US 20250256832A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2025/0256832 A1**

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

Walker et al.

(54) **FOLDING WINGTIP**

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(21) Appl. No.: **18/439,337**

(22) Filed: **Feb. 12, 2024**

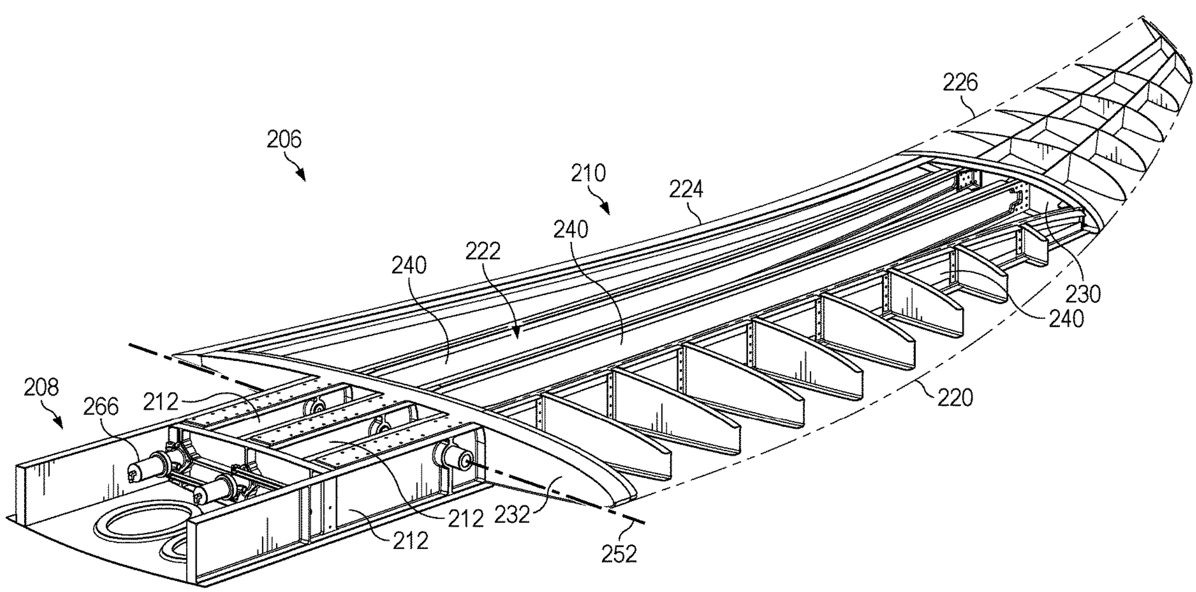
Publication Classification

(51) **Int. Cl.**
B64C 3/56 (2006.01)

(52) **U.S. Cl.**
CPC ***B64C 3/56*** (2013.01)

(57) **ABSTRACT**

A folding wingtip and method for folding said wingtip. The folding wingtip includes a multi-spar main box and a hinge fitting attached to the inboard end of each spar. A hinge line passes through each hinge fitting perpendicular to each spar. The wingtip is connected to a main section of an aircraft wing and is foldable with respect to the main section about the hinge line.



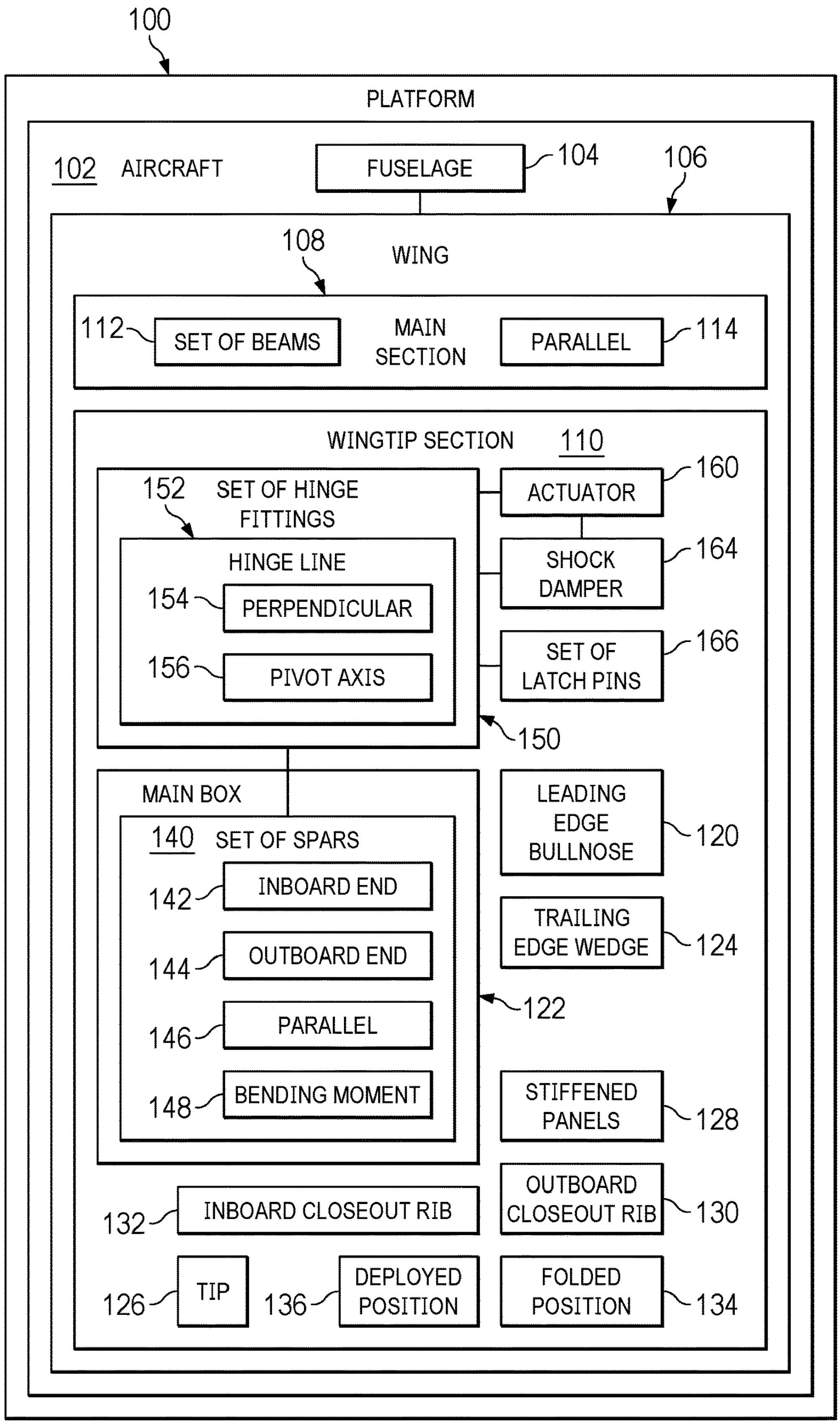

100
PLATFORM
102 AIRCRAFT
FUSELAGE
104
106
108
WING
112
SET OF BEAMS
MAIN SECTION
PARALLEL
114
WINGTIP SECTION
110
152
SET OF HINGE FITTINGS
HINGE LINE
154
PERPENDICULAR
156
PIVOT AXIS
ACTUATOR
160
SHOCK DAMPER
164
SET OF LATCH PINS
166
150
MAIN BOX
140
SET OF SPARS
142
INBOARD END
144
OUTBOARD END
146
PARALLEL
148
BENDING MOMENT
LEADING EDGE BULLNOSE
120
TRAILING EDGE WEDGE
124
122
STIFFENED PANELS
128
132
INBOARD CLOSEOUT RIB
OUTBOARD CLOSEOUT RIB
130
126
TIP
136
DEPLOYED POSITION
FOLDED POSITION
134

