or otherwise indicating any meaning of priority, physical order, arrangement in a list, and/or ordering in any way, but are merely used as labels and/or arbitrary names to distinguish elements for ease of understanding the disclosed examples. In some examples, the descriptor "first" may be used to refer to an element in the detailed description, while the same element may be referred to in a claim with a different descriptor such as "second" or "third." In such instances, it should be understood that such descriptors are used merely for identifying those elements distinctly within the context of the discussion (e.g., within a claim) in which the elements might, for example, otherwise share a same name.

[0077] As used herein, "approximately" and "about" modify their subjects/values to recognize the potential presence of variations that occur in real world applications. For example, "approximately" and "about" may modify dimensions that may not be exact due to manufacturing tolerances and/or other real world imperfections as will be understood by persons of ordinary skill in the art. For example, "approximately" and "about" may indicate such dimensions may be within a tolerance range of +/−10% unless otherwise specified herein.

[0078] Example isolators for panel assemblies and other structures are disclosed herein. Further examples and combinations thereof include the following:

[0079] Example 1 includes an apparatus to be coupled to an aviation system, the apparatus including a panel, a frame, and an isolator coupling the panel and the frame, the isolator including a first flange including a first side coupled to the panel, and a second side opposite the first side, a second flange including a third side coupled to the frame, and a fourth side opposite the third side, and a flexible bellows positioned between the first flange and the second flange, the flexible bellows including a first end coupled to the second side, and a second end coupled to the fourth side.

[0080] Example 2 includes the apparatus of any preceding example, wherein the flexible bellows includes at least 2 convolutions.

[0081] Example 3 includes the apparatus of any preceding example, wherein the panel is at least one of a window or an electrical panel.

[0082] Example 4 includes the apparatus of any preceding example, wherein the panel is a first panel, and further including a multi-panel assembly including the first panel, and a second panel coupled to the first panel.

[0083] Example 5 includes the apparatus of any preceding example, wherein the first panel is disposed in a first plane, and the second panel is disposed in a second plane different than the first plane.

[0084] Example 6 includes the apparatus of any preceding example, wherein the first panel and the second panel define an interior perimeter, the first flange coupled to the interior perimeter.

[0085] Example 7 includes the apparatus of any preceding example, wherein the frame includes a plate coupled to the second flange of the isolator, and a lip extending from the plate.

[0086] Example 8 includes the apparatus of any preceding example, wherein the flexible bellows, the first flange, and the second flange are integral.

[0087] Example 9 includes the apparatus of any preceding example, wherein the flexible bellows seals an exterior volume of the panel from an interior volume of the frame.

[0088] Example 10 includes the apparatus of any preceding example, wherein the isolator further

includes a spring disposed adjacent to a corner of the panel.
[0089] Example 11 includes the apparatus of any preceding example, wherein the spring extends between the first flange and the second flange.
[0090] Example 12 includes the apparatus of any preceding example, wherein the spring is disposed in an opening of the flexible bellows.
[0091] Example 13 includes an aviation system comprising a powerplant, a panel, a structure, and an isolator to isolate the panel from the powerplant, the isolator disposed between the panel and the structure a first flange coupled to the panel, a second flange coupled to the structure, and a flexible bellows having a first end extending from the first flange and a second end extending from the second flange.
[0092] Example 14 includes the aviation system of any preceding example, wherein the panel is a first panel, and further including a multi-panel assembly including the first panel, and a second panel joined to the first panel via a joint.
[0093] Example 15 includes the aviation system of any preceding example, wherein the first panel is positioned at an angle relative to the second panel.
[0094] Example 16 includes the aviation system of any preceding example, wherein the joint is a first joint and the isolator includes a second joint abutting the first joint.
[0095] Example 17 includes a flexible isolator to couple and isolate a panel and a frame, the flexible isolator including a first flange including a first portion disposed in a first plane, a second portion disposed in a second plane different than the first plane, and a joint disposed between the first portion and the second portion, a second flange, and a flexible bellows extending between the first flange and the second flange.
[0096] Example 18 includes the flexible isolator of any preceding example, wherein the joint is a first joint, the first portion includes a corner disposed within the first plane and the flexible bellows includes a first crest on a first side of the corner, a second crest on the first side of the corner, a third crest on a second side of the corner, a second joint disposed at the corner, the second joint including a first edge portion extending between the first crest and the third crest, and a second edge portion extending between the second crest and the third crest.
[0097] Example 19 includes the flexible isolator of any preceding example, wherein the corner is a first corner and the flexible bellows further includes a fourth crest on a third side of a second corner, and a fifth crest on a fourth side of the second corner, the fourth crest contiguous with the fifth crest.
[0098] Example 20 includes the flexible isolator of any preceding example, wherein the joint defines an internal angle of less than 180 degrees.
[0099] The following claims are hereby incorporated into this Detailed Description by this reference. Although certain example systems, apparatus, articles of manufacture, and methods have been disclosed herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all systems, apparatus, articles of manufacture, and methods fairly falling within the scope of the claims of this patent.

