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Leon et al.

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(45) **Date of Patent: Sep. 8, 2020**

(54) **FRANGIBLE FASTENERS WITH FLEXIBLE CONNECTORS FOR UNMANNED AIRCRAFT, AND ASSOCIATED SYSTEMS AND METHODS**

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(73) Assignee: **INSITU, INC.**, Bingen, WA (US)

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(51) **Int. Cl.**

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F16B 41/00	(2006.01)
B64C 23/06	(2006.01)
B64C 1/26	(2006.01)

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

CPC ***F16B 31/021*** (2013.01); ***B64C 23/069*** (2017.05); ***F16B 41/002*** (2013.01); *B64C 1/26* (2013.01); *B64C 2201/021* (2013.01); *B64C 2201/104* (2013.01); *Y10T 403/11* (2015.01)

(58) **Field of Classification Search**

CPC F16B 31/00; F16B 31/021; F16B 41/002; Y10T 403/11

USPC 411/2, 3, 5, 383; 470/8, 9

See application file for complete search history.

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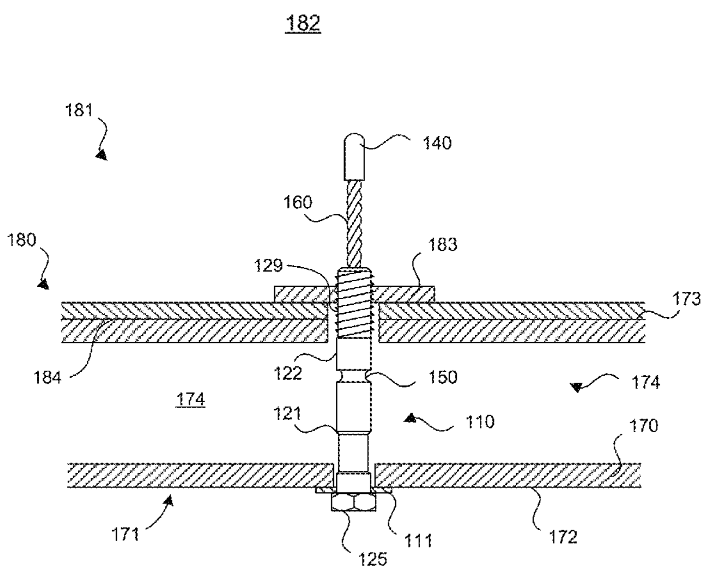
(57) **ABSTRACT**

Frangible fasteners with flexible connectors for unmanned aircraft, and associated systems and methods are disclosed. A representative aircraft includes a fuselage portion, a wing portion, a winglet carried by the wing portion, and a frangible fastener coupling the winglet portion to the wing portion. The frangible fastener can include an outer body with a first portion in contact with the wing portion, a second portion in contact with the winglet portion, and a frangible portion between the first and second portions. A flexible member is positioned at least partially within the outer body and is connected to the first portion so as to extend through and out of the second portion. A stop element is carried by the flexible member.

33 Claims, 11 Drawing Sheets



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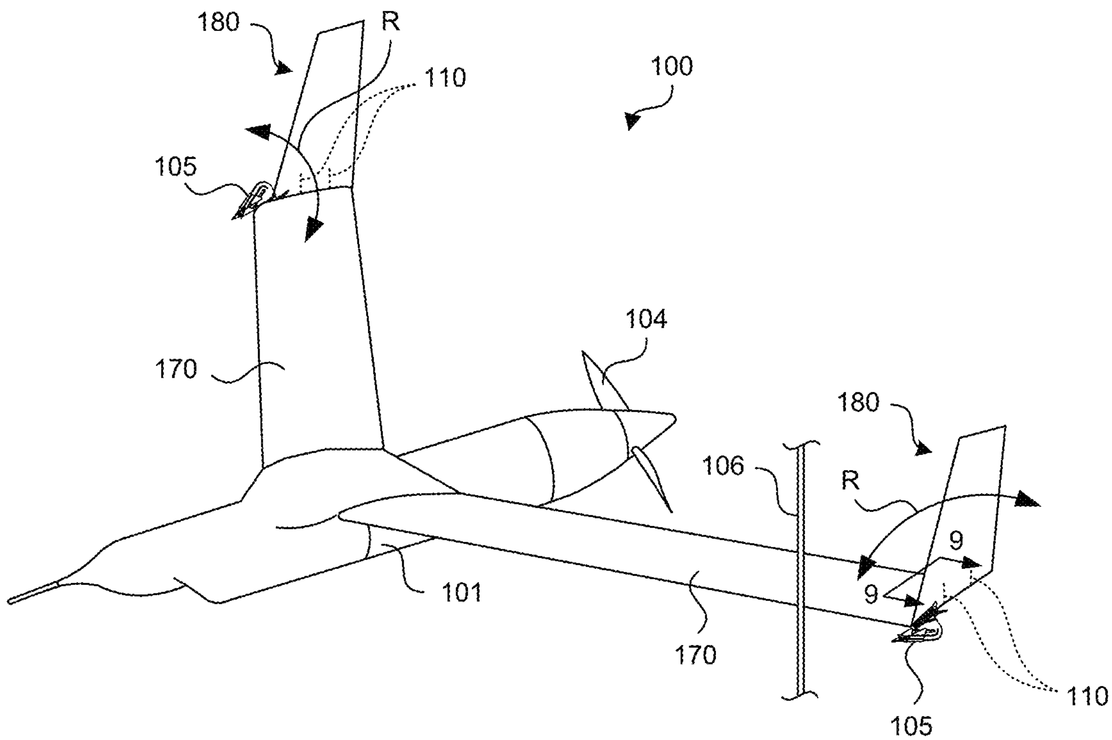