FIG. 1

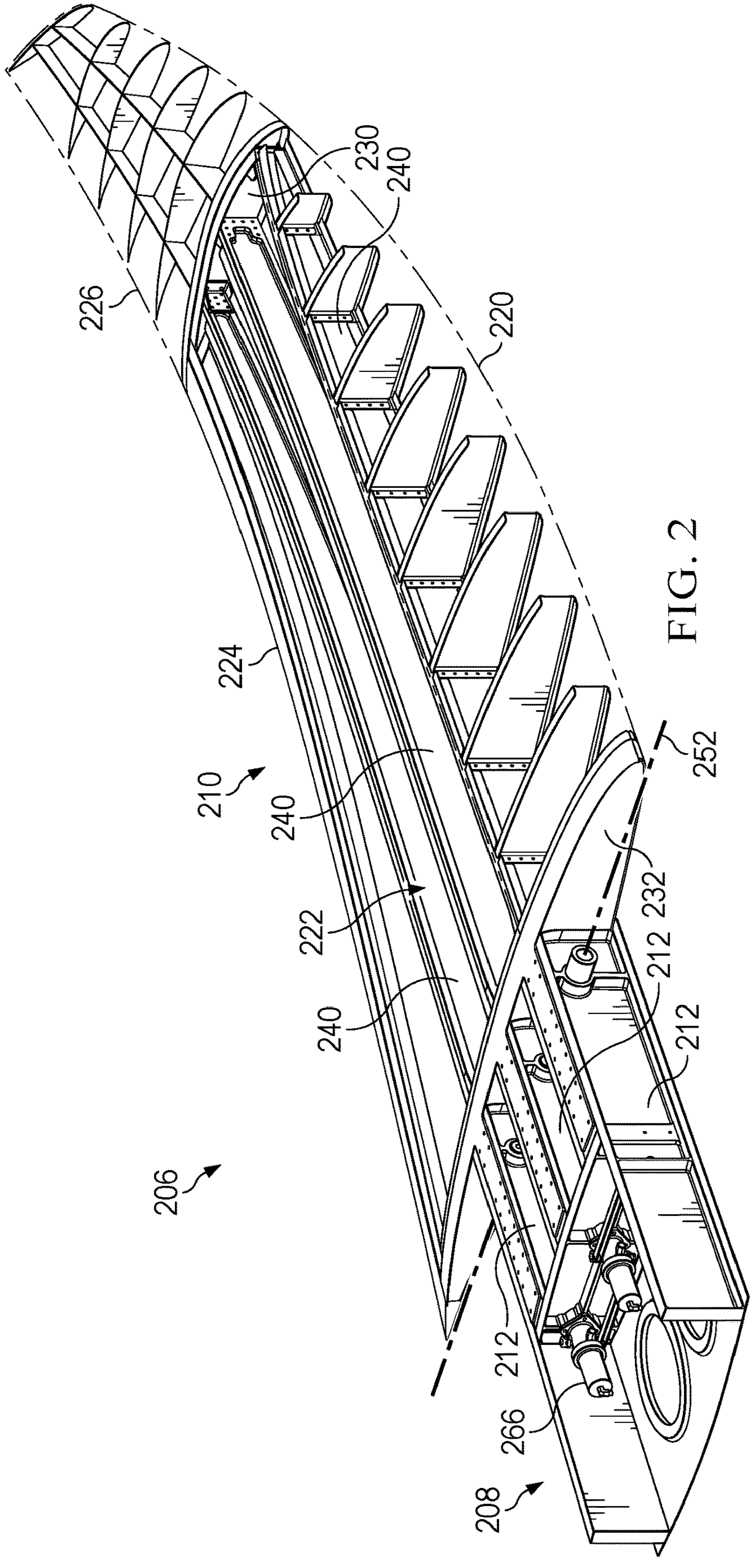

226
230
240
220
224
210
240
222
240
252
232
212
212
212
206
212
266
208

FIG. 2

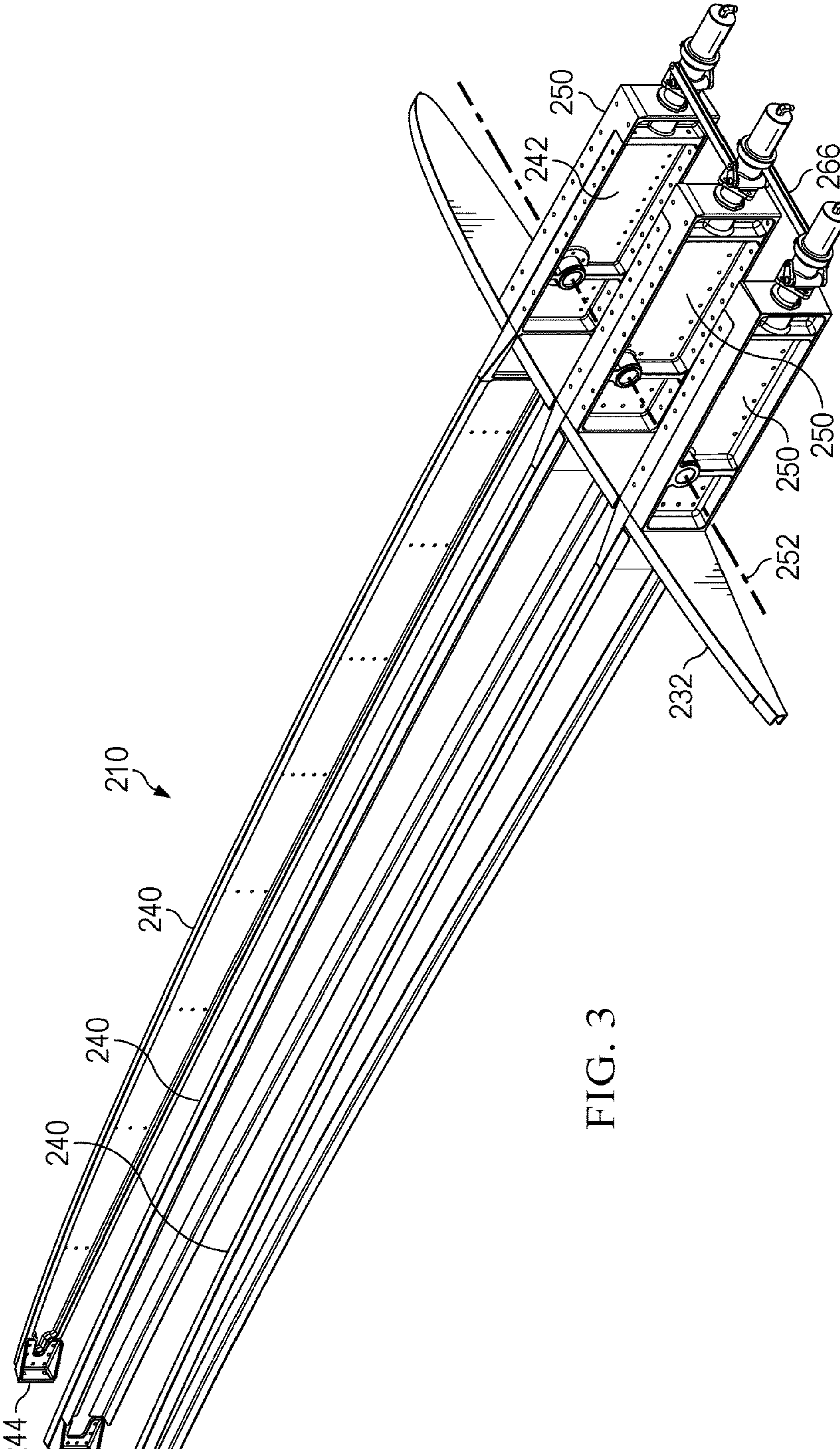


FIG. 3

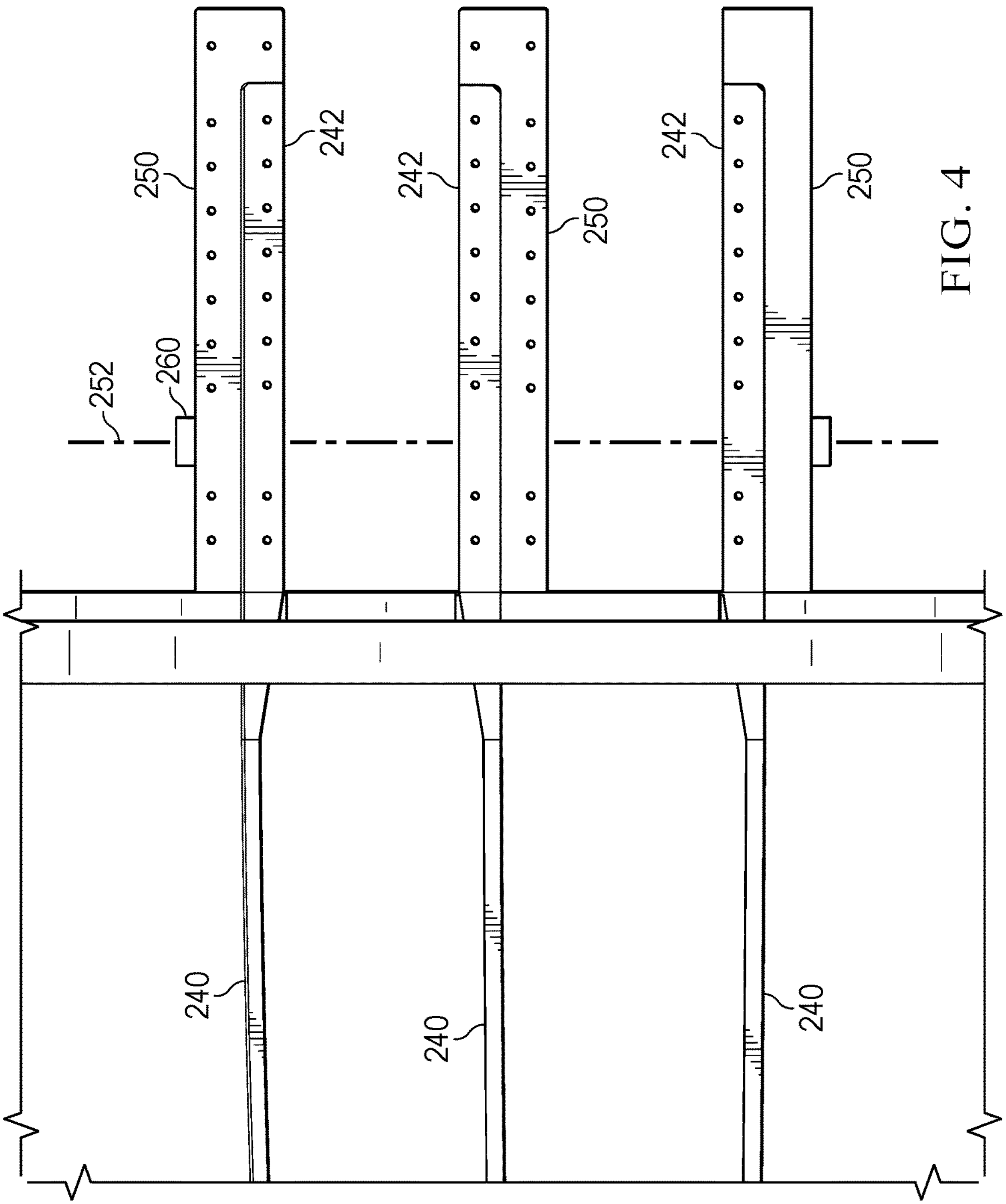


FIG. 4

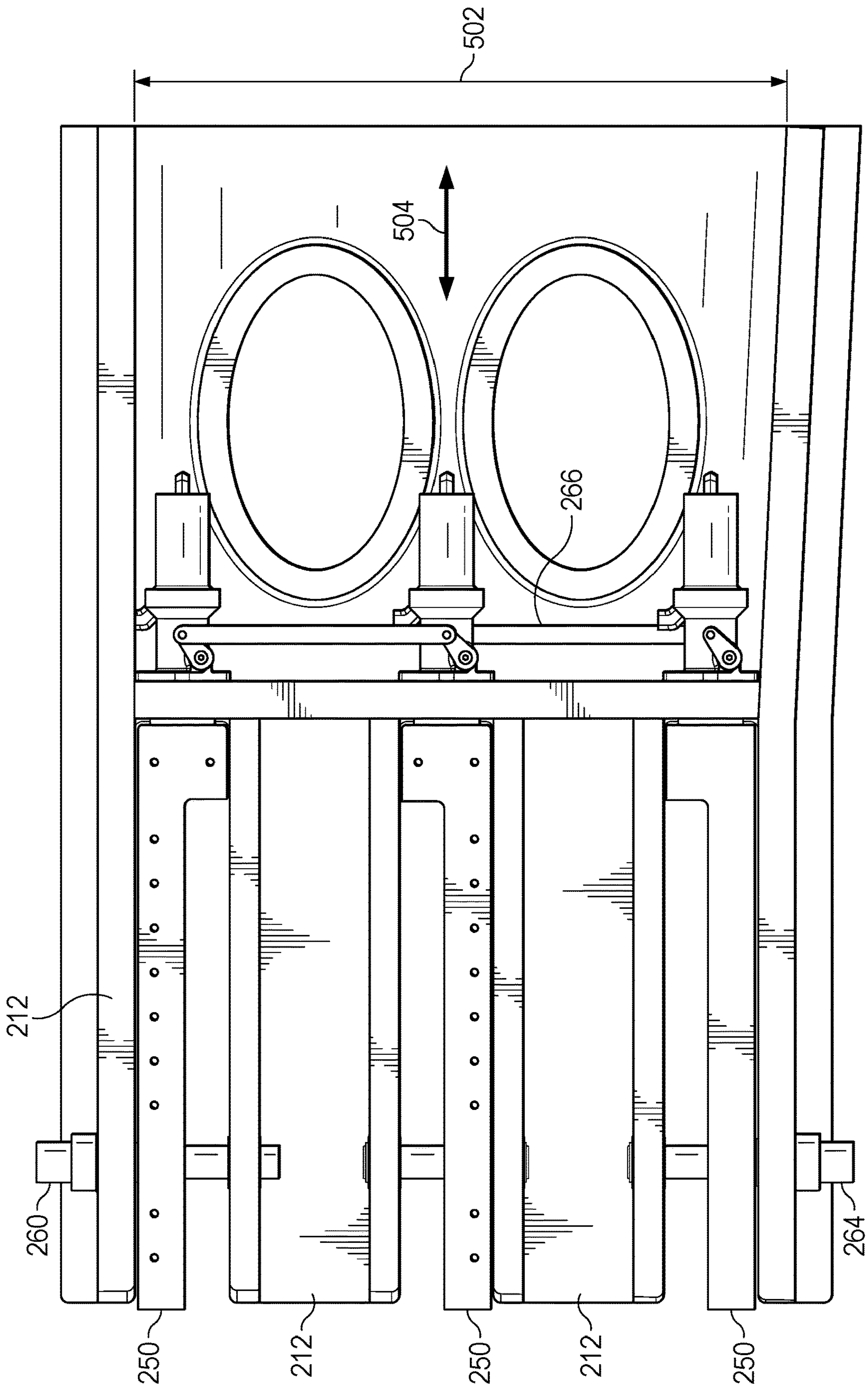


