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(54) **AERIAL DELIVERY SYSTEM**

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(57) **ABSTRACT**

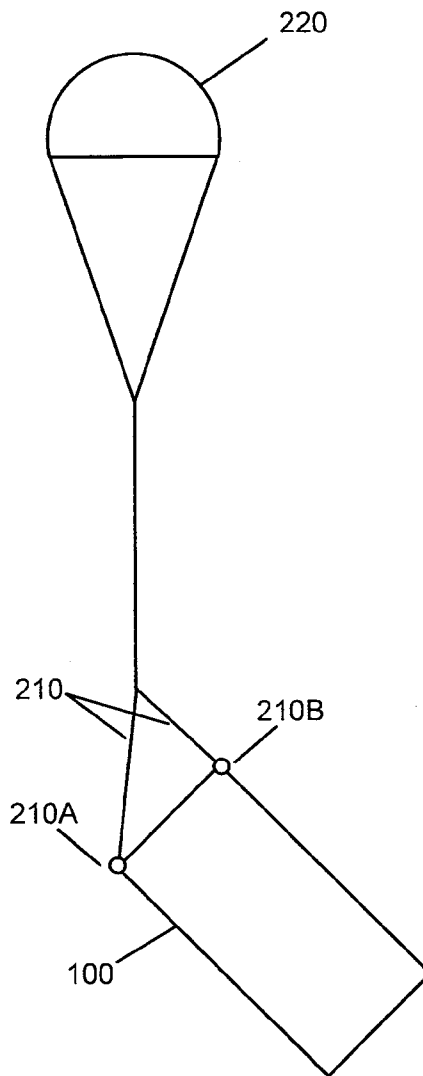
An aerial delivery system is configured to allow delivery of one or more releasable items after the system is extracted from an aircraft. One or more linear guidance devices and releasable securing mechanisms allow the aerial delivery system to deploy one or more releasable items at an appropriate time. The one or more releasable items may be deployed simultaneously, or in a staged or staggered fashion. Through use of drag or lift-producing devices, the system may be recovered and reused. The attitude and/or azimuth orientation of the system may be varied prior to, during, and/or after release of a releasable item.

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Related U.S. Application Data

(60) Provisional application No. 61/060,394, filed on Jun. 10, 2008.



