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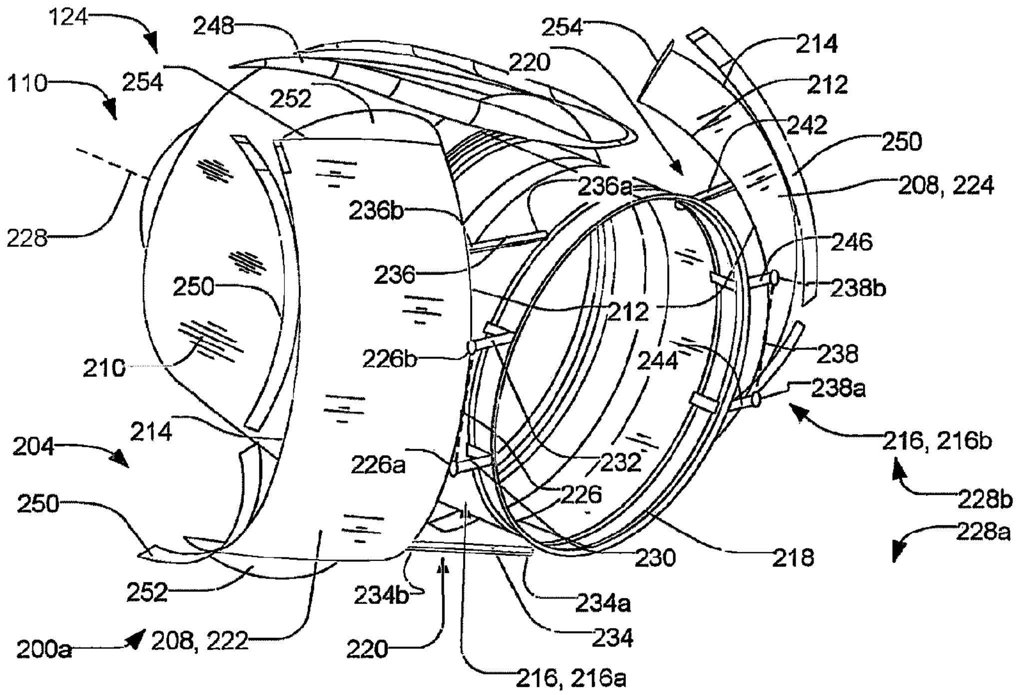

(57) Abrégé/Abstract:
Braking systems for aircraft are disclosed. An example braking system includes a fan cowl having a leading edge and a trailing edge. The braking system includes a hinge assembly coupled between the leading edge and a fan cage of an aircraft engine to enable the fan cowl to move between a stowed position and a deployed position. An actuator is coupled to the leading edge of the fan cowl, and the actuator is to move the fan cowl via the hinge from the stowed position to the deployed position in a direction away from the aircraft engine and toward a fore end of the aircraft to provide an air brake during a braking event.

ABSTRACT

Braking systems for aircraft are disclosed. An example braking system includes a fan cowl having a leading edge and a trailing edge. The braking system includes a hinge assembly coupled between the leading edge and a fan cage of an aircraft engine to enable the fan cowl to move between a stowed position and a deployed position. An actuator is coupled to the leading edge of the fan cowl, and the actuator is to move the fan cowl via the hinge from the stowed position to the deployed position in a direction away from the aircraft engine and toward a fore end of the aircraft to provide an air brake during a braking event.

BRAKE SYSTEMS FOR AIRCRAFT AND RELATED METHODS

FIELD OF THE DISCLOSURE

This disclosure relates generally to aircraft and, more specifically, to brake systems for aircraft and related methods.

BACKGROUND

Aircraft employ a variety of methods to perform braking operations during a landing event. For example, aircraft employ wheel brakes. Additional braking systems can be used in combination with or to supplement the wheel brakes. For example, aircraft employ adjustable flaps called speed brakes or spoilers located on the wings to provide an impedance to airflow to aid in deceleration. In some instances, aircraft employ thrust reversers that function to reverse airflow to provide reverse thrust during a landing event. While thrust reversers are effective in supplementing the wheel braking systems, thrust reversers are complex systems that typically include cascade baskets, blocker doors, drag links, translation and actuation systems, etc. As such, thrust reversers are relatively expensive systems to manufacture and maintain. Thrust reversers also increase nacelle weight, which decreases aircraft fuel efficiency.

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SUMMARY

In one embodiment, there is provided a braking system for an aircraft. The braking system comprises: a fan cage to house a fan of an aircraft engine, the fan cage having a fore edge proximate an air intake of the aircraft engine and an aft edge proximate an engine core of the aircraft engine; a fan cowl having a leading edge and a trailing edge; a hinge assembly to pivotally couple the leading edge of the fan cowl proximate the fore edge of the fan cage, the hinge assembly to enable the fan cowl to move between a stowed position and a deployed position; and an actuator coupled to the leading edge of the fan cowl, the actuator to move the fan cowl via the hinge assembly from the stowed position to the deployed position in a direction away from the aircraft engine and toward a fore end of the aircraft to provide an air brake during a braking event.

In another embodiment, there is provided a braking system for an aircraft. The braking system comprises: an aircraft engine defining an air intake upstream from an engine core; a first fan cowl movably coupled proximate the air intake of the aircraft engine, the first fan cowl to pivot about a first pivot axis proximate a leading edge of the air intake; and a second fan cowl movably coupled proximate the air intake of the aircraft engine, the second fan cowl to pivot about a second pivot axis proximate the leading edge of the air intake, each of the first fan cowl and the second fan cowl movable between a stowed position and a deployed position, the first fan cowl and the second fan cowl to rotate outwardly relative to the aircraft engine into an airflow stream in the deployed position to increase drag and provide an air brake to reduce a speed of the aircraft during at least a portion of a landing event.

In another embodiment, there is provided a method for braking an aircraft. The method comprises: detecting a landing event; determining a speed of the aircraft; and moving a first fan cowl about a pivot axis that is located proximate a leading edge of an aircraft engine from a stowed position to a deployed position into an airflow stream to increase drag and reduce the speed of the aircraft when the determined speed is less than a speed threshold.

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In another embodiment, there is provided a braking system for an aircraft. The braking system comprises a fan cowl having a leading edge and a trailing edge and movably coupled to an aircraft engine. The fan cowl is movable between a stowed position and a deployed position, the fan cowl being configured to rotate outwardly relative to the aircraft engine into an airflow stream in the deployed position to increase drag and provide an air brake to reduce a speed of the aircraft during at least a portion of a landing event. The fan cowl comprises: a first fan cowl movably coupled to an inboard side of the aircraft engine; and a second fan cowl movably coupled to an outboard side of the aircraft engine. The braking system further comprises a hinge assembly coupled between the leading edge and a fan cage of the aircraft engine to enable the fan cowl to move between the stowed position and the deployed position. The fan cowl has a first width when the fan cowl is in the stowed position and a second width when the fan cowl is in the deployed position, and the second width is greater than the first width. The braking system further comprises a kicker plate protruding from, and pivotally coupled relative to, the trailing edge of the fan cowl. The kicker plate provides a third width of the fan cowl that is greater than the second width. The first width, the second width, and the third width are perpendicular relative to a centerline of the aircraft engine. The braking system further comprises an actuator system coupled to the leading edge of the fan cowl, the actuator system being configured to move the fan cowl via the hinge assembly from the stowed position to the deployed position in a direction away from the aircraft engine and toward a fore end of the aircraft to provide the air brake during the landing event. The braking system further comprises a variable pitch fan, the variable pitch fan operable to provide braking force for the aircraft during the landing event.

In another embodiment, there is provided an aircraft comprising the braking system described above or any variants thereof.

In another embodiment, there is provided a method for braking an aircraft. The method comprising: detecting a landing event; determining a speed of the aircraft; and moving a fan cowl, comprising a first fan cowl and a second fan cowl, from a stowed

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position to a deployed position into an airflow stream to increase drag and reduce the speed of the aircraft when the determined speed is less than a speed threshold. The moving the fan cowl comprises: moving the first fan cowl, coupled to an inboard side of an aircraft engine, from a first stowed position to a first deployed position; and moving the second fan cowl, coupled to an outboard side of the aircraft engine, from a second stowed position to a second deployed position. The fan cowl has a first width when the fan cowl is in the stowed position and a second width when the fan cowl is in the deployed position, and the second width is greater than the first width. The method further comprises moving a kicker plate, pivotally coupled relative to a trailing edge of the fan cowl, to protrude from the trailing edge of the fan cowl and further interrupt or affect the airflow stream to increase drag. The kicker plate provides a third width of the fan cowl that is greater than the second width, and the first width, the second width, and the third width are perpendicular relative to a centerline of the aircraft engine. The method further comprises adjusting a pitch of fan blades of a variable pitch fan to provide braking force for the aircraft during the landing event.

In another embodiment, there is provided a computer-readable medium having stored thereon instructions which, when executed by one or more processors, cause the one or more processors to carry out the method described above or any variants thereof.

Although certain example methods, apparatus and articles of manufacture have been disclosed herein, the scope of coverage of this patent is not limited thereto.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an example aircraft having example brake system constructed in accordance with teachings of this disclosure.

FIG. **2**A is a perspective view of an example aircraft engine of FIG. **1** shown from an inboard side of the aircraft engine and showing an example air brake system in an example stowed position.

FIG. **2**B is a perspective view of an example aircraft engine of FIGS. **1** and **2**A shown from an outboard side of the aircraft engine.

FIG. **2**C is a perspective view of the example aircraft engine of FIG. **1** shown from the inboard side of the aircraft engine and showing the example air brake system in an example deployed position.

FIG. **2**D is a perspective view of the example aircraft engine of FIGS. **1** and **2**C shown from an outboard side of the aircraft engine.

FIG. **3**A is front view of the example aircraft engine of FIGS. **1**, **2**A and **2**B.

FIG. **3**B is front view of the example aircraft engine of FIGS. **1**, **2**C and **2**D.

FIG. **4**A is a side, partial view of the example aircraft of FIG. **1**.

FIG. **4**B is a perspective, partial view of the example aircraft of FIG. **4**A.

FIG. **5**A is perspective, partial view of the example aircraft of FIGS. **1**, **4**A and **4**B showing an example parachute system in an example deployed position.

FIG. **5**B is perspective, partial view of the example aircraft of FIGS. **1**, **4**A and **4**B showing the example parachute system in an example stowed position.

FIGS. **6-9** are side, partial views of the example aircraft of FIGS. **1**, **4**A, **4**B, **5**A and **5**B illustrating an example deployment sequence of the example parachute system disclosed herein.

FIG. **10** is a side, partial view of the example aircraft of FIGS. **1**, **4**A, 4B, **5**A and **5**B illustrating the example parachute system in the example deployed position.

FIGS. **11-14** are side, partial views of the example aircraft of FIGS. **1**, **4**A, **4**B, **5**A and **5**B illustrating an example retrieval sequence of the example parachute system disclosed herein.

FIG. **15** illustrates another example parachute system disclosed herein that can implement the example aircraft of FIG. **1**.

FIG. **16** illustrates the example parachute system of FIG. **15** in an example intermediate position.

FIG. **17** illustrates the example parachute system of FIGS. **15** and **16** in an example deployed position.

FIG. **18** is a side, partial view of another example aircraft and parachute system disclosed herein.

FIG. **19** is a top view of the example aircraft of FIG. **1** illustrating an emergency brake system disclosed herein.

FIG. **20**A is a side view of the example aircraft of FIG. **19** illustrating the emergency brake system in an example stowed position.

FIG. **20**B is a side view of the example aircraft of FIG. **19** illustrating the emergency brake system in an example deployed position.

FIG. **21** is a perspective, partial view of an example brake pad of the example emergency brake system of FIG. **20**B.

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FIG. **22** is a perspective, partial view of an example frame of the example emergency brake system of FIGS. **19-21**.

FIG. **23**A is a block diagram of the example brake system controller of FIG. **1**.

FIG. **23**B is a block diagram of an example hazardous condition identifier of FIG. **23**A.

FIGS. **24-26** are flowcharts representative of example methods that may be performed to implement the example brake system controller of FIGS. **23**A and **23**B.

FIG. **27** is a block diagram of an example processor platform capable of executing instructions to implement the methods of FIGS. **24-26** and the example brake system controller **130** of FIGS. **1**, **23**A and **23**B.

Certain examples are shown in the above-identified figures and described in detail below. In describing these examples, like or identical reference numbers are used to identify the same or similar elements. The figures are not necessarily to scale and certain features and certain views of the figures can be shown exaggerated in scale or in schematic for clarity and/or conciseness. Additionally, several examples have been described throughout this specification. Any features from any example can be included with, a replacement for, or otherwise combined with other features from other examples. In other words, the example disclosed herein are not mutually exclusive to each other. As used in this patent, stating that any part is in any way positioned on (e.g., located on, disposed on, formed on, coupled to, etc.) another part, means that the referenced part is either in contact with the other part, or that the referenced part is spaced from the other part with one or more intermediate part(s) located between the part. Stating that any part is in contact with another part means that there is no intermediate part between the two parts.

DETAILED DESCRIPTION

In known aircraft, thrust reversers are often used to decrease braking distance on a runway. However, thrust reversers require throttling the engines to create reverse thrust. Such throttling increases engine wear and tear. Additionally, thrust reversers often reduce braking capability because some of the reverse thrust creates lift. In some instances, thrust reversers may not be effective (e.g., may not be deployed quickly enough) to stop an aircraft if a collision with an object is imminent. Typically, thrust reversers cannot create **4-5** G-force of negative thrust and/or thrust reversers cannot be deployed below a certain speed. .

Example braking systems disclosed herein can supplement, or can be used in combination with, wheel brakes of an aircraft. Specifically, example braking systems disclosed herein enable deceleration of an aircraft during landing without the use of thrust reversers. Thus, example braking systems disclosed herein can significantly reduce complexity and weight of aircraft engines (e.g., by eliminating thrust reversers).

In some examples, example braking systems disclosed herein employ air brakes implemented with an aircraft engine. To provide deceleration during landing, examples disclosed herein employ aircraft engines that include air brakes. The air brakes can be provided by adjustable surfaces (e.g., doors) to provide impedance to airflow to aid in deceleration of the aircraft. For example, air brakes can be provided via fan cowl surfaces (e.g., doors) during landing. For example, portions of a fan cowling that also function as access doors to maintain a fan of the aircraft can be hinged from side surfaces instead of a top surface. In this manner, the fan cowl doors extend into (e.g., perpendicular relative to) an airflow stream to also function as an air brake to provide at least a portion of a braking force needed to reduce a speed of the aircraft during landing. Known fan cowls are typically hinged at an upper edge such that the cowl rotates upwardly relative to the aircraft engine to access the fan (e.g., during maintenance). In contrast to known fan cowls, example aircraft engines disclosed herein employ fan cowls that rotate outwardly relative to the center axis of the aircraft engine (i.e. the cowl opens from a side). Specifically, an example fan cowl disclosed herein rotates relative to an aircraft engine about a pivot axis aligned or adjacent a leading edge of the fan cowl. For example, the pivot axis is non-parallel to (e.g., perpendicular to) a longitudinal axis of the aircraft engine.

In some examples, to provide deceleration during landing, example braking systems disclosed herein includes a deployable parachute. Additionally, example braking systems disclosed herein enable recovery of the parachute for subsequent use. For instance, in contrast to known parachute systems, example braking systems disclosed herein employ a parachute retrieval system configured to recover the parachute from the deployed position to a stowed position for subsequent use. Example parachute retrieval systems automatically recover a deployed parachute and automatically fold the parachute for subsequent use. For example, the braking systems employ a reel system to retrieve and repackage a deployed parachute or umbrella in a launch tube for subsequent use.

In some examples, braking systems disclosed herein provide deployable emergency brakes for use during a landing event or failed take-off event that requires rapid deceleration of the aircraft. The emergency brakes include a brake pad deployable from an aircraft that engages a runway or ground surface to help stop the aircraft. Example emergency brake systems disclosed herein prevent or reduce runway excursions. In some examples, the emergency brake systems disclosed herein detect potential collisions with other objects (e.g., other aircraft) and deploy an emergency brake to stop the aircraft if possible, or greatly reduce a speed at impact with the detected object. Thus, the braking capability of the system prevents or reduces the impact of runway collisions. In some examples, emergency brakes disclosed herein can generate between approximately **4** and **5** G-of braking force during a rejected takeoff and/or emergency landing. In some examples, the emergency brake systems disclosed herein reduce risk of fire due to overheated brakes. Additionally, emergency brake systems disclosed herein can increase a weight on wheels during a rejected takeoff.

FIG. **1** is a perspective view of an aircraft **100** having an example braking system **102** in accordance with teachings of this disclosure. The aircraft **100** of the illustrated example is a commercial aircraft. However, the braking system **102** can be implemented with other aircraft, spacecraft or vehicles without departing from the scope of this disclosure. In some examples, the brake system **102** can be implemented with any other example aircraft such as, for example, military aircraft, transport aircraft and/or any other aircraft.

The aircraft **100** of the illustrated example includes a fuselage **104**, wings **106**, **108**, aircraft engines **110**, **112** supported by the respective wings **106**, **108**, and an empennage **114**. The aircraft engines **110**, **112** of the illustrated do not employ thrust reversers. To provide reverse thrust during landing, each of the aircraft engines **110**, **112** includes a variable pitch fan **116** (e.g., a variable pitch gear driven fan) driven by a core (e.g., a compressor or turbine) of the respective aircraft engines **110**, **112**. The variable pitch fan **116** includes fan blades **118** having a pitch that can be varied during landing to provide reverse thrust needed to slow or stop the aircraft **100**. In some examples, the variable pitch fan **116** serves as a primary means of slowing or decelerating the aircraft **100**. Additionally, the aircraft **100** includes wheels **120** that have wheel brakes **122** to decelerate and/or stop the aircraft **100** during landing. To further improve deceleration during landing, the wings **106**, **108** of the illustrated example include one or more flaps **123** (e.g., speed brakes or spoilers) that rotate into an airflow path to impede airflow and function as air brakes during landing.

To supplement the variable pitch fan **116** and/or the wheel brakes **122** during landing, the aircraft **100** of the illustrated example employs the brake system **102**. The brake system **102** of the illustrated example includes an air brake system **124** and a parachute system **126**. Additionally, to provide rapid deceleration of the aircraft **100** during emergency situations, the brake system **102** of the illustrated example includes an emergency brake system **128**. Thus, the aircraft **100** of the illustrated example includes the air brake system **124**, the parachute system **126** and the emergency brake system **128**. It should be understood that it is not necessary for an aircraft or a braking system to include all of the air brake system **124**, the parachute system **126**, and the emergency brake system **128**. For example, the aircraft **100** can include one or any combination of the air brake system **124**, the parachute system **126**, or the emergency brake system **128**. In some examples, the aircraft **100** can include the air brake system **124** without the parachute system **126** and/or the emergency brake system **128**. In some examples, the aircraft **100** can include the parachute system **126** without the air brake system **124** and/or the emergency brake system **128**. In some examples, the aircraft **100** can include the emergency brake system **128** without the air brake system **124** and/or the parachute system **126**.

The brake system **102** of the illustrated example is configured to deploy or activate during landing without pilot input. To deploy the brake system **102** of the illustrated example, the brake system **102** includes a brake system controller **130**. The brake system controller **130** can be communicatively coupled to an engine control system **132** (e.g., a Full Authority Digital Engine Controller (FADEC). In some examples, the brake system controller **130** and/or the engine control system **132** receives multiple input variables corresponding to current flight conditions including, for example, altitude, air speed, angle of attack, throttle lever position, air pressure, air temperature, and/or other parameter(s). In addition, some of the input variables (e.g., air density) are calculated or determined based on other measured conditions or parameter(s).

To receive flight parameters, the aircraft **100** of the illustrated example includes an airspeed sensor **134**, a weight on wheels sensor **136**, a hazardous condition sensor **138**, and a global positioning system (GPS) sensor **140**. The airspeed sensor **134** provides information to the brake system controller **130** and/or the engine control system **132** to determine the speed of the aircraft **100**. For example, the airspeed sensor **134** can include a pitot tube, Laser Imaging, Detection And Ranging (LIDAR) sensor(s), and/or any other sensor(s) to detect or determine a speed of the aircraft **100**. The weight on wheels sensor **136** provides information to the brake system controller **130** and/or the engine control system **132** to determine whether the aircraft **100** is on the ground or in flight. For example, the weight on wheels sensor **136** can be a pressure sensor and/or any other sensor to detect when the wheels **120** of the aircraft **100** engage a surface **142** of a runway **144**. The GPS sensor **140** provides information to the brake system controller **130** and/or the engine control system **132** to determine a location of the aircraft **100** relative to a reference. The hazardous condition sensor **138** provides information to the brake system controller **130** and/or the engine control system **132** to determine if a hazardous condition is present during a landing or takeoff event. For example, the hazardous condition sensor **138** includes one or more laser sensors (e.g., LIDAR sensors), optical sensors, proximity sensors, sonar sensors and/or any other sensors to image objects and/or the environment surrounding the aircraft **100**. For example, the hazardous condition sensor **138** can detect an object (e.g., an aircraft, etc.) in a pathway of the aircraft **100** and/or can detect a terminating end of a runway on which the aircraft **100** is preparing to take-off. The brake system controller **130** receives the information from the various sensors **134**, **136**, **138**, **140** and/or the engine control system **132** to determine and/or control the deployment of the air brake system **124**, the parachute system **126** and/or the emergency brake system **128**.

In some examples, the brake system **102** can be deployed manually. In some examples, a pilot, co-pilot, or other flight crew member(s) manually deploys the air brake system **124**, the parachute system **126** and/or the emergency brake system **128**. For example, the brake system **102** (e.g., the air brake system **124**, the parachute system **126**, and/or the emergency brake system **128**) can deploy via a user interface (e.g., a touch screen, a button, a lever, etc.) located in a cockpit **146** of the fuselage **104**. In some examples, one or more portions of the brake system **102** can deploy autonomously (e.g., without pilot input), while one or more other portions of the brake system **102** can deploy manually (e.g., via pilot input).

FIGS. **2**A-**2**D are perspective views of the aircraft engine **110** of FIG. **1**. FIG. **2**A depicts an inboard side **200**a of the aircraft engine **110** and shows the air brake system **124** of the aircraft engine **110** in a stowed position **202**. FIG. **2**B shows the air brake system **124** of the aircraft engine **110** in the stowed position **202** from an outboard side **200**b of the aircraft **100**. FIG. **2**C shows the air brake system **124** of the aircraft engine **110** in a deployed position **204** from the inboard side **200**a of the aircraft **100**. FIG. **2**D shows the air brake system **124** of the aircraft engine **110** in the deployed position **204** from the outboard side **200**b of the aircraft **100**. The aircraft engine **112** of FIG. **1** is identical to the aircraft engine **110**. For brevity, only the aircraft engine **110** will be discussed.

The aircraft engine **110** includes a nacelle **206** to house a core (e.g., the fan, a compressor, a turbine, a combustion chamber, etc.) of the aircraft engine **110**. The nacelle **206** includes a fan cowl **208** and an engine cowl **210**. The fan cowl **208** is movably coupled relative to the engine cowl **210** and/or an engine core between the stowed position **202** and the deployed position **204** to enable access to the variable pitch fan **116** (FIG. **1**) during maintenance. Additionally, the fan cowl **208** moves between the stowed position **202** and the deployed position **204** during landing to provide an air brake to decelerate the aircraft **100**. For example, the fan cowl **208** is an adjustable surface that provides impedance to airflow to aid in deceleration of the aircraft **100** during landing when the fan cowl is in the deployed position **204**.

The fan cowl **208** has a leading edge **212** and a trailing edge **214**. To move the fan cowl **208** between the stowed position **202** and the deployed position **204**, a hinge assembly **216** is coupled between the leading edge **212** and a fan cage **218** of the aircraft engine **110**. An actuator system **220** (FIGS. **2**C and **2**D) moves (e.g. rotates) the fan cowl **208** via the hinge assembly **216** between the stowed position **202** and the deployed position **204**.

The fan cowl **208** of the illustrated example includes a first fan cowl **222** (e.g., a first door) and a second fan cowl **224** (e.g., a second door). The first fan cowl **222** is movably coupled to the inboard side **200**a (e.g., half) of the aircraft engine **110** and the second fan cowl **224** is movably coupled to the outboard side **200**b (e.g., half) of the aircraft engine **110**. The first fan cowl **222** can move independently from the second fan cowl **224** between the stowed position **202** and the deployed position **204**.

To pivotally couple the first fan cowl **222** to the nacelle **206** (e.g., the fan cage **218**), the hinge assembly **216** includes a first hinge **216**a. The first hinge **216**a is positioned adjacent (e.g., closer to or at) the leading edge **212** of the first fan cowl **222** and enables rotation of the first fan cowl **222** about a first pivot axis **226**. The first pivot axis **226** is non-parallel relative to a centerline **228** of the aircraft engine **110**. To couple the first fan cowl **222** to the fan cage **218**, the first hinge **216**a includes a first bracket **230** (e.g., an L-bracket) and a second bracket **232** (e.g., an L-bracket). The first bracket **230** is located on a first side **228**a of (e.g., below) the centerline **228** of the aircraft engine **110** and the second bracket **232** is located on a second side **228**b of (e.g. above) the centerline **228** of the aircraft engine **110**. The first hinge **216**a includes a first hinge pin **226**a and a second hinge pin **226**b. The first hinge pin **226**a pivotally couples the first fan cowl **222** to the first bracket **230** and the second hinge pin **226**b pivotally couples the first fan cowl **222** to the second bracket **232.**

To rotate the first fan cowl **222** about the first pivot axis **226**, the actuator system **220** (FIGS. 2C and 2D) includes a first actuator **234** and a second actuator **236**. The first actuator **234** and the second actuator **236** have respective first ends **234**a, **236**a that are supported by (e.g., fixed to) the fan cage **218**. A second end **234**b of the first actuator **234** is coupled to a first portion (e.g., a lower portion) of the first fan cowl **222** (e.g., on the first side **228**a of the centerline **228**) and a second end **236**b of the second actuator **236** is coupled to a second portion (e.g., an upper portion) of the first fan cowl **222** (e.g., on the second side **228**b of the centerline

228). Specifically, the second end **234**b of the first actuator **234** and the second end **236**b of the second actuator **236** are mounted (e.g., fixed) to the first fan cowl **222** adjacent (e.g., closer to or at) the trailing edge **214** of the first fan cowl **222**. The first and second actuators **234**, **236** are hydraulic actuators (e.g., hydraulic pistons). However, in some examples, the first and second actuators **234**, **236** can be pneumatic actuators, electric actuators, and/or any other actuator(s) to rotate the first fan cowl **222** to the deployed position **204** and maintain the first fan cowl **222** in the deployed position **204** during a landing event.

Likewise, to pivotally couple the second fan cowl **224** to the nacelle **206** (e.g., the fan cage **218**), the hinge assembly **216** includes a second hinge **216**b. The second hinge **216b** is positioned adjacent (e.g., closer to or at) the leading edge **212** of the second fan cowl **224** and enables rotation of the second fan cowl **224** about a second pivot axis **238**. The second pivot axis **238** is non-parallel relative to the centerline **228** of the aircraft engine **110**. To couple the second fan cowl **224** to the fan cage **218**, the second hinge **216**b includes a third bracket **240** (e.g., an L-bracket) and a fourth bracket **242** (e.g., an L-bracket). The third bracket **240** is located on the first side **228**a of (e.g., below) the centerline **228** of the aircraft engine **110** and the fourth bracket **242** is located on the second side **228**b of (e.g. above) the centerline **228** of the aircraft engine **110**. The second hinge **216**b includes a third hinge pin **238**a and a fourth hinge pin **238**b. The third hinge pin **238**a pivotally couples the second fan cowl **224** to the third bracket **240** and the third hinge pin **238**a pivotally couples the second fan cowl **224** to the fourth bracket **242**. To rotate the second fan cowl **224** about the second pivot axis **238**, the actuator system **220** (FIGS. **2**C and **2**D) includes a third actuator **244** and a fourth actuator **246**. The third actuator **244** and the fourth actuator **246** have respective first ends **244**a, **246**a that are supported by (e.g., fixed to) the fan cage **218**. A second end **244**b of the third actuator **244** is coupled to a first portion (e.g., a lower portion) of the second fan cowl **224** (e.g., located on the first side **228**a of the centerline **228**) and a second end **246**b of the fourth actuator **246** is coupled to a second portion (e.g., an upper portion) of the second fan cowl **224** (e.g., located on the second side **228**b of the centerline **228**). The second end **244**b of the third actuator **244** and the second end **246**b of the fourth actuator **246** are mounted (e.g., fixed) to the second fan cowl **224** adjacent (e.g., closer to or at) the trailing edge **214** of the second fan cowl **224**. The third and fourth actuators **244**, **246** are hydraulic actuators (e.g., hydraulic pistons). However, in some examples, the third and fourth actuators **244**, **246** can be pneumatic actuators, electric actuators, and/or any other actuator(s) to rotate the second fan cowl **224** to the deployed position **204** and maintain the second fan cowl **224** in the deployed position **204** during a landing event.