FIG. 5

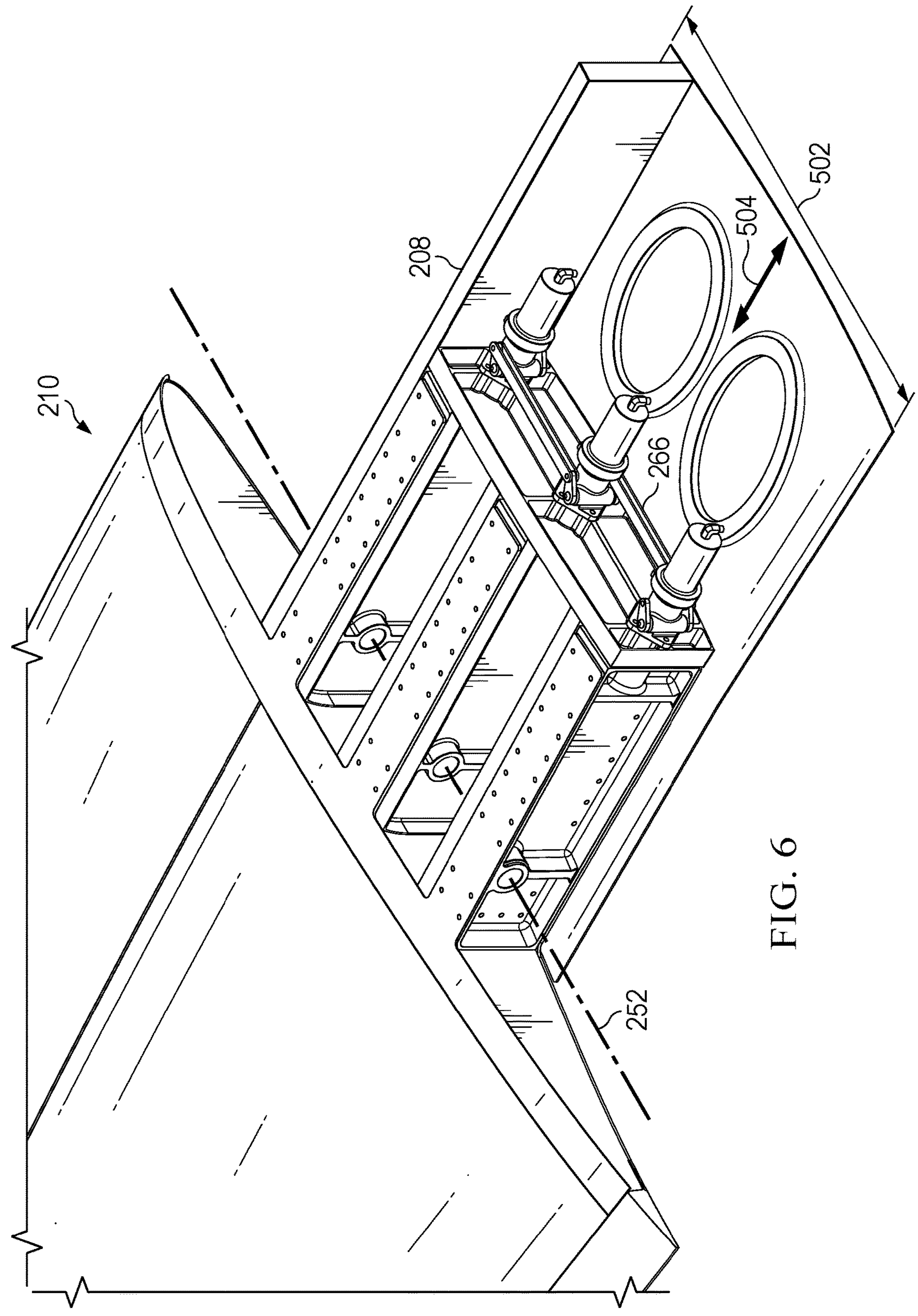


FIG. 6

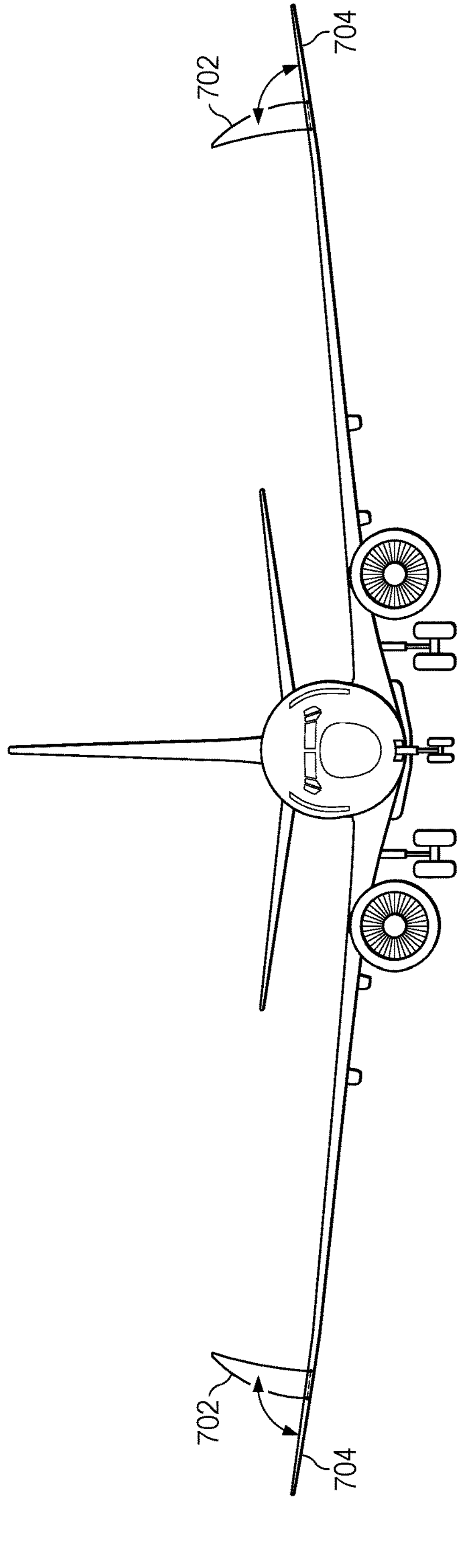


FIG. 7

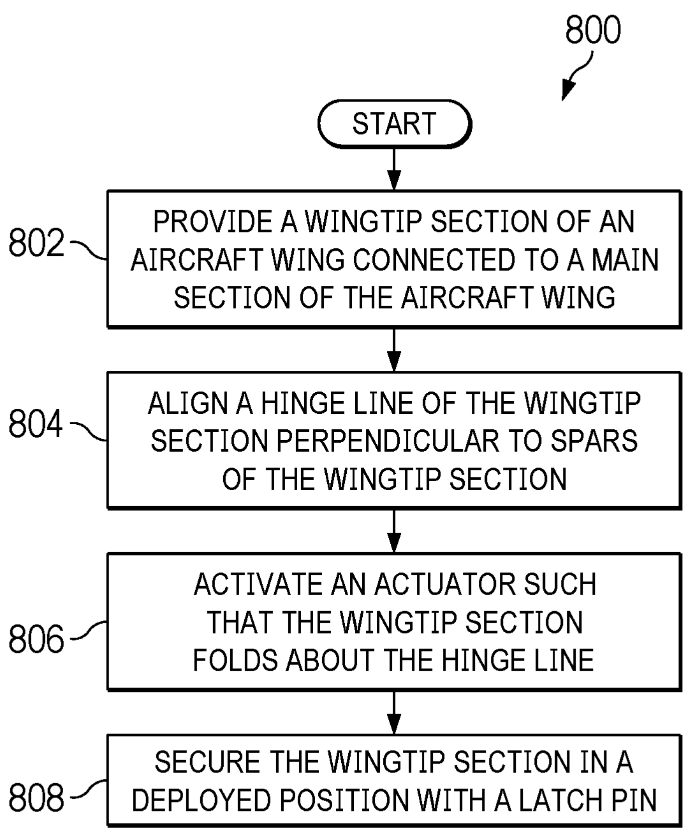

800
START
802
PROVIDE A WINGTIP SECTION OF AN AIRCRAFT WING CONNECTED TO A MAIN SECTION OF THE AIRCRAFT WING
804
ALIGN A HINGE LINE OF THE WINGTIP SECTION PERPENDICULAR TO SPARS OF THE WINGTIP SECTION
806
ACTIVATE AN ACTUATOR SUCH THAT THE WINGTIP SECTION FOLDS ABOUT THE HINGE LINE
808
SECURE THE WINGTIP SECTION IN A DEPLOYED POSITION WITH A LATCH PIN