Claims

1. An apparatus to be coupled to an aviation system, the apparatus including: a panel; a frame; and an isolator coupling the panel and the frame, the isolator including: a first flange including: a first side coupled to the panel; and a second side opposite the first side; a second flange including: a third side coupled to the frame; and a fourth side opposite the third side; and a flexible bellows positioned between the first flange and the second flange, the flexible bellows including: a first end coupled to the second side; and a second end coupled to the fourth side.
2. The apparatus of claim 1, wherein the flexible bellows includes at least 2 convolutions.
3. The apparatus of claim 1, wherein the panel is at least one of a window or an electrical panel.

4. The apparatus of claim 1, wherein the panel is a first panel, and further including a multi- panel assembly including: the first panel; and a second panel coupled to the first panel.
5. The apparatus of claim 4, wherein the first panel is disposed in a first plane, and the second panel is disposed in a second plane different than the first plane.
6. The apparatus of claim 5, wherein the first panel and the second panel define an interior perimeter, the first flange coupled to the interior perimeter.
7. The apparatus of claim 1, wherein the frame includes: a plate coupled to the second flange of the isolator; and a lip extending from the plate.
8. The apparatus of claim 1, wherein the flexible bellows, the first flange, and the second flange are integral.
9. The apparatus of claim 1, wherein the flexible bellows seals an exterior volume of the panel from an interior volume of the frame.
10. The apparatus of claim 1, wherein the isolator further includes a spring disposed adjacent to a corner of the panel.
11. The apparatus of claim 10, wherein the spring extends between the first flange and the second flange.
12. The apparatus of claim 10, wherein the spring is disposed in an opening of the flexible bellows.
13. An aviation system comprising: a powerplant; a panel; a structure; and an isolator to isolate the panel from the powerplant, the isolator disposed between the panel and the structure: a first flange coupled to the panel; a second flange coupled to the structure; and a flexible bellows having a first end extending from the first flange and a second end extending from the second flange.
14. The aviation system of claim 13, wherein the panel is a first panel, and further including a multi-panel assembly including: the first panel; and a second panel joined to the first panel via a joint.
15. The aviation system of claim 14, wherein the first panel is positioned at an angle relative to the second panel.
16. The aviation system of claim 14, wherein the joint is a first joint and the isolator includes a second joint abutting the first joint.
17. A flexible isolator to couple and isolate a panel and a frame, the flexible isolator including: a first flange including: a first portion disposed in a first plane; a second portion disposed in a second plane different than the first plane; and a joint disposed between the first portion and the second portion; a second flange; and a flexible bellows extending between the first flange and the second flange.
18. The flexible isolator of claim 17, wherein the joint is a first joint, the first portion includes a corner disposed within the first plane and the flexible bellows includes: a first crest on a first side of the corner; a second crest on the first side of the corner; a third crest on a second side of the corner; a second joint disposed at the corner, the second joint including: a first edge portion extending between the first crest and the third crest; and a second edge portion extending between the second crest and the third crest.
19. The flexible isolator of claim 18, wherein the corner is a first corner and the flexible bellows further includes: a fourth crest on a third side of a second corner; and a fifth crest on a fourth side of the second corner, the fourth crest contiguous with the fifth crest.
20. The flexible isolator of claim 17, wherein the joint defines an internal angle of less than 180 degrees.