Thus, first fan cowl **222** is symmetric or a mirror image of the second fan cowl **224** relative to the centerline **228** (e.g., or a vertical plane passing through the centerline **228**). In contrast to known fan cowls, which pivot about an upper hinge located adjacent a pylon **248** of the aircraft engine **110**, the trailing edges **214** of the first and second fan cowls **222** and **224** rotate in a direction away from the centerline **228** about the respective first and second pivot axes **226**, **238** positioned along the leading edge **212** of the respective first and second fan cowls **222**, **224**. For example, in the deployed position **204**, the trailing edges **214** are outboard of the leading edges **212**.

To further interrupt or affect airflow to increase drag when the fan cowl **208** is in the deployed position **204**, the first fan cowl **222** and the second fan cowl **224** of the illustrated example includes kicker plates **250** and chines **252**. The kicker plates **250** are located adjacent the trailing edge **214** of the respective first and second fan cowls **222**, **224**. The chines **252** are located at respective lateral edges **254** of the first fan cowl **222** and the second fan cowl **224** between the respective leading and the trailing edges **212**, **214**. The kicker plates **250** are movably (e.g., pivotally) coupled to respective first and second fan cowls **222**, **224** and the chines **252** are fixed to the first and second fan cowls **222**, **224**.

Referring to FIG. 2A, the fan cowl **208** (e.g., the first and second fan cowls **222**, **224**) provides an aerodynamic surface when the fan cowl **208** is in the stowed position **202** (e.g., when the first and second fan cowls **222**, **224** are in the stowed

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position **202**). In the stowed position **202**, the fan cowl **208** and the engine cowl **210** provide a continuous surface **256** of the nacelle **206** such that an outer surface **258** of the fan cowl **208** is substantially flush relative to an outer surface **260** of the engine cowl **210**. Further, an outer surface **262** of the kicker plates **250** are flush relative to the outer surface **260** of the fan cowl **208** and the engine cowl **210**. Thus, the fan cowl **208**, the kicker plates **250** and the engine cowl **210** provide a uniform or substantially smooth (e.g., aerodynamic) surface of the nacelle **206**.

Referring to FIG. **2**B, in the deployed position **204**, the first and second fan cowls **222**, **224** rotate outwardly relative to the aircraft engine **110** into an airflow stream to increase drag and provide an air brake to reduce a speed of the aircraft **100** during at least a portion of a landing event. Specifically, the trailing edges **214** of the first and second fan cowls **222**, **224** move (e.g., rotate) in a direction away from the fan cage **218** and toward the leading edge **212** (e.g., a fore end of the aircraft **100**). For example, the first and second fan cowls **222**, **224** are substantially perpendicular to an airflow stream when the first and second fan cowls **222**, **224** are in the deployed position **204**. In other words, the trailing edges **214** of the first and second fan cowls **222**, **224** rotate relative to the respective leading edges **212** via the hinge assembly **216** and the actuator system **220**. The first and second fan cowls **222**, **224** increase drag when the first and second fan cowls **222**, **224** are in the deployed position **204** compared to when the first and second fan cowls **222**, **224** are in the stowed position **202**.

FIGS. **3**A and **3**B are front views of the aircraft engine **110** of FIGS. **1** and **2**A-**2**D. FIG. **3**A is a front view of the aircraft engine **110** of FIGS. **2**A and **2**B showing the air brake system **124** in the stowed position **202**. FIG. **3**B is a front view of the aircraft engine **110** of FIGS. **2**C and **2**D showing the air brake system **124** in the deployed position **204**. In operation, a pitch of the fan blades **118** of the variable pitch fan **116** is adjusted (e.g., varied) to provide reverse thrust to slow down the aircraft **100** during landing. The air brake system **124** (e.g., the fan cowl **208**) is deployed to increase drag and further reduce the speed of the aircraft **100** during landing. The wheel brakes **122** (FIG. **1**) are also activated to stop the aircraft **100**. After the aircraft **100** has stopped and/or a speed of the aircraft **100** is reduced below a predetermined speed threshold (e.g., a predetermined speed), the fan cowl **208** is moved to the stowed position **202**. In some instances, upon landing, both the fan blades **118** and the air brake system **124** can be used to supplement the wheel brakes **122**. In some instances, the fan cowl **208** is deployed during landing only if additional braking force is needed. In some examples, the variable pitch fan **116** provides a majority of reverse thrust required to stop or decelerate the aircraft **100**, whereas the air brake system **124** supplements the variable pitch fan **116**. In some examples, the air brake system **124** can be used in combination with the wheel brakes **122** and/or the parachute system **126**. In some examples, the air brake system **124** provides approximately between **75**% and **85**% (e.g., **80**%) of a braking force and the wheel brakes **122** provide approximately between **15**% and **25**% (e.g., **20**%) of a braking force to stop an aircraft (e.g., the aircraft **100**) during a landing event.

In the deployed position **204** shown in FIG. **3**B, the trailing edge **214** of the first fan cowl **222** pivots about the first pivot axis **226** and the trailing edge **214** of the second fan cowl **224** pivots about the second pivot axis **238**. Specifically, the trailing edges **214** of the first and second fan cowls **222**, **224** extend away from the fan cage **218**. The trailing edges **214** of the respective first and second fan cowls **222**, **224** are positioned at a distance farther from the fan cage **218** when the fan cowl **208** is in the deployed position **204** than when the fan cowl is in the stowed position **202**. Additionally, in the deployed position **204**, the trailing edges **214** of the first and second fan cowls **222**, **224** are positioned farther from the fan cage **218** than the leading edges **212** of the first and second fan cowls **222**, **224**. For example, the fan cowl **208** has a first dimension **302** (e.g., a first width) when the fan cowl **208** is in the stowed position **202** and a second dimension **304** (e.g., a second width) when the fan cowl **208** is in the deployed position **204**, the second dimension **304** is greater than the first dimension **302**. The kicker plates **250** provide a third dimension **306** (e.g., a third width) of the fan cowl **208** that is greater than the second dimension

304. The first dimension **302**, the second dimension **304** and the third dimension **306** are perpendicular (e.g., horizontal) relative to the centerline **228** (FIGS. **2**A-**2**D) of the aircraft engine **110** in the orientation of FIGS. **3**A and **3**B.

The brake system controller **130** (FIG. **1**) operates the fan cowl **208** during landing. In some instances, the brake system controller **130** causes the first fan cowl **222** to move to the deployed position **204** simultaneously with the second fan cowl **224**. Such simultaneous deployment is advantageous when crosswind conditions do not affect landing of the aircraft **100**. In some such examples, to reduce (e.g., minimize or eliminate) the effects of crosswind on the aircraft **100**, the brake system controller **130** deploys the first fan cowl **222** prior to deploying the second fan cowl **224**. In this manner, crosswind effects can be reduced. For example, during crosswind conditions, deploying the second fan cowl **224** prior to, or simultaneously with, the first fan cowl **222** can alter an orientation of the aircraft **100** relative to a runway. Deploying the first fan cowl **222** (e.g., an inboard fan cowl) prior to the second fan cowl **224** (e.g., an outboard fan cowl) reduces a torque that can otherwise be imparted to the aircraft **100** by the crosswind. Regardless of a fan cowl deployment sequence (i.e., simultaneously or inboard prior to outboard), the aircraft engine **112** mirrors the deployment pattern of the aircraft engine **110**. In other words, a deployment pattern of the first and second fan cowls **222**, **224** of the aircraft engine **110** is symmetrical to a deployment sequence of the first and second fan cowls of the aircraft engine **112**.

FIG. **4**A is a partial, side view of the empennage of the aircraft **100** of FIG. **1**. FIG. **4**B is a partial, perspective view of the empennage **114** of the aircraft **100** of FIG. **1**. The parachute system **126** of the illustrated example is located or positioned in (e.g., supported by) the empennage **114** of the aircraft **100**. The parachute system **126** of the illustrated example deploys from an opening **400** (e.g., a vent) defined in the empennage **114**. To activate the parachute system **126**, the parachute system **126** includes an air injection system **402**. The air injection system **402** of the illustrated example includes a passageway **404** (e.g., a pipe) and a door

406. The passageway **404** can be provided via a duct, a hose, a channel, and/or any other passageway. The door **406** (e.g., a valve) is formed on the fuselage **104** and moves between a closed position **408** to prevent airflow to the passageway **404** and an open position **410** to allow airflow through the passageway **404**. The parachute system **126** can be positioned adjacent an auxiliary power unit (APU) **412** in the empennage **114** of the aircraft **100**. In some examples, the parachute system **126** can include a dedicated storage area spaced from or isolated from the APU **412**.

FIGS. **5**A and **5**B are partial, perspective cut-away views of the parachute system **126** of FIG. **4**. FIG. **5**A illustrates the parachute system **126** in a deployed position **500**. FIG. **5**B illustrates the parachute system **126** in a stowed position **502**. To move the parachute system **126** between the deployed position **500** and the stowed position **502**, the parachute system **126** includes a parachute launching system **504** and a parachute retrieval system **506**. The parachute launching system **504** includes the air injection system **402** and a launch tube **510**. Specifically, the parachute launching system **504** is configured to deploy a parachute **508** from a folded or packed condition (e.g., the stowed position **502** FIG. **5**B) positioned within the launch tube **510** to an unfolded condition (e.g., the deployed position **500** of FIG. **5**A) in an airstream of the aircraft **100** during landing.

To receive the parachute **508** when the parachute **508** is in the folded condition, the launch tube **510** includes a passageway or opening **516** between a first end **510a** of the launch tube **510** and a second end **510b** of the launch tube **510**. In the folded position (e.g., the stowed position **502**), at least a portion of the parachute **508** is positioned inside the opening **516** of the launch tube **510**. The launch tube **510** of the illustrated example includes a first tube **520** (e.g., an inner tube) and a second tube **522** (e.g., an outer tube). The first tube **520** of the illustrated example is (e.g., freely) slidable relative to the second tube **522** between an extended position **524** (FIG. **5**A) and a retracted position **526** (FIG. **5**B). The second tube **522** of the illustrated example is fixed to (e.g., a frame of) the empennage **114** or the fuselage **104**. The launch tube **510** includes a flared end **511** adjacent the first end **510**a to facilitate retrieval and/or deployment of the parachute **508**.

The first tube **520** has an outer diameter that is less than an inner diameter of the second tube **522**. Specifically, the first tube **520** moves (e.g., slides) from the retracted position **526** to the extended position **524** based on atmospheric air **501** provided to the launch tube **510** by the air injection system **402**. Specifically, the passageway **404** of the air injection system **402** is fluidically coupled to the opening **516** the launch tube **510** to direct airflow from the atmosphere to the opening **516** of the launch tube **510**. In particular, the passageway **404** of the illustrated example is fluidically coupled to the second tube **522** via a coupling **528**. For example, the coupling **528** is a T-shaped coupling when coupled or formed with the second tube **522**. In some examples, the passageway **404** can be directly coupled to the second end **510**b of the launch tube **510** and the atmospheric air **501** can be provided through the opening **516** at the second end **510**b of the launch tube **510**. The atmospheric air **501** causes the first tube **520** to slide from the retracted position **526** to the extended position **524** and causes the parachute **508** to unfold from the stowed position **502** in the first tube **520** to the deployed position **500**.

To retrieve the parachute after the parachute **508** is unfolded from the launch tube **510**, the parachute system **126** of the illustrated example includes the parachute retrieval system **506**. The parachute retrieval system **506** includes a reel **530** configured to pull the parachute **508** from the deployed position **500** to the stowed position **502** through the opening **516** of the launch tube **510**. To pull the parachute **508** from the deployed position **500** to the stowed position **502** via the reel **530**, the parachute retrieval system **506** includes a first cable **532**. The first cable **532** has a first end **532**a coupled to an inner surface **534** (e.g., an apex or center **534**a) of the parachute **508** and a second end **532**b opposite the first end **532**a coupled to a first drum **536** of the reel **530**. The first cable **532** passes through the opening **516** of the launch tube **510**. The first cable **532** is attached to the center **534**a of the parachute **508** to control a deployment and/or stow sequence and/or deployment and/or stow speed of the parachute system **126**. For example, the first cable **532** is attached to the center **534**a of the parachute **508** to control an unfolding pattern of the parachute **508** during a deployment operation and a folding pattern of the parachute **508** during a stowing operation.

Additionally, to maintain a shape of the parachute **508** when the parachute **508** is in the deployed position **500**, the parachute retrieval system **506** of the illustrated example includes a plurality of cables **540** coupled to a peripheral edge **542** of the parachute **508**. For example, the parachute retrieval system **506** includes a second cable **544** and a third cable **546**. The second cable **544** has a first end **544**a coupled to a first portion **542**a of the peripheral edge **542** of the parachute **508** and a second end **544**b coupled to a second drum **548** of the reel **530**. Likewise, the third cable **546** has a first end **546**a coupled to a second portion **542**b of the peripheral edge **542** of the parachute **508** and a second end **546**b coupled to a third drum **550** of the reel **530**. Each of the second and third cables **544**, **546** is positioned outside of the launch tube **510**. In other words, the second and third cables **544**, **546** do not pass inside the opening **516** (e.g., passageway) through an entire length of the launch tube **510** (i.e., in contrast to the first cable **532**). To guide or space the second and third cables **544**, **546**, the parachute system includes a guide **552** (e.g., a spacer ring). The guide **552** is supported by the launch tube **510**. For example, the guide **552** is coupled (e.g., fixed or attached) to the first tube **520**. The guide **552** slidably receives the second and third cables **544**, **546** and does not interfere with a parachute deployment operation and/or a parachute retrieval operation. The guide **552** also maintains a travel path of the second and third cables **544**, **546** and/or prevents the second cable **544** from intertwining with the third cable **546** during a parachute deployment operation and/or a parachute retrieval operation. Although only the second and third cables **544**, **546** are shown, in some examples, the parachute system **126** can include more than the second and third cables **544**, **546** coupled to different locations of the peripheral edge **542** of the parachute **508** and the guide **552**.

To retrieve the parachute **508** from the deployed position **500**, the parachute retrieval system **506** of the illustrated example includes a reel drive **554** to operate the reel **530**. The reel drive **554** of the illustrated example includes a motor **556** (e.g., an electric motor) and a transmission **558** (e.g., a gear train). The reel drive **554** of the illustrated example rotates the reel **530** in a first rotational direction (e.g., a clockwise direction in the orientation of FIGS. **5**A and **5**B) to wind the first, second and third cables **532**, **544**, **546** about the respective drums **536**, **548**, **550** to fold the parachute **508** to stowed position **502**. As the reel drive **554** rotates the reel **530** to wind the first, second, and third cables **532**, **544**, **546** about the respective drums **536**, **548**, **550**, engagement between the parachute **508** and the first tube **520** causes the first tube **520** to move the retracted position **526**. In the retracted position **526**, the first tube **520** causes the parachute **508** to fold (e.g., furl) in the opening **516** of the launch tube **510** as the reel drive **554** continues to rotate the reel **530** to cause the first, second, and third cables **532**, **544**, **546** to wind about the respective drums **536**, **548**, **550**. The parachute retrieval system **506** can include one or more sensors (e.g., an optical sensor, a rotary sensor, an encoder, an optical rotary sensor, etc.) to determine when the parachute **508** is in the stowed position **502** and stop operation of the motor **556**. The parachute retrieval system **506** retrieves the deployed parachute **508** and furls the parachute **508** in the stowed position **502** for subsequent use. In the stowed position **502**, at least a portion (e.g., the second ends **544**b, **546**b,) of the second and third cables **544**, **546** can be positioned in the opening **516** of the launch tube **510** via the first end **510**a of the opening **516** when the parachute **508** is in the stowed position **502** (FIG. **5**B).

Additionally, as noted above, the first cable **532** controls the stowing sequence of the parachute **508**. In other words, the first cable **532** being connected to the center **534**a of the inner surface **534** enables a furling pattern when stowing the parachute **508** in the launch tube **510**. When furling the parachute to the stowed position, the first cable **532** causes the center **534**a of the parachute **508** to enter the launch tube **510** prior to the peripheral edge **542** of the parachute **508**. In other words, the parachute **508** inverts or is turned inside out during the stowing operation.

Such configuration provides for automatic stowage of the parachute **508** within the launch tube **510** which enables subsequent use of the parachute **508** (e.g., without requiring a maintenance personnel to manually pack or furl the parachute **508** into the launch tube **510**). In particular, the systems describe herein provide for a parachute **508** that can be automatically re-packed within the launch tube **510** without the need for maintenance personnel to manually re-pack the parachute **508**.

Additionally, the reel (e.g., the first, second and third drums **536**, **548**, **550**) rotates freely to unfurl the parachute **508** during a deployment operation. For example, the transmission **558** can include a clutch to allow the reel **530** to rotate freely when the first, second and third cables unwind from the respective first, second and third drums **536**, **548**, **550**. To deploy the parachute **508**, the reel **530** rotates in a second rotational direction (e.g., a counterclockwise direction in the orientation of FIG. **5**B).

FIGS. **6**-**9** illustrate a deployment sequence operation of the parachute launching system **504** of FIGS. **1**, **5**A and **5**B. Referring to FIG. **6**, in operation, the brake system controller **130** (FIG. **1**) activates the parachute launching system **504** to deploy the parachute **508**. To deploy the parachute **508**, the door **406** of the air injection system **402** moves to the open position **410** to allow atmospheric air in the launch tube **510**. The atmospheric air causes the first tube **520** to slide relative to the second tube **522** from the retracted position **526** to the extended position **524**. Additionally, the reel drive **554** allows the reel **530** to rotate freely to enable the first, second and third cables **532**, **544**, **546** to unwind from the respective first, second and third drums **536**, **548**, **550**. In some examples, a clutch is activated to enable the reel **530** to rotate freely. In some examples, the reel drive **554** is configured to allow the reel **530** to rotate freely in a first rotational direction only to enable deployment of the parachute **508**.

Referring to FIG. **7**, as the atmospheric air continues to enter into the launch tube **510**, the atmospheric air causes the parachute **508** to exit the first tube **520**. Specifically, because the parachute **508** is turned inside-out when stored in the first tube **520**, the peripheral edge **542** of the parachute **508** exits first from first tube **520**. The second and third cables **544**, **546** cause the peripheral edge **542** to turn (e.g., curl) to unfurl the parachute **508** outside-side in. As the parachute **508** starts to take form, airflow **700** from an airstream facilitates removal of the parachute **508** from the launch tube **510**. The guide **552** prevents the second and third cables **544**, **546** from becoming entangled during deployment of the parachute **508**.

Referring to FIG. **8**, the second and third cables **544**, **546** guide the deployment and/or formation of the parachute **508** as the parachute **508** unfurls from the stowed position **502** to the deployed position **500**. Referring to FIG. **9**, the center **534**a is the last portion of the parachute **508** to exit the launch tube **510**.

FIG. **10** illustrates the parachute **508** in the deployed position **500**. In the deployed position **500**, the parachute **508** has a dimension **1000** (e.g., a diameter) of approximately between **15** feet and **25** feet (e.g., **20** feet). Additionally, the parachute **508** is a distance **1002** between approximately between **2** feet and **15** feet above the ground or runway **144** (e.g., approximately **5** feet).

FIGS. **11-14** illustrate a sequence for moving the parachute **508** from the deployed position **500** of FIG. **10** to the stowed position **502** of FIG. **5**B. To stow the parachute **508**, the brake system controller **130** (FIG. **1**) causes the door **406** of the air injection system **402** to move to the closed position **408**. Additionally, the brake system controller **130** activates the parachute retrieval system **506**. For example, the brake system controller **130** activates the motor **556** to cause the reel **530** to rotate in a wind direction. The transmission **558** of the reel drive **554** is engaged to enable the motor **556** to rotate the reel **530** (e.g., in a wind direction). In some examples, a clutch of the transmission **558** is activated to operatively couple the reel **530** and the transmission **558** to prevent the reel **530** from rotating freely when the motor **556** activates to cause the first, second and third cables **532**, **544**, **546** to wind about the respective first, second and third drums **536**, **548**, **550**.

Referring to FIG. **11**, the first cable **532** is positioned through the opening **516** of the launch tube **510** to cause the center **534**a of the parachute **508** to enter the launch tube **510** prior to the peripheral edge **542** entering the launch tube **510**. In other words, the center **534**a is inverted in the stowed position **502** relative to the deployed position **500**. To enable the center **534**a to enter prior to the peripheral edge **542**, the reel drive **554** rotates the first drum **532** to wind the first cable **532**. In some examples, the reel drive **554** operates the first drum **532** to rotate at a rate (e.g., rpm) greater than a rate of the second and third drums **548**, **550**. In some examples, the first, second and third drums **536**, **548**, **550** rotate at the same rate.

Referring to FIG. **12**, after center **534**a enters the first tube **520**, the reel drive **554** continues to rotate the reel **530**. As the first, second and third cables **532**, **544**, **546** wind about the respective first, second and third drums **536**, **548**, **550**, the parachute **508** is drawn into the first tube **520**. The guide **552** continues to guide the second and third cables **544**, **546** to prevent the second and third cables **544**, **546** from intertwining as the parachute **508** is packed to the stowed position **502**.

Referring to FIG. **13**, the peripheral edge **542** of the parachute **508** is the last portion of the parachute **508** to enter the launch tube **510**. The first, second and third cables **532**, **544**, **546** enable the stowing pattern.

Referring to FIG. **14**, the reel drive **554** continues to rotate the reel **530** to cause the first tube **520** to slide relative to the second tube **522** to the retracted position **524**. The brake system controller **130** deactivates the reel drive **554** when the parachute system **126** is in the stowed position **502**. The parachute **508** is ready to be deployed for subsequent use. Thus, the parachute retrieval system **506** furls the parachute **508** in the launch tube **510** for subsequent use without having to manually repack the parachute **508** in the launch tube **510**.

FIGS. **15-17** illustrate another parachute system **1500** that can implement the parachute system **126** of FIG. **1**. FIG. **15** illustrates the parachute system **1500** in a stowed position **1502**. FIG. **16** illustrates the parachute system **1500** in an intermediate position **1600**. FIG. **17** illustrates the parachute system **1500** in a deployed position **1700**. Referring to FIG. **15**, the parachute system **1500** of the illustrated example includes a parachute **1504** supported by a frame **1506** (e.g., a flexible frame). The frame **1506** provides or defines a shape of the parachute **1504** when the parachute **1504** is in the deployed position **1700** and/or the stowed position **1502**.

The frame **1506** includes a plurality of arms **1508** (e.g., flexible arms, spindles, etc.) to support the parachute **1504** and a central shaft **1510** to support the plurality of arms **1508**. For example, first ends **1512** of the arms **1508** are attached to the central shaft **1510** and respective second ends **1514** of the arms **1508** are attached to a peripheral edge **1504**a of the parachute **1504**. The first ends **1512** of the arms **1508** are coupled to the central shaft **1510** via a collar **1516**. The collar **1516** of the illustrated example is slidably coupled to the central shaft **1510**.

The parachute system **1500** includes a housing **1518** to house the parachute **1504**. The housing **1518** is to be positioned in an empennage (e.g., the empennage **114** of FIG. **1**) of an aircraft (e.g., the aircraft **100** of FIG. **1**). In some examples, the housing **1518** can be aligned with the opening **400** of the empennage **114** of FIG. **4**.

To move the parachute **1504** between the stowed position **1502** (e.g., as shown, for example, in FIG. **15**) and the deployed position **1700** (e.g., as shown, for example, in FIG. **17**), the parachute system **1500** includes a parachute launching/retrieval system **1520**. The parachute launching/retrieval system **1520** includes a first drive **1520**a and a second drive **1520**b. However, in other examples, the parachute system **1500** can include only one drive to deploy and/or stow the parachute **1504**. In other examples, the parachute system **1500** can include more than two drives to deploy and/or stow the parachute **1504**.

The first drive **1520**a moves the parachute **1504** in a rectilinear direction (e.g., a sideways or horizontal direction in the orientation of FIG. **15**) relative to the housing **1518** (e.g., or empennage) between a retracted position **1522** (e.g., shown in FIG. **15**) and an extended position **1702** (e.g., shown in FIG. **17**). To move the parachute **1504** in a rectilinear direction, the first drive **1520**a includes a motor **1524** and a transmission **1526**. The transmission **1526** transfers rotary motion of a shaft **1528** of the motor **1524** to linear motion of the parachute **1504** relative to the housing **1518** (e.g., via a gear train). For example, the transmission **1526** includes a rack and pinion configuration **1530** to move the parachute **1504** from the retracted position **1522** to the extended position **1702**. For example, a pinion gear **1530**a is coupled to the shaft **1528** of the motor **1524** and a rack gear **1530**b is coupled to the central shaft **1510**. In some examples, the transmission **1526** includes one or more gears (spur gears, bevel gears, etc.), chains, sprockets, pulleys belts and/or any other gear train system(s) for moving the parachute between the retracted position **1522** and the extended position **1702**.

The second drive **1520**b moves the parachute **1504** between a collapsed position **1532** shown in FIG. **15** and an expanded position **1704** (e.g., an unfolded or open position) shown in FIG. **17** via the collar **1516**. Specifically, the second drive **1520**b moves the collar **1516** along the central shaft **1510** to cause the parachute **1504** to move from the collapsed position **1532** and the expanded position **1704**. To extend the parachute **1504**, the second drive **1520**b moves the collar **1516** along the central shaft **1510** in a direction away from the housing **1518** in the orientation of FIGS. **15-17**. As the collar **1516** moves along the central shaft **1510** away from the housing **1518**, the peripheral edge **1504**a of the parachute **1504** moves outwardly away from the central shaft **1510** to form a cup shape as shown in the expanded position **1704**. To collapse the parachute **1504**, the second drive **1520**b moves the collar **1516** along the central shaft **1510** in a direction toward the housing **1518** in the orientation of FIGS. **15-17**. As the collar **1516** moves along the central shaft **1510** in a direction toward the housing **1518**, the peripheral edge **1504**a moves inwardly toward the central shaft **1510** to the collapsed position **1532**. In the collapsed position **1532**, the parachute **1504** is in an inside-out orientation. Thus, the parachute **1504** inverts when the parachute **1504** moves from the expanded position **1704** to the collapsed position **1532**.

To move the collar **1516** along the central shaft **1510**, the second drive **1520**b includes an actuator **1536** operatively coupled to the collar **1516**. A control system (e.g., the brake system controller **130** of FIG. **1**) commands the actuator **1536** to extend or retract an arm **1536**a coupled to the collar **1516** to move the collar **1516** along the central shaft **1510** and, thus, move the parachute **1504** between the expanded position **1704** and the collapsed position **1532**. The second drive **1520**b can be carried by the central shaft **1510** and/or the first drive **1520**a. For example, the second drive **1520**b can be supported by the rack gear **1530**b.

Referring to FIG. **16**, the first drive **1520**a and the second drive **1520**b operate concurrently to move the parachute **1504** between the stowed position **1502** and the deployed position **1700**. In other words, the first drive **1520**a can operate simultaneously with the operation of the second drive member **1520**b as the parachute **1504** moves between the stowed position **1502** and the deployed position **1700**. In some instances, the first drive **1520**a does not operate concurrently with the operation of the second drive **1520**b. In some such instances, the first drive **1520**a operates to move the parachute **1504** from the retracted position **1532** to the extended position **1702**. Subsequently, or after the parachute **1504** is in the extended position **1702**, the second drive **1520**b operates to move the collar **1516** to cause the parachute **1504** to move from the collapsed position **1532** to the expanded position **1704**. The operation of the first drive **1520**a and the second drive **1520**b are reversed to move the parachute **1504** from the deployed position **1700** to the stowed position **1502**. Similar to the parachute system **126** of FIG. **1**, the parachute system **1500** of FIGS. **15-17** enables automated packing of the parachute **1504** for subsequent use without requiring personnel to manually repack the parachute **1504** in the housing **1518**.

FIG. **18** is another aircraft **1800** having another parachute system **1802** disclosed herein. The aircraft **1800** of the illustrated example includes an empennage **1804** having a first portion **1806** to store the parachute system **1802** and a second portion **1808** to store an APU system (e.g., the APU **412** of FIG. **4**). The first portion **1806** is isolated or separate from the second portion **1808**. The first portion **1806** can include the parachute system **126** of FIGS. **1**, **5**A, **5**B and **6-14** or the parachute system **1500** of FIGS. **15-17**.