FIG. 8

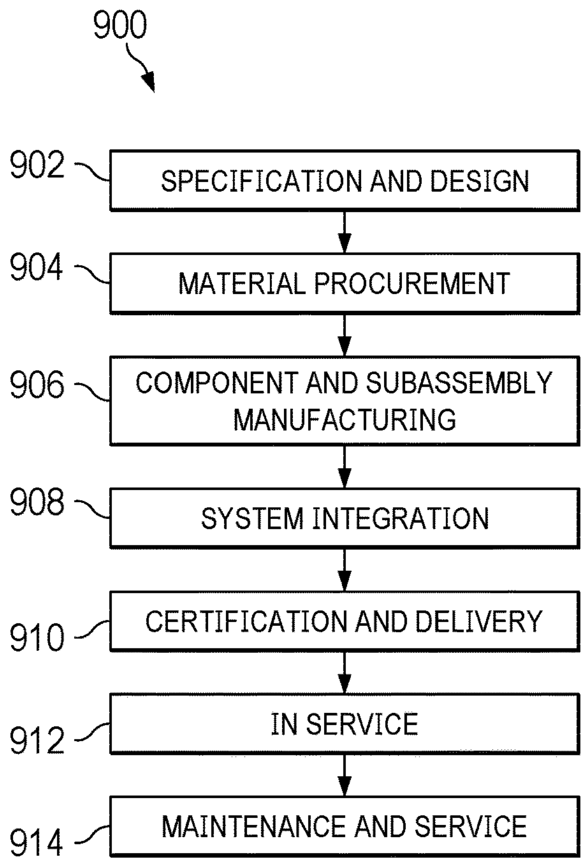

900
902
SPECIFICATION AND DESIGN
904
MATERIAL PROCUREMENT
906
COMPONENT AND SUBASSEMBLY MANUFACTURING
908
SYSTEM INTEGRATION
910
CERTIFICATION AND DELIVERY
912
IN SERVICE
914
MAINTENANCE AND SERVICE

FIG. 9

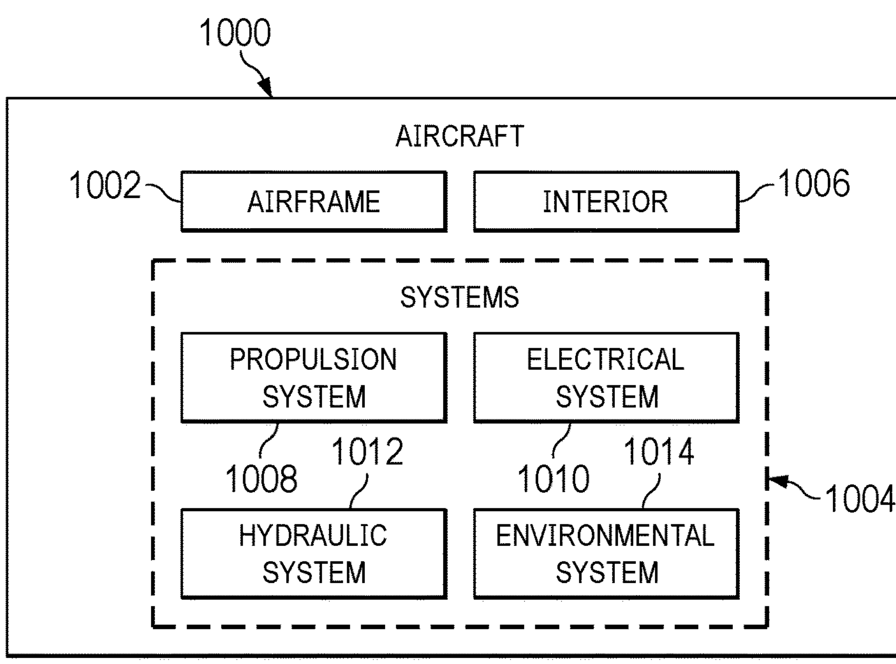

1000
AIRCRAFT
1002
AIRFRAME
INTERIOR
1006
SYSTEMS
PROPULSION SYSTEM
ELECTRICAL SYSTEM
1008
1012
1010
1014
1004
HYDRAULIC SYSTEM
ENVIRONMENTAL SYSTEM

FIG. 10

FOLDING WINGTIP

BACKGROUND INFORMATION

1. Field

[0001] The present disclosure relates generally to folding wingtips of aircraft. More specifically, the present disclosure relates to a multi-spar folding wingtip where the spars are perpendicular to a hinge line of the folding wingtip and bending loads of the folding wingtip are carried in the spars allowing for greater span length.

2. Background

[0002] Aircraft with folding wingtips address unique operational and spacing issues faced at airports and maintenance facilities. For example, in order to increase airport revenues, it may be desired to fit more aircraft gates at terminals into a preexisting airport footprint. In essence, a folding wingtip temporarily narrows the wing span of the aircraft, reducing the amount of space the aircraft occupies, thus allowing more aircraft to be fit side by side at airport terminals that have only a predetermined amount of gate space. Additionally, a folding wingtip allows for increasing the wing span of an aircraft during operation which increases aerodynamic efficiency and reduces fuel burn resulting in operating cost savings.

[0003] Current folding wingtip designs incorporate interlocking torque boxes and reinforced skin panels requiring multiple points of load transfer. The designs significantly increase the weight of the wing and thus are costly to manufacture and operate. Because of strength requirements, the design does not scale down to fit in a smaller structure.

[0004] Therefore, it would be desirable to have a method and apparatus that takes into account at least some of the issues discussed above, as well as other possible issues.

SUMMARY

[0005] An illustrative embodiment of the present disclosure provides a folding wingtip. The folding wingtip includes a spar, a hinge fitting, and a hinge line. The hinge fitting is connected to an inboard end of the spar. The hinge line passes through the hinge fitting perpendicular to the spar. The hinge line is a pivot axis for the folding wingtip.

[0006] Another illustrative embodiment of the present disclosure provides an aircraft wing with a folding wingtip. The aircraft wing includes a main section and a wingtip section. The main section of the aircraft wing is connected to a fuselage of an aircraft. The wingtip section of the aircraft wing is connected to the main section. The wingtip section includes at least three spars arranged in parallel with each other, a respective hinge fitting connected to a respective inboard end of each spar, and a hinge line. Each respective hinge fitting is pivotally connected to the main section. The hinge line is perpendicular to each spar. The hinge line is a pivot axis for folding the spars and respective hinge fittings relative to the main section of the aircraft wing.

[0007] A further illustrative embodiment of the present disclosure provides a method for folding a wingtip. A wingtip section of an aircraft wing is provided connected to a main section of the aircraft wing. The wingtip section comprises at least three spars arranged parallel with each other and a respective hinge fitting connected to a respective inboard end of each spar. A hinge line of the wingtip section is aligned perpendicular to the spars of the wingtip section. The hinge line passes through each respective hinge fitting. An actuator is activated such that the wingtip section folds about the hinge line. The hinge line provides a pivot axis for the wingtip section relative to the main section.

[0008] The features and functions can be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The novel features believed characteristic of the illustrative embodiments are set forth in the appended claims. The illustrative embodiments, however, as well as a preferred mode of use, further objectives and features thereof, will best be understood by reference to the following detailed description of an illustrative embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

[0010] FIG. **1** is an illustration of a block diagram of a platform in accordance with an illustrative embodiment;

[0011] FIG. **2** is an illustration of a folding wingtip in accordance with an illustrative embodiment;

[0012] FIG. **3** is an illustration of a set of spars of a folding wingtip in accordance with an illustrative embodiment;

[0013] FIG. **4** is an illustration of a set of hinge fittings connected to a set of spars in accordance with an illustrative embodiment;

[0014] FIG. **5** is an illustration a main section of a wing of an aircraft connected to a set of spars and hinge fittings in accordance with an illustrative embodiment;

[0015] FIG. **6** is an illustration a set of latch pins in accordance with an illustrative embodiment;

[0016] FIG. **7** is an illustration of a folding wingtip in a deployed position and a folded position in accordance with an illustrative embodiment;

[0017] FIG. **8** is an illustration of a flowchart of a process for folding a wingtip in accordance with an illustrative embodiment;

[0018] FIG. **9** is an illustration of a block diagram of an aircraft manufacturing and service method in accordance with an illustrative embodiment; and

[0019] FIG. **10** is an illustration of a block diagram of an aircraft in which an illustrative embodiment may be implemented.