FIG. 1

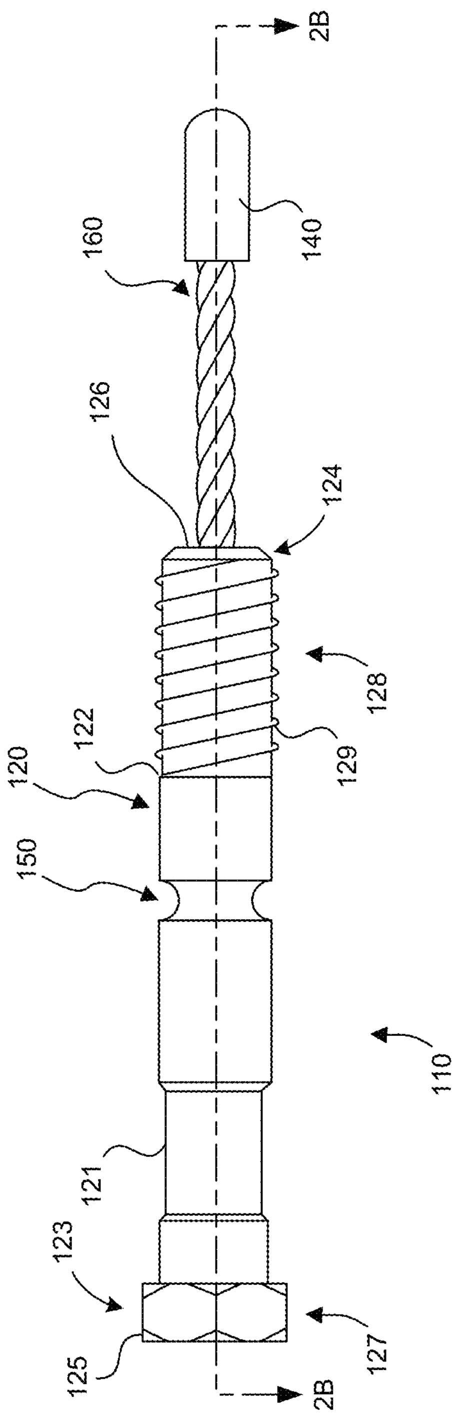
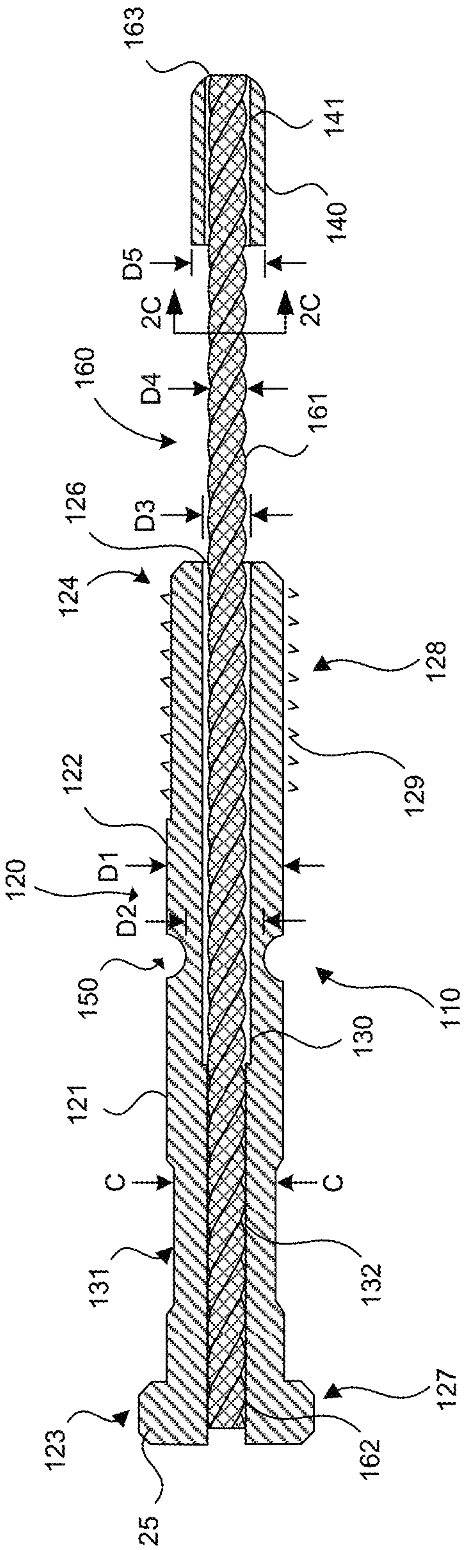


FIG. 2A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D2
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C
C
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132
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127
162
125

FIG. 2B

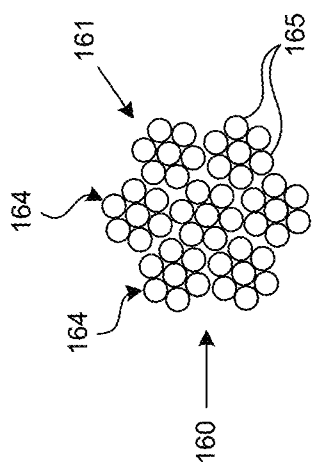
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FIG. 2C

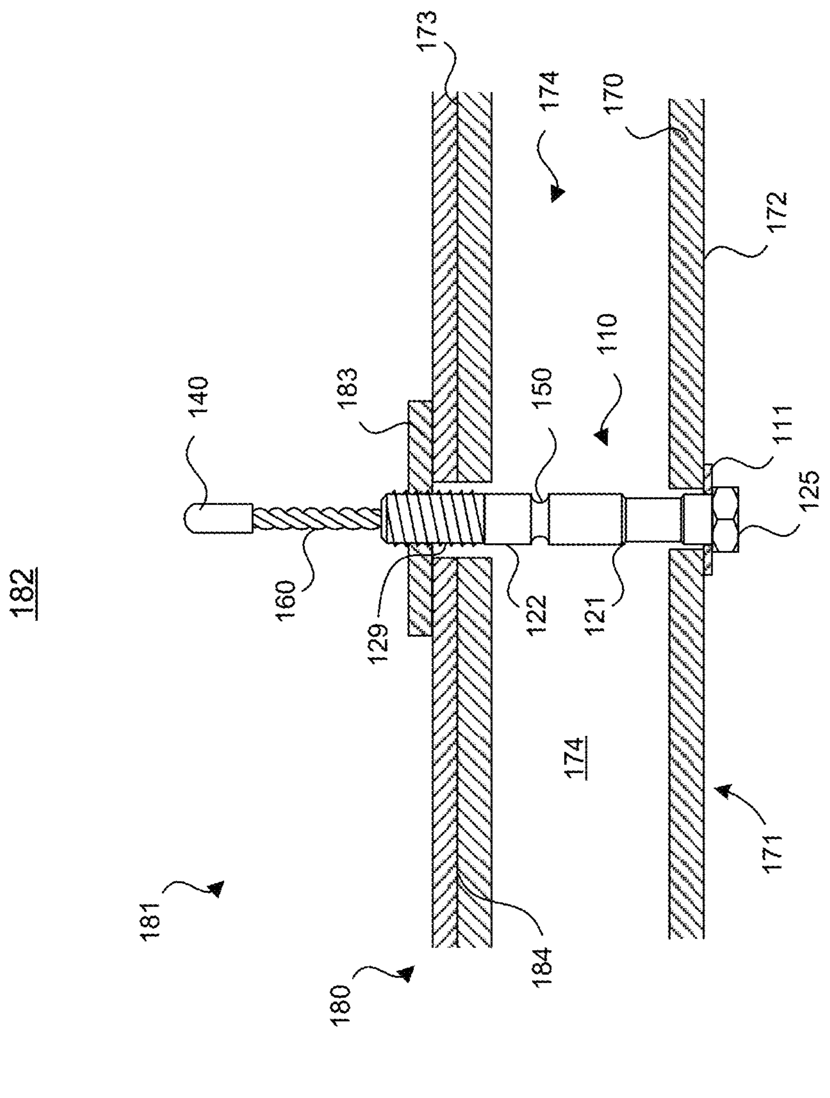
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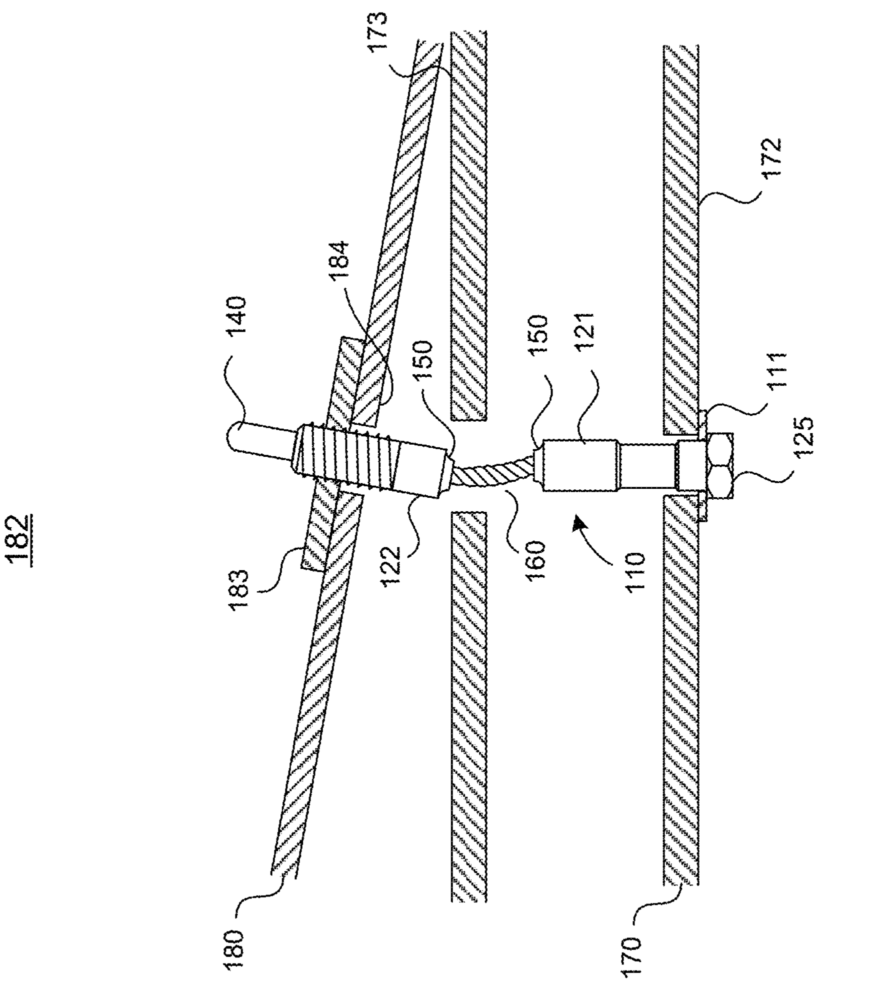
FIG. 3