FIG. **19** is a top view of the example aircraft **100** of FIG. **1**. The aircraft **100** of the illustrated example includes the emergency brake system **128**. The emergency brake system **128** includes a brake **1900** positioned between a nose **1902** and a tail **1904** of the aircraft **100**. The brake **1900** has a first dimension **1906** (e.g., a length parallel to a longitudinal axis **1908** of the aircraft **100**) and a second dimension **1910** (e.g., a width perpendicular to the longitudinal axis **1908** of the aircraft). In some examples, the first dimension **1906** is approximately between **5** feet and **30** feet (e.g., **10** feet) and the second dimension is approximately between **5** feet and **15** feet (e.g., **10** feet). The brake **1900** of the illustrated example has a rectangular shape. In some examples, the brake **1900** can have a square shape and/or any other shape. For example, a greater surface of area of the brake **1900** (e.g., defined by the first dimension **1906** and the second dimension **1910** the shorter a stopping distance provided by the brake **1900**. For example, a brake having a surface area of **49** square feet can provide an aircraft weighing **41,000** Kg and moving at **12** knots a stopping distance of between approximately **770** meters and **775** meters and a brake having a surface area of **100** square feet can provide a stopping distance of between approximately **1540** meters and **1550** meters. In some examples, the brake **1900** can generate approximately between **4** and **5** G-force of negative thrust during deployment or operation. Additionally, the brake **1900** can be deployed to generate such negative thrust more quickly than, for example, reverse thrusters.

FIG. **20**A is a side view of the example aircraft of FIG. **19** illustrating the emergency brake system in an example stowed position **2001**. The brake **1900** is stored at a lower surface of the fuselage **104**. In some examples, the brake **1900** is stored at a belly of the fuselage **104**. The brake **1900** is covered by a cover **2003** (e.g., an aluminum skin). In some such examples, the cover **2003** is removed via a cover actuator **2005** (e.g., a drag chute, a pyrotechnic actuator, an airbag actuator, etc.). In some examples, movement of the brake **1900** to a deployed position **2000** (FIG. **2**B). In some examples, the fuselage **104** includes doors that open to deploy the brake **1900**.

FIG. **20**B is a side view of the aircraft **100** showing the brake **1900** in a deployed position **2000**. The brake **1900** includes a frame **2002** (e.g., a sled, a housing, a hub, etc.) to support a brake pad **2004** and pivot arms **2006** (e.g., braces or links) that pivot the brake **1900** from a stowed position to the deployed position **2000**. In some examples, the brake pad **2004** includes a plurality of brake pads. The pivot arms **2006** are coupled (e.g., pivotally coupled) to the fuselage **104**. To form a seal between the brake pad **2004** and the surface **142** of the runway **144**, the brake **1900** of the illustrated example includes a plurality of actuators **2012** (e.g., suction generators). The actuators **2012** of the illustrated example generate a vacuum between the brake pad **2004** and the surface **142** to form a seal around or within a peripheral boundary or peripheral edge **2004**a (e.g., a perimeter) (FIG. **21**) of the brake pad **2004** when the brake pad **2004** is in engagement with the surface **142**. For example, the actuators **2012** of the illustrated example can be pyrotechnic actuators (e.g., airbag actuators), pneumatic actuators, vacuum generators, and/or any other type of actuator to provide a seal at a peripheral edge **2004**a of the brake pad **2004**. Additionally, to cause downward airflow and/or a force on the frame **2002** during operation, the brake **1900** includes airfoils **2016**. The airfoils **2016** are formed on or supported by the pivot arms **2006**. However, in other examples, the airfoils **2016** can be formed on or supported by the frame **2002** and/or another portion of the brake **1900** or the aircraft **100**.

FIG. **21** is a partial, perspective view of the brake **1900** illustrates a pad surface **2100** of the brake pad **2004**. The brake pad **2004** includes a plurality of raised surfaces or protrusions **2102** to increase friction between the brake pad **2004** and the surface **142**. To fluidly couple the actuators **2012** and the pad surface **2100**, the brake pad **2004** includes a plurality of openings **2104**. Respective ones of the openings **2104** fluidly couple to respective ones of the actuators **2012**. In this manner, the actuators **2012** apply a vacuum to generate a force to pull the brake **1900** against (e.g., to seal against) the surface **142** of the runway **144**. The brake pad **2004** include a non-asbestos organic (NAO) material, glass, fiber, rubber, carbon, Kevlar and/or any other suitable material(s).

FIG. **22** is a partial, perspective view of the brake **1900** in the deployed position **2000**. Each of the actuators **2012** include a hose or tube **2202** to fluidly couple a respective one of the openings **2104** (FIG. **21**) to a canister **2204** of the actuator **2012**. In some examples, the canister **2204** contains the pyrotechnic material(s). Also, in some examples, the canister **2204** can be located in the fuselage **104** of the aircraft. In some examples, the canister **2204** can be positioned on a surface of the fuselage **104**. The tube **2202** is coupled to the frame **2002** via a connector **2206**. In some examples, the connector **2206** includes or houses the pyrotechnic material to generate a vacuum at the pad surface **2100**. In some such examples, the tube **2202** is removed.

The brake **1900** of the illustrated example can be deployed to prevent runway excursions. The brake system controller **130** of FIG. **1** is configured to deploy the brake **1900** automatically (e.g., without pilot or crew input) during an emergency. In some examples, the brake **1900** can be deployed manually by a pilot or crew via an actuator in the cockpit of the fuselage **104**.

FIG. **23**A is a schematic illustration of the brake system controller **130** of FIG. **1**. FIG. **23**B is a schematic illustration of the hazardous condition identifier **2308**. The example brake system controller **130** of the illustrated example includes an example brake system monitor **2302**, an example airspeed determiner **2304**, an example crosswind determiner **2306**, and an example hazardous condition identifier **2308**, an example weight on wheels determiner **2310**, an example air brake operator **2312**, an example parachute operator **2314**, an example emergency brake operator **2316**, and an example data store **2318**, and a landing event activator **2320**. The brake system monitor **2302** includes an example comparator **2322**. The comparator **2322** can be implemented by one or more comparators. In some examples, the example brake system monitor **2302**, the example airspeed determiner **2304**, the example crosswind determiner **2306**, the example hazardous condition identifier **2308**, the example weight on wheels determiner **2310** , the example air brake operator **2312**, the example parachute operator **2314**, the example emergency brake operator **2316**, the example data store **2318**, the landing event activator **2320**, and the alarm generator **2346** are in communication via a communication bus **2324**.

The hazardous condition identifier **2308** includes an example signal processor **2301**, an example map constructor **2303**, an example GPS processor **2305**, an example inertial measurement unit **2309**, and a predictive modeler **2307**.

The example brake system monitor **2302** of the illustrated example analyzes signals from the airspeed determiner **2304**, the crosswind determiner **2306**, the hazardous condition identifier **2308**, the weight on wheels determiner **2310**, the landing event activator **2320** and/or other parameters provided from, for example, the engine control system **132** of FIG. **1**, an air traffic control tower and/or any other sensor(s) sensors of the aircraft **100** of FIG. **1**. For example, the signals received by the brake system monitor **2302** and/or by the airspeed determiner **2304**, the crosswind determiner **2306**, the hazardous condition identifier **2308**, the weight on wheels determiner **2310** and the landing event activator **2320** can be binary value(s) (e.g., on/off), digital value(s) (e.g., binary bit "**1**" or "**0**"), and/or analog values. Based on the signals received, the brake system monitor **2302** determines whether to activate the air brake system **124**, the parachute system **126** and/or the emergency brake system **128**. For example, the brake system monitor **2302** is communicatively coupled to, and processes signals from, the airspeed determiner **2304**, the crosswind determiner **2306**, the hazardous condition identifier **2308**, the weight on wheels determiner **2310**, and/or the landing event activator **2320** to determine activation of the brake system **102**.

The brake system monitor **2302** monitors for activation of the air brake system **124** and the parachute system **126** in response to receiving a communication, command or a signal from the landing event activator **2320**. In some examples, the

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landing event activator **2320** provides a first signal to disable the brake system monitor **2302** from monitoring for a landing event or provides a second signal different than the first signal to enable the brake system monitor **2302** to monitor for a landing event. For example, during a take-off event, the landing event activator **2320** disables the brake system monitor **2302** to prevent activation of the air brake system **124** and the parachute system **126**. However, during a landing event, the landing event activator **2320** enables the brake system monitor **2302** to activate or operate the air brake system **124** and the parachute system **126**. The landing event activator **2320** does not disable or affect operation or activation of the emergency brake system **128** when the landing event activator disables the brake system monitor **2302** during a take-off event. Thus, during a take-off event, the brake system monitor **2302** can activate the emergency brake system **128**.

To disable operation of the air brake system **124** and the parachute system **126** during a take-off event, the landing event activator **2320** receives a first input signal (e.g., a binary bit "**0**" value). To enable operation of the air brake system **124** and the parachute system **126** during a landing event, the landing event activator **2320** receives a second input signal (e.g. a binary bit "**1**" value). For example, a pilot may provide the first input signal to disable the air brake system **124** and the parachute system **126** during a take-off event via an input device (e.g., a lever, a button, a touch screen, etc.) in a cockpit of the aircraft **100**.

The brake system monitor **2302** monitors for detection of the aircraft **100** in flight or on the surface **142** in response to receiving a communication, command or a signal from the weight on wheels determiner **2310**. The weight on wheels determiner **2310** of the illustrated example determines whether the aircraft **100** is on the surface **142** or in flight based on signals received from the weight on wheels sensor **136**. For example, the weight on wheels sensor **136** can be configured to output a first signal (e.g., an output signal of the binary bit "**1**") when the wheels **120** of the aircraft **100** are in contact with the surface **142** and a second signal (e.g., an output signal of the binary bit "**0**") when the wheels **120** of the aircraft **100** are not in contact with the surface **142**. The weight on wheels determiner **2310** determines that the aircraft **100** is on the surface **142** based on the first signal received (e.g., an output signal of the binary bit "**1**" from the weight on wheels sensor **136**) and determines that the aircraft **100** is not on the surface **142** based on a second signal received (e.g., an output signal of the binary bit "**0**" from the weight on wheels sensor **136**). Based on the signals received, the weight on wheels determiner **2310** communicates a first signal (e.g., a binary bit "**1**" value) to the brake system monitor **2302** representative of the aircraft **100** being on the surface **142** or communicates a second signal (e.g., a binary bit "**0**" value) to the brake system monitor **2302** representative of the aircraft **100** being in flight. When the brake system monitor **2302** receives the first signal from the weight on wheels determiner **2310** indicative of the aircraft **100** being in flight, the brake system monitor **2302** ignores (e.g., does not process) and/or does not receive signals from the airspeed determiner **2304**, the hazardous condition identifier **2308** and/or the crosswind determiner **2306**. In some examples, when the weight on wheels determiner **2310** detects that the aircraft **100** is in flight, the brake system monitor **2302** can be in a sleep mode to prevent operation of the brake system **102** until the brake system monitor **2302** is activated by the landing event activator **2320**.

The brake system monitor **2302** monitors aircraft speed in response to commands, communication or signals received from the airspeed determiner **2304**. The airspeed determiner **2304** receives output signals from the airspeed sensor **134** and analyzes the signals to determine a speed (e.g., velocity) of the aircraft **100**. For example, the airspeed sensor **134** can be a barometric sensor (e.g., a pitot tube and a static port) that measures a pressure differential between ram air pressure and static pressure. The airspeed determiner **2304** can convert the signals from the airspeed sensor **134** to an electrical signal (e.g., a digital signal, an analog signal, etc.) corresponding to an airspeed of the aircraft **100** based on the signals from the airspeed sensor **134**. For example, the airspeed determiner **2304** can include a pneumatic to current (P/I) converter that converts a pressure reading from the airspeed sensor **134** to a corresponding airspeed value.

The crosswind determiner **2306** receives a crosswind value via parameters provided to the engine control system **132** and/or the brake system controller **130** from other sensors and/or received input(s). For example, an air traffic control center can provide crosswind information to the engine control system **132** and/or the crosswind determiner **2306**. In some examples, information or data (e.g., a reference crosswind value) may be provided to the crosswind determiner **2306** and/or the engine control system **132** via an input/output interface (e.g., a display, a touch screen, a visual indicator, etc.) positioned in a cockpit of the aircraft **100**. In some examples, the aircraft **100** can include sensors (e.g. LIDAR sensors) to measure air velocity and the crosswind determiner **2306** can be configured to measure a crosswind associated with an orientation of the aircraft **100** relative to the runway **144**. The crosswind determiner **2306** communicates a crosswind value to the brake system monitor **2302**.

The brake system monitor **2302** monitors for hazardous conditions in response to commands, communication or signals received from the hazardous condition identifier **2308**. The hazardous condition identifier **2308** monitors or identifies potentially hazardous conditions during a landing event and/or a takeoff event. For example, the hazardous condition identifier **2308** communicates to the brake system monitor **2302** a first signal (e.g., an output signal of the binary bit "**1**") representative of an identified hazardous condition and a second signal (e.g., an output signal of the binary bit "**0**") representative of a hazardous condition not identified or not present.

To monitor for hazardous conditions, the hazardous condition identifier **2308** receives signals from the hazardous condition sensor **138** (e.g., LIDAR sensors) and the GPS sensor **140**. Referring to FIG. **23**B, the signal processor **2301** of the hazardous condition identifier **2308** processes the signal(s) from the hazardous condition sensor **138**. For example, as noted above, the hazardous condition sensor **138** can include one or more LIDAR sensors, radar sensors, sonar sensors and/or high powered camera sensors that detect objects such as vehicles (e.g., aircraft), edges of the runway **144**, etc. The signal processor **2301** receives the signals can converts the signals for processing by the map constructor **2303**. The map constructor **2303** employs software to map an image corresponding to the environment surrounding the aircraft **100** when the aircraft **100** is on the runway **144**. The GPS processor **2305** receives signals from the GPS sensor **140** and information from an inertial measurement unit (IMU) **2309** to determine geolocation information corresponding to the aircraft **100**. The predictive modeler **2307** receives the imaged map provided by the map constructor **2303** and the geolocation information from the GPS processor **2305** to determine if a hazardous condition is imminent based on a location of the aircraft **100** relative to a detected hazard. For example, the predictive modeler **2307** can include hard coded rules, obstacle avoidance algorithms, smart object discrimination, and/or any other predictive modeling technique(s).

In some examples, to detect a potentially hazardous condition, the predictive modeler **2307** analyzes the imaged map from the map constructor **2303** to detect or identify an end of the runway **144** during a takeoff event or a landing event. If the predictive modeler **2307** detects the end of the runway **144**, the predictive modeler **2307** retrieves aircraft speed from the airspeed determiner **2304** and/or the brake system monitor **2302**, the weight on wheels signal from the weight on wheels determiner **2310**, and/or an angle of attack of the aircraft **100** from the various parameters provided to the brake system monitor **2302** via the engine control system **132**. For example, the predictive modeler **2307** determines a distance between the aircraft **100** and the end of the runway **144** (e.g., via the GPS processor **2305**) and calculates a braking distance required to stop the aircraft **100** prior to reaching the end of the runway **144**. If the predictive modeler **2307** determines that the aircraft **100** can stop within the given distance based on the aircraft speed provided by the airspeed determiner **2304** (e.g., which can also be used to determine a rate of deceleration during landing) and/or the aircraft **100** can take-off prior to reaching the end of the runway **144** based on the angle of attack, the predictive modeler **2307** determines that a hazardous condition is not present. If the angle of attack is not sufficient for takeoff and/or the airspeed of the aircraft **100** is such that the aircraft

100 cannot stop prior to the end of the runway **144**, the predictive modeler **2307** identifies a hazardous condition and communicates a hazardous condition to the brake system monitor **2302**.

In some examples, to determine a potentially hazardous condition, the predictive modeler **2307** analyzes the imaged map to determine a presence of an object (e.g., another aircraft) in a travel path of the aircraft **100**. The predictive modeler **2307** obtains geolocation information from the GPS processor **2305** to determine a distance between the aircraft **100** and the identified object and obtains the airspeed of the aircraft **100** from the airspeed determiner **2304** and/or the brake system monitor **2302**. If the distance between the aircraft **100** and the identified object is such that the aircraft **100** cannot avoid a collision with the identified object, the predictive modeler **2307** identifies a hazardous condition and communicates a hazardous condition signal to the brake system monitor **2302**. If the distance between the aircraft **100** and the identified object is such that the aircraft **100** can avoid a collision with the identified object based on the distance and the airspeed information, the predictive modeler **2307** determines that a hazardous condition is not present and communicates a non-hazardous condition signal to the brake system monitor **2302**.

Referring to FIG. **23A**, the brake system monitor **2302** operates the air brake operator **2312**, the parachute operator **2314** and/or the emergency brake operator **2316** in response to the signals received from the airspeed determiner **2304**, the hazardous condition identifier **2308**, the crosswind determiner **2306** and/or the landing event activator **2320**. For example, the brake system monitor **2302** commands the air brake operator **2312** based on the signals received from the weight on wheels determiner **2310**, the airspeed determiner **2304**, the crosswind determiner **2306**, and the landing event activator **2320**. In some examples, the brake system controller **130** does not include the crosswind determiner **2306** and the brake system monitor **2302** commands the air brake operator **2312** based on the signals received from the weight on wheels determiner **2310**, the airspeed determiner **2304** and the landing event activator **2320**.

For example, the brake system monitor **2302** activates the air brake system **124** when the brake system monitor **2302** receives a signal from the landing event activator **2320** to monitor for a landing event, a signal from the weight on wheels determiner **2310** indicative that the aircraft **100** is on the surface **142** of the runway **144**, a measured airspeed value from the airspeed determiner **2304**, and a measured crosswind value from the crosswind determiner **2306**.

The brake system monitor **2302** compares the measured speed from the airspeed determiner **2304** to a speed threshold (e.g., **60** knots). For example, the brake system monitor **2302** retrieves or obtains the speed threshold from the data store **2318** and employs the comparator **2322** to compare the measured airspeed value from the airspeed determiner **2304** and the speed threshold from the data store **2318**. The speed threshold can be provided in the data store **2318** via a user input. Additionally, in some examples, brake system monitor **2302** compares, via the comparator **2322**, the measured crosswind value to a crosswind threshold (e.g., **10** knots, **20** knots, etc.). For example, the brake system monitor **2302** retrieves or obtains the crosswind threshold from the data store **2318** and employs the comparator **2322** to compare the measured crosswind value from the crosswind determiner **2306** and the crosswind threshold from the data store **2318**. The crosswind threshold can be provided in the data store **2318** via a user input.

When the crosswind determiner **2306** is not employed, the brake system monitor **2302** commands the air brake operator **2312** to deploy the first and second fan cowls **222**, **224** of the respective aircraft engines **110**, **112** in a synchronous deployment sequence. For example, the air brake operator **2312** can command the first actuator **234**, the second actuator **236**, the third actuator **244**, and the fourth actuator **246** to simultaneously or substantially simultaneously (e.g., within a **10** seconds of each other) actuate or deploy the first and second fan cowls **222**, **224** to the deployed position **204**.

When the crosswind determiner **2306** is employed, the brake system monitor **2302** activates the air brake operator **2312** in response to the weight on wheels determiner **2310** detecting that the aircraft **100** is on the surface **142**, the airspeed determiner **2304** detecting that the aircraft speed is greater than the speed threshold, and the crosswind determiner **2306** detecting that the crosswind is greater than the crosswind threshold. In some such examples, the brake system monitor **2302** commands the air brake operator **2312** to deploy the first and second fan cowls **222**, **224** of the respective aircraft engines **110**, **112** in an asynchronous deployment sequence. For example, the air brake operator **2312** can cause the first actuator **234** and the second actuator **236** of the aircraft engine **110**, and the first actuator **234** and the second actuator **236** of the aircraft engine **112** to activate simultaneously to deploy the first fan cowls **222** of the respective aircraft engines **110**, **112** (e.g., the inboard side fan cowls) prior to deployment of the second fan cowls **224** (e.g., the outboard side fan cowls). In some such examples, the brake system monitor **2302** continues to monitor the measured crosswind from the crosswind determiner **2306** and commands the air brake operator to deploy the second fan cowls **224** of the aircraft engines **110**, **112** when the measured crosswind value is less than or equal to the crosswind threshold. In some such examples, the brake system monitor **2302** commands the air brake operator **2312** to activate the third actuator **244** and the fourth actuator **246** to deploy the second fan cowls **224** of the aircraft engines **110**, **112**.

When the first and second fan cowls **222**, **224** are in the deployed position **204**, the brake system monitor **2302** continues to monitor the measured airspeed of the aircraft **100** provided by the airspeed determiner **2304** to the speed threshold. The brake system monitor **2302** commands the air brake operator **2312** to move the first and second fan cowls **222**, **224** from the deployed position **204** to the stowed position **202** when the brake system monitor **2302** determines that the airspeed the measured airspeed from the airspeed determiner **2304** is less than or equal to the speed threshold.

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The brake system monitor **2302** activates the parachute operator **2314** in response to the weight on wheels determiner **2310** detecting that the aircraft **100** is on the surface **142** and the brake system monitor **2302** determining that the measured airspeed from the airspeed determiner **2304** is greater than the speed threshold. In response, the brake system monitor **2302** commands the parachute operator to **2314** to activate the parachute launching system **504** (e.g., the air injection system **402**). For example, the parachute operator **2314** causes the door **406** to move to the open position **410**, which causes the launch tube **510** to deploy the parachute **508**. When the parachute **508** is in the deployed position **500**, the brake system monitor **2302** continues to monitor the measured airspeed of the aircraft **100** provided by the airspeed determiner **2304**. When the brake system monitor **2302** determines that the measured airspeed of the aircraft **100** is less than or equal to the speed threshold, the brake system monitor **2302** commands the parachute operator **2314** to activate the parachute retrieval system **506**. In some examples, the parachute operator **2314** activates the motor **556** for a predetermined period of time and/or until the parachute operator **2314** and/or the brake system monitor **2302** receives a signal from an encoder or proximity switch indicative of the parachute **508** being in the stowed position **502**.

The brake system monitor **2302** activates the emergency brake operator **2316** in response to the weight on wheels determiner **2310** detecting that the aircraft **100** is on the surface **142** and the hazardous condition identifier **2308** determining that a hazardous condition is present. In response, the brake system monitor **2302** commands cover actuator **2005** to actuate to remove the cover **2003** from the emergency brake system **128** and cause the emergency brake system **128** to move from the stowed position **2001** to the deployed position **2000**. Additionally, the brake system monitor **2302** commands the emergency brake operator **2316** to actuate or activate the emergency brake actuators **2012** to generate a vacuum on the brake pad **2004** when the brake pad **2004** is on the surface **142**. In some examples, prior to deploying the emergency brake system **128**, the brake system monitor **2302** commands an alarm generator **2346** to generate an alarm in a passenger cabin of the aircraft **100**. The alarm provides warning to passengers so that the passengers can move to a brace position.

While an example manner of implementing the brake system controller **130** of FIG. **1** is illustrated in FIGS. **23**A and **23**B, one or more of the elements, processes and/or devices illustrated in FIGS. **23**A and **23**B may be combined, divided, re-arranged, omitted, eliminated and/or implemented in any other way. Further, the example brake system monitor **2302**, the example airspeed determiner **2304**, the example crosswind determiner **2306**, the example hazardous condition identifier **2308**, the example weight on wheels determiner **2310** , the example air brake operator **2312**, the example parachute operator **2314**, the example emergency brake operator **2316**, the example data store **2318**, the landing event activator **2320**, the example comparator **2322**, the example signal processor **2301**, the example map constructor **2303**, the example GPS processor **2305**, the example predictive modeler **2307**, the example inertial measurement unit **2309** and/or, more generally, the example brake system controller **130** of FIGS. **1**, **23**A and **23**B may be implemented by hardware, software, firmware and/or any combination of hardware, software and/or firmware. Thus, for example, any of the example brake system monitor **2302**, the example airspeed determiner **2304**, the example crosswind determiner **2306**, the example hazardous condition identifier **2308**, the example weight on wheels determiner **2310** , the example air brake operator **2312**, the example parachute operator **2314**, the example emergency brake operator **2316**, the example data store **2318**, the landing event activator **2320**, the example comparator **2322**, the example signal processor **2301**, the example map constructor **2303**, the example GPS processor **2305**, the example predictive modeler **2307**, the example inertial measurement unit **2309** and/or, more generally, the example brake system controller **130** of FIG. **1** could be implemented by one or more analog or digital circuit(s), logic circuits, programmable processor(s), programmable controller(s), graphics processing unit(s) (GPU(s)), digital signal processor(s) (DSP(s)), application specific integrated circuit(s) (ASIC(s)), programmable logic device(s) (PLD(s)) and/or field programmable logic device(s) (FPLD(s)). When reading any of the apparatus or system claims of this patent to cover a purely software and/or firmware implementation, at least one of the example brake system monitor **2302**, the example airspeed determiner **2304**, the example crosswind determiner **2306**, the example hazardous condition identifier **2308**, the example weight on wheels determiner **2310** , the example air brake operator **2312**, the example parachute operator **2314**, the example emergency brake operator **2316**, the example data store **2318**, the landing event activator **2320**, the example comparator **2322**, the example signal processor **2301**, the example map constructor **2303**, the example GPS processor **2305**, the example predictive modeler **2307**, the example inertial measurement unit **2309** is/are hereby expressly defined to include a non-transitory computer readable storage device or storage disk such as a memory, a digital versatile disk (DVD), a compact disk (CD), a Blu-ray disk, etc. including the software and/or firmware. Further still, the example brake system controller **130** of FIG. **1** may include one or more elements, processes and/or devices in addition to, or instead of, those illustrated in FIGS. **23**A and **23**B, and/or may include more than one of any or all of the illustrated elements, processes and devices. As used herein, the phrase "in communication," including variations thereof, encompasses direct communication and/or indirect communication through one or more intermediary components, and does not require direct physical (e.g., wired) communication and/or constant communication, but rather additionally includes selective communication at periodic intervals, scheduled intervals, aperiodic intervals, and/or one-time events

Flowcharts representative of example methods **2400-2700** for implementing the brake system controller **130** of FIGS. **1**, **23**A and **23**B is shown in FIGS. **24-27**. The flowcharts are representative of hardware logic, machine readable instructions, hardware implemented state machines, and/or any combination thereof for implementing the brake system controller **130** of FIG. **1**. The machine readable instructions may be an executable program or portion of an executable program for execution by a computer processor such as the processor **2712** shown in the example processor platform **2700** discussed below in connection with FIG. **27**. The program may be embodied in software stored on a non-transitory computer readable storage medium such as a CD-ROM, a floppy disk, a hard drive, a DVD, a Blu-ray disk, or a memory associated with the processor **2712**, but the entire program and/or parts thereof could alternatively be executed by a device other than the processor **2712** and/or embodied in firmware or dedicated hardware. Further, although the example program is described with reference to the flowcharts illustrated in FIGS. **24-26**, many other methods of implementing the example brake system controller **130** may alternatively be used. For example, the order of execution of the blocks may be changed, and/or some of the blocks described may be changed, eliminated, or combined. Additionally or alternatively, any or all of the blocks may be implemented by one or more hardware circuits (e.g., discrete and/or integrated analog and/or digital circuitry, an FPGA, an ASIC, a comparator, an operational-amplifier (op-amp), a logic circuit, etc.) structured to perform the corresponding operation without executing software or firmware.

As mentioned above, the example processes of FIGS. **24-26** may be implemented using executable instructions (e.g., computer and/or machine readable instructions) stored on a non-transitory computer and/or machine readable medium such as a hard disk drive, a flash memory, a read-only memory, a compact disk, a digital versatile disk, a cache, a random-access memory and/or any other storage device or storage disk in which information is stored for any duration (e.g., for extended time periods, permanently, for brief instances, for temporarily buffering, and/or for caching of the information). As used herein, the term non-transitory computer readable medium is expressly defined to include any type of computer readable storage device and/or storage disk and to exclude propagating signals and to exclude transmission media.

"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, and (**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, and (**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, and (**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 and/or steps, 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, and (**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 and/or steps, 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, and (**3**) at least one A and at least one B.

Referring to FIG. **24**, the method **2400** begins when the brake system monitor **2302** determines whether to monitor for a landing event (block **2402**). If at block **2402** the brake system monitor **2302** receives a signal from the landing event activator **2320** to not monitor for a landing event, the brake system monitor **2302** determines not to monitor for a landing event and the process returns to block **2402**.