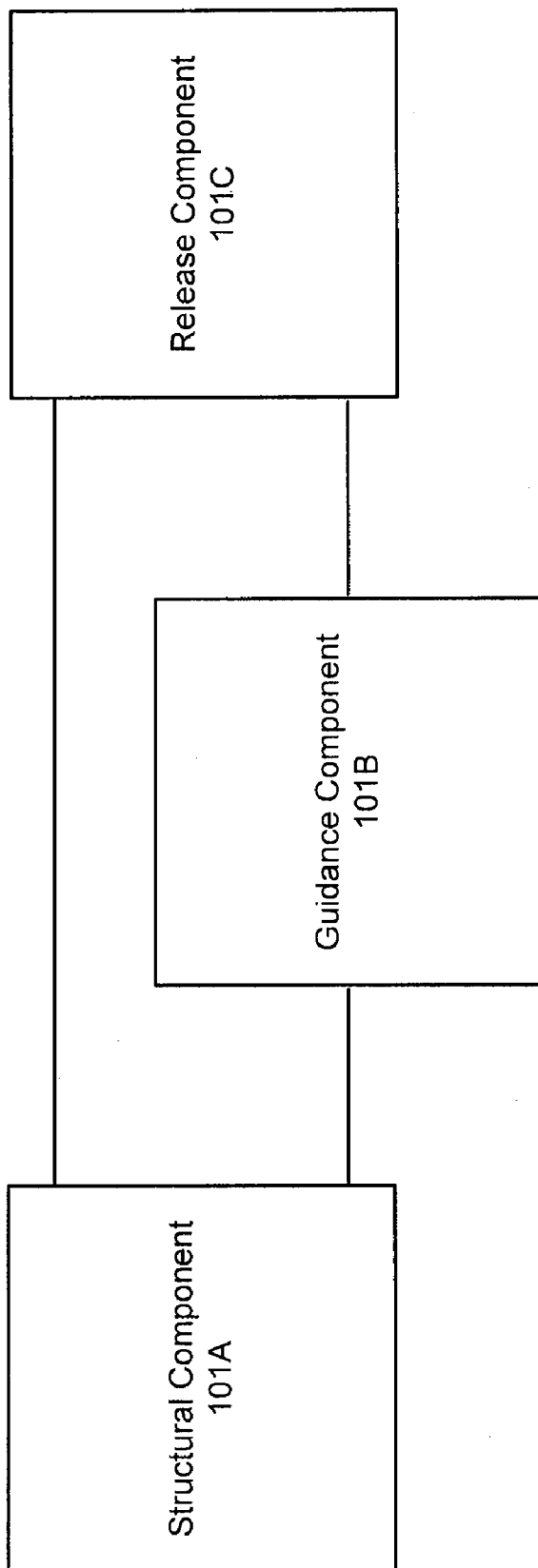


FIG. 1A

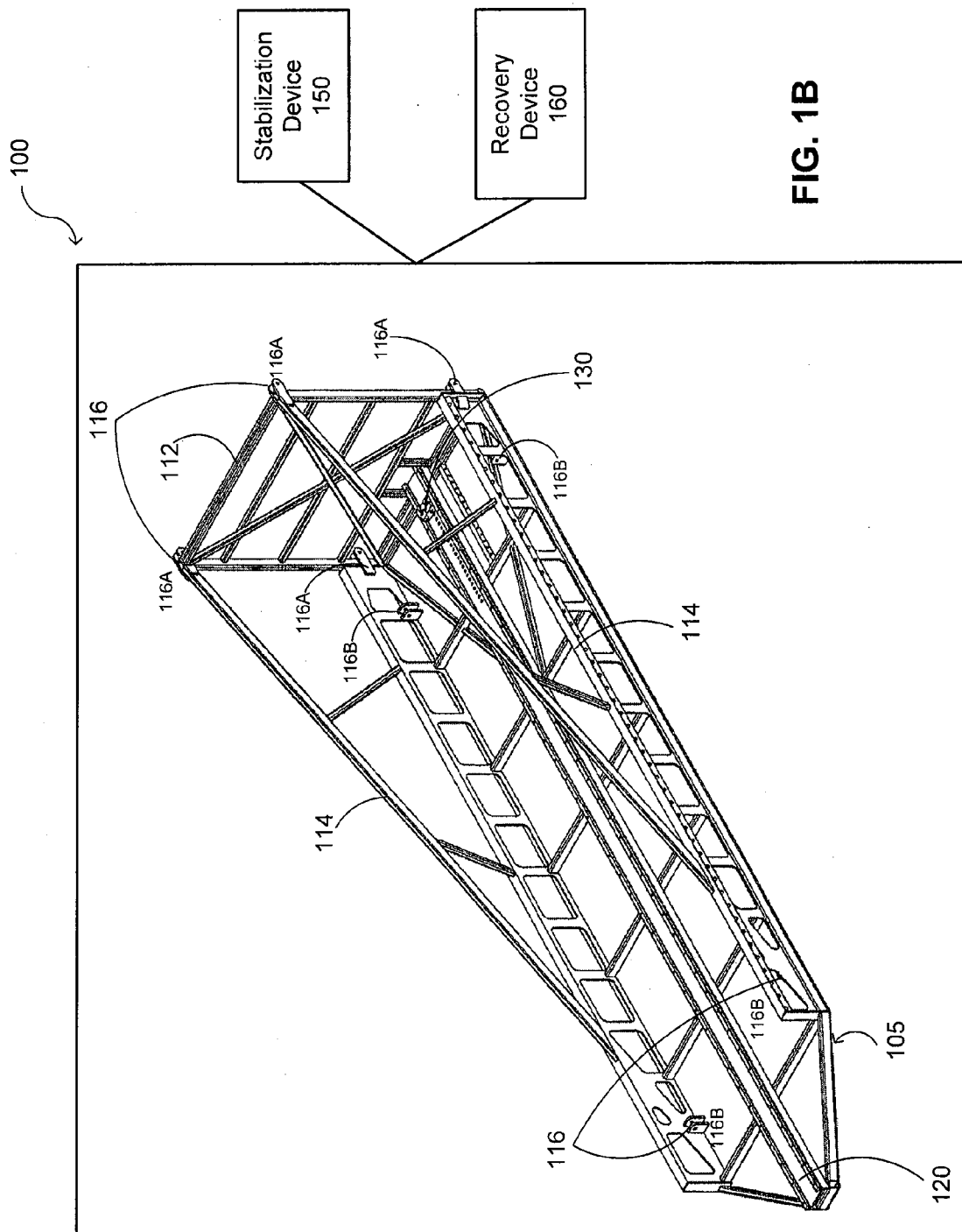


FIG. 1B

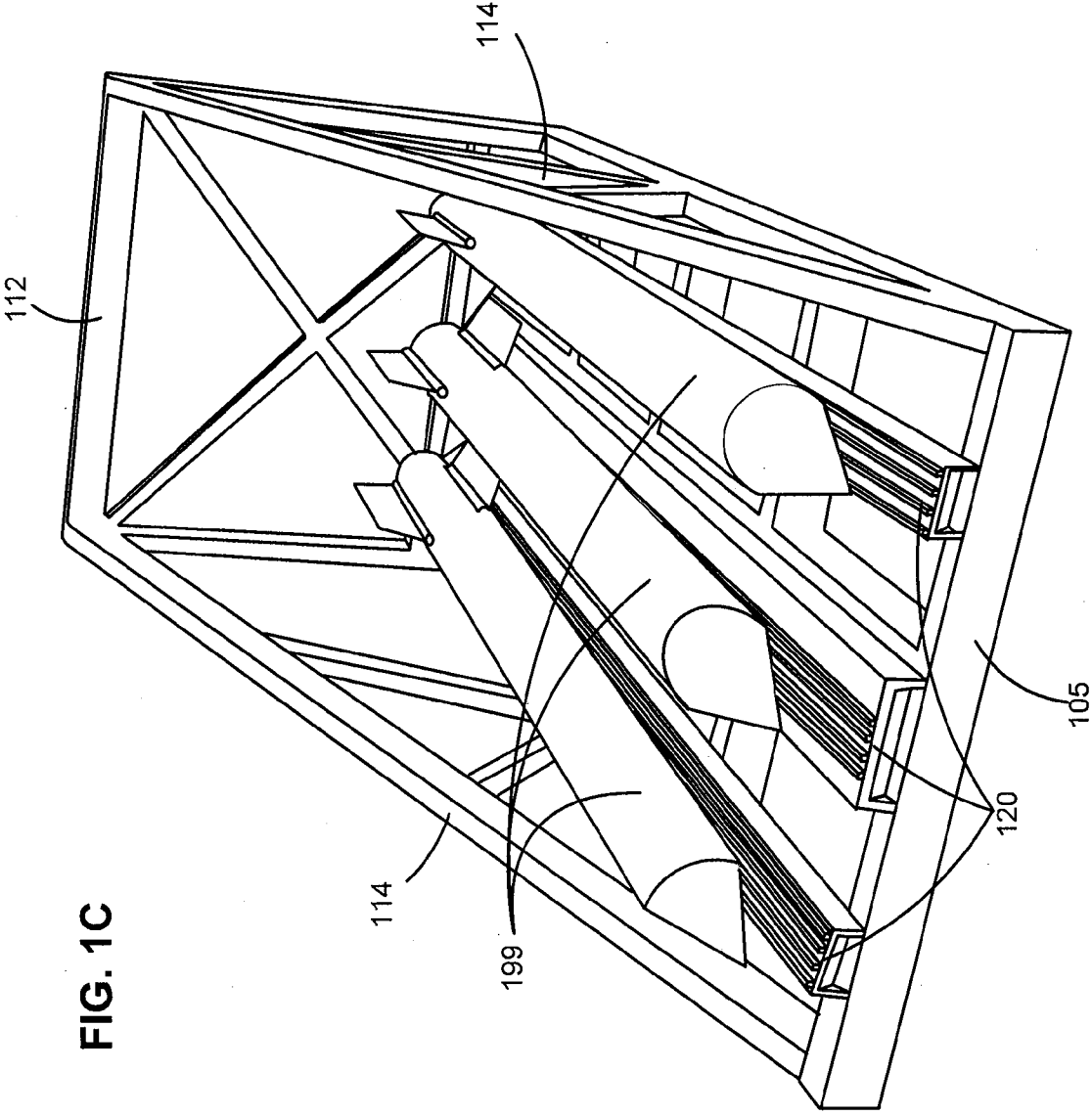


FIG. 1C

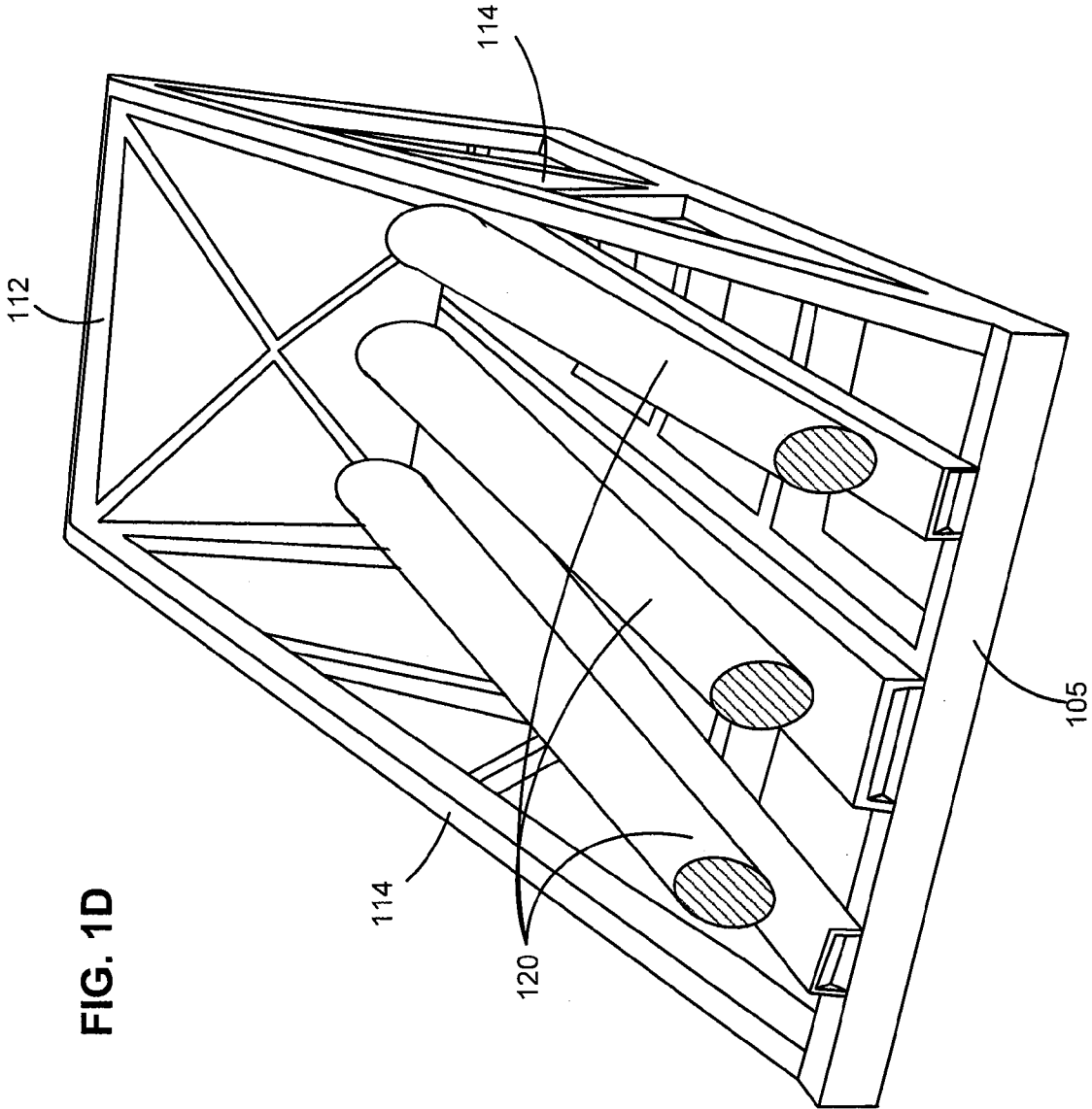


FIG. 1D

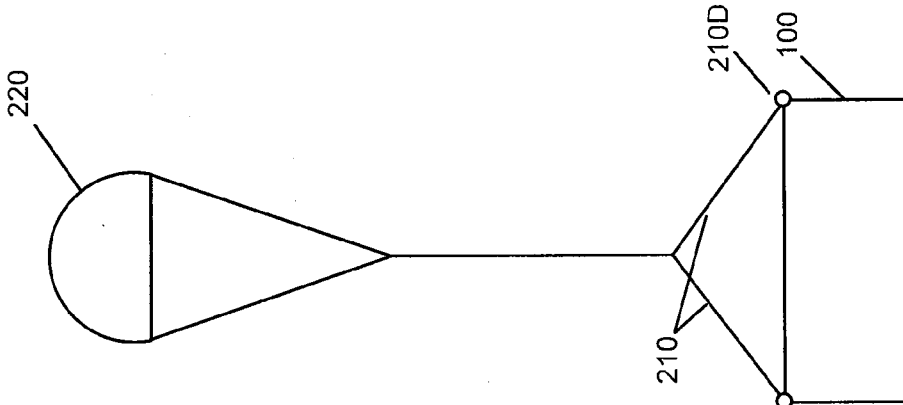


FIG. 2A

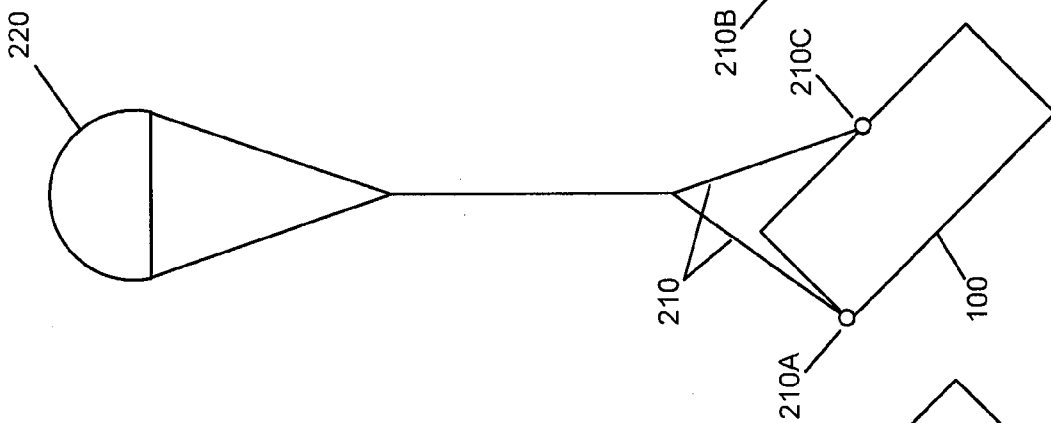


FIG. 2B

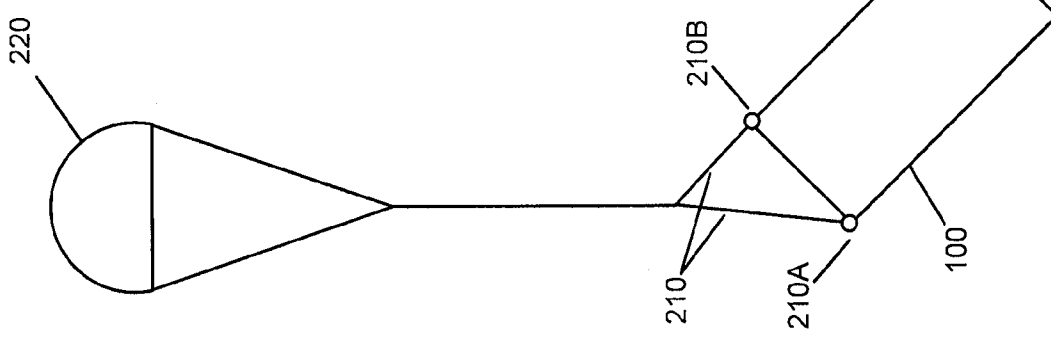


FIG. 2C

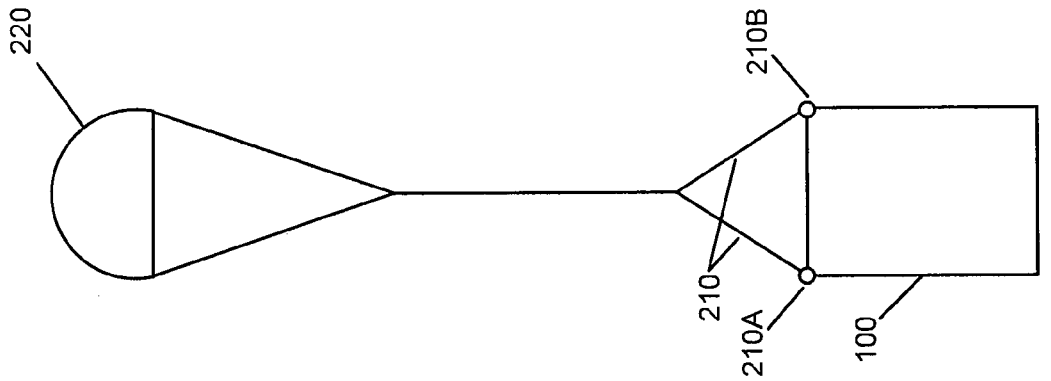
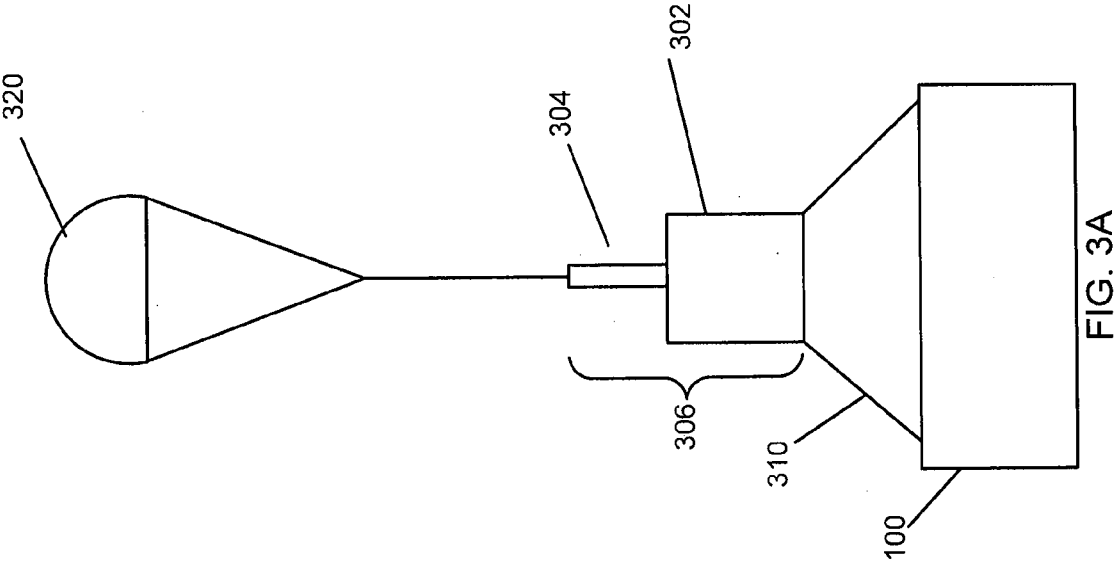
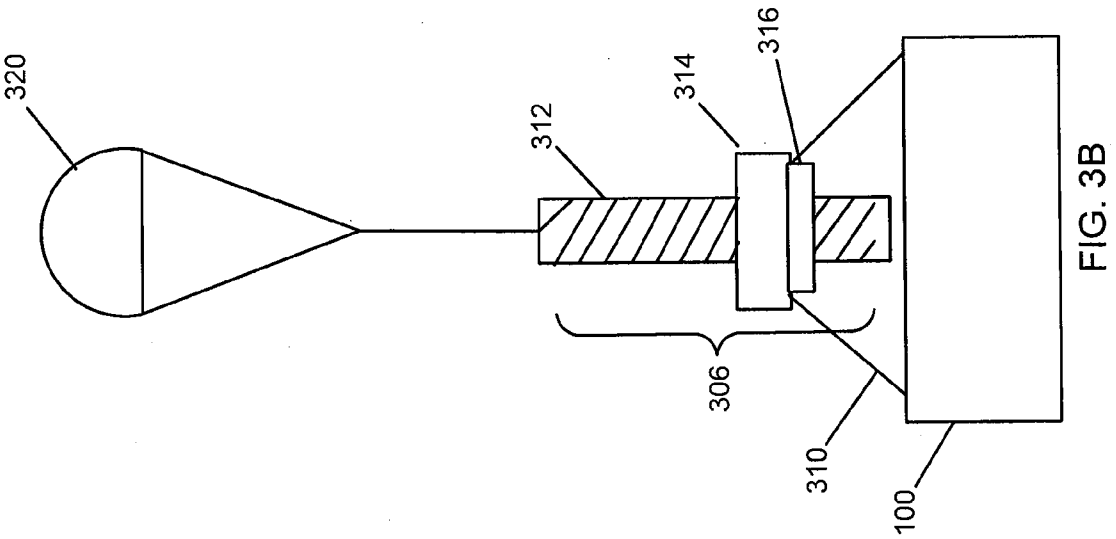


FIG. 2D



AERIAL DELIVERY SYSTEM
CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a non-provisional of U.S. Provisional No. 61/060,394 filed on Jun. 10, 2008 and entitled "AERIAL DELIVERY SYSTEM." This provisional application is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to aerial delivery, particularly delivery achieved via mid-air extraction from an aircraft.

BACKGROUND

[0003] Aerial delivery is a term used to describe extracting an item from an aircraft in flight and then enabling a safe recovery of the item by use of an aerodynamic decelerator, which is most often a parachute system. Additionally, the aerial delivery operation is typically conducted from a cargo-type aircraft. The process may utilize very specific aerial delivery equipment and may adhere to very specific aerial delivery operational procedures. Often, the extracted item consists of an aerial delivery system containing cargo of some sort.