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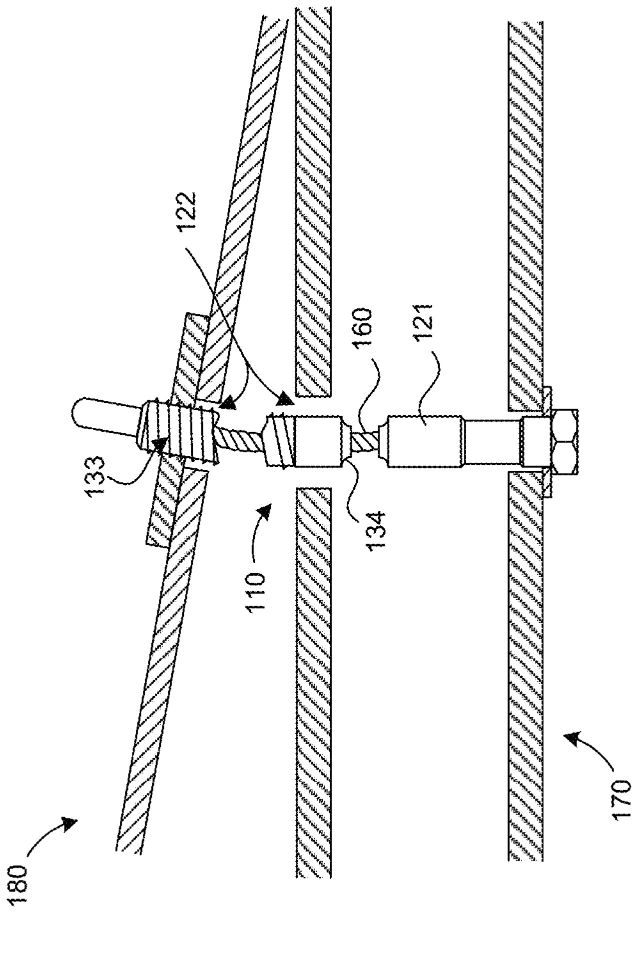

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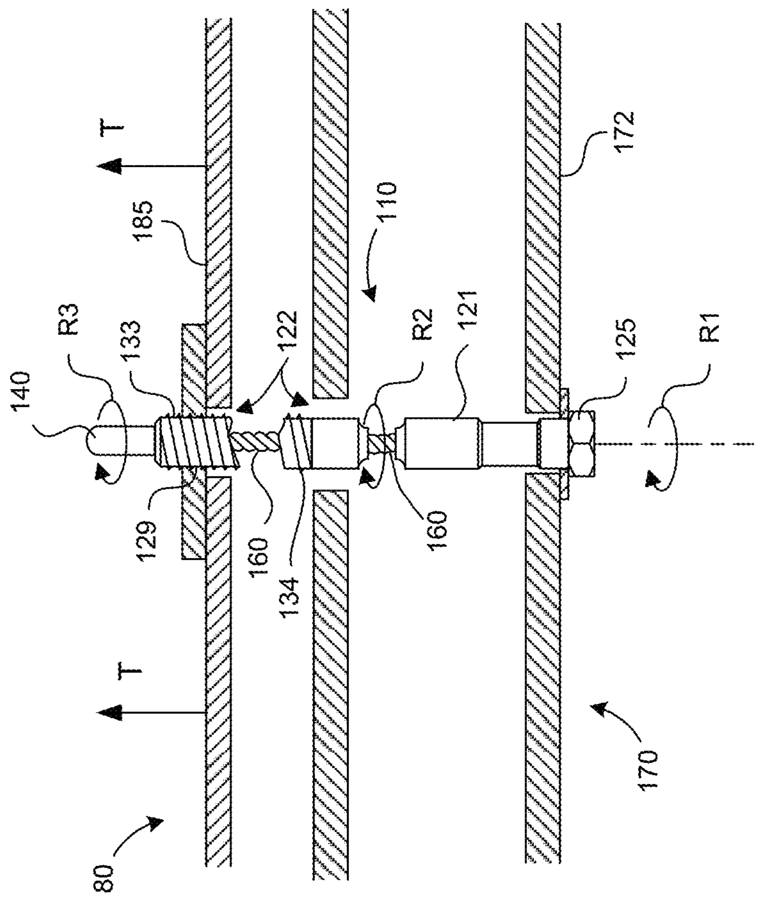
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FIG. 6