DETAILED DESCRIPTION

[0020] The illustrative embodiments recognize and take into account one or more different considerations. For example, the illustrative embodiments recognize and take into account that an aircraft wing that is foldable provides advantages such as space saving and operational efficient upgrades.

[0021] The illustrative embodiments also recognize and take into account that current folding wingtip designs prioritize reducing aerodynamic drag on the folded wingtip during locomotion on the ground.

[0022] The illustrative embodiments also recognize and take into account that current folding wingtip designs may not be possible on today's smaller commercial aircraft due to space constraints within the wing and/or damage tolerance requirements.

[0023] The illustrative embodiments also recognize and take into account that current folding wingtip designs incorporate interlocking torque boxes and reinforced skin panels requiring multiple points of load transfer. The designs significantly increase the weight of the wing and thus are costly to manufacture and operate. The designs, because load is carried in the skins of the wing, are also expensive to repair if damage occurs to the wing during operation, storage, or ground transportation.

[0024] Thus, the illustrative embodiments provide a folding wingtip where the bending moment of the wingtip is carried in the spars of the wingtip. This is a departure from the usual practice of carrying the bending moment in the skins. The disclosed folding wingtip minimizes the loads transfer into hinge fittings connected to the spars which allows wingtip panels to be light enough to crush in the event of a wingtip collision when the wingtip is folded up protecting the main part of the wing from damage.

[0025] The illustrative embodiments provide a folding wingtip where the hinge line (or fold line) is perpendicular to the spars which provides more room inside the fixed wing section for latch pin actuators and allows greater separation between the fold line and the latch pins, which reduces the latch pin loads in flight. The disclosed design also distributes the forces more evenly between the multiple latch pins.

[0026] With reference now to the figures and, in particular, with reference to FIG. **1**, an illustration of a block diagram of a platform is depicted in accordance with an illustrative example. Platform **100** has aircraft **102** in this illustrative example.

[0027] The illustration of aircraft **102** in FIG. **1** is not meant to imply physical or architectural limitations to the manner in which an illustrative example may be implemented. For example, although aircraft **102** may be a commercial aircraft, aircraft **102** may be a military aircraft, a rotorcraft, a helicopter, an unmanned aerial vehicle, or any other suitable aircraft.

[0028] Although the illustrative examples are described with respect to an aircraft, the illustrative example may be applied to other types of platforms. The platform may be, for example, a mobile platform, a stationary platform, a land-based structure, an aquatic-based structure, or a space-based structure. More specifically, the platform may be an aircraft, a surface ship, a tank, a personnel carrier, a train, a spacecraft, a space station, a satellite, a submarine, an automobile, a power plant, a bridge, a dam, a house, a manufacturing facility, a building, a tool, a mechanical structure, or some other suitable platform or structure where a folding wingtip is desirable.

[0029] In this illustrative example, platform **100** takes the form of aircraft **102**. In this illustrative example, when platform **100** takes the form of aircraft **102**, aircraft **102** includes fuselage **104** and wing **106**. Wing **106** is connected to fuselage **104**.

[0030] As used herein, a first component "connected to" or "coupled to" or "associated with" a second component means that the first component can be connected directly or indirectly to the second component. The connection is a physical association. In other words, additional components may be present between the first component and the second component. The first component is considered to be indirectly connected to the second component when one or more additional components are present between the two components. When the first component is directly connected to the second component, no additional components are present between the two components.

[0031] For example, a first component can be considered to be physically connected to a second component by at least one of being secured to the second component, bonded to the second component, mounted to the second component, welded to the second component, fastened to the second component, or connected to the second component in some other suitable manner. The first component also can be connected to the second component using a third component. The first component can also be considered to be physically connected to the second component by being formed as part of the second component, an extension of the second component, or both.

[0032] Wing **106** includes main section **108** and wingtip section **110**. Wingtip section **110** folds with respect to main section **108**.

[0033] Main section **108** of wing **106** includes set of beams **112**. Each beam of set of beams **112** is arranged parallel **114** to each of the other beams of set of beams **112**.

[0034] As used herein, a "set of," when used with reference to items, means one or more items. For example, a "set of beams **112**" is one or more beams.

[0035] As used herein, the phrase "at least one of," when used with a list of items, means different combinations of one or more of the listed items can be used, and only one of each item in the list may be needed. In other words, "at least one of" means any combination of items and number of items may be used from the list, but not all of the items in the list are required. The item can be a particular object, a thing, or a category.

[0036] For example, without limitation, "at least one of item A, item B, or item C" may include item A, item A and item B, or item B. This example also may include item A, item B, and item C or item B and item C. Of course, any combination of these items can be present. In some illustrative examples, "at least one of" can be, for example, without limitation, two of item A; one of item B; and ten of item C; four of item B and seven of item C; or other suitable combinations.

[0037] Wingtip section **110** of wing **106** is pivotally connected to main section **108** of wing **106**. Wingtip section **110** includes leading edge bullnose **120**, main box **122**, trailing edge **124**, and tip **126**. Stiffened panels **128** encase or cover leading edge bullnose **120**, main box **122**, trailing edge **124** to form an aerodynamic shape of wing **106**.

[0038] Outboard closeout rib **130** caps the outboard ends of leading edge bullnose **120**, main box **122**, trailing edge wedge **124**. Outboard closeout rib **130** connects tip **126** to leading edge bullnose **120**, main box **122**, and trailing edge wedge **124**. Inboard closeout rib **132** caps the inboard ends of leading edge bullnose **120**, main box **122**, and trailing edge wedge **124**. Wingtip section **110** is pivotable or foldable with respect to main section **108**. As a result, wingtip section **110** has a folded position **134** and a deployed position **136**. In folded position **134**, wingtip section **110** is folded with respect to main section **108**. In deployed position **136**, wingtip section **110** is locked with respect to main section **108** and wing **106** is operational for flying. In other words, in deployed position **136**, the position of wingtip section **110** relative to main section **108** provides a continuous curvature of wing **106**.

[0039] Main box **122** includes set of spars **140**. Set of spars **140** can be any number of spars. In an illustrative example set of spars **140** includes at least three spars. Each spar of set of spars **140** has inboard end **142** and outboard end **144**. Each spar of set of spars **140** is arranged parallel **146** to each of the other spars of set of spars **140**. Stiffened panels **128** cover set of spars **140** within main box **122**. Set of spars **140** carry bending moment **148** of wingtip section **110**. In solid mechanics, a bending moment is the reaction induced in a structural element when an external force or moment is applied to the element, causing the element to bend. When wingtip section **110** folds with respect to main section **108**, set of spars **140** carries the majority of bending moment **148** associated with the weight of wingtip section **110** as it folds with respect to main section **108**. A majority is defined in the typical sense to mean at least over half of bending moment **148**, for example at least 51% to 100% of bending moment **148**, is carried by set of spars **140**. In contrast to current folding wingtip designs, bending moment **148** is carried in the spars rather than stiffened panels **128**, with the stiffened panels only being relied on for aerodynamic pressure loads and torsional stiffness of wing **106**.

[0040] Set of hinge fittings **150** are connected to set of spars **140**. A respective hinge fitting of set of hinge fittings **150** is connected to an inboard end of each spar of set of spars **140**. The inboard ends of each spar of set of spars **140** extends through inboard closeout rib **132**. A respective hinge fitting of set of hinge fittings **150** is connected to each inboard end of each spar of set of spars **140** that extends through closeout rib **132**. Hinge line **152** passes through each hinge fitting of set of hinge fittings **150**. Because a respective hinge fitting of set of hinge fittings **150** is connected to the inboard ends of each spar of set of spars **140**, hinge line **152** also passes through each inboard end of each spar of set of spars **140**. Hinge line **152** is perpendicular **154** to each spar of set of spars **140**. Hinge line **152** provides pivot axis **156** for folding wingtip section **110** with respect to main section **108**.