[0004] Two general types of extraction are utilized. Gravity extraction is the technique of using positive aircraft pitch angle, or by using some other force to cause the item to simply roll or slide out of the aircraft, which is typically followed by a parachute being deployed by a lanyard that is anchored to the aircraft. Parachute extraction is a technique whereby a parachute is first deployed out the rear of the cargo compartment, and the parachute is used to pull the item from the aircraft. Both techniques may conform to guidelines regarding length, weight, mass, etc., of the item being extracted in order to achieve a safe extraction operation. Generally speaking, relatively short and/or relatively lightweight items may be gravity extracted, but relatively long and/or relatively heavy items may preferably be parachute extracted, which removes the item from the aircraft quickly to prevent it from adversely affecting the aircraft's center of balance.

[0005] Items having a generally cylindrical shape, such as bombs that are powered by gravity, will typically be released from the belly or wing of a bomber or fighter aircraft. In practice, these items are released vertically but their longitudinal axis is substantially horizontal. Because the lower bomb racks in a bomb bay may be repositioned before other items can be released from racks above them, a simultaneous release of all items in the bomb bay cannot generally be conducted. The relatively long release time, coupled with a relatively high airspeed that is a feature of these aircraft, prevents the items from impacting in a concentrated area. Instead, the resulting impact path of the items is quite lengthy and the resulting impact effect is known as carpet bombing.

[0006] For aerial launching of chemical energy powered items, such as missiles, yet another technique is used. In this scenario, items are loaded into linear guidance devices, which are typically referred to as launchers. Typically, these launchers are either tubular or monorail (dovetail) in design, and are mounted substantially horizontally on fighter airplanes or helicopters. In practice, these items are generally powered by a self-contained rocket motor, allowing only one item to be loaded per launcher. Otherwise, the rocket blast from the front

item could damage the item behind it, perhaps even causing it to explode while it is still in the launcher.