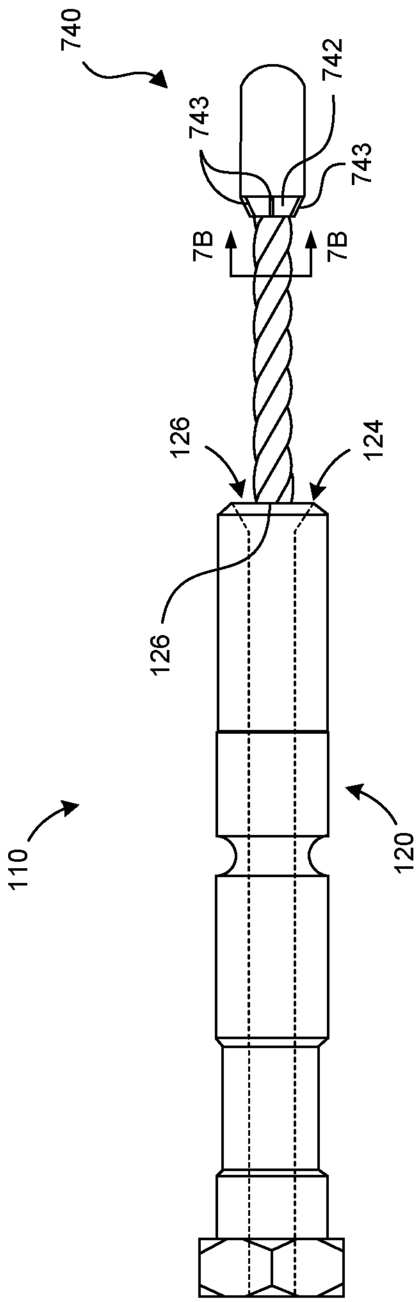

FIG. 7A

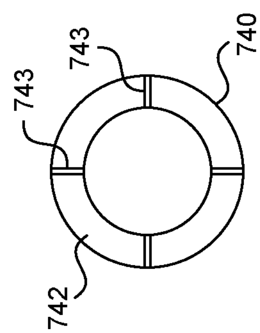

FIG. 7B

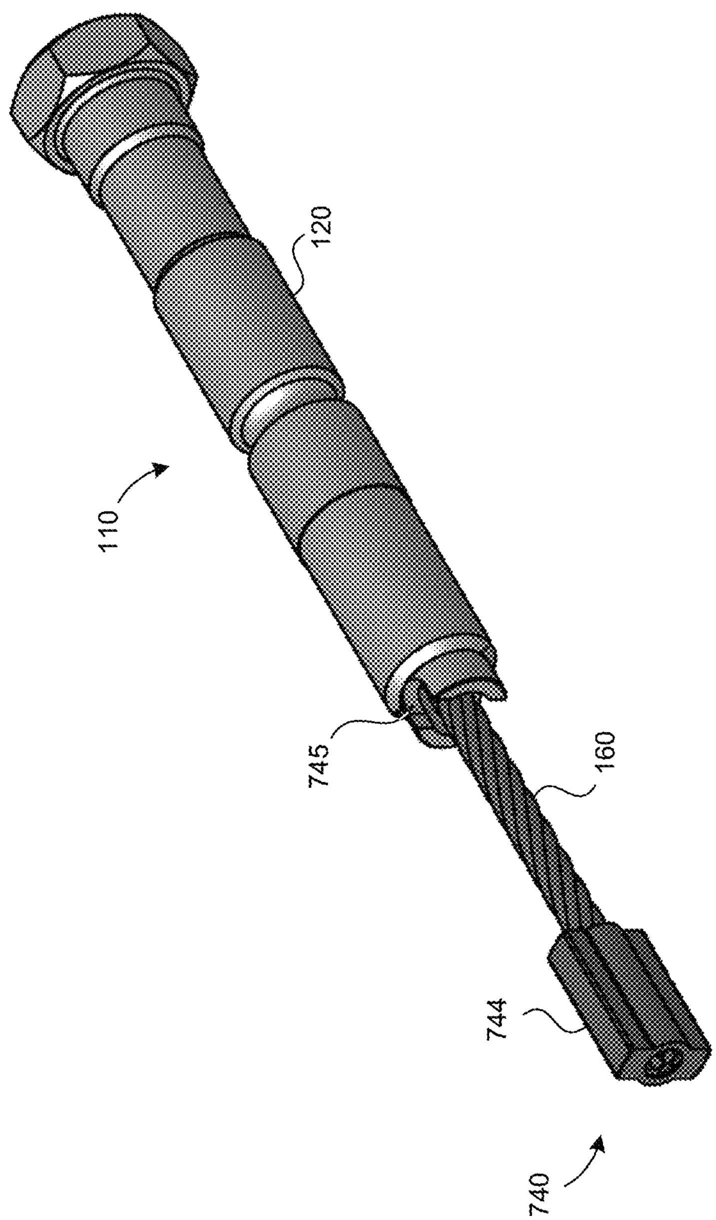

FIG. 7C

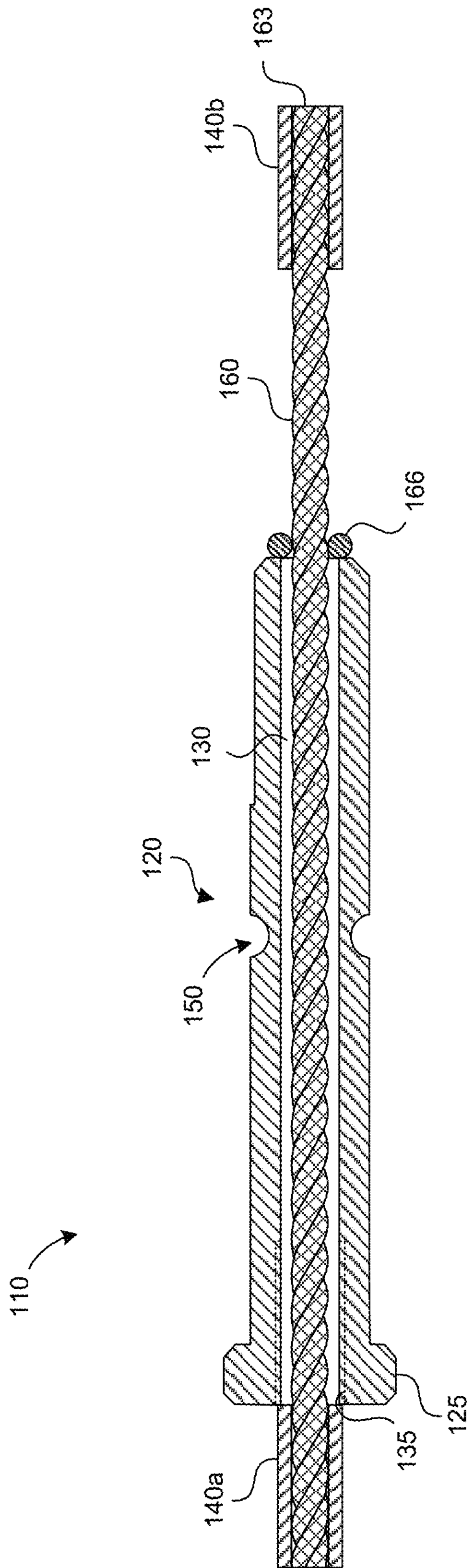

FIG. 8

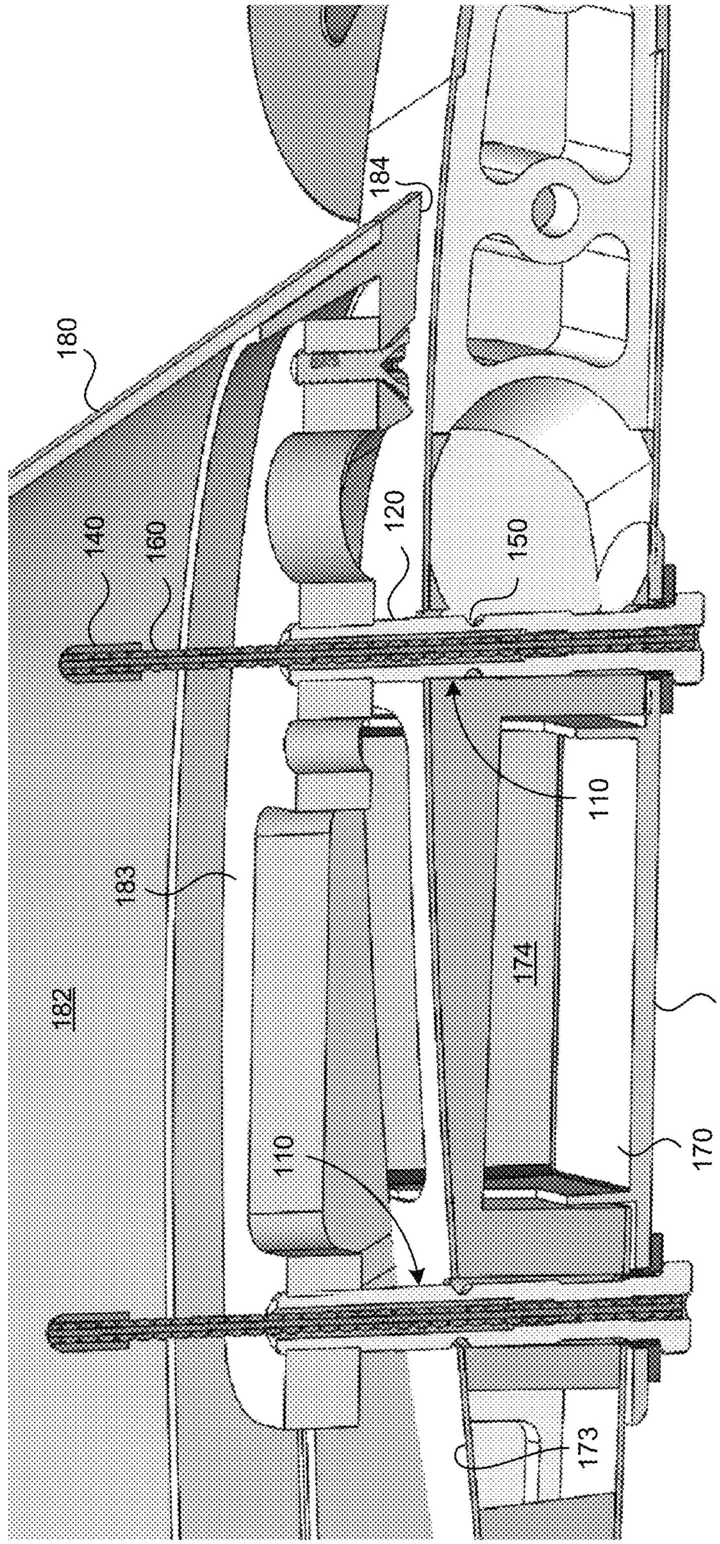

FIG. 9

FRANGIBLE FASTENERS WITH FLEXIBLE CONNECTORS FOR UNMANNED AIRCRAFT, AND ASSOCIATED SYSTEMS AND METHODS

TECHNICAL FIELD

The present technology is directed generally to frangible fasteners with flexible connectors for unmanned aircraft, and associated systems and methods.