If at block **2402** the brake system monitor **2302** receives a signal from the landing event activator **2320** to monitor for a landing event, the brake system monitor **2302** monitors for a landing event (block **2404**).

The brake system monitor **2302** determines if a landing event is detected (block **2406**). For example, the brake system monitor **2302** receives information from the weight on wheels determiner **2310** to detect if the aircraft **100** is in flight or on the surface **142**. If at block **2406** the weight on wheels determiner **2310** communicates a first signal to the brake system monitor **2302** representative of the aircraft **100** in flight, the brake system monitor **2302** determines that a landing event has not occurred, and the process returns to block **2402**.

If at block **2406** the weight on wheels determiner **2310** communicates a second signal to the brake system monitor **2302** representative of the aircraft **100** in contact with the surface **142**, then the brake system monitor **2302** determines that a landing event is detected and monitors the aircraft speed (block **2408**).

For example, the brake system controller **130** receives a measured airspeed value from the airspeed determiner **2304** and compares the measured airspeed value to an airspeed threshold to determine if the measured airspeed value is less than the speed threshold (block **2410**).

If at block **2410** the brake system monitor **2302** determines that the measured airspeed value is greater than the airspeed threshold, the brake system monitor **2302** detects if a crosswind determiner **2306** is activated (block **2412**).

If at block **2412** the brake system monitor **2302** determines that the crosswind determiner **2306** is activated, the brake system monitor **2302** obtains the crosswind value from the crosswind determiner **2306** (block **2414**).

The brake system monitor **2302** determines if the crosswind value is less than a crosswind threshold (block **2416**). For example, the brake system monitor **2302** compares, via the comparator **2322**, the crosswind value and the crosswind threshold.

If at block **2416** the brake system monitor **2302** determines that the crosswind value is not less than the crosswind threshold, the air brake operator **2312** causes the inboard fan cowls **222** of the respective aircraft engines **110, 112** to move to the deployed position **204** (block **2418**). In some such examples, only the first and second actuators **234, 236** are actuated to an extended position to deploy the inboard fan cowls **222**.

After the inboard fan cowls **222** are moved to the deployed position **204**, the brake system monitor **2302** compares the next measured aircraft speed to a crosswind affect threshold (block **2420**). For example, during crosswind conditions, crosswinds may not impact aircraft performance when the airspeed is less than the crosswind affect threshold value (e.g., **70** knots). If at block **2420** the brake system monitor **2302** determines that the measured airspeed value is not less than the crosswind affect threshold, the process returns to block **2408**.

If at block **2420** the brake system monitor **2302** determines that the airspeed value is less than the crosswind affect threshold, the air brake operator **2312** deploys the outboard fan cowls **224** of the respective aircraft engines **110, 112** (block **2422**). The process returns to block **2408**.

If at block **2412** the brake system monitor **2302** determines that the crosswind determiner **2306** is not activated and/or if at block **2416** the brake system monitor **2302** determines that the crosswind value is less than the crosswind threshold, the brake system monitor **2302** commands the air brake operator **2312** to move the inboard and outboard fan cowls **222**, **224** to the deployed position **204** (block **2424**). For example, the brake system monitor **2302** commands the air brake operator **2312** to deploy (e.g., simultaneously) the inboard and outboard fan cowls **222**, **224** using a synchronous deployment sequence. The process then returns to block **2408**.

If at block **2410** the brake system controller **130** determines that the measured airspeed value is not greater than the speed threshold, the brake system controller **130** commands the air brake operator **2312** to stow the inboard and outboard fan cowls **222, 224** (block **2426**). For example, the airspeed threshold may be an airspeed at which the air brake system **124** is not effective to reduce aircraft speed. In some examples, the airspeed threshold is between approximately **50** knots and **60** knots. In some examples, the airspeed threshold is zero knots.

Referring to FIG. **25**, the method **2500** begins when the brake system monitor **2302** determines whether to monitor for a landing event (block **2502**). If at block **2502** the brake system monitor **2302** receives a signal from the landing event activator **2320** to not monitor for a landing event, the brake system monitor **2302** determines not to monitor for a landing event and the process returns to block **2502**.

If at block **2502** the brake system monitor **2302** receives a signal from the landing event activator **2320** to monitor for a landing event, the brake system monitor **2302** monitors for detection of a landing event (block **2504**).

The brake system monitor **2302** determines if a landing event is detected (block **2506**). For example, the brake system monitor **2302** receives information from the weight on wheels determiner **2310** to detect if the aircraft **100** is in flight or on the surface **142**. If at block **2506** the weight on wheels determiner **2310** communicates a first signal to the brake system monitor **2302** representative of the aircraft **100** in flight, the brake system monitor **2302** determines that a landing event has not occurred, and the process returns to block **2502**.

If at block **2506** the weight on wheels determiner **2310** communicates a second signal to the brake system monitor **2302** representative of the aircraft **100** being in contact with the surface **142**, then the brake system monitor **2302** determines that a landing event is detected and monitors the aircraft speed (block **2508**).

To monitor the aircraft speed, the brake system controller **130** receives a measured airspeed value from the airspeed determiner **2304** and compares the measured airspeed value to an airspeed threshold to determine if the measured airspeed value is less than the airspeed threshold (block **2510**).

If at block **2510** the brake system monitor **2302** determines that the measured airspeed value is greater than the airspeed threshold, the brake system monitor **2302** deploys the parachute (block **2512**). For example, the brake system monitor **2302** causes the parachute operator **2314** to activate the parachute launching system **504**. For example, the parachute operator **2314** activates the air injection system **402** by commanding the door **406** to move to the open position **410**. The process returns to block **2508**.

If at block **2510** the brake system controller **130** determines that the measured airspeed value is not greater than the speed threshold, the brake system controller **130** commands the parachute operator **2314** to retrieve the parachute **508** (block **2514**). For example, to retrieve the parachute **508**, the parachute operator **2314** activates the parachute retrieval system **506** by commanding the motor **556** to rotate the reel **530** in the wind direction.

Referring to FIG. **26**, the method **2600** begins when the brake system controller **130** detects whether the aircraft **100** is on the surface **142** (block **2602**). For example, the brake system monitor **2302** receives signals from the weight on wheels determiner **2310** to determine if the aircraft **100** is in flight or on the surface **142**.

If a potentially hazardous condition is not detected (block **2608**), the process returns to block **2602**. If a potentially hazardous condition is detected (block **2608**), the hazardous condition identifier **2308** determines the aircraft speed (block **2610**). For example, the hazardous condition identifier **2308** receives the aircraft speed from the airspeed determiner **2304**.

The hazardous condition identifier **2308** determines a distance between the aircraft **100** and a hazardous condition (block **2612**). The hazardous condition identifier **2308** determines if a braking distance is sufficient to avoid the identified hazardous condition (block **2614**). If at block **2614** the braking distance is sufficient to avoid the potentially hazardous condition, the process returns to block **2602**. If at

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block **2614** the braking distance is not sufficient to avoid the potentially hazardous condition, the brake system monitor **2302** activates a warning (block **2616**) and activates the emergency brake (block **2618**). For example, the emergency brake operator **2316** commands or otherwise causes the alarm generator **2346** to activate and initiate an alarm. For example, the alarm is initiated in the fuselage **104** to warn passengers to move to a brace position because the emergency brake system **128** is going to activate within, for example, a predetermined time frame (e.g., **20** seconds). After expiration of the predetermined time frame, the emergency brake operator **2316** activates the cover actuator **2005** to deploy the brake pad **2004** and activates the emergency brake actuators **2012** to provide a vacuum or seal about the peripheral edge **2004**a of the brake pad **2004**.

FIG. **27** is a block diagram of an example processor platform **2700** structured to execute the instructions of FIGS. **24-26** to implement the brake system controller **130** of FIGS. **23**A and **23**B. The processor platform **2700** can be, for example, a server, a personal computer, a workstation, an Internet appliance, or any other type of computing device.

The processor platform **2700** of the illustrated example includes a processor **2712**. The processor **2712** of the illustrated example is hardware. For example, the processor **2712** can be implemented by one or more integrated circuits, logic circuits, microprocessors, GPUs, DSPs, or controllers from any desired family or manufacturer. The hardware processor may be a semiconductor based (e.g., silicon based) device. In this example, the processor implements the example brake system monitor **2302**, the example airspeed determiner **2304**, the example crosswind determiner **2306**, the example hazardous condition identifier **2308**, the example weight on wheels determiner **2310** , the example air brake operator **2312**, the example parachute operator **2314**, the example emergency brake operator **2316**, the example data store **2318**, the landing event activator **2320**, the example comparator **2322**, the example signal processor **2301**, the example map constructor **2303**, the example GPS processor **2305**, the example predictive modeler **2307**, the example inertial measurement unit **2309** and/or, more generally, the example brake system controller **130** of FIGS. **1**, **23**A and **23**B.

The processor **2712** of the illustrated example includes a local memory **2713** (e.g., a cache). The processor **2712** of the illustrated example is in communication with a main memory including a volatile memory **2714** and a non-volatile memory **2716** via a bus **2718**. The volatile memory **2714** may be implemented by Synchronous Dynamic Random Access Memory (SDRAM), Dynamic Random Access Memory (DRAM), RAMBUS® Dynamic Random Access Memory (RDRAM®) and/or any other type of random access memory device. The non-volatile memory **2716** may be implemented by flash memory and/or any other desired type of memory device. Access to the main memory **2714**, **2716** is controlled by a memory controller.

The processor platform **2700** of the illustrated example also includes an interface circuit **2720**. The interface circuit **2720** may be implemented by any type of interface standard, such as an Ethernet interface, a universal serial bus (USB), a Bluetooth® interface, a near field communication (NFC) interface, and/or a PCI express interface.

In the illustrated example, one or more input devices **2722** are connected to the interface circuit **2720**. The input device(s) **2722** permit(s) a user to enter data and/or commands into the processor **2712**. The input device(s) can be implemented by, for example, an audio sensor, a microphone, a camera (still or video), a keyboard, a button, a mouse, a touchscreen, a track-pad, a trackball, isopoint and/or a voice recognition system.

One or more output devices **2724** are also connected to the interface circuit **2720** of the illustrated example. The output devices **2724** can be implemented, for example, by display devices (e.g., a light emitting diode (LED), an organic light emitting diode (OLED), a liquid crystal display (LCD), a cathode ray tube display (CRT), and/or an in-place switching (IPS) display, a touchscreen, etc.). The interface circuit **2720** of the illustrated example, thus, typically includes a graphics driver card, a graphics driver chip and/or a graphics driver processor.

The interface circuit **2720** of the illustrated example also includes a communication device such as a transmitter, a receiver, a transceiver, a modem, a residential gateway, a wireless access point, and/or a network interface to facilitate exchange of data with external machines (e.g., computing devices of any kind) via a network **2726**. The communication can be via, for example, an Ethernet connection, a digital subscriber line (DSL) connection, a telephone line connection, a coaxial cable system, a satellite system, a line-of-site wireless system, a cellular telephone system, etc.

The processor platform **2700** of the illustrated example also includes one or more mass storage devices **2728** for storing software and/or data. Examples of such mass storage devices **2728** include floppy disk drives, hard drive disks, compact disk drives, Blu-ray disk drives, redundant array of independent disks (RAID) systems, and digital versatile disk (DVD) drives.

The machine executable instructions **2732** of FIGS. **24-26** may be stored in the mass storage device **2728**, in the volatile memory **2714**, in the non-volatile memory **2716**, and/or on a removable non-transitory computer readable storage medium such as a CD or DVD.

The following paragraphs provide various examples of the example apparatus disclosed herein.

In some examples, a braking system for an aircraft includes a fan cowl having a leading edge and a trailing edge. The braking system includes a hinge assembly coupled between the leading edge and a fan cage of an aircraft engine to enable the fan cowl to move between a stowed position and a deployed position. An actuator is coupled to the leading edge of the fan cowl, and the actuator is to move the fan cowl via the hinge from the stowed position to the deployed position in a direction away

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from the aircraft engine and toward a fore end of the aircraft to provide an air brake during a braking event.

In some examples, a kicker plate protrudes from the trailing edge of the fan cowl.

In some examples, the kicker plate is pivotally coupled relative to the trailing edge of the fan cowl.

In some examples, a chine located at a lateral edge of the fan cowl between the leading edge and the trailing edge.

In some examples, the braking system further includes a variable pitch fan, the variable pitch fan operable to provide braking force for the aircraft.

In some examples, the fan cowl is configured to provide access to the variable pitch fan during a maintenance operation.

In some examples, the braking system further includes a variable pitch gear driven fan.

In some examples, a braking system for an aircraft, the braking system includes an aircraft engine, a first fan cowl movably coupled to an inboard side of the aircraft engine, and a second fan cowl movably coupled to an outboard side of the aircraft engine. Each of the first and second fan cowls are movable between a stowed position and a deployed position. The first and second fan cowls rotate outwardly relative to the aircraft engine into an airflow stream in the deployed position to increase drag and provide an air brake to reduce a speed of the aircraft during at least a portion of a landing event.

In some examples, the first and second fan cowls are substantially perpendicular to the airflow stream when the first and second fan cowls are in the deployed position and substantially parallel to the airflow stream when the fan cowl is in the stowed position.

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In some examples, the first and second fan cowls provide an aerodynamic engine cowl surface when the first and second fan cowls are in the stowed position.

In some examples, the first and second fan cowls to increase drag when the first and second fan cowls are in the deployed position relative to when the first and second fan cowls are in the stowed position.

In some examples, a first hinge to pivotally couple the fan cowl to the aircraft engine and a second hinge to pivotally couple the second fan cowl to the aircraft engine.

In some examples, the aircraft engine includes a variable pitch fan to provide reverse thrust during the landing event.

In some examples, the first fan cowl is movable between the stowed position and deployed position independently from the second fan cowl.

In some examples, the system includes a controller to: detect a landing event; determine a speed of the aircraft; compare the speed of the aircraft to a speed threshold; and deploy the first fan cowl and the second fan cowl in response to the determined speed being within the speed threshold.

In some examples, the controller is to: detect a landing event; determine a first speed of the aircraft; compare the first speed of the aircraft to a first speed threshold; determine a crosswind vector; and compare the crosswind vector to a crosswind vector threshold.

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In some examples, the controller is to deploy the first fan cowl and the second fan cowl simultaneously in response to the crosswind vector being less than the crosswind vector threshold and the determined first speed is less than the first speed threshold.

In some examples, the controller is to deploy the first fan cowl to the deployed position in response to the crosswind vector is greater than the crosswind vector threshold and the determined first speed is less than the first speed threshold.

In some examples, the controller is to: determine a second speed of the aircraft after the first fan cowl is moved to the deployed position; compare the second speed of the aircraft to a second speed threshold; and move the second fan cowl to the deployed position in response to determining that the determined second speed is less than the second speed threshold.

In some examples, a method for braking an aircraft includes: detecting a landing event; determining a speed of the aircraft; and moving a first fan cowl from a stowed position to a deployed position into an airflow stream to increase drag and reduce the speed of the aircraft when the determined speed is less than a speed threshold.

In some examples, the method includes rotating a second fan cowl from a stowed position to a deployed position into the airflow stream to increase drag and reduce the speed of the aircraft when the determined speed is less than the speed threshold.

In some examples, the method includes moving the first and second fan cowls to the respective deployed positions simultaneously.

In some examples, a braking system for an aircraft includes a parachute launching system configured to deploy a parachute from a stowed position within a launch tube of the parachute launching system to a deployed position in an airstream of the aircraft. The braking system includes a parachute retrieval system including a first cable configured to recover the parachute from the deployed position to the stowed position for subsequent use.

In some examples, the launch tube includes a passageway between a first end of the launch tube and a second end of the launch tube to receive the parachute when the parachute is in the stowed position.

In some examples, the parachute launching system includes an air injection system to deploy the parachute.

In some examples, the air injection system includes a pipe to direct airflow from atmosphere through the passageway of the launch tube.

In some examples, the air injection system includes a door formed on the fuselage and movable between an open position to allow pressurized air to flow to the launch tube and a closed position to prevent pressurized air to flow to the launch tube.

In some examples, the parachute retrieval system includes a reel configured to pull the parachute from the deployed position to the stowed position through the passageway of the launch tube via the first cable.

In some examples, the first cable has a first end coupled to an inner surface of an apex of the parachute and a second end opposite the first end coupled to the reel.

In some examples, the first cable is to pass through the passageway of the launch tube.

In some examples, a second cable having a third end coupled to the reel and a fourth end coupled to a peripheral edge of the parachute.

In some examples, the second cable is positioned outside of the passageway of the launch tube.

In some examples, a portion of the fourth end of the second cable is positioned in the passageway of the launch tube when the parachute is in the stowed position.

In some examples, the fourth end of the second cable is positioned in the second end of the launch tube.

In some examples, a system includes a first tube and a second tube slidably coupled within the first tube between a stowed position and a deployed position. A parachute is positioned in the second tube. An air injection system to provide pressurized air in the second tube when the second tube is in the deployed position, where the pressurized air is to cause the parachute to deploy from the second tube. A parachute retrieval system to pull the parachute into the second tube for subsequent use.

In some examples, a drive is coupled to the second tube. The drive to move the second tube between the stowed position and the deployed position.

In some examples, the parachute retrieval system includes a reel.

In some examples, a plurality of cables, respective first ends of the cables to couple to the parachute and respective second ends of the cables to couple to the reel.

In some examples, the reel is to wind the cables to pull the parachute into the second tube.

In some examples, a method for braking an aircraft includes: ejecting a parachute via a launch tube from an empennage of an aircraft to unfurl the parachute in an airstream of the aircraft; retrieving the parachute via a retrieval system; and repacking the parachute in the launch tube via the retrieval system for subsequent use.

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In some examples, the retrieving of the parachute includes activating a reel to wind a cable attached to the parachute.

In some examples, the repacking the parachute includes pulling the parachute into the launch tube via the cable when the reel winds the cable.

In some examples, a braking system for an aircraft includes a brake pad movably coupled to a lower section of a fuselage of the aircraft. The brake pad is movable between a stowed position and a deployed position. An actuator is configured to deploy the brake pad from the fuselage during an emergency braking event. The brake pad is to engage a surface of a runway and increase frictional force to reduce a speed of the aircraft during the emergency braking event.

In some examples, a sled pivotally coupled to the fuselage via one or more links, where the sled is to support the brake pad.

In some examples, the brake pad includes a plurality of openings and a plurality of suction generators, each of the suction generators in fluid communication with a respective one of the openings.

In some examples, the suction generators are to provide a suction force through the openings to maintain the brake pad in engagement with the surface of the runway during the emergency braking event.

In some examples, the suction force is to cause a peripheral edge of the brake pad to seal against the surface of the runway when the brake pad is in engagement with the runway during the emergency braking event.

In some examples, the system includes a controller to: identify a hazardous condition; determine a braking distance required to avoid the hazardous condition based on at least one of a measured speed of the aircraft or a deceleration of the aircraft; and in response to determining that the braking distance is insufficient to avoid the hazardous condition, command the actuator to deploy the emergency brake pad and activate the suction generators.

In some examples, the hazardous condition includes at least one of an end of the runway or an object.

In some examples, the braking system further includes a variable pitch fan, the variable pitch fan operable to provide braking force for the aircraft.

In some examples, the emergency braking event includes at least one of a landing event or a failed take-off attempt.

In some examples, the brake system is to generate between approximately **4** g-force and **5** g-force of negative thrust during the emergency braking event.

In some examples, a braking system for an aircraft includes a housing, a braking device carried by the housing, a link to pivotally couple the housing to a fuselage, and a suction generator to generate a vacuum within a peripheral boundary of the braking device when the braking device is in engagement with a surface of a runway.

In some examples, an actuator is to move the braking device from a stowed position to a deployed position.

In some examples, an airfoil carried by at least one of the link or the housing, the airfoil to generate a downward force on the braking device when the braking device is in a deployed position.

In some examples, the suction generator is to generate a vacuum within a perimeter of the braking device to maintain the braking device in engagement with the runway when the braking device is in a deployed position.

In some examples, an area of the braking device is approximately **100** square feet.

In some examples, the braking device includes a plurality of brake pads.

In some examples, the braking device is capable of generating up to **5** g-force of negative thrust during an emergency braking event.

In some examples, a method for stopping an aircraft includes: identifying a hazardous condition; determining a braking distance required to avoid the hazardous condition based on at least one of a measured speed of the aircraft or a deceleration of the aircraft; and in response to determining that the braking distance is insufficient to avoid the identified hazardous condition, deploying an emergency brake pad.

In some examples, the method includes activating a suction generator after deploying the emergency brake pad.

In some examples, the method includes deploying the emergency brake includes operating an actuator to cause the brake pad to pivot from a lower surface of a fuselage of the aircraft from a stowed position to a deployed position.

Although certain example methods, apparatus and articles of manufacture have been disclosed herein, the scope of coverage of this patent is not limited thereto. On the contrary, this patent covers all methods, apparatus and articles of manufacture fairly falling within the scope of the claims of this patent.

EMBODIMENTS IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A braking system for an aircraft, the braking system comprising:

a fan cage to house a fan of an aircraft engine, the fan cage having a fore edge proximate an air intake of the aircraft engine and an aft edge proximate an engine core of the aircraft engine;

a fan cowl having a leading edge and a trailing edge;

a hinge assembly to pivotally couple the leading edge of the fan cowl proximate the fore edge of the fan cage, the hinge assembly to enable the fan cowl to move between a stowed position and a deployed position; and

an actuator coupled to the leading edge of the fan cowl, the actuator to move the fan cowl via the hinge assembly from the stowed position to the deployed position in a direction away from the aircraft engine and toward a fore end of the aircraft to provide an air brake during a braking event.

2. The braking system of claim **1**, further including a kicker plate protruding from the trailing edge of the fan cowl.

3. The braking system of claim **2**, wherein the kicker plate is pivotally coupled relative to the trailing edge of the fan cowl.

4. The braking system of any one of claims **1-3**, further including a chine located at a lateral edge of the fan cowl between the leading edge and the trailing edge.

5. The braking system of any one of claims **1-4**, further including a variable pitch fan, the variable pitch fan operable to provide braking force for the aircraft.

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6. The braking system of claim **5**, wherein the fan cowl is configured to provide access to the variable pitch fan during a maintenance operation.

7. The braking system of any one of claims **1-6**, further including a variable pitch gear driven fan.

8. The braking system of any one of claims **1-7**, wherein the hinge assembly includes a first hinge and a second hinge, the first hinge located below a centerline of the aircraft engine, the second hinge located above the centerline of the aircraft engine.

9. The braking system of any one of claims **1-8**, wherein the fan cowl includes a first fan cowl positioned on a first side of a pylon of the aircraft engine and a second fan cowl positioned on a second side of the pylon opposite the first side.

10. A braking system for an aircraft, the braking system comprising:

an aircraft engine defining an air intake upstream from an engine core;

a first fan cowl movably coupled proximate the air intake of the aircraft engine, the first fan cowl to pivot about a first pivot axis proximate a leading edge of the air intake; and

a second fan cowl movably coupled proximate the air intake of the aircraft engine, the second fan cowl to pivot about a second pivot axis proximate the leading edge of the air intake, each of the first fan cowl and the second fan cowl movable between a stowed position and a deployed position, the first fan cowl and the second fan cowl to rotate outwardly relative to the aircraft engine into an airflow stream in the deployed position to increase drag and provide an air brake to reduce a speed of the aircraft during at least a portion of a landing event.

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11. The braking system of claim **10**, wherein the first fan cowl is substantially perpendicular to the airflow stream when the first fan cowl is in the deployed position and substantially parallel to the airflow stream when the first fan cowl is in the stowed position.

12. The braking system of claim **10** or **11**, wherein the second fan cowl is substantially perpendicular to the airflow stream when the second fan cowl is in the deployed position and substantially parallel to the airflow stream when the second fan cowl is in the stowed position.

13. The braking system of any one of claims **10**-**12**, wherein the first fan cowl and the second fan cowl provide an aerodynamic engine cowl surface when the first fan cowl and the second fan cowl are in the stowed position.

14. The braking system of any one of claims **10**-**13**, wherein the first fan cowl and the second fan cowl increase drag when the first fan cowl and the second fan cowl are in the deployed position relative to when the first fan cowl and the second fan cowl are in the stowed position.

15. The braking system of any one of claims **10**-**14**, further including a first hinge to pivotally couple the first fan cowl to the aircraft engine and a second hinge to pivotally couple the second fan cowl to the aircraft engine.

16. The braking system of any one of claims **10**-**15**, wherein the aircraft engine includes a variable pitch fan to provide reverse thrust during the landing event.

17. The braking system of any one of claims **10**-**16**, wherein the first fan cowl is movable independently from the second fan cowl.

18. The braking system of any one of claims **10**-**17**, further including a controller to:

detect the landing event;

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determine the speed of the aircraft;

compare the speed of the aircraft to a speed threshold; and

deploy the first fan cowl and the second fan cowl in response to the determined speed being within the speed threshold.

19. The braking system of any one of claims **10**-**17**, further including a controller to:

detect the landing event;

determine a first speed of the aircraft;

compare the first speed of the aircraft to a first speed threshold;

determine a crosswind vector; and

compare the crosswind vector to a crosswind vector threshold.

20. The braking system of claim **19**, wherein the controller is to deploy the first fan cowl and the second fan cowl simultaneously in response to the crosswind vector being less than the crosswind vector threshold and the determined first speed being less than the first speed threshold.

21. The braking system of claim **19**, wherein the controller is to deploy the first fan cowl to the deployed position in response to the crosswind vector being greater than the crosswind vector threshold and the determined first speed being less than the first speed threshold.

22. The braking system of claim **21**, wherein the controller is further to:

determine a second speed of the aircraft after the first fan cowl is moved to the deployed position;

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compare the second speed of the aircraft to a second speed threshold; and

move the second fan cowl to the deployed position in response to determining that the determined second speed is less than the second speed threshold.

23. A method for braking an aircraft, the method comprising:

detecting a landing event;

determining a speed of the aircraft; and

moving a first fan cowl about a pivot axis that is located proximate a leading edge of an aircraft engine from a stowed position to a deployed position into an airflow stream to increase drag and reduce the speed of the aircraft when the determined speed is less than a speed threshold.

24. The method of claim **23**, further including rotating a second fan cowl from a stowed position to a deployed position into the airflow stream to increase drag and reduce the speed of the aircraft when the determined speed is less than the speed threshold.

25. The method of claim **24**, further including moving the first fan cowl and the second fan cowl to the respective deployed positions simultaneously.

26. A braking system for an aircraft, the braking system comprising:

a fan cowl having a leading edge and a trailing edge and movably coupled to an aircraft engine, wherein the fan cowl is movable between a stowed position and a deployed position, the fan cowl being configured to rotate outwardly relative to the aircraft engine into an airflow stream in the deployed position to increase drag and provide an air brake to reduce a

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speed of the aircraft during at least a portion of a landing event, and the fan cowl comprises:

a first fan cowl movably coupled to an inboard side of the aircraft engine; and

a second fan cowl movably coupled to an outboard side of the aircraft engine;

a hinge assembly coupled between the leading edge and a fan cage of the aircraft engine to enable the fan cowl to move between the stowed position and the deployed position, wherein the fan cowl has a first width when the fan cowl is in the stowed position and a second width when the fan cowl is in the deployed position, and the second width is greater than the first width;

a kicker plate protruding from, and pivotally coupled relative to, the trailing edge of the fan cowl, wherein the kicker plate provides a third width of the fan cowl that is greater than the second width, wherein the first width, the second width, and the third width are perpendicular relative to a centerline of the aircraft engine;

an actuator system coupled to the leading edge of the fan cowl, the actuator system being configured to move the fan cowl via the hinge assembly from the stowed position to the deployed position in a direction away from the aircraft engine and toward a fore end of the aircraft to provide the air brake during the landing event; and

a variable pitch fan, the variable pitch fan operable to provide braking force for the aircraft during the landing event.

27. The braking system of claim **26**, further including a chine located at a lateral edge of the fan cowl between the leading edge and the trailing edge.

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28. The braking system of claim **26** or **27**, wherein the fan cowl is configured to provide access to the variable pitch fan during a maintenance operation.

29. The braking system of claim **28**, wherein the braking system further includes a variable pitch gear driven fan.

30. The braking system of any one of claims **26**-**29**, wherein the first fan cowl and the second fan cowl are substantially perpendicular to the airflow stream when the fan cowl is in the deployed position and substantially parallel to the airflow stream when the fan cowl is in the stowed position.