[0007] In yet another scenario, the GBU-43/B Massive Ordnance Air Blast ("MOAB") munition is secured in a cradle atop an aerial delivery system that is parachute extracted from the cargo compartment of a cargo aircraft. The MOAB cradle is just that—a cradle; and, because the MOAB is a winged item, it must be separated from its cradle immediately outside the aircraft, with the extraction parachute still attached to the aerial delivery system, before the cradle can pitch or roll significantly—otherwise, the MOAB is likely to be damaged or released in an undesirable attitude. In the separation process, the MOAB has forward momentum due to inertia imparted by the aircraft, but the aerial delivery system and cradle will slow significantly, due to drag created by the still attached extraction parachute. The aerial delivery system will also pitch, with its leading edge going downward due to gravity and aerodynamic forces. The combination of relative longitudinal motion and a pitch-down of the aerial delivery system and cradle, allow the platform and cradle to move down and rearward, away from the MOAB. However, because this separation technique does not provide linear guidance control, or roll and yaw control, relative to the cradle, the rear control surfaces of the MOAB must be in a retracted configuration until after the separation event has occurred. Even though this marginally controlled separation technique is acceptable for the MOAB, it may be unsuitable if the separation event were significantly delayed after the system has been released from the aircraft. Further, because the separation technique provides no directional control or roll and yaw control for the separating item, it may be unsuitable for launching items with extended rear-mounted control surfaces, such as fins. With no directional or roll and yaw control, it may also be unsuitable for simultaneously launching multiple items that have any type of extended control surfaces.

SUMMARY

[0008] An aerial delivery system enables delivery of releasable items after extraction from an aircraft. In an exemplary embodiment, an aerial delivery system comprises a platform, a first linear guidance device coupled to the platform, and a releasable securing mechanism. The releasable securing mechanism is configured to couple a releasable item to the first linear guidance device.

[0009] In another exemplary embodiment, a method comprises coupling a first releasable item to an aerial delivery system comprising a first releasable securing mechanism. A drogue parachute is deployed to cause the aerial delivery system to exit an aircraft. A first releasable securing mechanism is activated to separate the first releasable item from the aerial delivery system. The releasable item separates from the aerial delivery system under the influence of a linear guidance device.

[0010] In another exemplary embodiment, a method for controlling the attitude of a payload comprises coupling a first strap having a first length to the payload, and coupling a second strap having a second length to the payload. The second length is different from the first length. The first strap and the second strap are coupled to a parachute, and the payload is deployed from an aircraft. The parachute is deployed to cause the payload to achieve a predetermined orientation responsive to the weight of the payload.

[0011] In another exemplary embodiment, a method for controlling the azimuth of a payload comprises coupling a

payload to a rotation mechanism, coupling the rotation mechanism to a parachute, deploying the payload from an aircraft, deploying the parachute to cause the payload to be suspended beneath the parachute, and activating the rotation mechanism to cause the payload to rotate with respect to the parachute.

[0012] In another exemplary embodiment, a method for controlling the azimuth of a payload comprises issuing a first move command to a motor. The motor is coupled to a payload and to a parachute. Responsive to the first move command, a motor shaft is moved a first time to rotate the payload with respect to the parachute to bring the payload into a desired azimuth orientation. Responsive to a change in the azimuth orientation of the payload, a second move command is issued to the motor. Responsive to the second move command, a motor shaft is moved a second time to rotate the payload with respect to the parachute to restore the payload to a desired azimuth orientation.

[0013] In another exemplary embodiment, a computer-readable medium has stored thereon, computer-executable instructions that, if executed by a system, cause the system to perform a method comprising issuing a first move command to a motor. The motor is coupled to a payload and to a parachute. Responsive to the first move command, a motor shaft is moved a first time to rotate the payload with respect to the parachute to bring the payload into a desired azimuth orientation. Responsive to a change in the azimuth orientation of the payload, a second move command is issued to the motor. Responsive to the second move command, a motor shaft is moved a second time to rotate the payload with respect to the parachute to restore the payload to a desired azimuth orientation.

[0014] The contents of this summary section are provided only as a simplified introduction to the disclosure, and are not intended to be used to limit the scope of the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] With reference to the following description, appended claims, and accompanying drawings:

[0016] FIG. 1A illustrates a block diagram of an aerial delivery system in accordance with various exemplary embodiments of the invention;

[0017] FIG. 1B represents an aerial delivery system in accordance with an exemplary embodiment of the invention;

[0018] FIG. 1C illustrates an aerial delivery system comprising multiple linear guidance devices in accordance with an exemplary embodiment of the invention;

[0019] FIG. 1D illustrates an aerial delivery system comprising multiple tubular linear guidance devices in accordance with an exemplary embodiment of the invention;

[0020] FIGS. 2A-2D illustrate an aerial delivery system configured for varied attitudes in accordance with various exemplary embodiments of the invention; and

[0021] FIGS. 3A-3B illustrate an aerial delivery system configured for various azimuth orientations in accordance with an exemplary embodiment of the invention.

DETAILED DESCRIPTION

[0022] The following description is of various exemplary embodiments only, and is not intended to limit the scope, applicability or configuration of the present disclosure in any way. Rather, the following description is intended to provide a convenient illustration for implementing various embodi-

ments including the best mode. As will become apparent, various changes may be made in the function and arrangement of the elements described in these embodiments without departing from the scope of the appended claims.

[0023] For the sake of brevity, conventional techniques for aerial delivery may not be described in detail herein. Furthermore, the connecting lines shown in various figures contained herein are intended to represent exemplary functional relationships and/or physical couplings between various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in a practical aerial delivery system.

[0024] An aerial delivery system may be any system configured to support a payload during extraction from an aircraft and/or during the resulting descent and contact with the ground. In accordance with an exemplary embodiment, and with reference to FIG. 1A, an aerial delivery system generally comprises a structural component 101A, a guidance component 101B, and a release component 101C. Structural component 101A is configured to provide support to a payload during and/or after extraction of the payload from an aircraft. Guidance component 101B is coupled to structural component 101A, and is configured to at least partially guide and/or direct the separation of the payload from the aerial delivery system. Release component 101C is coupled to structural component 101A and/or guidance component 101B, and is configured to secure the payload to guidance component 101B until separation of the payload is desired.

[0025] Moreover, an aerial delivery system may be configured with any appropriate components and/or elements configured to support a payload during extraction from an aircraft and/or during the resulting descent and contact with the ground. For example, with reference now to FIGS. 1A, 1B and 1C, and in accordance with an exemplary embodiment, an aerial delivery system 100 comprises structural component 101A (for example, platform 105), at least one guidance component 101B (for example, linear guidance device 120), and at least one release component 101C (for example, releasable securing mechanism 130). At least one releasable item 199 is coupled to linear guidance device 120, and is prevented from separating by releasable securing mechanism 130. In various exemplary embodiments, structural component 101A further comprises an upright rear section 112, at least one upright side section 114, and at least one sling attachment fitting 116. In an exemplary embodiment, a stabilization device 150 is coupled to aerial delivery system 100. In another exemplary embodiment, a recovery device 160 is coupled to aerial delivery system 100. In various exemplary embodiments, both a stabilization device 150 and a recovery device 160 are coupled to aerial delivery system 100.

[0026] Platform 105 may comprise any suitable material or structure configured to be deployed via the cargo door of an aircraft. In accordance with an exemplary embodiment, platform 105 comprises a substantially planar structure with supporting ribs or other reinforcing elements. In an exemplary embodiment, platform 105 is made of aluminum. In another exemplary embodiment, platform 105 is made of steel. In an exemplary embodiment, platform 105 is coupled to upright rear section 112, two upright side sections 114, and at least one linear guidance device 120. Moreover, platform 105 may comprise various structural elements, materials, and configurations suitable to be deployed via the cargo door of an air-

craft. Additionally, platform **105** may be coupled to any appropriate components of aerial delivery system **100**, as desired.