BACKGROUND

Frangible fasteners are commonly used in unmanned aircraft or air vehicles (UAVs) to secure various components (e.g., fuselage, wings, winglets, empennage, etc.) of the aircraft together. Frangible fasteners can help minimize damage to the aircraft during landing and/or other high-impact operations. For example, many conventional unmanned aircraft include wings connected to the fuselage with frangible (e.g., plastic) screws. If the aircraft crashes or is subjected to a high-impact load, the plastic screws break, thereby allowing the wings to completely separate from the fuselage. This arrangement often results in less damage to the wings and fuselage as compared to configurations in which the wings are rigidly connected to the fuselage.

One concern with this arrangement, however, is that in many cases it may be undesirable to allow many of the relatively expensive, delicate components of the aircraft to break free from the aircraft during operation. These components can be seriously damaged and/or destroyed after detachment from the aircraft. Another concern with this arrangement is that when such components break completely free from the aircraft, the electrical connections or other system connections between the aircraft and the respective component are completely broken. Repairing these connections can be extremely expensive and time-consuming.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partially schematic, isometric illustration of an unmanned aircraft having one or more components coupled with frangible fasteners or links configured in accordance with embodiments of the present technology.

FIG. **2**A is a partially schematic, side elevation view of a fastener having a flexible member configured in accordance with an embodiment of the present technology.

FIG. **2**B is a partially schematic, side cross-sectional illustration of an embodiment of the frangible fastener taken substantially along line **2**B-**2**B of FIG. **2**A.

FIG. **2**C is a partially schematic, cross-sectional illustration of an embodiment of the frangible fastener taken substantially along line **2**C-**2**C of FIG. **2**B.

FIG. **3** is a partially schematic, partially cross-sectional illustration of a frangible fastener installation in accordance with embodiments of the present technology.

FIG. **4** is a partially schematic, partially cross-sectional illustration of a frangible fastener installation with the frangible fastener broken in accordance with an embodiment of the present technology.

FIG. **5** is a partially schematic, partially cross-sectional illustration of a frangible fastener installation with the frangible fastener broken in two places in accordance with an embodiment of the present technology.

FIG. **6** is a partially schematic, cross-sectional illustration of a process for removing post-break frangible fasteners in accordance with embodiments of the present technology.

FIG. **7**A is a partially schematic, side elevation view of a frangible fastener having a stop element configured in accordance with some embodiments of the present technology.

FIG. **7**B is a partially schematic, cross-sectional illustration of an embodiment of a frangible fastener taken substantially along line **7**B-**7**B of FIG. **7**A.

FIG. **7**C is a partially schematic, isometric view of a frangible fastener having a stop element configured in accordance with some embodiments of the present technology.

FIG. **8** is a partially schematic cross-sectional illustration of a frangible fastener having a flexible member with two stop elements in accordance with an embodiment of the present technology.

FIG. **9** is a partially schematic, isometric cut-away illustration of a wing and winglet connected with frangible fasteners in accordance with embodiments of the present technology, and taken substantially along line **9**-**9** of FIG. **1**.

DETAILED DESCRIPTION

The present technology is directed generally to frangible fasteners with flexible connectors for unmanned aircraft, and associated systems and methods. In particular embodiments, the frangible fastener is installed on an unmanned aircraft having a fuselage, a wing, and a winglet carried by the wing. The frangible fastener can couple the winglet to the wing, and can include an outer body with a first portion in contact with the wing, a second portion in contact with the winglet, and a frangible portion between the first and second portions. The frangible fastener can further include a flexible member positioned at least partially within the outer body and connected to the first portion. The flexible member can extend through and out of the second portion, and can carry a stop element. In operation, when the wing or winglet is subjected to a load above a threshold load, the frangible fastener breaks at the frangible portion, allowing the winglet to move away from the wing, but in a manner constrained by the flexible member. As will be described in further detail below, the flexible member can provide advantages over existing devices that include frangible fasteners with more rigid connections.

Many specific details of certain embodiments of the disclosure are set forth in the following description and in FIGS. **1**-**9** to provide a thorough understanding of these embodiments. Well-known structures, systems, and methods often associated with such systems have not been shown or described in detail to avoid unnecessarily obscuring the description of the various embodiments of the disclosure. In addition, those of ordinary skill in the relevant art will understand that additional embodiments may be practiced without several of the details described below.

FIG. **1** is a partially schematic, isometric illustration of an unmanned aircraft **100** having one or more components coupled with frangible fasteners or links configured in accordance with some embodiments of the present technology. The unmanned aircraft **100** can include a fuselage (or a fuselage portion) **101**, a pair of wings (or wing portions) **170** extending outwardly from the fuselage **101**, and a propeller **104** positioned at the aft end of the fuselage **101** to propel the aircraft **100** during flight. Each wing **170** can include an upwardly extending winglet (or winglet portion) **180** for lateral stability and control. Each wing **170** can also include a capture device **105** (e.g., a hook or wing hook). After completing a mission, the aircraft **100** is "captured" in flight by flying the wing **170** into a capture line **106** or other elongated fixture. The capture device **105** engages the capture line **106**, bringing the aircraft **100** to rest. In the illustrated embodiment, the winglets **180** are partially removable elements releasably coupled to the corresponding wings **170** with one or more frangible fasteners or links **110** (shown schematically). Although each winglet **180** is shown in FIG. **1** attached with two frangible fasteners **110**, it will be appreciated that a different number of fasteners **110** may be used in some embodiments. Furthermore, the frangible fasteners **110** may be used throughout the aircraft **100** to couple any of a variety of suitable different components together.

As described in detail below, the frangible fasteners **110** are fasteners that will readily break when a threshold force (e.g., a force above a predetermined level) is applied to the winglet **180** and/or the wing **170**, e.g., during the capture operation described above. Such a force may cause the winglet **180** to rotate toward and away from the wing **170** (as indicated by arrows R in FIG. **1**), and/or twist, rotate and/or translate in other directions. The frangible fasteners **110** in the illustrated embodiment, however, do not completely break. Rather, the frangible fasteners **110** include two discrete members that can move relative to each other by up to a fixed distance while remaining coupled to each other. Compared with conventional frangible fasteners that completely break when subjected to a force, the frangible fasteners **110** are expected to prevent components of the aircraft (e.g., the winglets **180**) from breaking completely away from the aircraft **100** and contacting the ground or other structures. In addition, by not completely breaking apart, the frangible fasteners **110** are expected to prevent damage and/or destruction of the electrical (or other system) connections between the wing **170** and a respective winglet **180** if the winglet **180** breaks away from the aircraft **100**. Further details regarding the frangible fasteners **110** are described further below with reference to FIGS. **2**A-**9**.

FIG. **2**A is a partially schematic side elevation view of a representative frangible fastener **110**, configured in accordance with embodiments of the present technology. The frangible fastener **110** can include an outer body **120** having a first portion **121**, a second portion **122**, and a frangible portion **150** between the first and second portions **121**, **122**. The outer body **120** can have a hollow internal cavity with an opening **126** from which a flexible member **160** extends. The flexible member **160** can carry a stop element **140**. The frangible fastener **110** can be connected between two components and, when it breaks at the frangible portion **150**, the stop member **140** can prevent the two components from moving apart from each other by more than the length of the flexible member **160**.