[0041] Actuator **160** is mounted to set of hinge fittings **150** or set of beams **112**. Actuator **160** motivates the movement of wingtip section **110** relative to main section **108** about hinge line **152**. Shock damper **164** is mounted to set of hinge fittings **150** or set of beams **112**. Shock damper **164** softens the movement of wingtip section **110** relative to main section **108**. Shock damper **164** prevents abrupt starts and starts of the movement of wingtip section **110** relative to main section **108**. Shock damper **164** prevents fatigue of wingtip section **110** if wingtip section **110** comes to a hard stop.

[0042] Set of latch pins **166** is removably engaged with set of hinge fittings **150**. In an illustrated example, a respective latch pin of set of latch pins **166** is removably engaged with each respective hinge fitting of set of hinge fittings **150**. Set of latch pins **166** engage set of hinge fittings **150** to secure wingtip section **110** in deployed position **136**. In other words, when set of latch pins **166** is engaged with set of hinge fittings **150**, wingtip section **110** cannot pivot about hinge line **152**. In other words, when set of latch pins **166** is engaged with set of hinge fittings **150**, set of spars **140** cannot fold about hinge line **152**. Set of latch pins **166** are evenly distributed along hinge line **152**. Set of latch pins **166** move with respect to set of hinge fittings **150** in a direction parallel with each spar of set of spars **140**.

[0043] With reference next to FIG. **2**, an illustration of a folding wingtip is depicted in accordance with an illustrative embodiment. In this illustrative example and the illustrative examples that follow, the same reference numeral may be used in more than one figure. This reuse of a reference numeral in different figures represents the same element in the different figures. The components illustrated in FIG. **2** are examples of physical implementations of main section **108** and wingtip section **110** of wing **106** of aircraft **102** shown in block form in FIG. **1**.

[0044] As illustrated, wing **206** includes main section **208** and wingtip section **210**. Main section **208** is connected to a fuselage of an aircraft. Additional components of wing **206** (not shown) may be present between main section **208** and the fuselage of the aircraft. Wingtip section **210** folds with respect to main section **208** about hinge line **252**.

[0045] Main section **208** includes set of beams **212**. Each beam of set of beams **212** is arranged parallel to each of the other beams of set of beams **212**. Set of beams **212** are sized and shaped to fit between the respective hinge fittings. Hinge line **252** passes through each beam of set of beams **212**.

[0046] Wingtip section **210** is pivotally connected to main section **208** of wing **206**. Wingtip section **210** includes leading edge bullnose **220**, main box **222**, trailing edge **224**, and tip **226**. Stiffened panels (not shown) encase leading edge bullnose **220**, main box **222**, and trailing edge **224** to form an airfoil profile of wingtip section **210** and thus wing **206**. Main box **222** includes set of spars **240**. Each spar of set of spars **240** is parallel to each other.

[0047] Outboard closeout rib **230** caps the outboard ends of leading edge bullnose **220**, main box **222**, trailing edge wedge **224**. Outboard closeout rib **230** connects tip **226** to leading edge bullnose **220**, main box **222**, and trailing edge wedge **224**. Inboard closeout rib **232** caps the inboard ends of leading edge bullnose **220**, main box **222**, and trailing edge wedge **224**. Set of spars **240** extends through inboard closeout rib **232** for connection with main section **208**.

[0048] Wingtip section **210** is pivotable or foldable with respect to main section **208** about hinge line **252**. Hinge line **252** is perpendicular to each spar of set of spars **240**. As a result, wingtip section **210** has a folded position **702** (shown in FIG. **7**) and a deployed position **704** (shown in FIG. **7**). In folded position **702**, wingtip section **210** is folded with respect to main section **208**. In deployed position **704**, wingtip section **210** is locked in an orientation suitable for flight operations.

[0049] With reference next to FIGS. **3-6**, illustrations of a folding wingtip are depicted in accordance with an illustrative embodiment. Set of spars **240** can be any number of spars. In this illustrative example, set of spars **240** includes at least three spars. Each spar of set of spars **240** has inboard end **242** and outboard end **244**. Each spar of set of spars **240** is arranged parallel to each of the other spars of set of spars **240**. Set of spars **240** carry the bending moment of wingtip section **210**. When wingtip section **210** folds with respect to main section **208** about hinge line **252**, set of spars **240** carries the majority of the bending moment associated with wingtip section **210** during folding as it folds with respect to main section **208** and during flight operations.

[0050] Set of hinge fittings **250** are connected to set of spars **240**. A respective hinge fitting of set of hinge fittings **250** is connected to inboard end **242** of each spar of set of spars **240**. The inboard ends of each spar of set of spars **240** extends through inboard closeout rib **232**. A respective hinge fitting of set of hinge fittings **250** is connected to each inboard end **242** of each spar of set of spars **240** that extends through closeout rib **232**. Hinge line **252** passes through each hinge fitting of set of hinge fittings **250**. Hinge line **252** also passes through each inboard end **242** of each spar of set of spars **240**. Hinge line **252** is perpendicular to each spar of set of spars **240**. Hinge line **252** provides a pivot axis for folding wingtip section **210** with respect to main section **208**.

[0051] Actuator **260** (shown in FIG. **5**) is mounted to set of hinge fittings **250** or set of beams **212**. Actuator **260** may be a dual actuator, where each actuator works simultaneously or independently to initiate the movement/folding of wingtip section **210**. Actuator **260** motivates the movement of wingtip section **210** relative to main section **208** about hinge line **252**. Actuator **260**, as depicted, is a non-limiting example of structure that is capable of imparting a force to cause rotational movement of the wingtip section relative to the main section of the wing. Other mechanical structures that are capable of imparting the force to cause the rotational movement of the wingtip section relative to the main section are considered as well.

[0052] Shock damper **264** is mounted to set of hinge fittings **250** or set of beams **212**. Shock damper **264** prevents abrupt starts and starts of the movement of wingtip section **210** relative to main section **208** and prevents fatigue of wingtip section **210**.

[0053] Set of latch pins **266** is removably engaged with set of hinge fittings **250**. In an illustrated example, a respective latch pin of set of latch pins **266** is removably engaged with each respective hinge fitting of set of hinge fittings **250**. Set of latch pins **266** engage set of hinge fittings **250** to secure wingtip section **210** in deployed position **704**. When set of latch pins **266** is engaged with set of hinge fittings **250**, wingtip section **210** cannot pivot about hinge line **252**. Set of latch pins **266** are evenly distributed along hinge line **152** over distance **502**. This distributes forces evenly between each latch pin of set of latch pins **266**. Set of latch pins **266** move with respect to set of hinge fittings **250** in direction **504**. Direction **504** is parallel with each spar of set of spars **240**.

[0054] With reference next to FIG. **8**, an illustration of a flowchart of a process **800** for folding a wingtip is depicted in accordance with an illustrative embodiment. The method depicted in FIG. **8** may be used in conjunction with the wing depicted in FIGS. **1-7**.

[0055] The process begins by providing a wingtip section of an aircraft wing that is connected to a main section of the aircraft wing (operation **802**). The wingtip section includes at least three spars arranged parallel with each other. The wingtip section also includes a respective hinge fitting connected to a respective inboard end of each spar of the spars. The process continues by aligning a hinge line of the wingtip section perpendicular to the spars (operation **804**). The hinge line passes through each respective hinge fitting. At operation **806**, the process activates an actuator to fold the wingtip section about the hinge line. The hinge line provides a pivot axis for the wingtip section relative to the main section. At operation **808**, once the wingtip section is unfolded relative to the main section, the process secures the wingtip section in a deployed position with a latch pin. The latch pin extends in a direction parallel with the spars into each respective hinge fitting. The set of latch pins are evenly distributed along the hinge line.