[0027] Linear guidance device **120** may be any appropriate structure configured to guide at least one releasable item **199** as it separates from aerial delivery system **100**. In accordance with an exemplary embodiment, at least one linear guidance device **120** is provided. In an exemplary embodiment, linear guidance device **120** is a monorail. In another exemplary embodiment, and with momentary reference to FIG. **1D**, linear guidance device **120** is a tubular structure. Further, linear guidance device **120** may be configured in a manner which allows release of releasable items **199** having extended, rear-mounted control surfaces (e.g., fins, wings, flanges, stabilizer bars, and/or the like). Moreover, although referred to as “linear”, linear guidance device **120** may be configured with various curves, angles, and/or the like, as appropriate.

[0028] Linear guidance device **120** is coupled to platform **105**. Linear guidance device **120** may also be coupled to rear section **112** and/or side section **114**, and/or to one or more additional linear guidance devices **120**. In an exemplary embodiment, linear guidance device **120** is made of aluminum. In another exemplary embodiment, linear guidance device **120** is made of steel. Moreover, linear guidance device **120** may be made of any suitable material configured to guide, support, and/or otherwise interact with a releasable item **199**. In an exemplary embodiment, aerial delivery system **100** is configured with one linear guidance device **120**. In another exemplary embodiment, aerial delivery system **100** is configured with two linear guidance devices **120**. Moreover, aerial delivery system **100** may be configured with any desired number of linear guidance devices **120**.

[0029] With reference now to FIG. **1C**, multiple linear guidance devices **120** may be coupled to platform **105**. In an exemplary embodiment, multiple linear guidance devices **120** are located alongside one another. In another exemplary embodiment, multiple linear guidance devices **120** are located atop one another. In other exemplary embodiments, multiple linear guidance devices **120** may be arranged in a grid or other three-dimensional pattern. Moreover, multiple linear guidance devices **120** may be arranged in any suitable manner configured to allow release of multiple releasable items **199**. Further, each linear guidance device **120** may guide one releasable item **199**. Each linear guidance device **120** may also guide multiple releasable items **199**, for example releasable items **199** installed in a “heel to toe” configuration. Moreover, aerial delivery system **100** may comprise any combination of linear guidance devices **120**, releasable items **199**, and/or releasable securing mechanisms **130**.

[0030] Releasable securing mechanism **130** may be any suitable mechanism configured to allow releasable item **199** to separate from linear guidance device **120**. With reference to FIGS. **1B** and **1C**, in accordance with an exemplary embodiment, a releasable item **199** is secured to a linear guidance device **120** via releasable securing mechanism **130**. In an exemplary embodiment, releasable securing mechanism **130** is a pyrotechnic device configured to sever one or more restraining straps (e.g., a reefing cutter, and/or the like). In another exemplary embodiment, releasable securing mechanism **130** is an explosive bolt. In yet another exemplary embodiment, releasable securing mechanism comprises a stored energy spring configured to impart a force to a releasable item **199**. In this embodiment, releasable item **199** may

be at least partially ejected from aerial delivery system **100** responsive to the operation of the stored energy spring. Moreover, releasable securing mechanism **130** may comprise any suitable material, machinery, components, and/or configurations suitable to cause and/or permit releasable item **199** to separate from linear guidance device **120**.

[0031] Moreover, structural component **101A** of aerial delivery system **100** may comprise any combination of reinforcing members, supporting members, platforms, walls, sections, fasteners, braces, joints, links, welds, couplings, and/or the like. For example, returning to FIGS. **1A-1C**, and in various exemplary embodiments, structural component **101A** further comprises an upright rear section **112**, at least one upright side section **114**, and at least one sling attachment fitting **116**. In other exemplary embodiments, structural component **101A** further comprises at least one sling attachment fitting **116**. In still other exemplary embodiments, structural component **101A** further comprises two upright side sections **114**. Moreover, structural component **101A** may comprise any combination of platforms **105**, upright rear sections **112**, upright side sections **114**, sling attachment fittings **116**, and/or the like, as desired.

[0032] Rear section **112** may comprise any suitable material or structure configured to be deployed via the cargo door of an aircraft. Further, rear section **112** may comprise any suitable material or structure configured to couple with suspension slings and/or other components of aerial delivery system **100**. In accordance with an exemplary embodiment, upright rear section **112** comprises a substantially planar structure with supporting ribs or other reinforcing elements. In an exemplary embodiment, rear section **112** is made of aluminum. In another exemplary embodiment, rear section **112** is made of steel. Rear section **112** is coupled to platform **105** and to side sections **114**. Four sling attachment fittings **116**, for example sling attachment fittings **116A**, are coupled to rear section **112**. Sling attachment fittings **116A** are preferably located at the four corners of rear section **112**. However, sling attachment fittings **116A** may be coupled to various locations of rear section **112**, and more or less sling attachment fittings **116A** may be provided as appropriate. Further, sling attachment fittings **116A** may be located on aerial delivery system **100** in any manner configured to allow aerial delivery system **100** to achieve a desired orientation, for example a substantially vertical orientation, once extracted from an aircraft.

[0033] Side section **114** may comprise any suitable material or structure configured to be deployed via the cargo door of an aircraft. Further, side section **114** may comprise any suitable material or structure configured to couple with suspension slings and/or other components of aerial delivery system **100**. In accordance with an exemplary embodiment, an upright side section **114** comprises a substantially planar structure with supporting ribs or other reinforcing elements. In an exemplary embodiment, side section **114** is made of aluminum. In another exemplary embodiment, side section **114** is made of steel. Moreover, in various exemplary embodiments, side section **114** is made of cable, textile material, and/or the like. Side section **114** is coupled to platform **105** and to rear section **112**.

[0034] In an exemplary embodiment, two sling attachment fittings **116**, such as sling attachment fittings **116B**, are coupled to each side section **114**. Sling attachment fittings **116B** are preferably located near the front and rear of each side section **114**. However, sling attachment fittings **116B**

may be coupled to various locations of each side section 112, and more or fewer sling attachment fittings 116B may be provided as appropriate. Further, sling attachment fittings 116B may be located on aerial delivery system 100 in any manner configured to allow aerial delivery system 100 to achieve a desired orientation, for example a substantially horizontal orientation, after a recovery device is deployed. For example, sling attachment fittings may be located at the corners of platform 105. Moreover, any number of sling attachment fittings 116A and/or 116B may be located on aerial delivery system 100 in any manner configured to allow aerial delivery system 100 to achieve a desired attitude after a recovery device is deployed. For example, a sling attachment fitting 116B may be located near the midpoint of each side section 114. These sling attachment fittings 116B, in connection with sling attachment fittings 116B located at the rear of each side section 114, will enable aerial delivery system 100 to achieve an inclined attitude after a stabilization device 150 is deployed.