The outer body **120** can include a first end **123** (e.g., at the first portion **121**) having a first attachment element **127**, and a second end **124** (e.g., at the second portion **122**) having a second attachment element **128**. The first attachment element **127** can include a head **125** (e.g., a hexagonal bolt head) that contacts one component, and the second attachment element **128** can include external threads **129** that contact another component.

FIG. **2**B is a partially schematic, cross-sectional illustration of an embodiment of the frangible fastener shown in FIG. **2**A. FIG. **2**B illustrates the internal cavity **130** of the outer body **120** from which the flexible member **160** extends. The flexible member **160** can be fixedly attached to the first portion **121** for example, at a crimp region **131**. To fasten the flexible member **160** to the first portion, the first portion **121** is crimped at the crimp region **131**, as indicated by arrows C, forming a crimp joint **132** with the flexible member **160**.

The outer body **120** has an outer diameter D**1** at the first portion **121** and/or the second portion **122**, that is greater than a corresponding diameter D**2** at the frangible portion **150**. Accordingly, when a bending load is applied to the outer body **120**, it will preferentially fracture at the frangible portion **150**. The internal cavity **130** has a diameter D**3** that is greater than an outer diameter D**4** of the flexible member **160**. Accordingly, when the frangible portion **150** breaks, the second portion **122** can slide over the flexible member **160** toward the stop element **140**. The stop element **140** has an outer diameter D**5** that is greater than the inner diameter D**3** of the internal cavity **130**. Accordingly, the stop element **140** prevents the second portion **122** from moving beyond the stop element **140**. The stop element **140** can be fastened to the flexible member **160** at a crimp joint **141** positioned toward a second end **163** of the flexible member **160**. A corresponding first end **162** of the flexible member **160** can be recessed from the first end **123** of the outer body **120**, or, it may protrude slightly from the first end **123** by virtue of the crimping operation performed at the crimp region **131**.

In particular embodiments, the foregoing diameters, and in particular, the concentricity of the foregoing diameters is controlled to provide consistency from one frangible fastener **110** to another. For example, the internal cavity diameter D**3** is deliberately kept concentric with the frangible portion diameter D**2**, as eccentricity between these two diameters may weaken the frangible portion **150**.

The flexible member **160** can have any of a variety of suitable configurations. In a particular configuration, the flexible member **160** is formed from a stranded cable **161**. It is expected that the cable construction of the flexible member **160** facilitates forming the crimp joint **132**, and is expected to allow the flexile member **160** to undergo significant bending (e.g., elastic bending) without breaking. For example, during the crimping operation, material from the outer body **120** can enter the interstices between strands and/or filaments of the cable **161** to further secure the cable **161** to the outer body **120**. In addition, the stranded nature of the cable is expected to better resist fracturing than a solid construction. For example, some individual strands may break during operation, without causing the break to extend to other strands and/or causing the flexible member **160** to fail.

FIG. **2**C is a cross-sectional illustration of a representative cable **161** formed from multiple strands **164**, in particular, seven strands **164**. Each strand **164** can be formed from multiple (e.g., seven) filaments **165**. In other embodiments, the cable **161** can include other suitable numbers of strands **164** and/or other suitable numbers of filaments **165**. In still further embodiments, the flexible member **160** can have other constructions, including a solid wire construction, although a stranded construction may provide better fatigue resistance and/or a better connection with the outer body **120**, as described above.

FIG. **3** schematically illustrates a representative frangible fastener **110** connecting a first component **171** and a second component **181** in accordance with an embodiment of the present technology. The first component **171** can include the wing or wing portion **170** described above, and the second component **181** can include the winglet or winglet portion **180** described above. The wing **170** has a lower surface **172**, an upper surface **173**, and an interior region **174** in between. The winglet **180** has a lower surface **184** carrying an internally threaded nut plate **183**, and an interior region **182**. The frangible fastener **110** can be installed with the first portion **121** operably engaged with the wing lower surface **172**, e.g., with the head **125** bearing against the wing lower surface **172**, or with an intermediate member (such as a washer **111**) bearing against the wing lower surface **172** to distribute the load from the fastener **110** to the wing **170**. The first portion **121** of the frangible fastener **110** extends into the wing interior **174**, and the second portion **122** is threadably engaged with the nut plate **183** of the winglet **180**. In some embodiments, the external threads **129** of the second portion **122** are not further bonded to the nut plate **183**, e.g., with Loctite® or another chemical agent. This arrangement can facilitate removing the frangible fastener **110**, as described later with reference to FIG. **6**. Because the installed frangible fastener **110** is under tension, the need for a chemical locking agent can be reduced or eliminated. The flexible member **160** and stop element **140** project into the winglet interior region **182**. The stop element **140** is not directly or fixedly connected to the winglet **180** so that when the frangible fastener **110** breaks, the winglet **180** and the stop element **140** can move relative to each other. Upon installation, the head **125** is torqued, e.g., to a specified seating torque which is a specific percentage below the torsional strength of the frangible region, to place the frangible fastener **110** in tension, without overly stressing the frangible portion **150**.

If the joint between the wing **170** and the winglet **180** is subject to a load (e.g., a bending load) greater than a threshold load, the frangible fastener **110** will break at the frangible portion **150**, as shown in FIG. **4**. Once the frangible fastener **110** breaks, the winglet **180** will move relative to the wing **170**, within the constraints provided by the flexible member **160** and the stop element **140**. As the winglet **180** moves relative to the wing **170**, the flexible member **160** may put a bending load on the projecting second portion **122**, which remains threadably attached to the nut plate **183**. This in turn may cause the second portion to break, e.g., near the winglet lower surface **184**, as shown in FIG. **5**. Accordingly, the second portion **122** now includes an attached second portion **133**, and a loose second portion **134**. The loose second portion **134** can move along the flexible member **160**, but is still constrained by the first portion **121** and the attached second portion **133**.

Once the unmanned aircraft **100** (FIG. **1**) has been brought to rest after capture, the frangible fastener **110** is removed. The first component (e.g., the wing **170**) and the second component (e.g., the winglet **180**) are inspected, and the second component is reattached to the first component with a new frangible fastener **110**.

FIG. **6** illustrates a representable technique for removing the broken frangible fastener **110**. As described above, the external threads **129** are not further secured to the nut plate **183** with a chemical agent but are simply threaded. Accordingly, the frangible fastener **110** can be removed by unthreading it from the winglet **180**. As a result of the flexibility of the flexible member **160** connecting the fastener head **125** to the external threads **129**, and the sliding fit between the flexible member **160** and the second portion **122** the operator may employ additional steps to complete the removal process. In particular, the operator can apply a tension to the flexible member **160** by pulling the winglet **180** upwardly away from the wing **170** (as indicated by arrows T), causing the stop element **140** to bear tightly against the attached second portion **133**. While the flexible member **160** remains under tension, with the stop element **140** positioned tightly against the attached second portion **133**, the operator can rotate the head **125** counterclockwise as indicated by arrow R**1**, causing the flexible member **160** to rotate counterclockwise, as indicated by arrow R**2**, which in turn causes the stop element **140** and the attached second portion **133** to rotate counterclockwise as indicated by arrow R**3** so as to unthread the external threads **129** from the nut plate **183**. In this manner, the frangible fastener **110** can be removed and replaced. This process can be used whether the second portion **122** is in two pieces (as shown in FIG. **6**) or one piece (as shown in FIG. **4**). To facilitate this operation, the elements making up the flexible member **160** (e.g., the strands and filaments described above) can be deliberately twisted in a direction that causes them to tighten together when the flexible member is rotated counter-clockwise. If, as may occur in some instances, the foregoing operation is not easily accomplished, the operator can clip the flexible member **160** and can remove the remaining elements of the fastener **110** by accessing the interior region **182** of the winglet **180**.