31. The braking system of any one of claims **26**-**30**, wherein the first fan cowl and the second fan cowl provide an aerodynamic engine cowl surface when the fan cowl is in the stowed position.

32. The braking system of any one of claims **26**-**31**, wherein the first fan cowl and the second fan cowl are configured to increase drag when the fan cowl is in the deployed position relative to when the fan cowl is in the stowed position.

33. The braking system of any one of claims **26**-**32**, wherein the hinge assembly includes a first hinge to pivotally couple the first fan cowl to the aircraft engine and a second hinge to pivotally couple the second fan cowl to the aircraft engine.

34. The braking system of any one of claims **26**-**33**, wherein the first fan cowl is movable independently from the second fan cowl.

35. The braking system of any one of claims **26**-**34**, further including a controller configured to:

detect the landing event;

determine the speed of the aircraft;

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compare the speed of the aircraft to a speed threshold; and

deploy the first fan cowl and the second fan cowl in response to the determined speed being within the speed threshold.

36. The braking system of claim **35**, wherein the controller causes the first fan cowl to move simultaneously with the second fan cowl.

37. The braking system of claim **35**, wherein the controller causes the first fan cowl to move prior the second fan cowl.

38. An aircraft comprising the braking system of any one of claims **1**-**22** and **26**-**37**.

39. A method for braking an aircraft, the method comprising:

detecting a landing event;

determining a speed of the aircraft;

moving a fan cowl, comprising a first fan cowl and a second fan cowl, from a stowed position to a deployed position into an airflow stream to increase drag and reduce the speed of the aircraft when the determined speed is less than a speed threshold, wherein the moving the fan cowl comprises:

moving the first fan cowl, coupled to an inboard side of an aircraft engine, from a first stowed position to a first deployed position; and

moving the second fan cowl, coupled to an outboard side of the aircraft engine, from a second stowed position to a second deployed position, wherein the fan cowl has a first width when the fan cowl is in the stowed position and a second width when the fan cowl is in the deployed position, and the second width is greater than the first width;

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moving a kicker plate, pivotally coupled relative to a trailing edge of the fan cowl, to protrude from the trailing edge of the fan cowl and further interrupt or affect the airflow stream to increase drag, wherein the kicker plate provides a third width of the fan cowl that is greater than the second width, and the first width, the second width, and the third width are perpendicular relative to a centerline of the aircraft engine; and

adjusting a pitch of fan blades of a variable pitch fan to provide braking force for the aircraft during the landing event.

40. A computer-readable medium having stored thereon instructions which, when executed by one or more processors, cause the one or more processors to carry out the method of any one of claims **23**-**25** and **39**.

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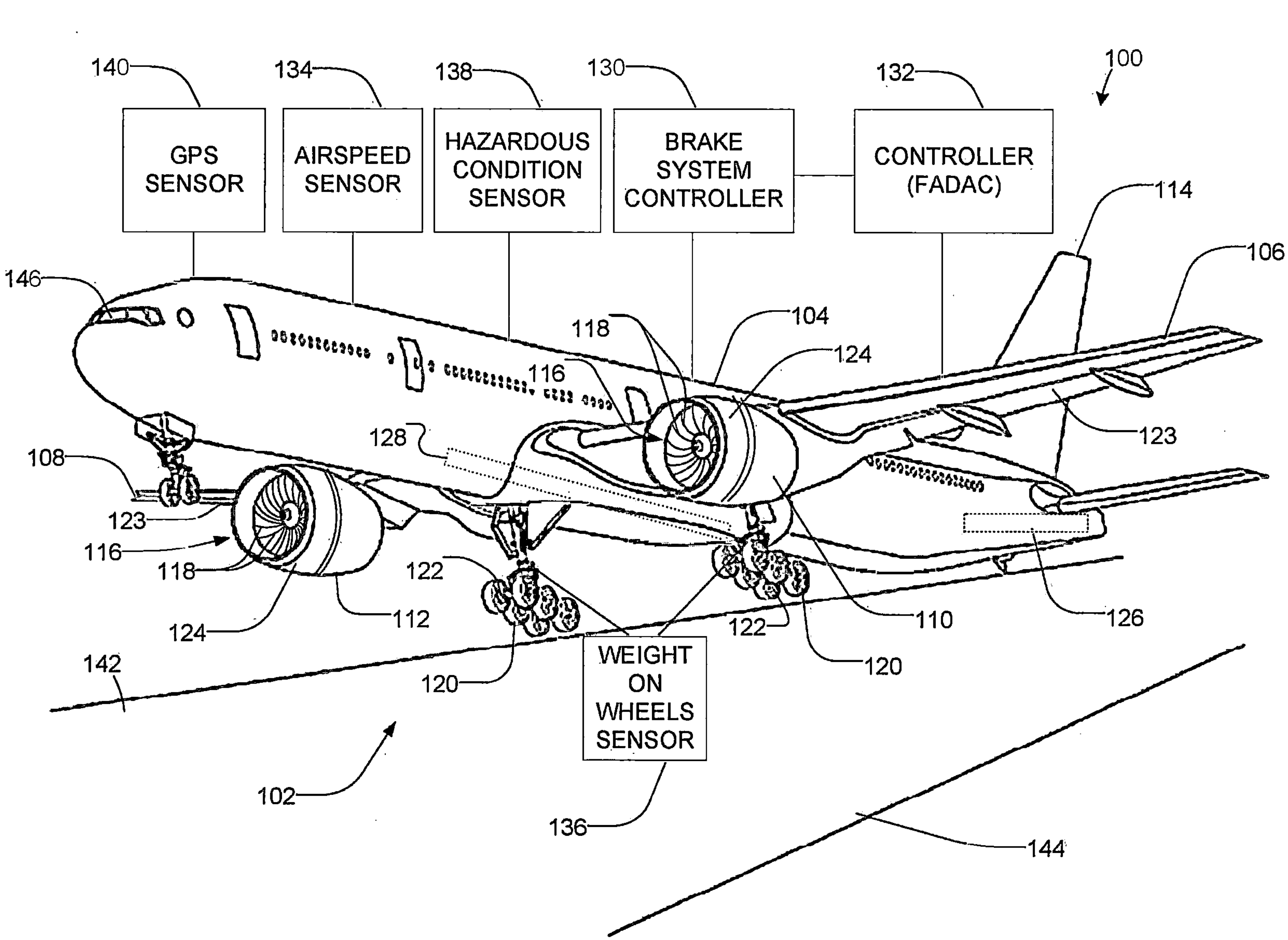

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AIRSPEED SENSOR
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FIG. 1

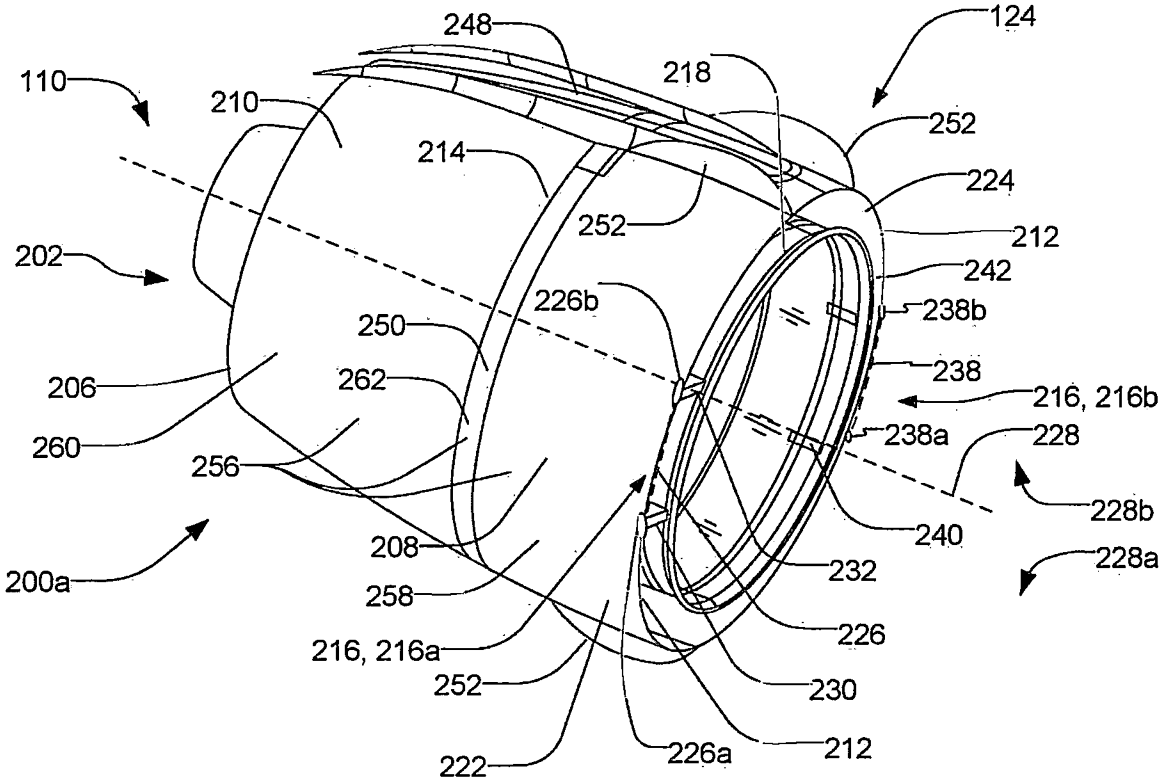
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FIG. 2A

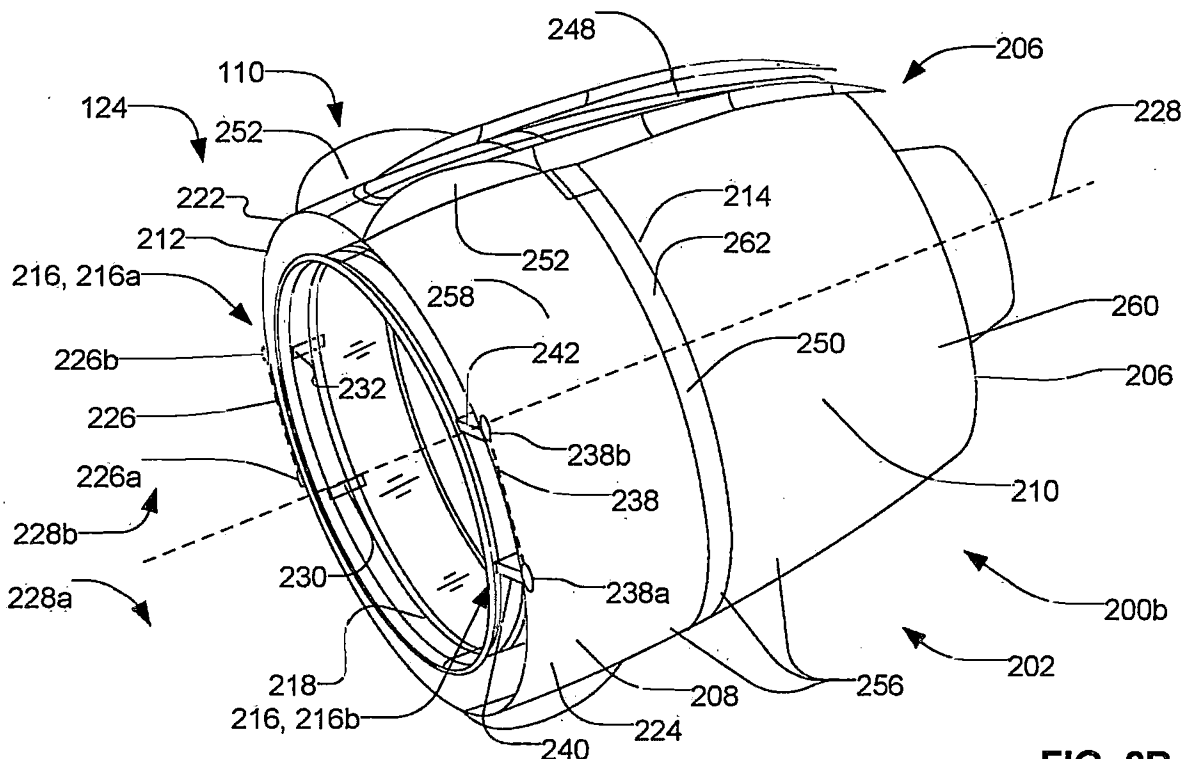
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FIG. 2B

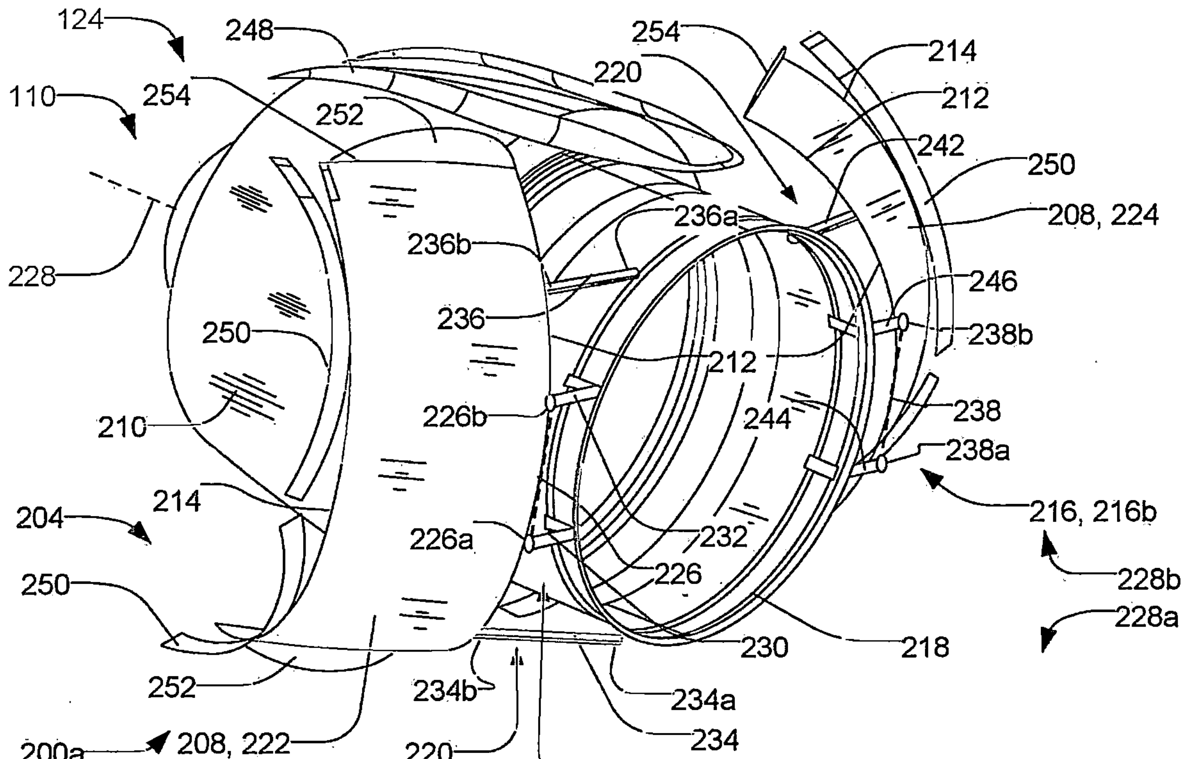
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FIG. 2C

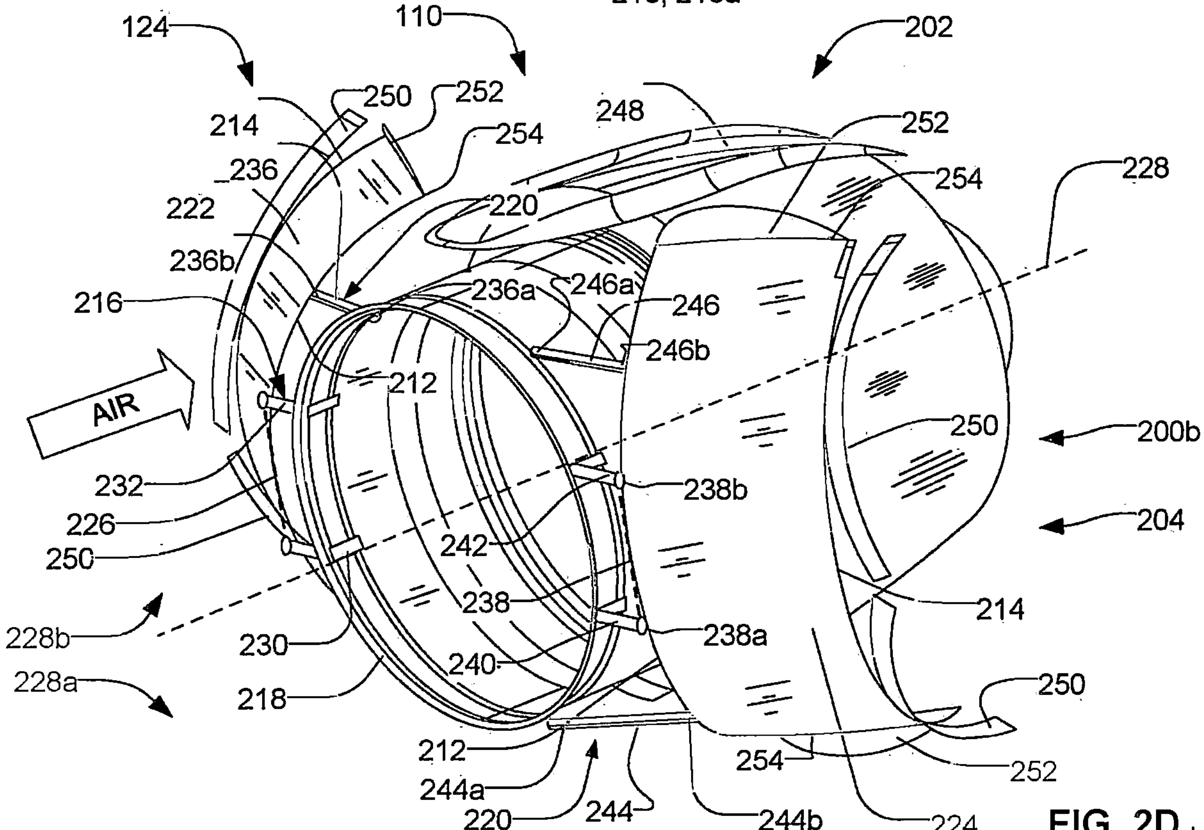
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FIG. 2D