[0035] Stabilization device 150 may comprise any drag or lift-producing device configured to orient aerial delivery system 100 in a desired orientation (for example, a substantially vertical orientation) once extracted from an aircraft. Continuing to reference FIG. 1B, and in accordance with an exemplary embodiment, stabilization device 150 comprises a ballistic parachute. A ballistic parachute serves to slow the vertical velocity of aerial delivery system 100 and/or to keep it in a substantially vertical orientation as it drifts with the wind. In another exemplary embodiment, stabilization device 150 comprises a guided parachute. A guided parachute will not only slow the descent velocity and provide vertical stabilization to aerial delivery system 100, it may be used to allow aerial delivery system 100 to loiter over a particular point on the surface, or it may be used to allow aerial delivery system 100 to omnidirectionally traverse the wind column in which it is descending.

[0036] In an exemplary embodiment, stabilization device 150 is coupled to aerial delivery system 100 at sling attachment fitting locations 116A. Multiple suspension slings connect sling attachment fitting locations 116A to a parachute release device, for example the parachute release assembly disclosed in U.S. Pat. No. 7,264,205. A webbing suspension riser assembly connects the parachute release device to the stabilization device suspension member convergence point. Moreover, stabilization device 150 may be coupled to aerial delivery system 100 at any suitable location configured to orient aerial delivery system 100 in a desired orientation (for example, a vertical orientation, a horizontal orientation, a partially inclined orientation, and/or the like) once extracted from an aircraft. Further, stabilization device 150 may be coupled to aerial delivery system 100 in a manner configured to allow stabilization device 150 to be separated from aerial delivery system 100.

[0037] In an exemplary embodiment, stabilization device 150 functions as an extraction parachute configured to drag aerial delivery system 100 from an aircraft. Alternatively, a separate extraction parachute may drag aerial delivery system 100 from the aircraft. This separate extraction parachute may also function as a pilot parachute to deploy stabilization device 150.

[0038] When separated from aerial delivery system 100, stabilization device 150 may trigger deployment of recovery device 160. Alternatively, stabilization device 150 may be separated from aerial delivery system 100 without deploying

any recovery device, causing aerial delivery system 100 to fall and consequently be damaged or destroyed upon impact with the ground.

[0039] Recovery device 160 may comprise any drag or lift-producing device configured to allow aerial delivery system 100 to be recovered and/or reused. Continuing to reference FIG. 1B, and in accordance with an exemplary embodiment, recovery device 160 comprises a ballistic parachute. In another exemplary embodiment, recovery device 160 comprises a guided parachute.

[0040] In an exemplary embodiment, recovery device 160 is coupled to aerial delivery system assembly 100 at sling attachment fitting locations 116B. Moreover, recovery device 160 may be coupled to aerial delivery system 100 at any suitable location and/or in any suitable manner configured to orient aerial delivery system 100 in a desired orientation (for example, a substantially horizontal orientation, a substantially vertical orientation, and/or the like) once extracted from an aircraft.

[0041] In accordance with an exemplary embodiment, after being extracted from an aircraft, aerial delivery system 100 will begin transitioning to a vertical attitude due to drag produced by stabilization device 150. With aerial delivery system 100 stabilized in a generally vertical attitude, at least one releasable item 199 may be released at the users' discretion. According to an exemplary embodiment, aerial delivery system 100 may contain only one releasable item 199. In other exemplary embodiments, aerial delivery system 100 contains multiple releasable items 199. A releasable item 199 may be configured for any specific purpose. For example, releasable item 199 could be a target for a tracking system; alternatively, releasable item 199 could be a test vehicle, which could be allowed to free fall to obtain a desired velocity for parachute testing; further, releasable item 199 could be a piece of ordnance too large to fit a conventional aircraft. Upon activation of releasable securing mechanism 130, gravity causes releasable item 199 to separate from aerial delivery system 100 under the influence of linear guidance device 120.

[0042] In an exemplary embodiment, releasable item 199 is allowed to fall with a ballistic trajectory. In another exemplary embodiment, releasable item 199 is steered, as "smart bombs" are steered. Further, a releasable item 199 may be equipped with a ballistic or guided parachute system. Thus, if multiple releasable items 199 are released, they may all land in one small area or, by using specific time intervals between releases and/or by using drag or lift-producing devices to slow the descent rate or to provide traversing capability of releasable items 199, multiple targets can be reached. Moreover, as discussed below, the attitude and/or azimuth of aerial delivery system 100 may be varied before and/or between releases in order to more effectively direct releasable items 199 toward one or more targets.

[0043] Multiple releasable items 199 may be dropped individually, or they may be dropped simultaneously, or they may be released as any combination of the two. For example, successive individual releasable items 199, such as "bunker buster" bombs, may be released, each time-sequenced to arrive in a manner configured to form a successively deeper crater, and then multiple releasable items 199 may be released simultaneously to act as a "knockout punch."

[0044] Further, in accordance with various exemplary embodiments, because releasable items 199 are dependent on gravity to extract them from linear guidance device 120, multiple chemical propelled devices (such as missiles) can be

accommodated by individual linear guidance devices **120** (e.g., by delaying rocket motor ignition until each missile has separated from linear guidance device **120**). Additionally, because aerial delivery system **100** will have minimal air-speed once extracted from an aircraft, an entire group of releasable items **199** may be released to impact in one concentrated area instead of having a typical carpet-bombing pattern, even if no guidance system is used. Further, release of one or more releasable items **199** may be delayed for an extended period after aerial delivery system **100** has been extracted from an aircraft. In various exemplary embodiments, release of a releasable item **199** from aerial delivery system **100** may be delayed for a time between about five (5) seconds and one (1) minute after extraction of aerial delivery system **100**. However, release of a releasable item **199** may be delayed any appropriate amount of time configured to achieve a desired delivery objective for releasable item **199**.

[0045] If aerial delivery system **100** is to descend into hostile terrain, or into a combat zone, it may be preferable to allow aerial delivery system **100** to simply land at a relatively high rate of descent under stabilization device **150**. Alternatively, it may be preferable to release stabilization device **150** in mid-air, causing aerial delivery system **100** to crash, and allowing one or more components of aerial delivery system **100** to be damaged or destroyed. For this purpose, a parachute release mechanism, such as the mechanism disclosed in U.S. Pat. No. 7,264,205, may be suitably employed.

[0046] However, aerial delivery system **100** may be expensive and, if conditions allow, it is very likely that a system user will desire to reuse aerial delivery system **100** or a portion thereof. According to an exemplary embodiment, a release mechanism can be used to release stabilization device **150** from aerial delivery system **100**. The departing stabilization device **150** may then function as a pilot parachute to deploy a recovery device **160**. Recovery device **160** may also be deployed in any suitable manner known in the art.

[0047] Moreover, during descent of aerial delivery system **100**, it may be desirable to control the attitude of aerial delivery system **100**. For example, if a releasable item **199** comprises a chemical-propelled rocket, it may be desirable to allow the rocket to be launched at a certain attitude (for example, at a 90 degree angle to the vertical, at a 135 degree angle to the vertical, and/or the like) rather than directly downward. Accordingly, the aerial delivery system **100** of the present disclosure may be configured to support varied attitudes. With reference now to FIGS. 2A-2D, and in accordance with various exemplary embodiments, aerial delivery system **100** may be configured to achieve various attitudes once deployed. For example, with reference now to FIG. 2A, a generally rectangular aerial delivery system **100** may be suspended beneath a parachute **220** via one or more slings **210** coupled to aerial delivery system **100** at locations **210A** and **210B**. Slings **210** are of about equal length; thus, aerial delivery system **100** is oriented substantially vertically.