As discussed above, the process of removing a broken frangible fastener **110** can be aided by tightly, snugly, or intimately engaging the stop element **140** with the attached second portion **133**. FIGS. **7A-7C** illustrate representative techniques for facilitating such an engagement. Beginning with FIG. **7A**, a representative stop element **740** in accordance with a particular embodiment can include an inwardly tapered surface **742** facing toward the opening **126** at the second end **124** of the outer body **120**. When the stop element **740** is drawn tightly against the outer body **120**, the inwardly tapered surface **742** can enter the opening **126** and provide additional friction that facilitates rotating a second portion **122** in the manner described above with reference to FIG. **6**.

To provide additional friction, the frangible fastener **110** can include one or more of further friction-enhancing elements. For example, the interior surfaces of the opening **126** at the second end **124** of the outer body **120** can be tapered, as shown in FIG. **7A**, to provide additional contact with the correspondingly tapered surface **742** of the stop element **740**. In addition to or in lieu of the foregoing feature, the stop element **740** can include ribs or other projections **743** that extend away from the tapered surface **742** and that can engage with (e.g., cut into) the surfaces of the opening **126** in the outer body **120**. For example, the stop element **740** can be formed from a harder material (e.g., stainless steel) than the material forming the outer body **120** (e.g., aluminum). FIG. **7B** is a cross-sectional illustration of the fastener **110**, illustrating the stop element **740** with four ribs **743**, in accordance with some embodiments of the present technology. In other embodiments, the stop element **740** can include other numbers of ribs **743** (e.g. 2, 3, 5) and/or other friction-enhancing features.

FIG. **7C** illustrates still another representative arrangement in which the stop element **740** has been shaped (e.g., crimped or otherwise formed) to include an outwardly extending key **744**. The outer body **120** can include a corresponding keyway or key slot **745** sized to receive the key **744**. In operation, the operator draws the stop element **740** against the outer body **120**, rotates the flexible member **160** until the key **744** drops into the keyway **745**, and then continues to rotate the flexible member **160** to unscrew the second portion **722** from the component to which it is attached. In a particular aspect of this embodiment, the end of the outer body **120** in which the keyway **745** is located can be unthreaded so as to reduce or eliminate the likelihood for cross-threading the fastener **110** during installation.

In a further representative embodiment, the flexible member **160** can include multiple stop elements **140**, rather than one stop element and a crimp joint. For example, as shown in FIG. **8**, the flexible member **160** can include a first stop element **140***a* toward the first end **162**, and a second element **140***b* toward the second end **163**. The presence of the second stop element **140***b* can eliminate the need for the crimp joint **141** described above. Instead, the internal cavity **130** within the outer body **120** can have a clearance fit throughout its length, relative to the flexible member **160**. A potential advantage of this construction is that it eliminates the need to crimp the outer body **120**. Conversely, an advantage of the arrangement described above with reference to FIGS. **2**A and **2**B is that the crimp joint **141** reduces or eliminates the extent to which the flexible member **160** (or the first stop element **140***a*) protrudes outwardly from the head **125**.

In some embodiments, the frangible fastener **110** shown in FIG. **8** may be installed in an upside-down orientation, with the head **125** below the second stop element **140***b*. To prevent the flexible member **160** and the second stop element **140***b* from sliding downwardly through the cavity **130**, and causing the first stop element **140***a* and a portion of the flexible member **160** to project further beyond the head **125**, the frangible fastener **110** can include a resistance element **166**. The resistance element **166** can include a rubber band, RTV silicone bead, or another flexible element positioned on or around the flexible member **160** and/or at the end of the outer body **120** to prevent the flexible member **160** from sliding downwardly under the force of gravity. When larger forces are placed on the frangible fastener **110** (e.g., the frangible portion **150** breaks), the motion of the flexible member **160** can overcome the resistance provided by the resistance element **166**, to allow relative motion between the wing and winglet.

In still further embodiments, the outer body **120** can include a recess **135** into which the first stop element **140***a* fits. This arrangement can reduce or eliminate the extent to which the first stop element **140***a* extends outwardly from the head **125**, so as to reduce drag and/or the likelihood for the first stop element **140***a* to snag foreign objects. In this embodiment, the frangible fastener **110** can also include a resistance element **166** to prevent the flexible member **160** from moving under the force of gravity, as discussed above.

FIG. **9** is a partially schematic, partially cut-away illustration of a representative wing **170** and winglet **180** fastened with two frangible fasteners **110** in accordance with some embodiments of the present technology. As shown in FIG. **9**, the nut plate **183** can extend into the interior **182** of the winglet **180** to account for the curvature of the wing upper surface **173**. As is also shown in FIG. **9**, the wing **170** and the winglet **180** can include access apertures that allow access to the respective interior regions **174**, **182** to service these components, and if necessary, remove portions of the frangible fasteners **110** after use.

Embodiments of the present technology can provide one or more of several advantages when compared with existing frangible fasteners. For example, some existing frangible fasteners include a threaded connection between the first end of a generally rigid member (instead of a flexible member) and the outer body. If, during installation, the outer body is overtightened relative to the rigid threaded member inside, the torque can weaken the frangible portion and cause it to fail prematurely. By crimping the flexible member to the outer body at a position spaced apart from the frangible region, embodiments of the presently disclosed frangible fastener are expected to be less likely to produce such stresses at the frangible region.

Another expected advantage of embodiments that include a flexible member (when compared with a relatively non-flexible member) is that a flexible member can bend multiple times (after the frangible region breaks), without itself breaking. For example, when the frangible fastener is used to attach a winglet to wing, after the frangible region breaks, the winglet can move rapidly and repeatedly back and forth relative to the wing before coming to rest. This movement can cause a rigid attachment member to break, and thereby cause the winglet to fall completely away from the wing. By integrating a flexible member into the frangible fastener, this outcome can be avoided.

From the foregoing, it will be appreciated that specific embodiments of the present technology have been described herein for purposes of illustration, but that various modifications may be made without deviating from the technology. For example, representative frangible fasteners can be used to connect components other than a wing and a winglet. The aircraft can have configurations other than those specifically shown and described herein, for example configurations in which portions of components (e.g., fuselages, wings, and/or winglets) are blended with each other (e.g., a blended wing/body configuration). The flexible members described above can have constructions other than the stranded constructions described above, for example, a solid construction that is configured to limit breakage caused by repeated bending. Representative frangible fasteners have been shown herein with the first portion in contact with the aircraft wing, and the second portion in contact with the winglet. In other embodiments, the orientation of the frangible fastener can be reversed. The frangible portion can have a rounded or radiused cross-sectional shape, as shown in several of the Figures, or it can have a "V-shaped" or other suitably shaped cross-section.

In a particular embodiment, the outer body can be manufactured from aluminum and the flexible member from stainless steel. In other embodiments, these components can be made from other suitable materials. The surface finishes of these components (and in particular at the frangible region) can be controlled to produce consistent results.

Certain aspects of the technology described in the context of particular embodiments may be combined or eliminated in other embodiments. For example, the crimp connection between the flexible member and the outer body may be eliminated in favor of a second stop element. Further, while advantages associated with certain embodiments of the technology have been described in the context of those embodiments, other embodiments may also exhibit such advantages, and not all embodiments need necessarily exhibit such advantages to fall within the scope of the present technology. Accordingly, the present disclosure and associated technology can encompass other embodiments not expressly shown or described herein.

We claim:

1. An unmanned aircraft, comprising:

a wing;

a winglet carried by the wing; and

a frangible fastener coupling the winglet to the wing, the frangible fastener including:

an outer body having a first portion terminating at a first end of the outer body and in contact with the wing, a second portion terminating at a second end of the outer body opposite the first end of the outer body and in contact with the winglet, and a frangible portion located between the first and second portions, the first portion including a head integrally formed at the first end of the outer body, the second portion including external threads;

a flexible member positioned at least partially within the outer body, the flexible member having a first end oriented toward the first end of the outer body, and a second end oriented toward the second end of the outer body, the first end of the flexible member fixedly connected to the first portion, the flexible member extending through the second portion such that the second end of the flexible member is located outside of the outer body; and

a stop element fixedly connected to the second end of the flexible member and spaced apart from the second end of the outer body, the stop element being configured to contact the second end of the outer body when the second portion separates from the first portion in response to the frangible portion breaking.