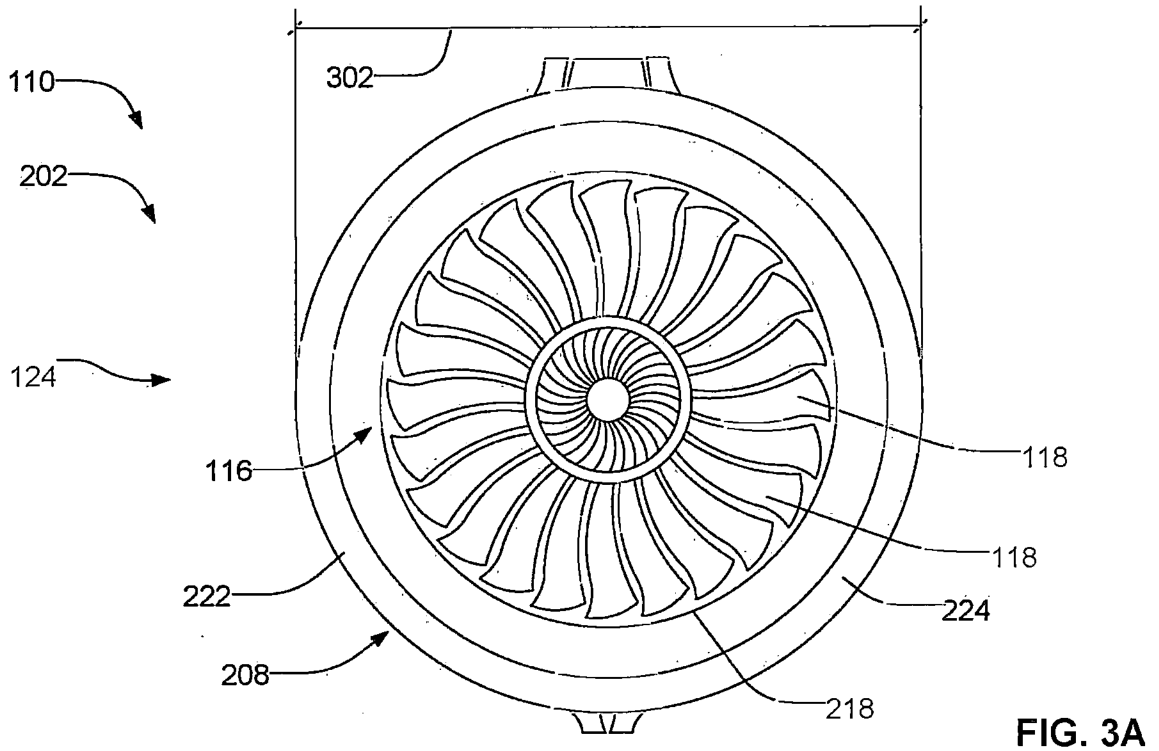

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FIG. 3A

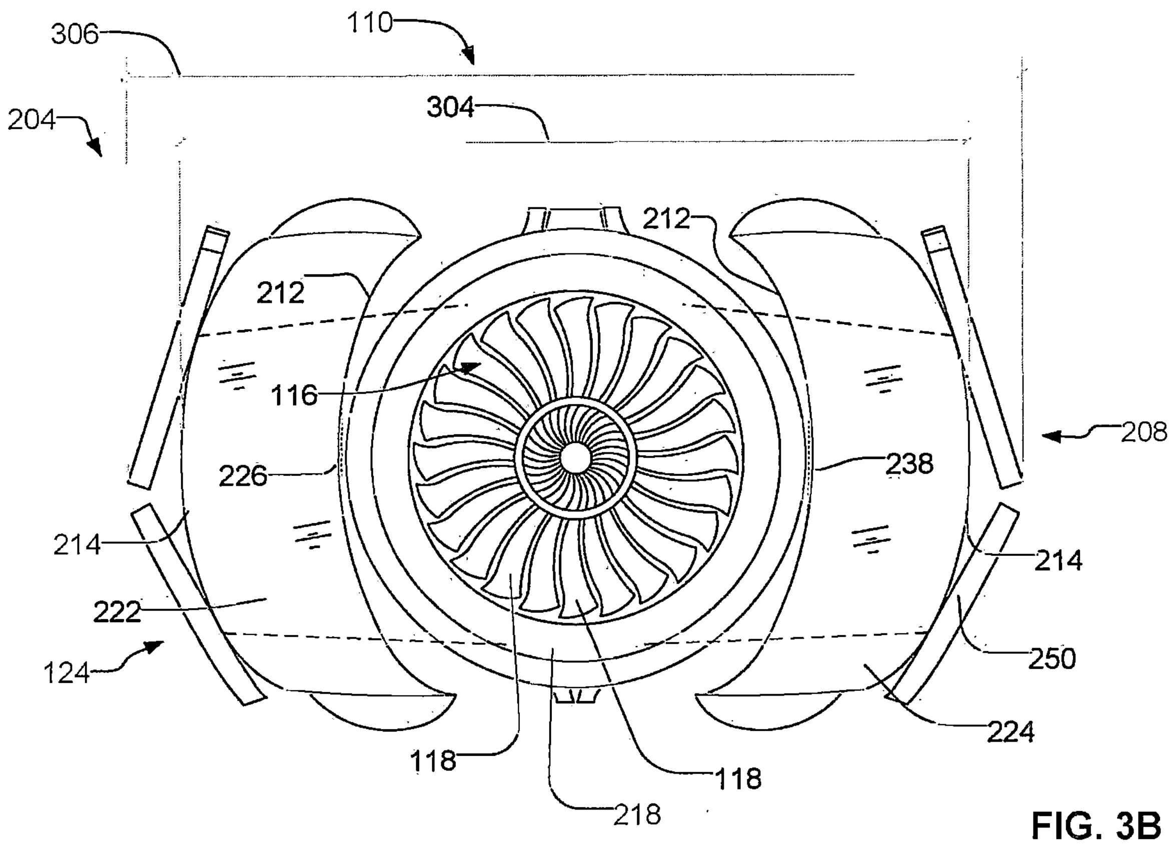

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FIG. 3B

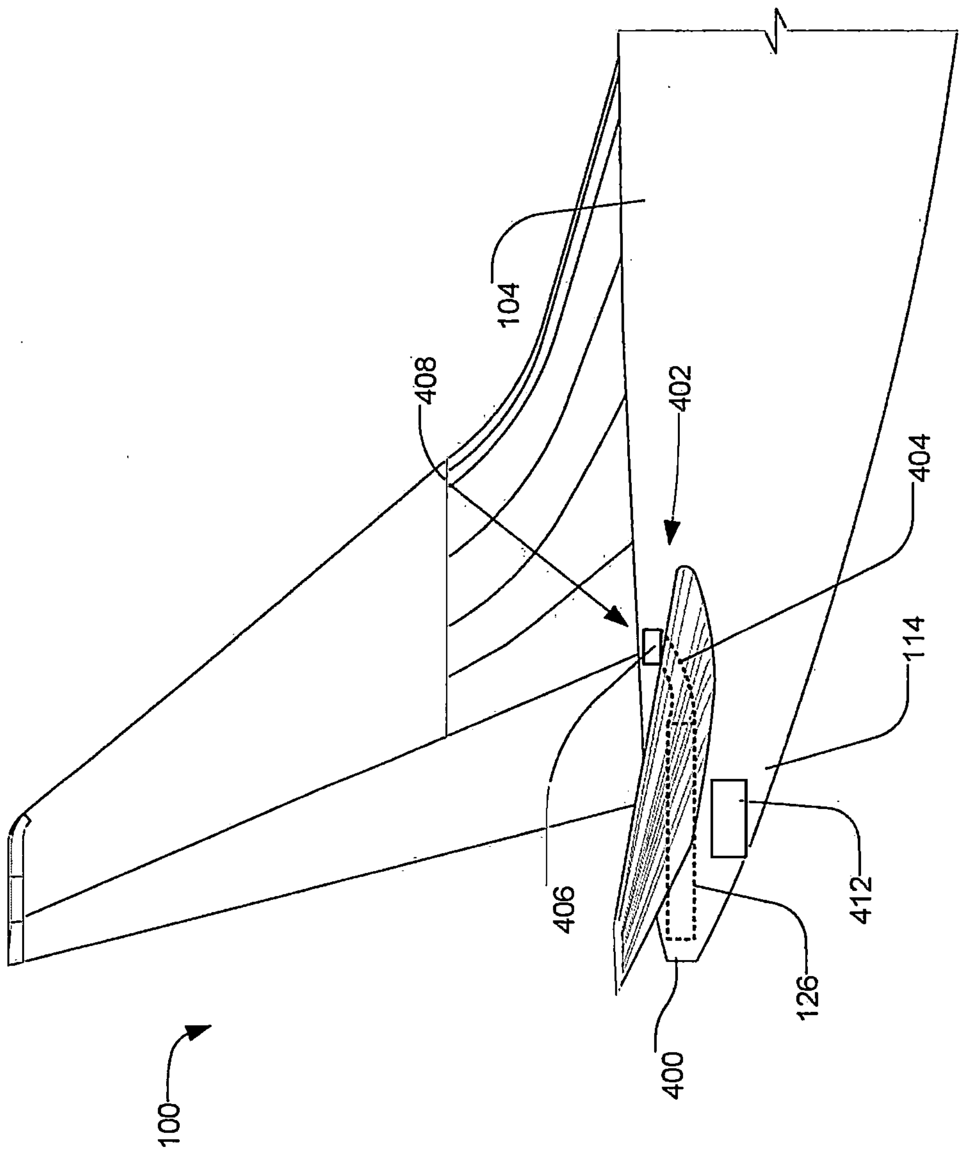

FIG. 4A

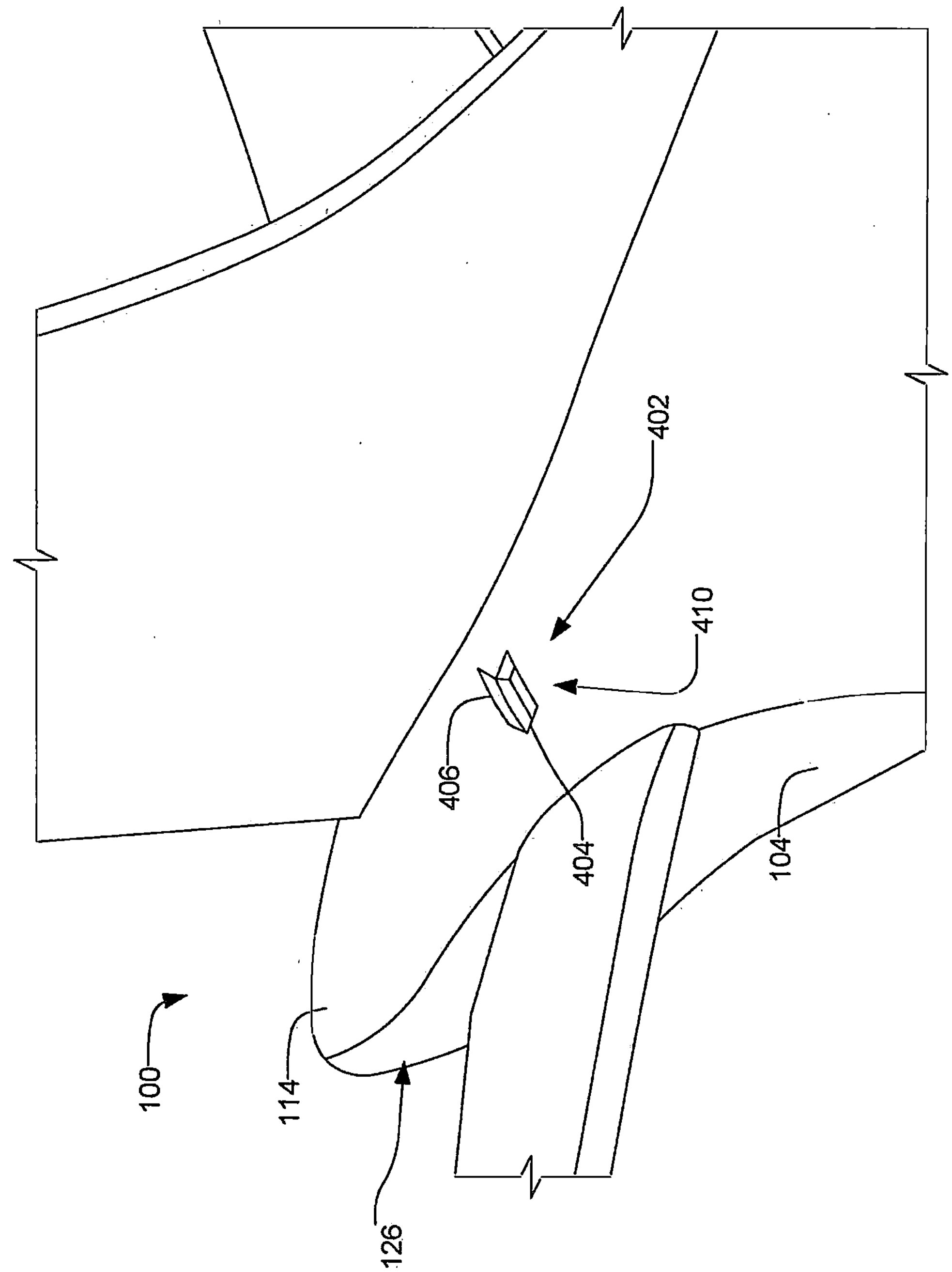

FIG. 4B

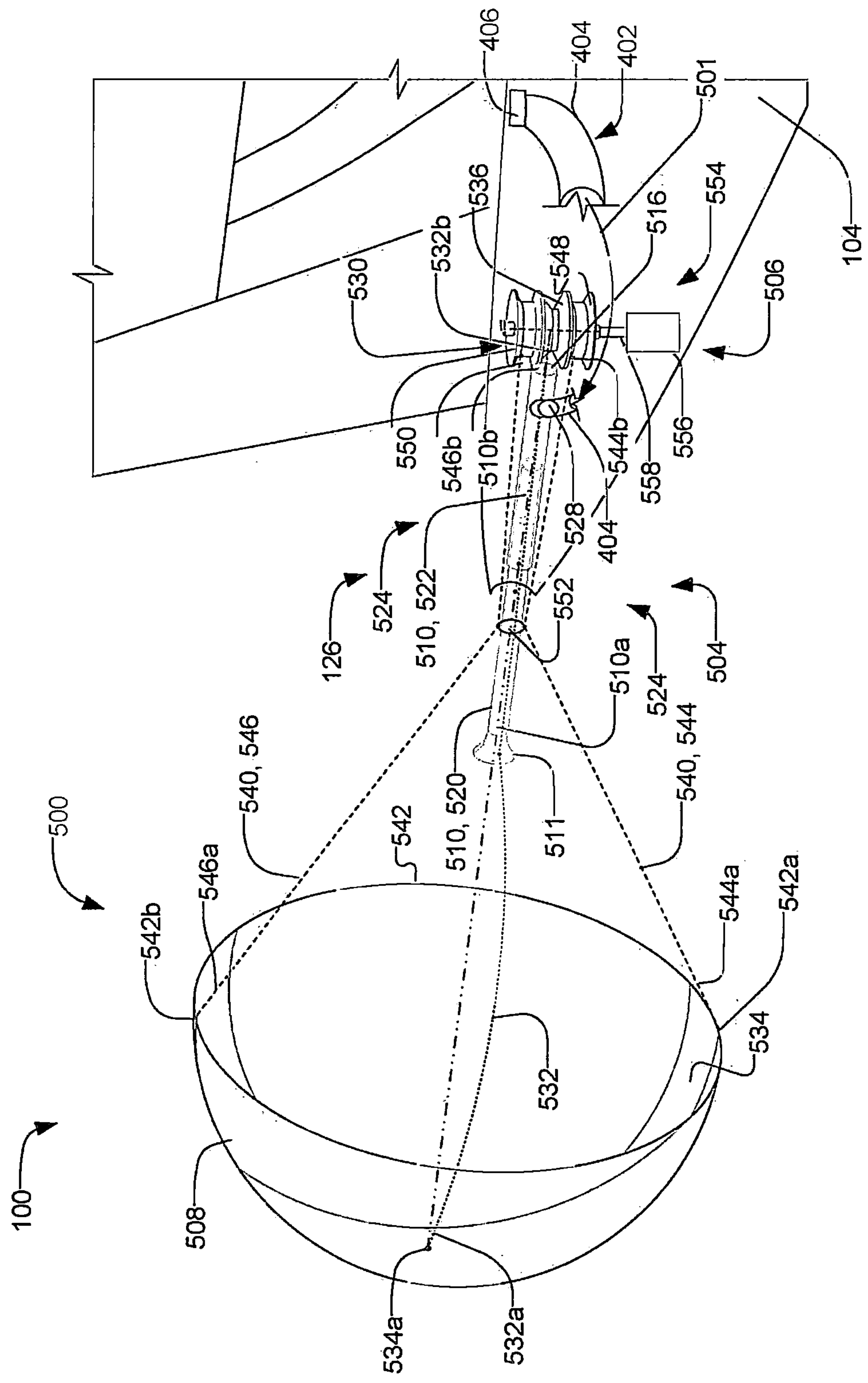

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FIG. 5A

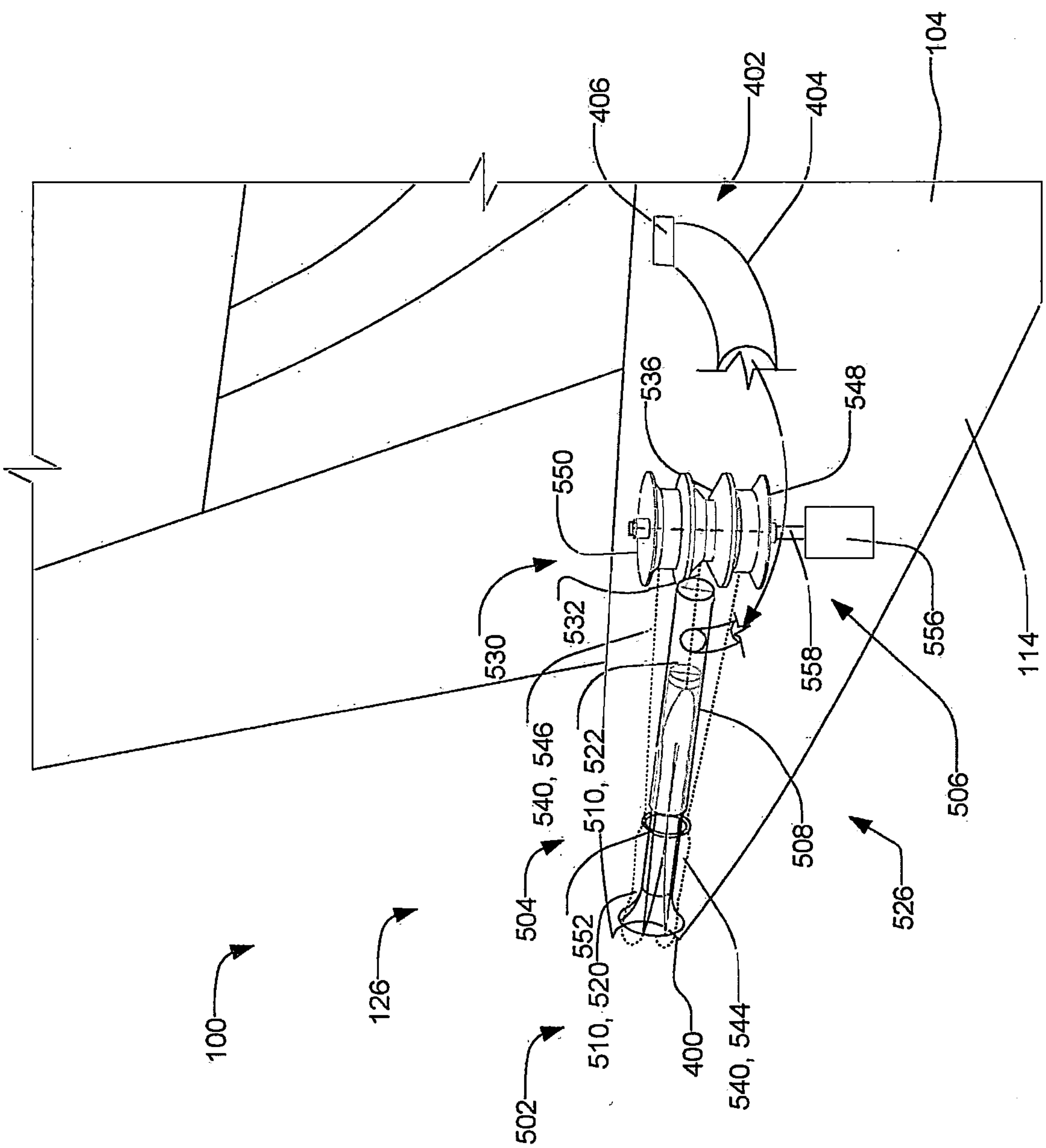
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FIG. 5B