[0056] In some alternative implementations of an illustrative example, the function or functions noted in the blocks may not be necessary or may occur out of the order noted in the figures. For example, in some cases, two blocks shown in succession may be performed substantially concurrently, or the blocks may sometimes be performed in the reverse order, depending upon the functionality involved. Also, other blocks may be added in addition to the illustrated blocks in a flowchart or block diagram.

[0057] The illustrative embodiments of the disclosure may be further described in the context of aircraft manufacturing and service method **900** as shown in FIG. **9** and aircraft **1000** as shown in FIG. **10**. Turning first to FIG. **9**, an illustration of a block diagram of an aircraft manufacturing and service method is depicted in accordance with an illustrative embodiment. During pre-production, aircraft manufacturing and service method **900** may include specification and design **902** of aircraft **1000** in FIG. **10** and material procurement **904**.

[0058] During production, component and subassembly manufacturing **906** and system integration **908** of aircraft **1000** in FIG. **10** takes place. Thereafter, aircraft **1000** in FIG. **10** may go through certification and delivery **910** in order to be placed in service **912**. While in service **912** by a customer, aircraft **1000** in FIG. **10** is scheduled for routine maintenance and service **914**, which may include modification, reconfiguration, refurbishment, and other maintenance, service, or inspection.

[0059] The apparatus of this disclosure may be installed on an aircraft during component and subassembly manufacturing **906**. In addition, the apparatus of this disclosure may be retrofitted onto aircraft **1000** in FIG. **10** during routine maintenance and service **914** as part of a modification, reconfiguration, or refurbishment of aircraft **1000** in FIG. **10**.

[0060] Each of the processes of aircraft manufacturing and service method **900** may be performed or carried out by a system integrator, a third party, an operator, or some combination thereof. In these examples, the operator may be a customer. For the purposes of this description, a system integrator may include, without limitation, any number of aircraft manufacturers and major-system subcontractors; a third party may include, without limitation, any number of vendors, subcontractors, and suppliers, and an operator may be an airline, a leasing company, a military entity, a service organization, and so on.

[0061] With reference now to FIG. **10**, an illustration of a block diagram of an aircraft is depicted in which an illustrative embodiment may be implemented. In this example, aircraft **1000** is produced by aircraft manufacturing and service method **900** in FIG. **9** and may include airframe **1002** with plurality of systems **1004** and interior **1006**. Examples of systems **1004** include one or more of propulsion system **1008**, electrical system **1010**, hydraulic system **1012**, and environmental system **1014**. Any number of other systems may be included. Although an aerospace example is shown, different illustrative embodiments may be applied to other industries, such as the automotive industry.

[0062] Apparatuses and methods embodied herein may be employed during at least one of the stages of aircraft manufacturing and service method **900** in FIG. **9**. In one illustrative example, components or subassemblies produced in component and subassembly manufacturing **906** in FIG. **9** may be fabricated or manufactured in a manner similar to components or subassemblies produced while aircraft **1000** is in service **912** in FIG. **9**. As yet another example, one or more apparatus embodiments, method embodiments, or a combination thereof may be utilized during production stages, such as component and subassembly manufacturing **906** and system integration **908** in FIG. **9**. One or more apparatus embodiments, method embodiments, or a combination thereof may be utilized while aircraft **1000** is in service **912**, during maintenance and service **914** in FIG. **9**, or both. The use of a number of the different illustrative embodiments may substantially expedite the assembly of aircraft **1000**, reduce the cost of aircraft **1000**, or both expedite the assembly of aircraft **1000** and reduce the cost of aircraft **1000**.

[0063] The description of the different illustrative embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. Further, different illustrative embodiments may provide different features as compared to other desirable embodiments. The embodiment or embodiments selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

1. A folding wingtip of a wing of an aircraft, comprising:
a spar;
a hinge fitting connected to an inboard end of the spar; and
a hinge line passing through the hinge fitting and perpendicular to the spar, wherein the folding wingtip is configured to be pivotally connected to a main section of the wing and wherein the hinge line is a pivot axis for the folding wingtip with respect to the main section.

2. The folding wingtip of claim **1**, further comprising:
a latch pin removably engaged with the hinge fitting, wherein when the latch pin is engaged with the hinge fitting, the folding wingtip cannot pivot about the hinge line.

3. The folding wingtip of claim **2**, wherein the latch pin moves with respect to the hinge fitting in a linear direction parallel with the spar.

4. The folding wingtip of claim **1**, wherein the spar further comprises:
at least three spars arranged parallel with each other; and
a respective hinge fitting connected to an inboard end of each spar, wherein the hinge line passes through each respective hinge fitting and is perpendicular to each of the at least three spars.

5. The folding wingtip of claim **4**, further comprising:
a set of latch pins, wherein a respective latch pin of the set of latch pins is removably engaged with each respective hinge fitting.

6. The folding wingtip of claim **5**, wherein the set of latch pins are evenly distributed in a direction along the hinge line.

7. The folding wingtip of claim **4**, further comprising:
stiffened panels connected to the at least three spars, the stiffened panels forming a leading edge bullnose and a trailing edge wedge of the folding wingtip.

8. The folding wingtip of claim **4**, wherein a majority of a bending moment of the folding wingtip is carried in the at least three spars.

9. An aircraft wing with a folding wingtip, comprising:
a main section connected to a fuselage of an aircraft; and
a wingtip section pivotally connected to the main section;
the wingtip section comprising:
at least three spars arranged parallel with each other;
a respective hinge fitting connected to a respective inboard end of each spar of the at least three spars, each spar and each respective hinge fitting pivotally connected to the main section; and
a hinge line perpendicular to each spar of the at least three spars, wherein the hinge line is a pivot axis for folding the at least three spars and each respective hinge fitting relative to the main section.

10. The aircraft wing of claim **9**, wherein the hinge line passes through each respective hinge fitting and each respective inboard end of each spar.

11. The aircraft wing of claim **9**, further comprising:
a latch pin removably engaged with the respective hinge fitting, wherein when the latch pin is engaged with the respective hinge fitting, the at least three spars cannot fold about the hinge line.

12. The aircraft wing of claim **11**, wherein the latch pin moves with respect to the respective hinge fitting in a direction parallel with the at least three spars.

13. The aircraft wing of claim **9**, further comprising:
a set of latch pins, wherein a respective latch pin of the set of latch pins is removably engaged with each respective hinge fitting.

14. The aircraft wing of claim **13**, wherein the set of latch pins are evenly distributed in a direction along the hinge line.

15. The aircraft wing of claim **9**, further comprising:
stiffened panels connected to the at least three spars, the stiffened panels forming a leading edge bullnose and a trailing edge wedge of the wingtip section.

16. The aircraft wing of claim **9**, wherein a majority of a bending moment of the wingtip section is carried in the at least three spars.

17. The aircraft wing of claim **9**, wherein the main section further comprises a set of parallel beams sized and shaped to fit between the respective hinge fittings, and wherein the hinge line passes through each beam of the set of parallel beams.

18. A method for folding a wingtip, comprising:
providing a wingtip section of an aircraft wing pivotally connected to a main section of the aircraft wing, wherein the wingtip section comprises at least three spars arranged parallel with each other and a respective hinge fitting connected to a respective inboard end of each spar of the at least three spars;
aligning a hinge line of the wingtip section perpendicular to the at least three spars of the wingtip section, wherein the hinge line passes through each respective hinge fitting and each spar; and
activating an actuator such that the wingtip section folds about the hinge line, wherein the hinge line provides a pivot axis for the wingtip section to rotate relative to the main section.

19. The method of claim **18**, wherein the wingtip section has a folded position and a deployed position, the method further comprising:

securing the wingtip section in the deployed position with a latch pin extending in a linear direction parallel with the at least three spars into each respective hinge fitting.

20. The method of claim **18**, wherein the wingtip section has a folded position and a deployed position, the method further comprising:

securing the wingtip section in the deployed position with a set of latch pins engaged with the at least three spars, wherein the set of latch pins are evenly distributed along the hinge line.

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