2. The aircraft of claim **1**, wherein the first portion is crimped to the flexible member.

3. The aircraft of claim **1**, wherein the flexible member includes a cable.

4. The aircraft of claim **1**, wherein the flexible member includes a solid wire.

5. The aircraft of claim **1**, wherein the stop element is crimped to the flexible member.

6. The aircraft of claim **1**, wherein the outer body has a hollow internal cavity with an opening located at the second end of the outer body, and wherein the flexible member includes a cable positioned within the hollow cavity, the cable extending through the opening and away from the second end of the outer body, the stop element having an outer diameter that is larger than an inner diameter of the opening.

7. The aircraft of claim **6**, wherein the cable has an outer diameter that is less than the outer diameter of the stop element.

8. The aircraft of claim **1**, wherein an outer diameter of the first portion is greater than an outer diameter of the frangible portion.

9. The aircraft of claim **1**, wherein the winglet includes an internally threaded aperture, and wherein the external threads of the second portion of the frangible fastener are threadably received in the internally threaded aperture.

10. The aircraft of claim **1**, wherein the second portion is configured to slide along the flexible member between the first portion and the stop element when the second portion is separated from the first portion in response to the frangible portion breaking.

11. The aircraft of claim **1**, wherein the winglet includes an interior region, the second end of the flexible member being located within the interior region.

12. The aircraft of claim **1**, wherein the winglet includes an internally threaded aperture, the external threads of the second portion of the frangible fastener being threadably received in the internally threaded aperture.

13. The aircraft of claim **12**, wherein the winglet includes a nut plate located within an interior region of the winglet, the nut plate including the internally threaded aperture.

14. A frangible fastener for coupling a first component to a second component, the frangible fastener comprising:

an outer body having:

a first portion terminating at a first end of the outer body, the first portion including a head integrally formed at the first end of the outer body and positionable to contact the first component;

a second portion terminating at a second end of the outer body opposite the first end of the outer body, the second portion including external threads positionable to contact the second component; and

a frangible portion located between the first and second portions;

a flexible member positioned at least partially within the outer body, the flexible member having a first end oriented toward the first end of the outer body, and a second end oriented toward the second end of the outer body, the first end of the flexible member fixedly connected to the first portion, the flexible member extending through the second portion such that the second end of the flexible member is located outside of the outer body; and

a stop element fixedly connected to the second end of the flexible member and spaced apart from the second end of the outer body, the stop element being configured to contact the second end of the outer body when the second portion separates from the first portion in response to the frangible portion breaking.

15. The frangible fastener of claim **14**, wherein the first portion is crimped to the flexible member.

16. The frangible fastener of claim **14**, wherein the flexible member includes a cable.

17. The frangible fastener of claim **16**, wherein the stop element is crimped to the cable.

18. The frangible fastener of claim **14**, wherein the outer body includes an opening through which the flexible member extends, and wherein the stop element includes a tapered portion configured to slideably enter the opening when the second portion separates from the first portion in response to the frangible portion breaking.

19. The frangible fastener of claim **14**, wherein the outer body includes an opening through which the flexible member extends, and wherein the stop element includes a tapered edge configured to cut into the outer body around the opening when the second portion separates from the first portion in response to the frangible portion breaking.

20. The frangible fastener of claim **14**, wherein the outer body includes an opening through which the flexible member extends, the opening having a key slot, and wherein the stop element includes a key positioned to slideably enter the key slot when the second portion separates from the first portion in response to the frangible portion breaking.

21. The frangible fastener of claim **14**, wherein the outer body has a hollow internal cavity with an opening located at the second end of the outer body, and wherein the flexible member includes a cable positioned within the hollow cavity, the cable extending through the opening and away from the second end of the outer body, the stop element being having an outer diameter that is larger than an inner diameter of the opening.

22. The frangible fastener of claim **14**, wherein an outer diameter of the first portion is greater than an outer diameter of the frangible portion.

23. A method for manufacturing an unmanned aircraft, the method comprising:

attaching a first component of the unmanned aircraft to a second component of the unmanned aircraft with a frangible fastener, the frangible fastener including:

an outer body having a first portion terminating at a first end of the outer body, a second portion terminating at a second end of the outer body opposite the first end of the outer body, and a frangible portion located between the first and second portions, the first portion including a head integrally formed at the first end of the outer body, the second portion including external threads;

a flexible member positioned at least partially within the outer body, the flexible member having a first end oriented toward the first end of the outer body, and a second end oriented toward the second end of the outer body, the first end of the flexible member fixedly connected to the first portion, the second end of the flexible member extending through the second portion such that the second end of the flexible member is located outside of the outer body; and

a stop element fixedly connected to the second end of the flexible member and spaced apart from the second end of the outer body, the stop element being configured to contact the second end of the outer body when the second portion separates from the first portion in response to the frangible portion breaking; and

wherein attaching the first aircraft component to the second aircraft component includes:

threadably engaging the second portion of the outer body to the second aircraft component; and

operably engaging the first portion of the outer body with the first aircraft component.

24. The method of claim **23**, wherein threadably engaging the second portion of the outer body to the second aircraft component includes positioning the second end of the flexible member within an interior region of the second aircraft component.

25. The method of claim **23**, wherein operably engaging the first portion of the outer body with the first aircraft component includes contacting the head of the first portion of the outer body with a surface of the first aircraft component.

26. The method of claim **23**, wherein operably engaging the first portion of the outer body with the first aircraft component includes contacting the head of the first portion of the outer body with a washer, and contacting the washer with a surface of the first aircraft component.

27. The method of claim **23**, wherein the first aircraft component includes an aircraft wing.

28. The method of claim **23**, wherein the second aircraft component includes a winglet.

29. A method for operating an unmanned aircraft, the method comprising:

launching the unmanned aircraft, the unmanned aircraft having a first component and a second component connected to the first component with a frangible fastener, the frangible fastener including:

an outer body having a first portion terminating at a first end of the outer body, a second portion terminating at a second end of the outer body opposite the first end of the outer body, and a frangible portion located between the first and second portions, the first portion including a head integrally formed at the first end of the outer body, the second portion including external threads, the first portion being operably engaged to the first component, the second portion being threadably engaged to the second component;

a flexible member positioned at least partially within the outer body, the flexible member having a first end oriented toward the first end of the outer body, and a second end oriented toward the second end of the outer body, the first end of the flexible member fixedly connected to the first portion, the second end of the flexible member extending through the second portion such that the second end of the flexible member is located outside of the outer body; and

a stop element fixedly connected to the second end of the flexible member and spaced apart from the second end of the outer body, the stop element being configured to contact the second end of the outer body when the second portion separates from the first portion in response to the frangible portion breaking; and

placing a load on the unmanned aircraft, the load breaking the frangible portion, the first component remaining connected to the second component by the flexible member following the breaking of the frangible portion, the flexible member allowing movement of the first component relative to the second component following the breaking of the frangible portion, the movement being limited by the stop element.

30. The method of claim **29**, wherein the stop element does not limit the movement of the first component relative to the second component prior to the breaking of the frangible portion.

31. The method of claim **29**, wherein placing the load on the unmanned aircraft includes contacting the unmanned aircraft with a capture line, and releasably securing the unmanned aircraft to the capture line.

32. The method of claim **29**, wherein the frangible fastener is a first frangible fastener, and wherein the method further comprises:

detaching the second component from the first component by removing the first frangible fastener following the breaking of the frangible portion of the first frangible fastener; and

re-attaching the second component to the first component with a second frangible fastener.

33. The method of claim **29**, wherein the method further comprises removing the frangible fastener by:

placing tension on the flexible member to draw the stop element into contact with the second end of the outer body; and

rotating the first portion, while the flexible member is under tension, to unthread the second portion from the second component.

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