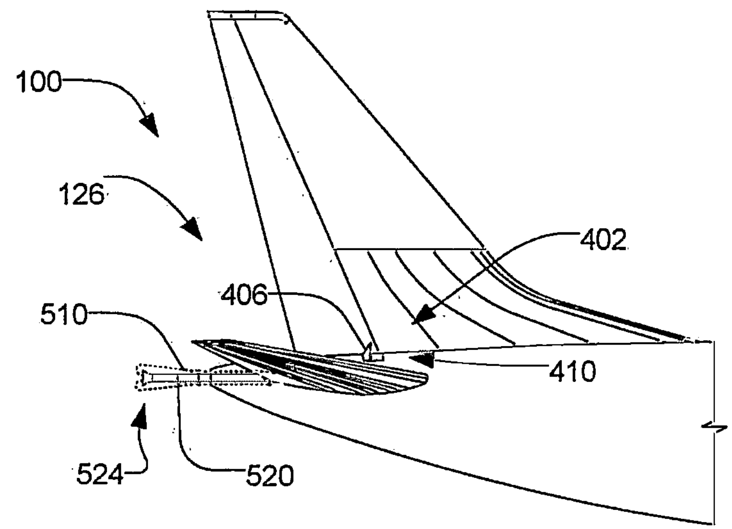

FIG. 6

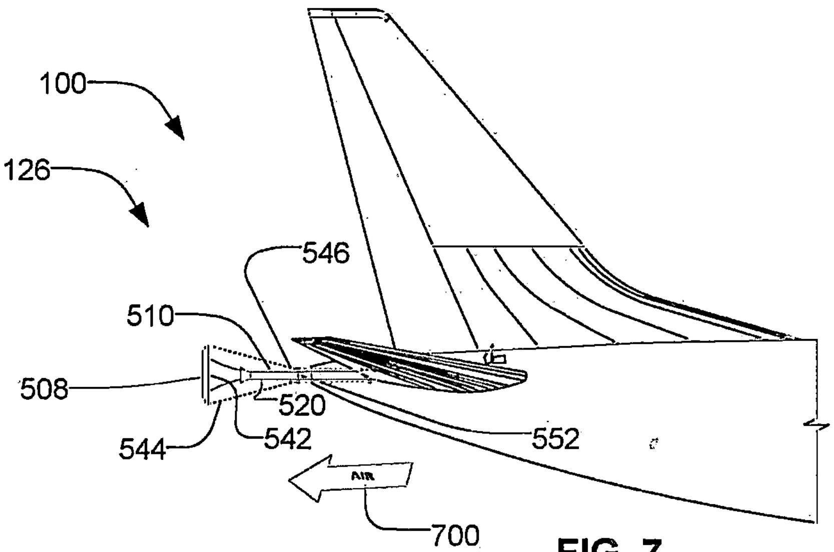

FIG. 7

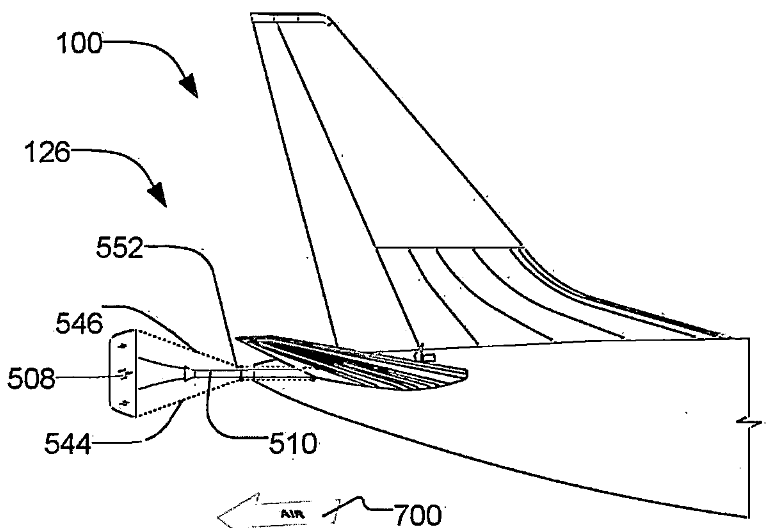

FIG. 8

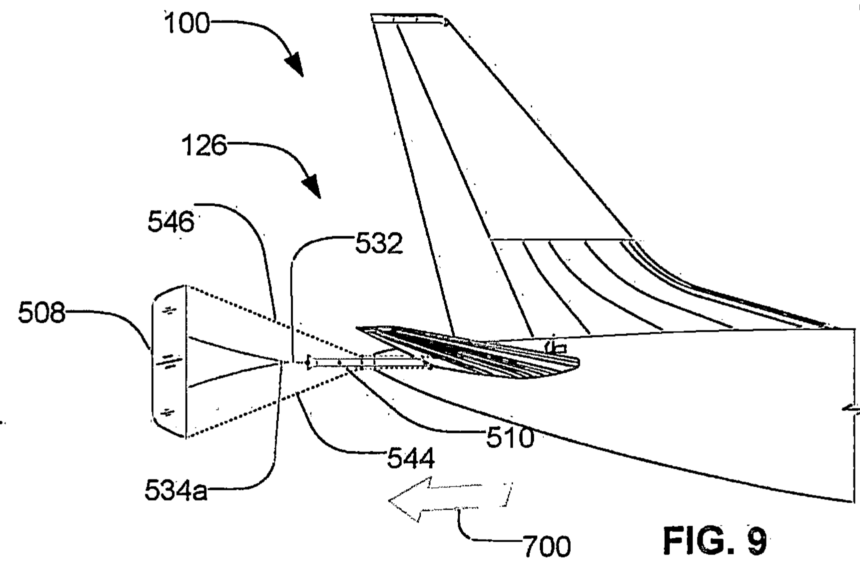

FIG. 9

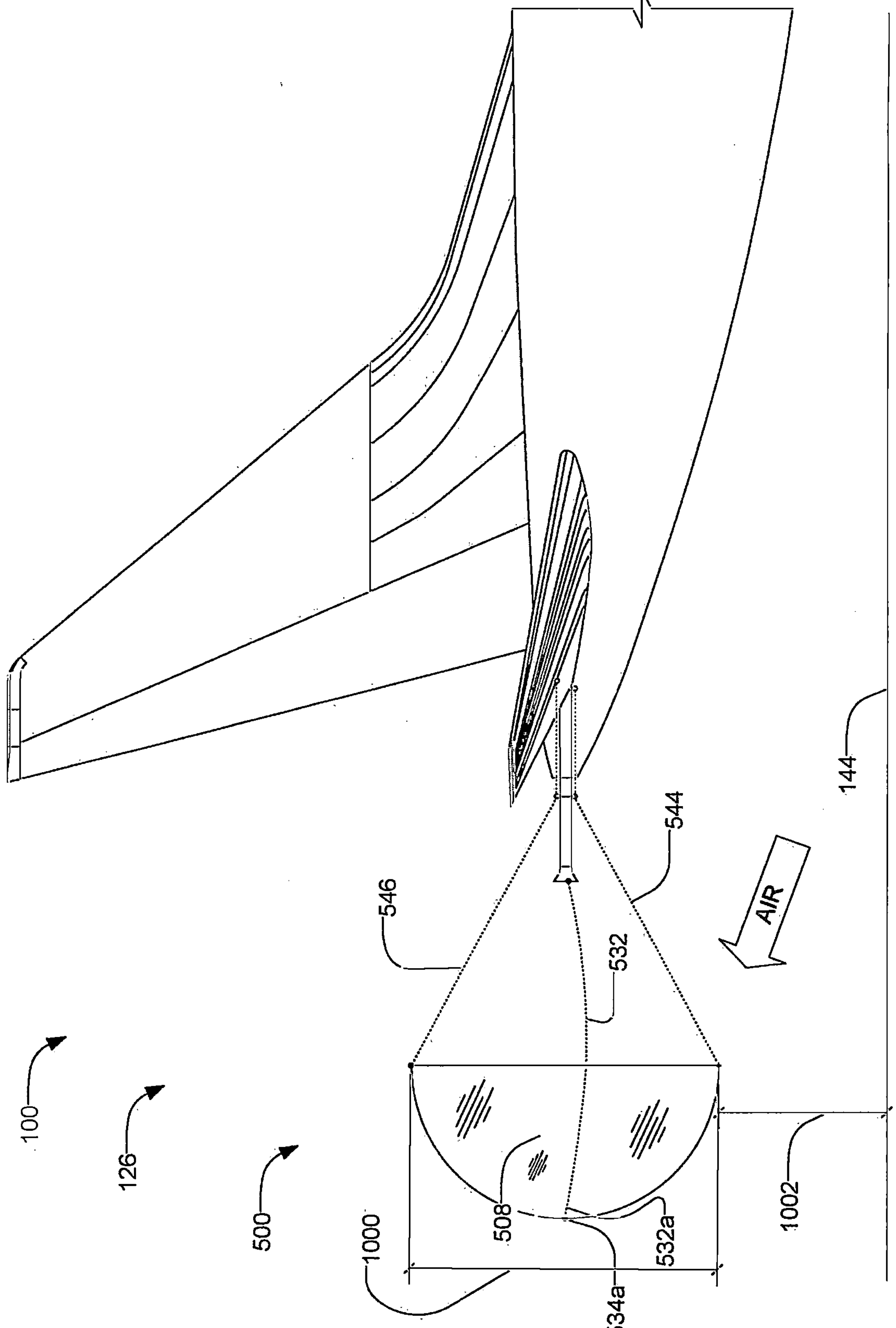

FIG. 10

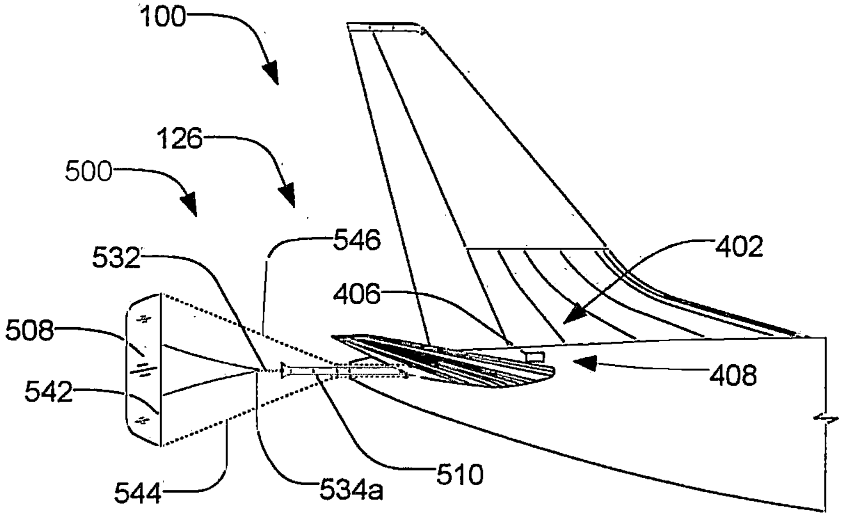

FIG. 11

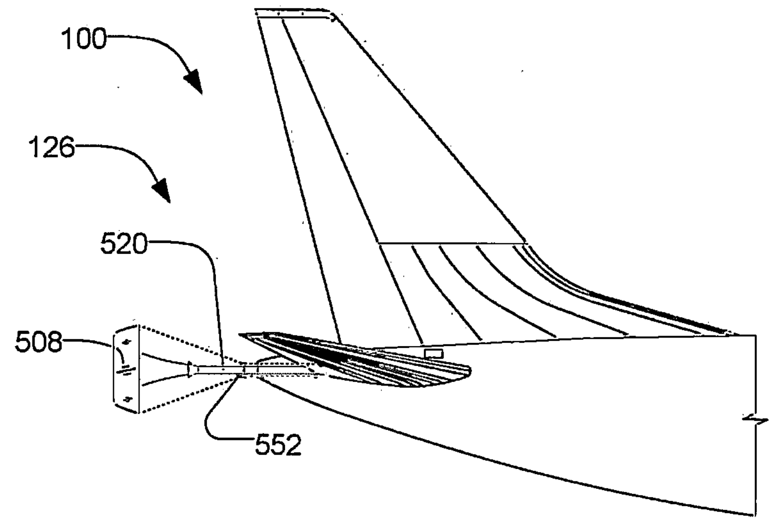

FIG. 12

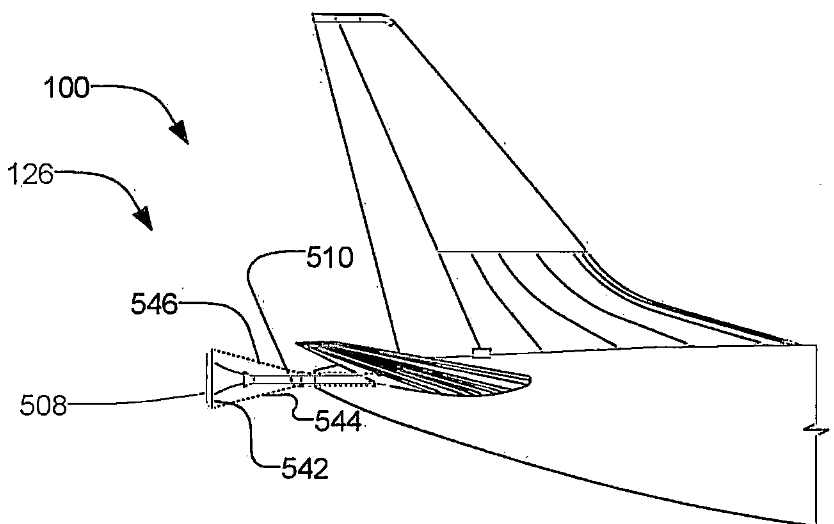

FIG. 13

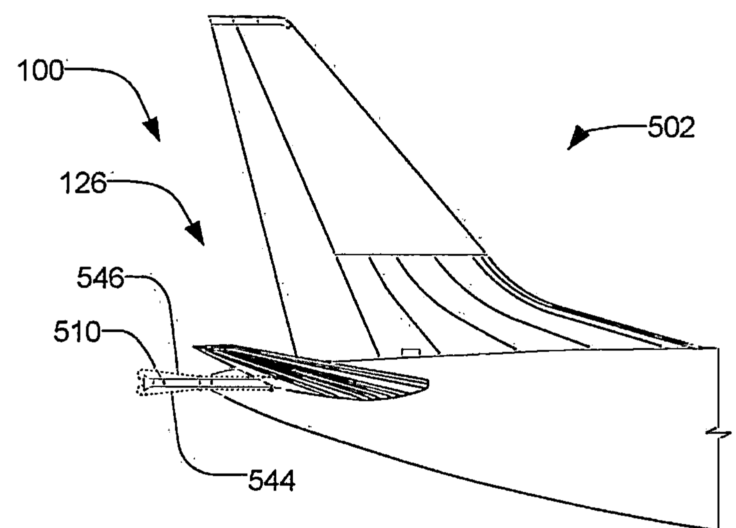

FIG. 14

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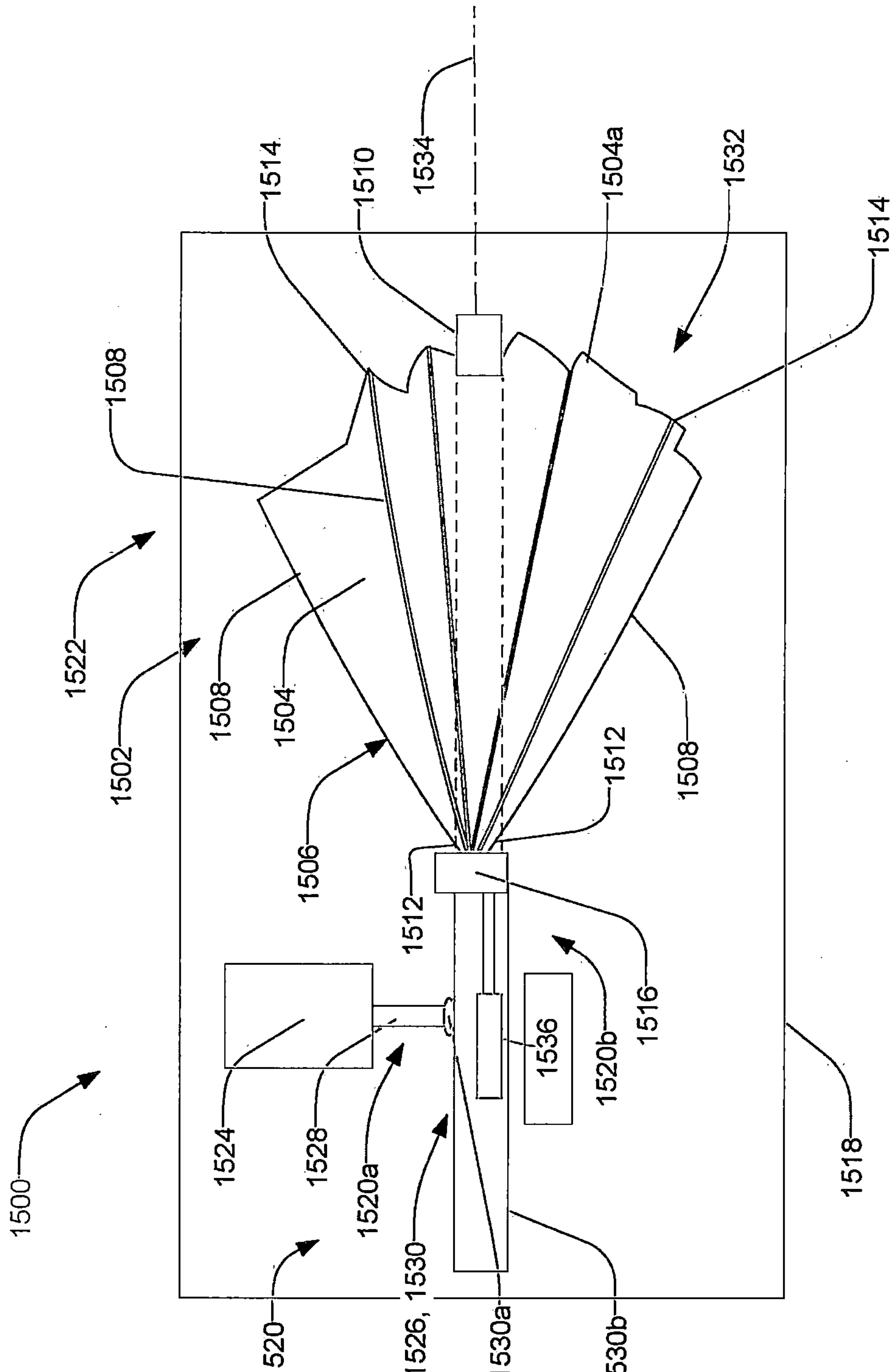
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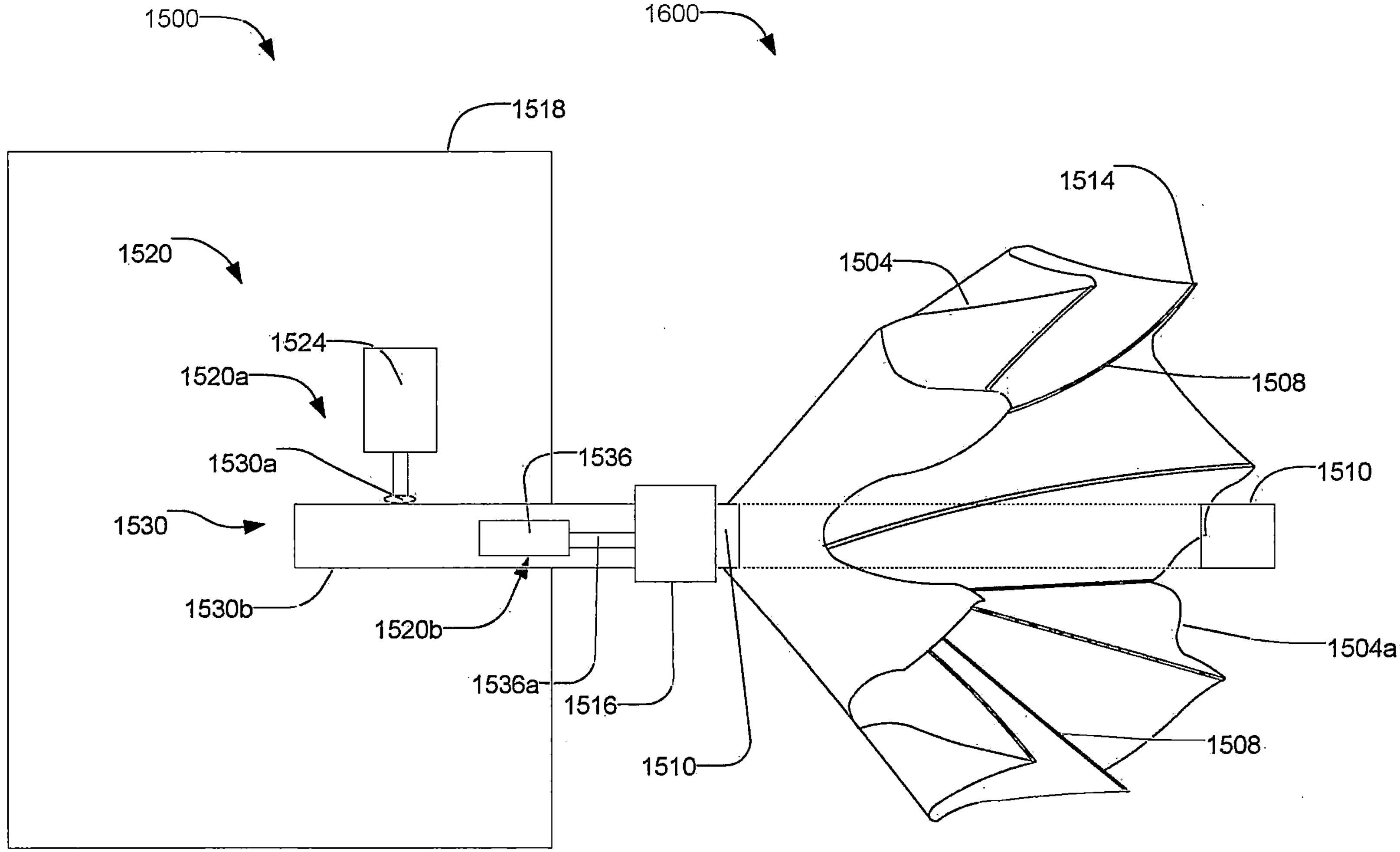
FIG. 15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1530a
1536
1510
1530
1530b
1520b
1504a
1536a
1516
1508
1510

FIG. 16

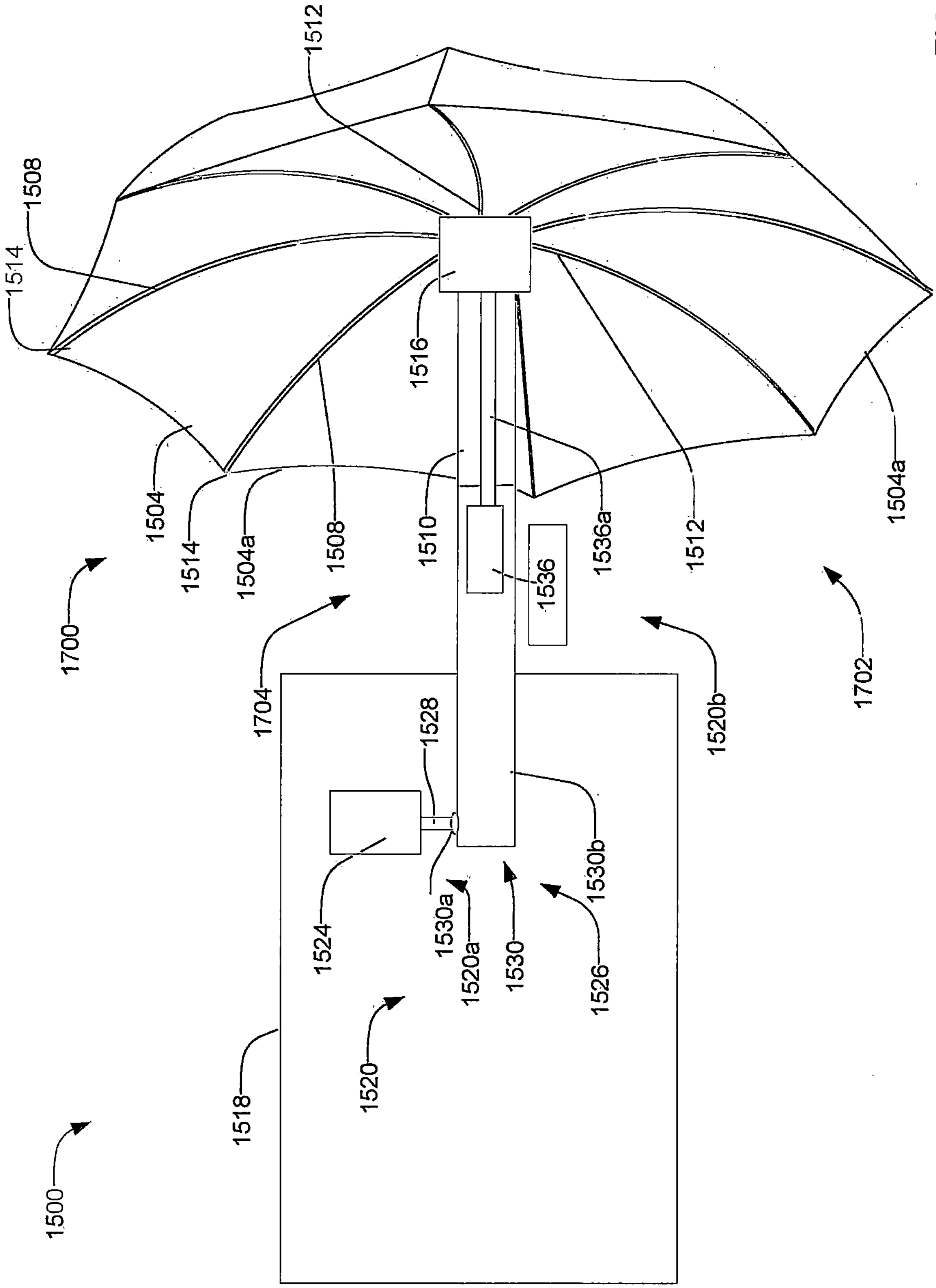

1512
1508
1514
1514
1516
1504
1514
1504a
1508
1510
1536a
1512
1504a
1536
1700
1704
1520b
1702
1528
1530b
1524
1530a
1520a
1530
1526
1520
1518
1500

FIG. 17

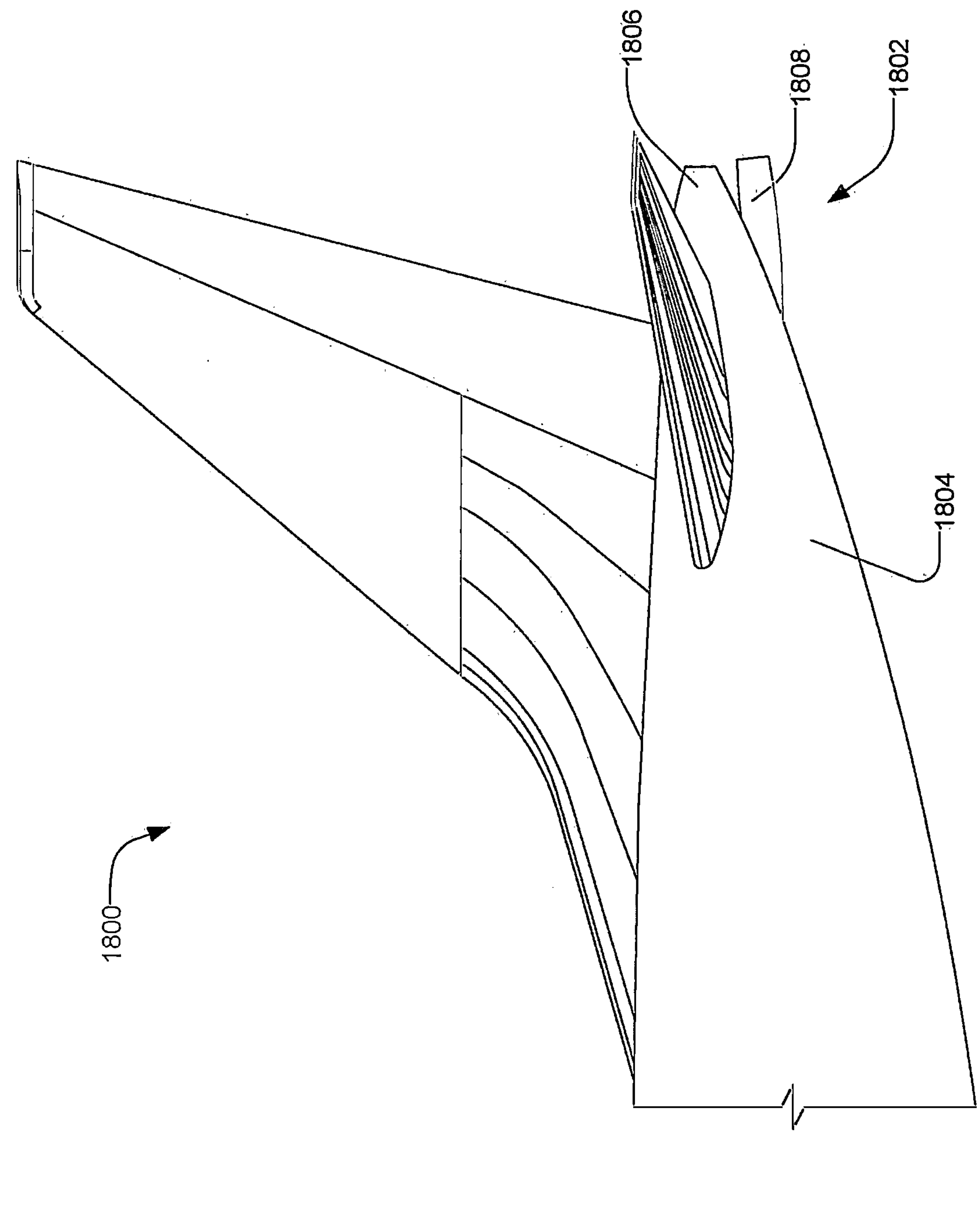


FIG. 18

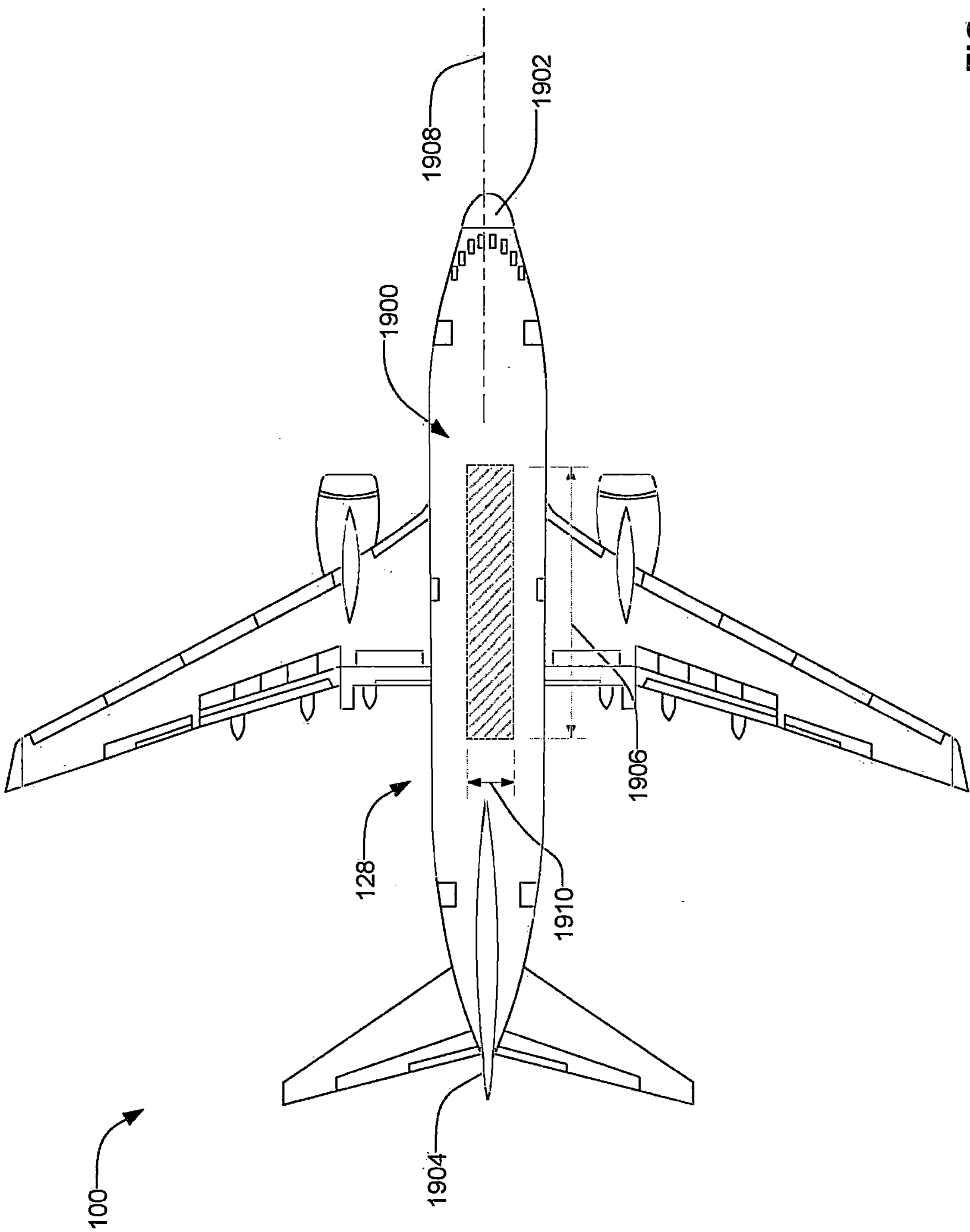


FIG. 19

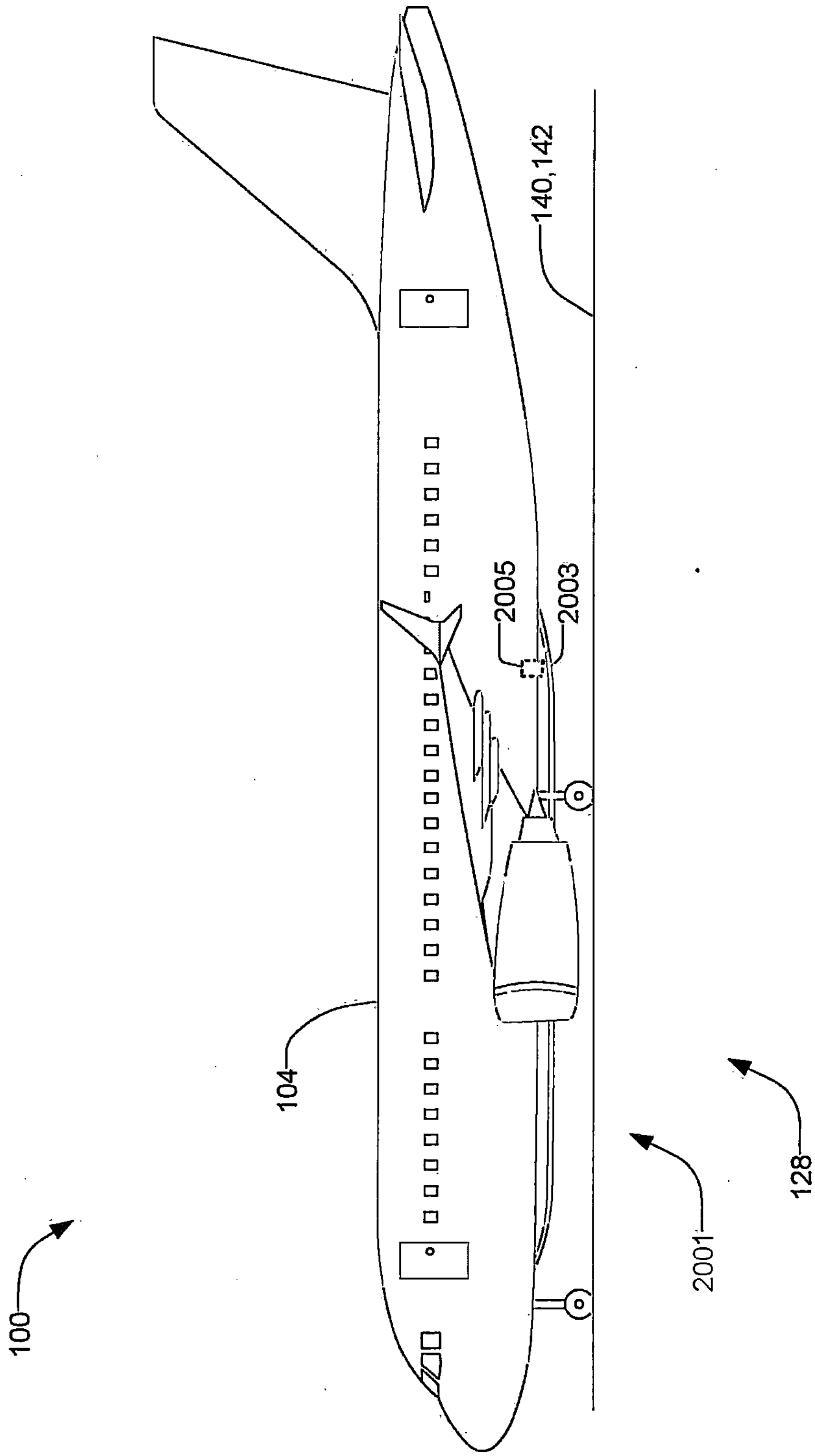


FIG. 20A

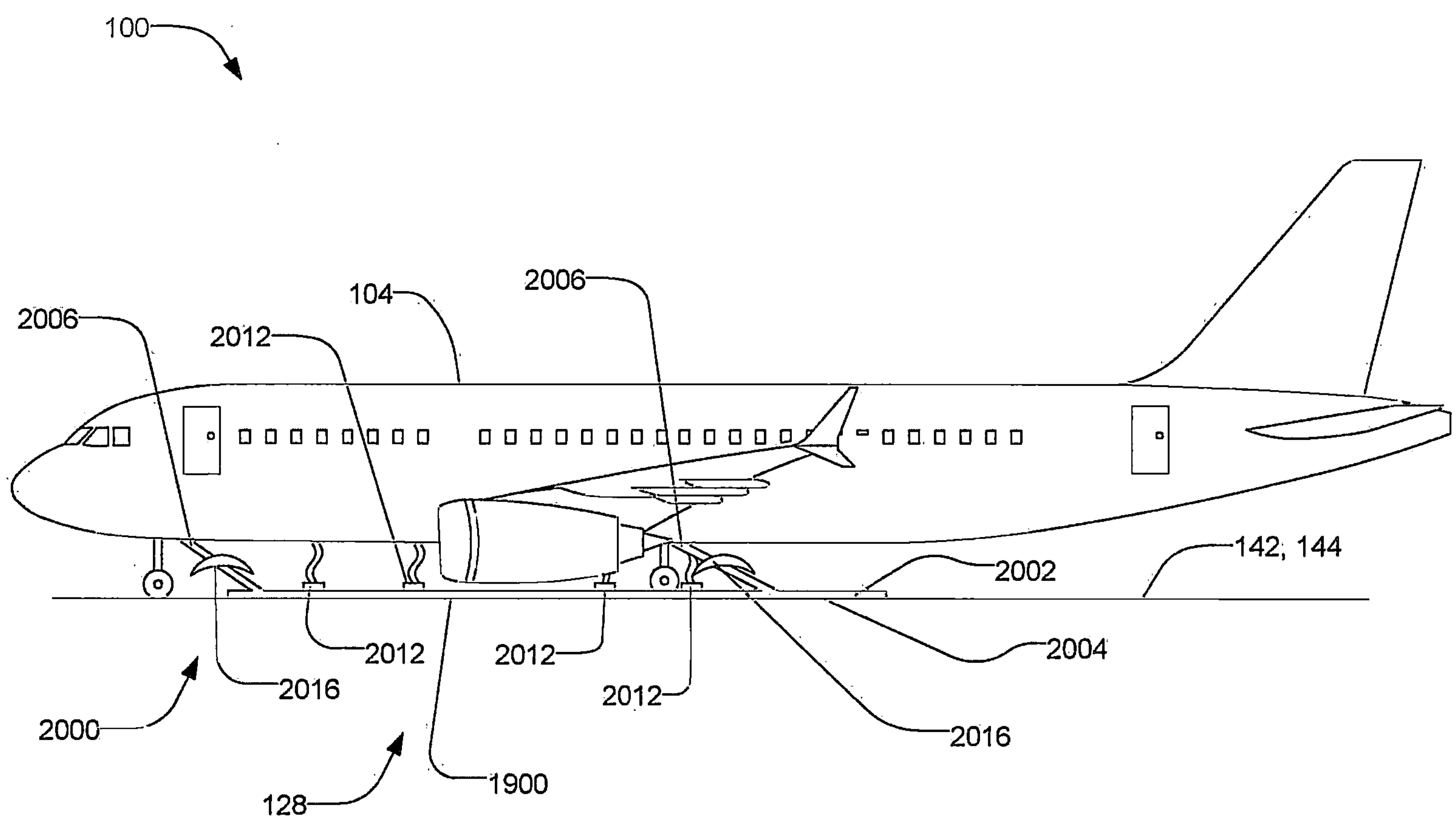
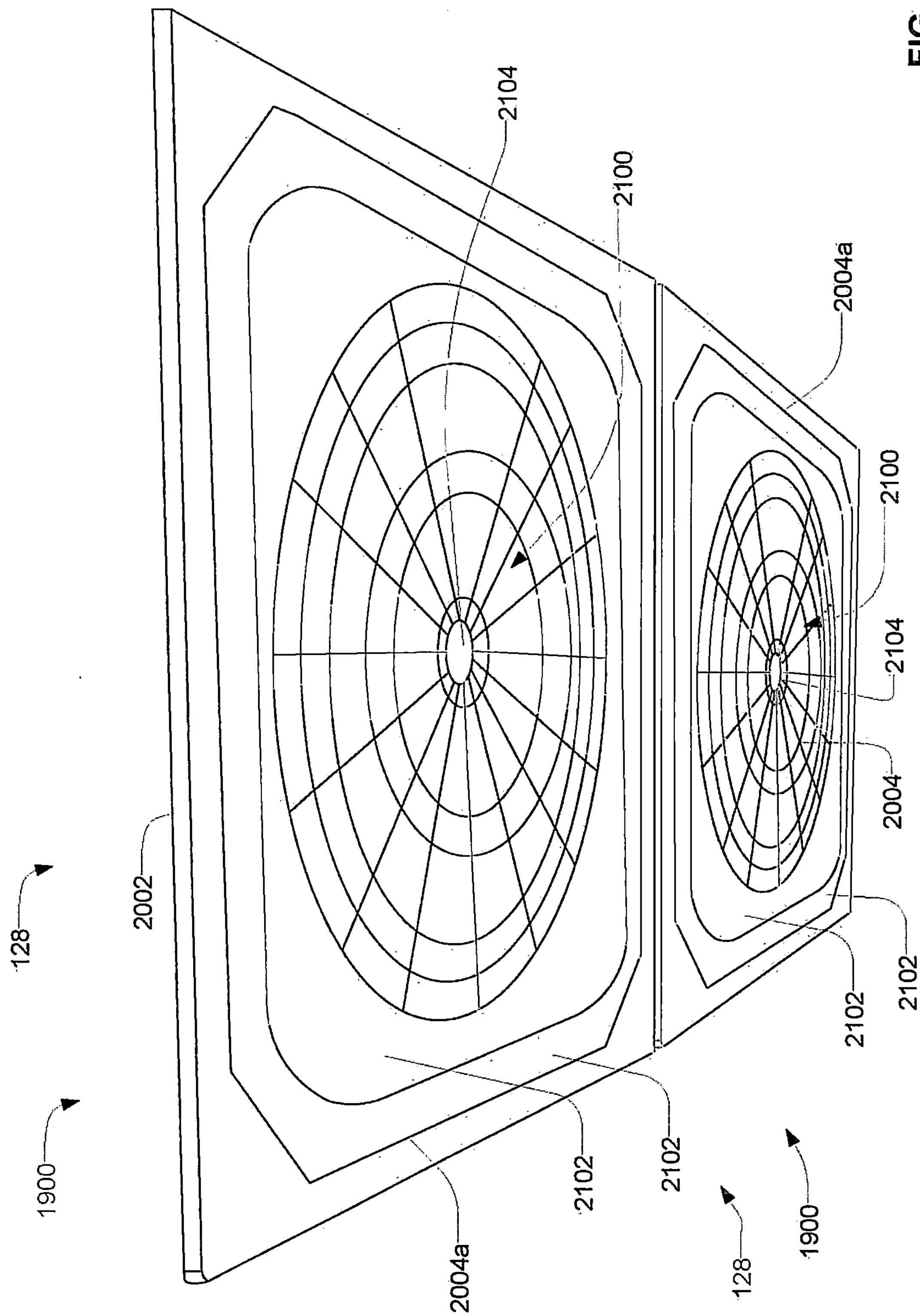

100
2006
2012
104
2006
142, 144
2002
2004
2012
2012
2012
2016
2016
2000
128
1900

FIG. 20B



2104
2100
2004a
2100
2104
2004
2102
2102
2002
128
1900
2004a
2102
2102
128
1900

FIG. 21

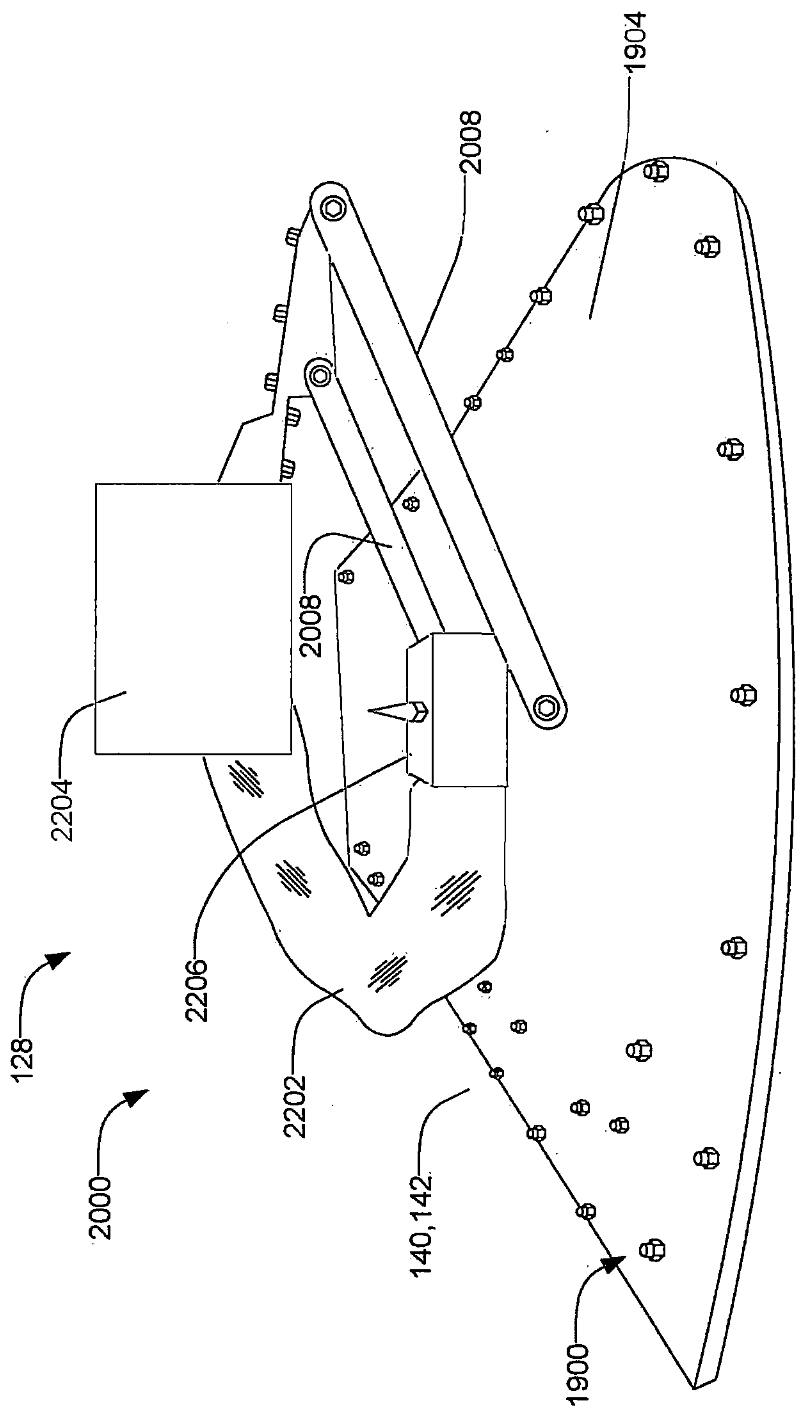


FIG. 22

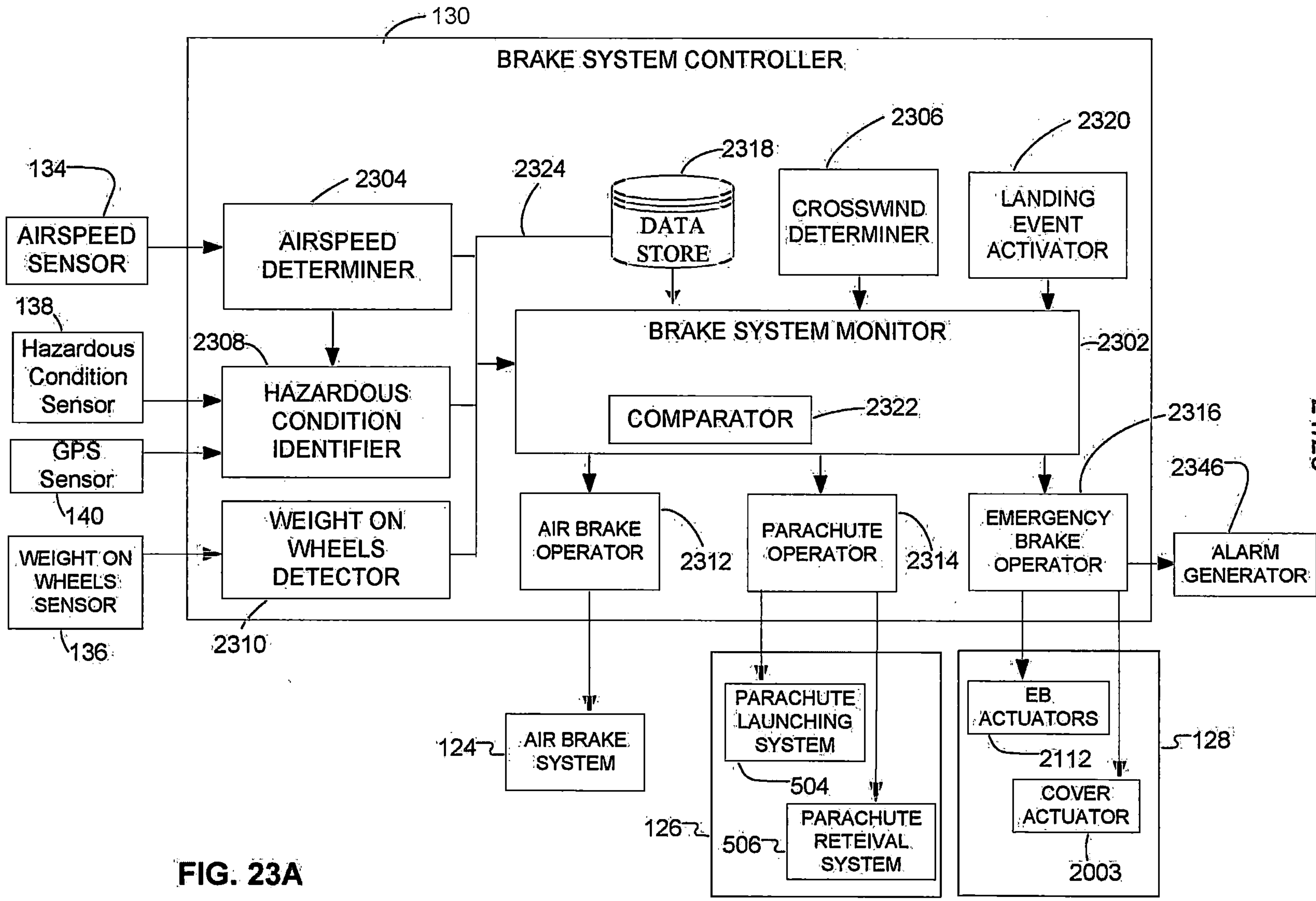

130
BRAKE SYSTEM CONTROLLER
134
AIRSPEED SENSOR
138
Hazardous Condition Sensor
GPS Sensor
140
WEIGHT ON WHEELS SENSOR
136
2304
AIRSPEED DETERMINER
2308
HAZARDOUS CONDITION IDENTIFIER
WEIGHT ON WHEELS DETECTOR
2310
2324
2318
DATA STORE
2306
CROSSWIND DETERMINER
2320
LANDING EVENT ACTIVATOR
BRAKE SYSTEM MONITOR
2302
COMPARATOR
2322
AIR BRAKE OPERATOR
2312
PARACHUTE OPERATOR
2314
EMERGENCY BRAKE OPERATOR
2316
2346
ALARM GENERATOR
124
AIR BRAKE SYSTEM
PARACHUTE LAUNCHING SYSTEM
504
126
506
PARACHUTE RETEIVAL SYSTEM
EB ACTUATORS
2112
128
COVER ACTUATOR
2003

FIG. 23A

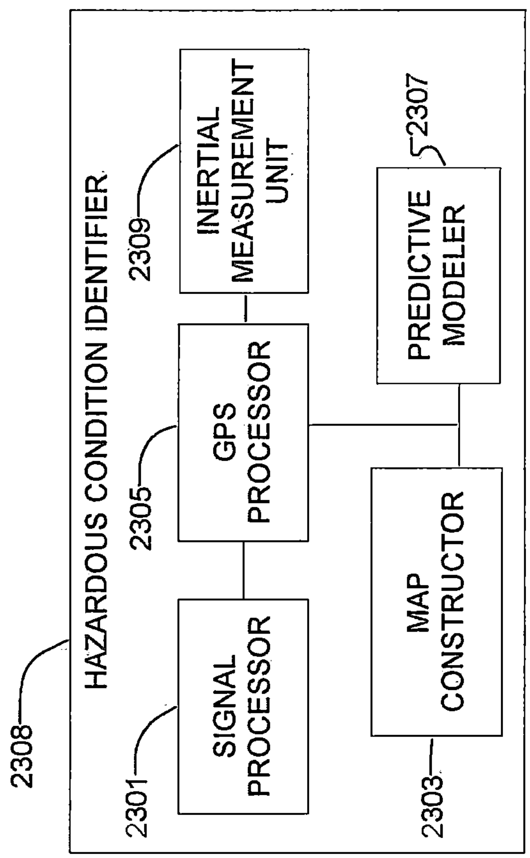
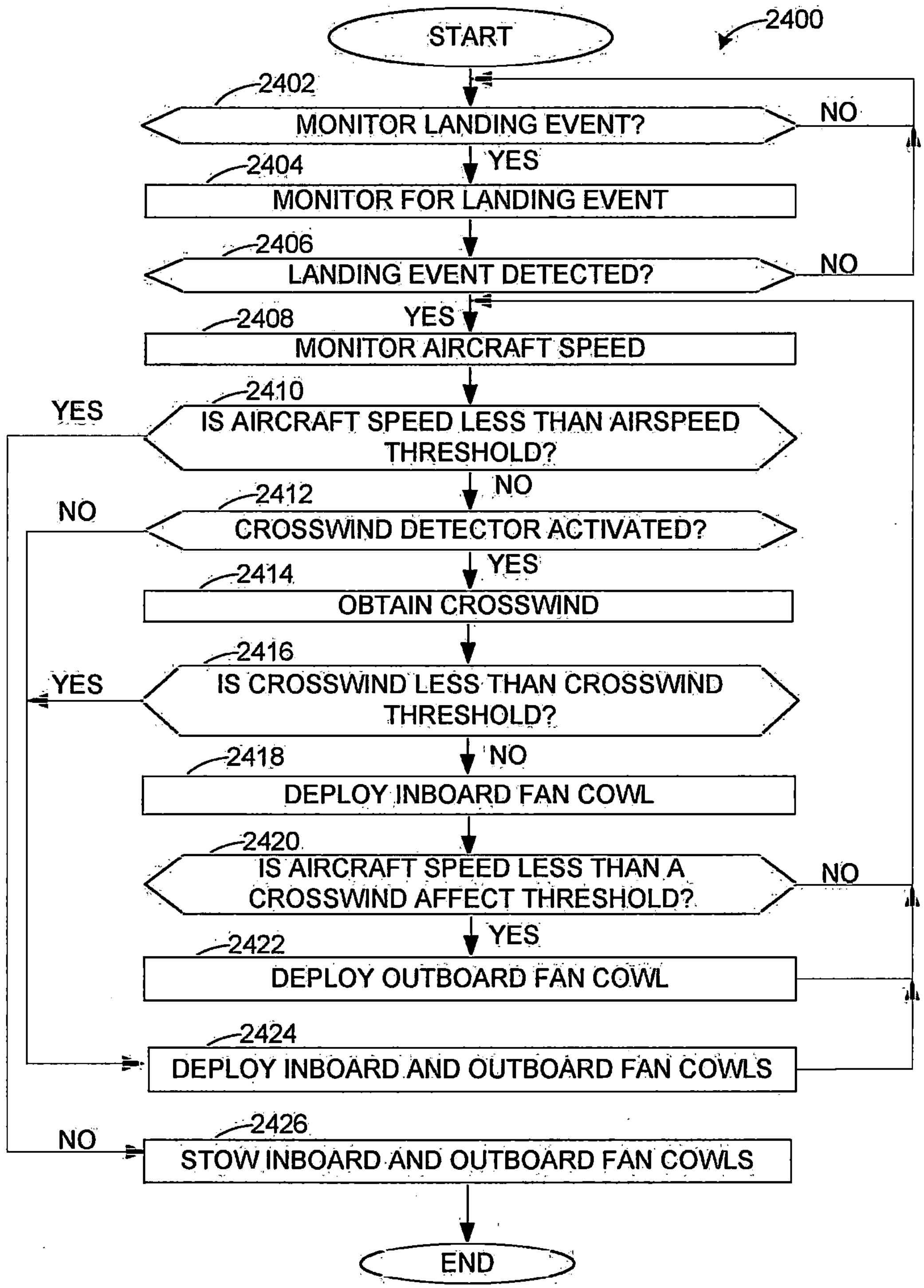

2308
HAZARDOUS CONDITION IDENTIFIER
2301
SIGNAL PROCESSOR
2305
GPS PROCESSOR
2309
INERTIAL MEASUREMENT UNIT
2303
MAP CONSTRUCTOR
PREDICTIVE MODELER
2307

FIG. 23B



2400
START
2402
MONITOR LANDING EVENT?
NO
YES
2404
MONITOR FOR LANDING EVENT
2406
LANDING EVENT DETECTED?
NO
YES
2408
MONITOR AIRCRAFT SPEED
2410
YES
IS AIRCRAFT SPEED LESS THAN AIRSPEED THRESHOLD?
NO
2412
NO
CROSSWIND DETECTOR ACTIVATED?
YES
2414
OBTAIN CROSSWIND
2416
YES
IS CROSSWIND LESS THAN CROSSWIND THRESHOLD?
NO
2418
DEPLOY INBOARD FAN COWL
2420
IS AIRCRAFT SPEED LESS THAN A CROSSWIND AFFECT THRESHOLD?
NO
YES
2422
DEPLOY OUTBOARD FAN COWL
2424
DEPLOY INBOARD AND OUTBOARD FAN COWLS
2426
NO
STOW INBOARD AND OUTBOARD FAN COWLS
END

FIG. 24

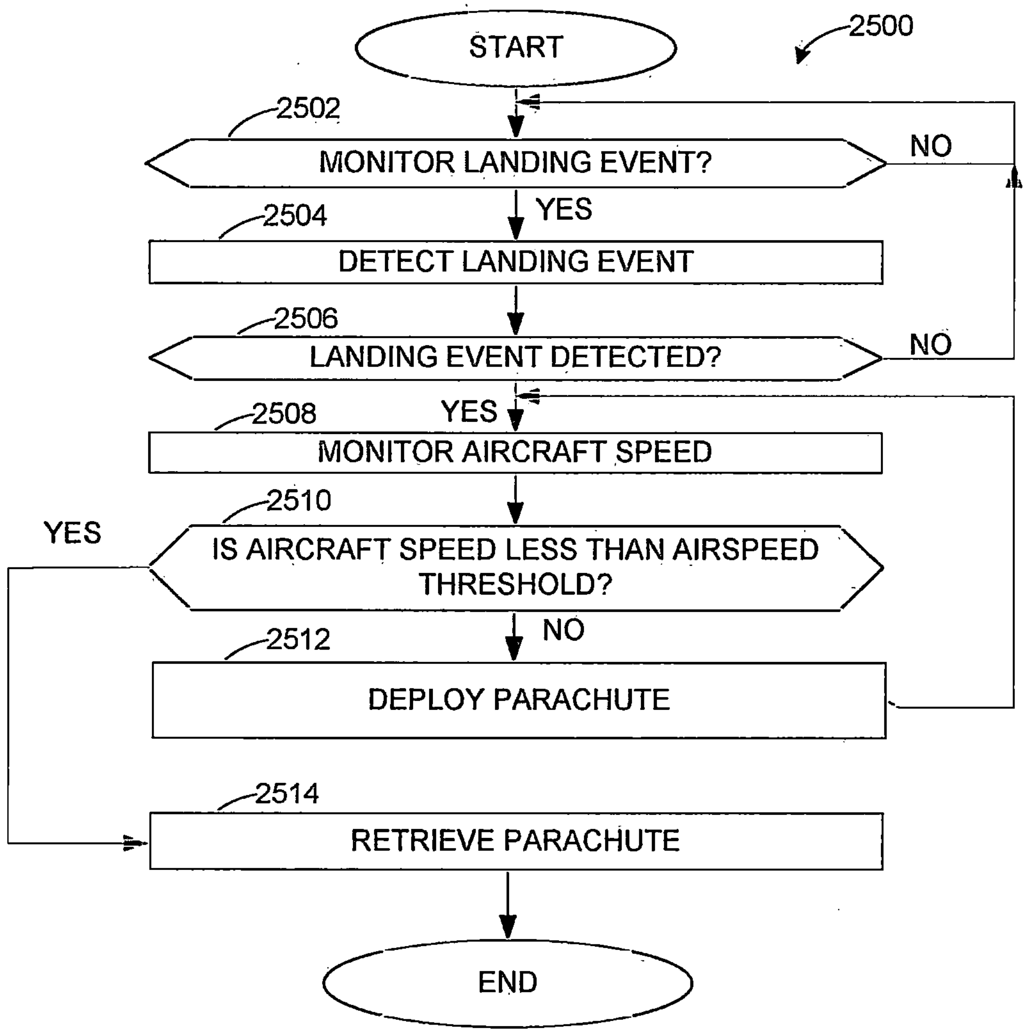

2500
START
2502
MONITOR LANDING EVENT?
NO
YES
2504
DETECT LANDING EVENT
2506
LANDING EVENT DETECTED?
NO
2508
YES
MONITOR AIRCRAFT SPEED
2510
YES
IS AIRCRAFT SPEED LESS THAN AIRSPEED THRESHOLD?
NO
2512
DEPLOY PARACHUTE
2514
RETRIEVE PARACHUTE
END

FIG. 25

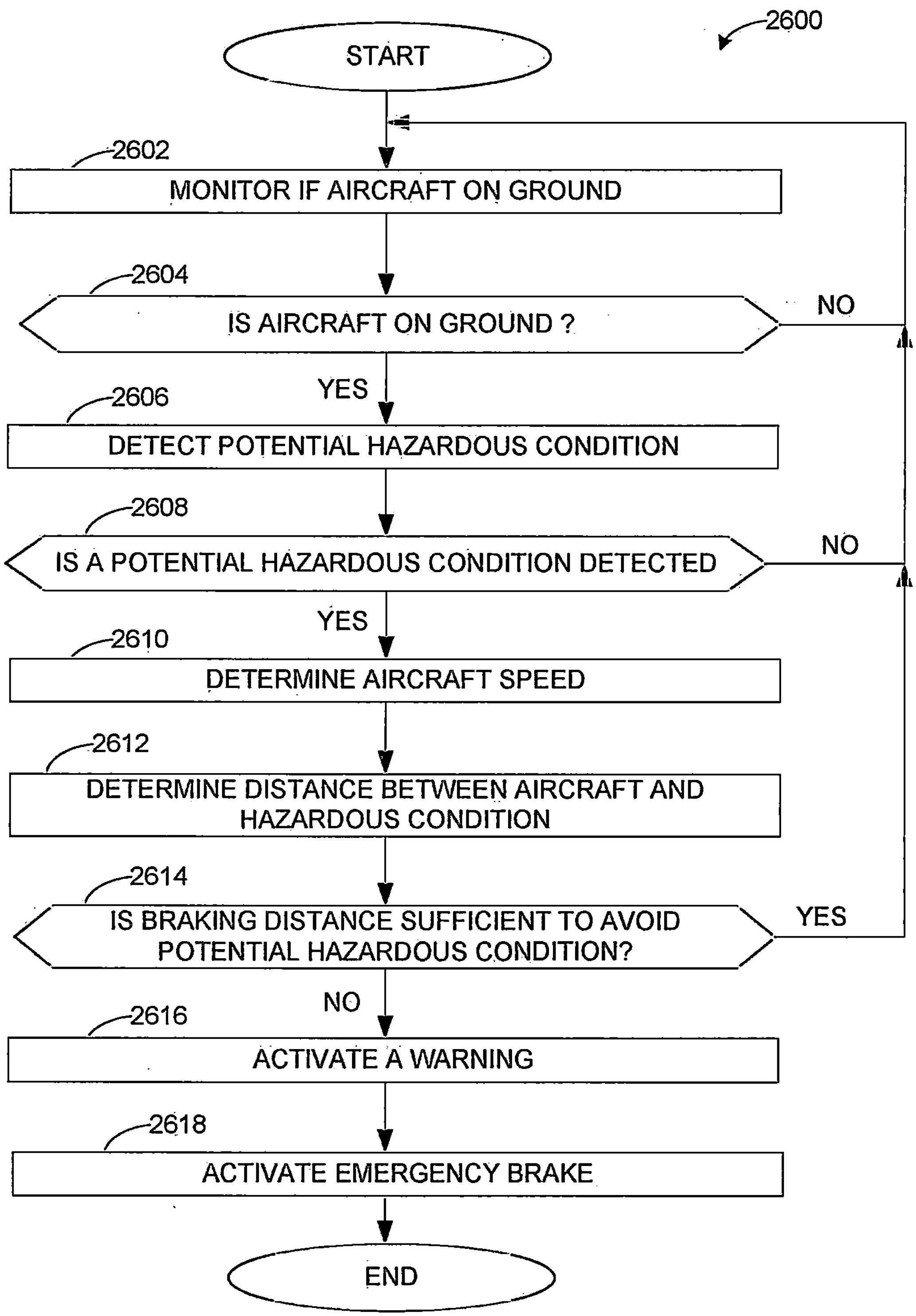

2600
START
2602
MONITOR IF AIRCRAFT ON GROUND
2604
IS AIRCRAFT ON GROUND ?
NO
YES
2606
DETECT POTENTIAL HAZARDOUS CONDITION
2608
IS A POTENTIAL HAZARDOUS CONDITION DETECTED
NO
YES
2610
DETERMINE AIRCRAFT SPEED
2612
DETERMINE DISTANCE BETWEEN AIRCRAFT AND HAZARDOUS CONDITION
2614
IS BRAKING DISTANCE SUFFICIENT TO AVOID POTENTIAL HAZARDOUS CONDITION?
YES
NO
2616
ACTIVATE A WARNING
2618
ACTIVATE EMERGENCY BRAKE
END

FIG. 26

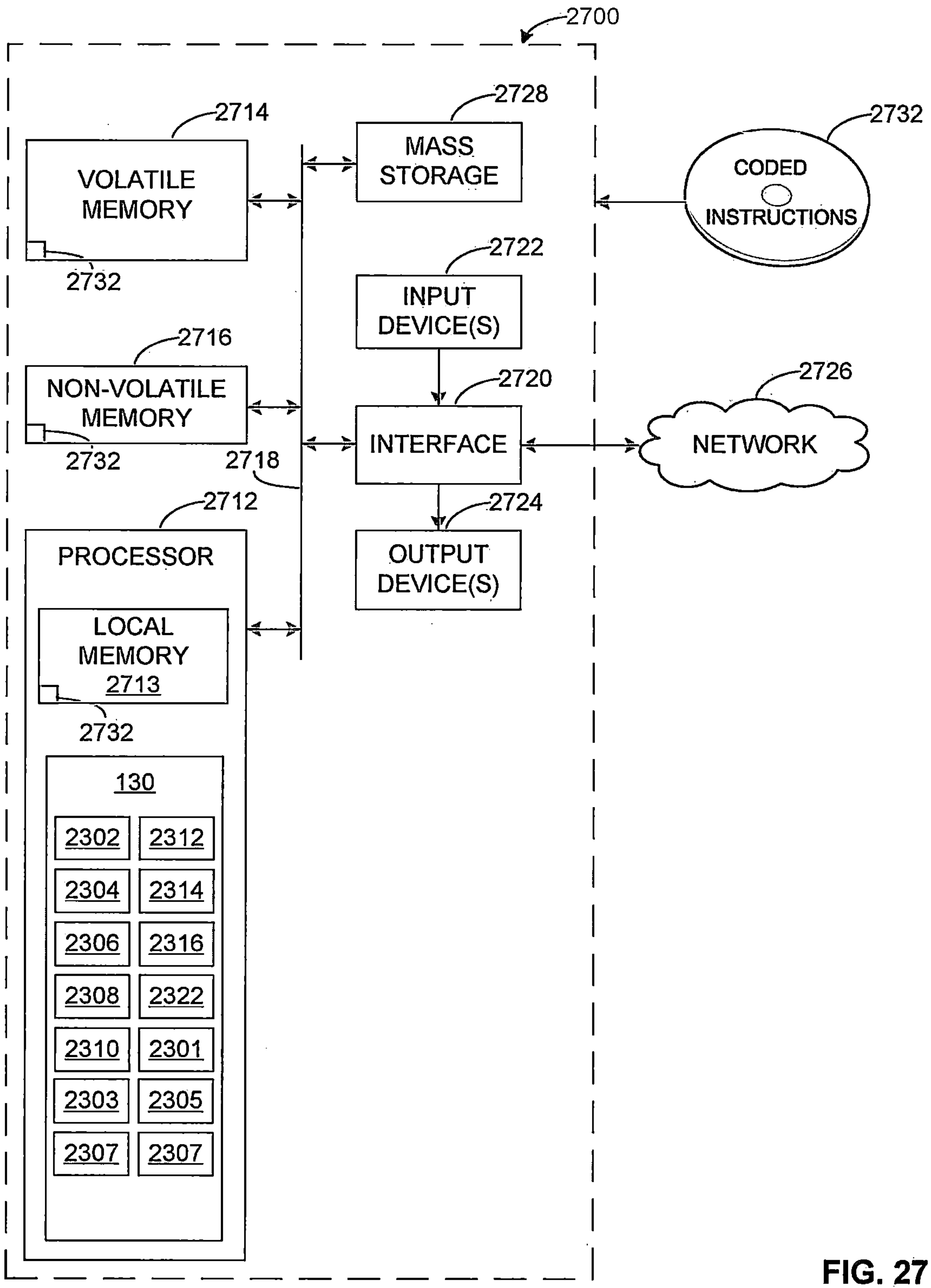
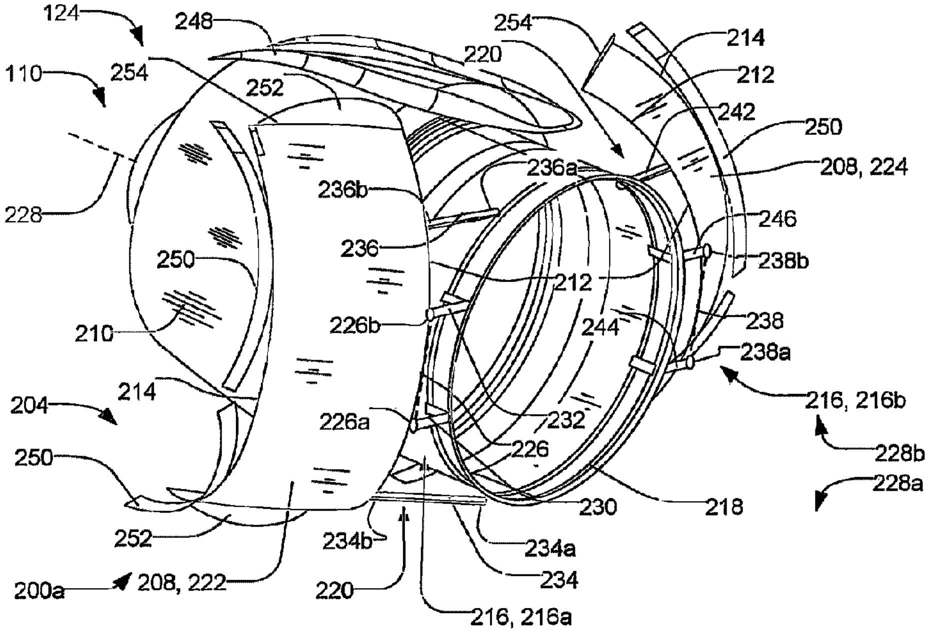

2700
2714
VOLATILE MEMORY
2732
2728
MASS STORAGE
2732
CODED INSTRUCTIONS
2722
INPUT DEVICE(S)
2716
NON-VOLATILE MEMORY
2732
2718
2720
INTERFACE
2726
NETWORK
2712
PROCESSOR
2724
OUTPUT DEVICE(S)
LOCAL MEMORY
2713
2732
130
2302
2312
2304
2314
2306
2316
2308
2322
2310
2301
2303
2305
2307
2307

FIG. 27


124
248
254
220
214
212
110
254
252
242
250
228
236a
208, 224
236b
246
236
238b
250
212
210
244
226b
238
238a
214
216, 216b
204
232
226a
226
228b
250
230
218
228a
252
234b
234a
234
200a
208, 222
220
216, 216a