[0048] However, the attitude of aerial delivery system **100** may be varied by changing the length of one or more slings **210**. With reference now to FIG. 2B, in an exemplary embodiment, aerial delivery system **100** is coupled to one or more slings **210** at locations **210A** and **210B**. As illustrated, the length of sling **210** coupled to location **210B** is shorter than the length of sling **210** coupled to location **210A**. Thus, due to the uneven sling length, aerial delivery system **100** is oriented at least partially away from the vertical, as shown. In this manner, mid-air release of one or more releasable items **199**

at an angle away from vertical may be achieved. For example, when releasable item **199** is a chemical-propelled rocket, the rocket may be at least partially pointed toward a desired target, and thus post-release course corrections and other adjustments to the trajectory of releasable item **199** can be reduced.

[0049] Moreover, the attitude of aerial delivery system **100** may also be varied by changing the location of one or more sling attachment fittings. With reference now to FIG. 2C, in an exemplary embodiment, aerial delivery system **100** is coupled to one or more slings **210** at locations **210A** and **210C**. As illustrated, although the length of sling **210** coupled to location **210A** is about the same as the length of sling **210** coupled to location **210C**, aerial delivery system **100** is oriented away from the vertical as a result of the placement of locations **210A** and **210C**. As before, mid-air release of one or more releasable items **199** at an angle away from vertical may thus be achieved. Moreover, with further reference to FIG. 2D, various sling mounting locations may be utilized to achieve a desired attitude of aerial delivery system **100**.

[0050] In addition to controlling, selecting, and/or otherwise modifying the attitude of aerial delivery system **100**, the azimuth of aerial delivery system can be controlled, selected, and/or otherwise modified in order to “point” aerial delivery system **100** in a desired direction. For example, aerial delivery system **100** may be coupled to a guided parachute, and aerial delivery system **100** may thus be “pointed” via operation of the guided parachute. Moreover, aerial delivery system **100** may also be configured to achieve a modified azimuth orientation when coupled to either a guided parachute or a non-guided parachute. For example, aerial delivery system **100** may be further equipped with a rotating mechanism located between the payload portion of aerial delivery system **100** and the parachute. In this manner, aerial delivery system **100** may be configured to achieve a particular azimuth orientation responsive to operation of the rotating mechanism. Such flexibility can be extremely valuable, for example, when orienting chemical-propelled rockets for eventual release and separation from aerial delivery system **100**.

[0051] Turning now to FIG. 3A, and in accordance with various exemplary embodiments, illustrated is a mechanism for achieving azimuth control of aerial delivery system **100** while descending under the influence of parachute **320**. Aerial delivery system **100** is coupled to one or more slings **310**. A rotation mechanism **306** is disposed between slings **310** and parachute **320**. Rotation mechanism **306** may comprise any suitable mechanism configured to impart a rotational force. For example, rotation mechanism **306** may comprise an electric motor, a spring, a threaded screw, and/or the like.

[0052] In an exemplary embodiment, rotation mechanism **306** comprises an electric motor **302** powered by a battery. Motor **302** may be coupled to control and guidance electronics, for example electronics configured to bring aerial delivery system **100** into a preset azimuth orientation, for example due west (270 degrees). Moreover, motor **302** and/or the associated control and guidance electronics may be configured for remote control, such that the azimuth orientation of aerial delivery system **100** may be repeatedly modified and/or updated, for example responsive to commands from a system operator. Motor **302** further comprises motor shaft **304**, which is coupled to a suspension line of parachute **320**. Upon activation of motor **302**, motor shaft **304** is rotated, and aerial delivery system **100** thus rotates beneath parachute **320**

responsive to the rotation of motor shaft **304**. In this manner, aerial delivery system **100** may be oriented as desired.

[0053] Rotation mechanism **306** may also take advantage of the weight of aerial delivery system **100** to achieve a modified azimuth orientation. With reference now to FIG. 3B, in accordance with various exemplary embodiments, aerial delivery system **100** is suspended beneath parachute **320**. Aerial delivery system **100** is coupled to rotation mechanism **306** via one or more slings **310**. Rotation mechanism **306** comprises a lead screw **312**, a nut **314**, and a brake **316**. Slings **310** may be fastened to rotation mechanism **306** as appropriate, for example at nut **314**. Lead screw **312** and nut **314** are releasably engaged.

[0054] Lead screw **312** may comprise any suitable structure configured to translate a linear force (for example, a force exerted by aerial delivery system **100** due to gravity) at least partially into a rotational force. For example, lead screw **312** may comprise a threaded screw, a corkscrew, and/or the like. In an exemplary embodiment, lead screw **312** comprises a low-pitch threaded rod. Lead screw **312** is coupled to nut **314**. Lead screw **312** is further configured with an arresting device (for example, a blocking pin) in order to prevent separation of lead screw **312** and nut **314** at the end of travel. Lead screw **312** is further coupled to brake **316** in order to allow aerial delivery system **100** to be controllably rotated beneath parachute **320** as nut **314** “unscrews” along lead screw **312** responsive to the weight of aerial delivery system **100**. In an exemplary embodiment, lead screw **312** is an aluminum cylinder configured with a sling attachment fitting at a first end, and a stop pin at a second end. Lead screw **312** is further configured with a threaded outer groove configured to rotatably couple with nut **314**. Moreover, lead screw **312** may comprise any suitable material and may be configured in any appropriate manner in order to cause and/or permit rotation of aerial delivery system **100**.

[0055] Nut **314** may comprise any suitable structure configured to couple to lead screw **312**. Further, nut **314** may comprise any suitable structure configured to receive at least a portion of rotational force generated by the interaction of lead screw **312** and nut **314**, for example by nut **314** moving along rotating threads of lead screw **312**. In an exemplary embodiment, nut **314** is an aluminum structure configured with multiple strap attachment points, and further configured with a threaded inner hole configured to rotatably couple with lead screw **312**. However, nut **314** may comprise any suitable material and may be configured in any appropriate manner in order to rotate responsive to the weight of aerial delivery system **100**.

[0056] Brake **316** may be any suitable device, mechanism, or system configured to retard the rotation of nut **314** along lead screw **312**. In an exemplary embodiment, brake **316** comprises a mechanical clamp. In various other exemplary embodiments, brake **316** comprises a band brake controlled by an electromechanical solenoid. Brake **316** is configured to releasably engage with lead screw **312** to prevent and allow movement of nut **314**. Moreover, brake **316** may be configured for remote control in order to allow a system operator to controllably modify the azimuth orientation of aerial delivery system **100**.

[0057] The weight of aerial delivery system **100** beneath parachute **320** provides a downward force, which is at least partially translated into a rotational force by the interaction of lead screw **312** and nut **314**. Initially, brake **316** is engaged, preventing nut **314** from “unscrewing” along lead screw **312**.

As brake **316** is loosened, nut **314** begins to rotate along lead screw **312**, resulting in a modified azimuth orientation for aerial delivery system **100**. Brake **316** may be re-engaged at any point, fixing nut **314** against lead screw **312** at a desired position. Brake **316** may also be repeatedly engaged and loosened in order to adjust the azimuth orientation of aerial delivery **100** as desired, for example responsive to wind gusts, inadvertent rotation of parachute **320**, and/or the like. In this manner, aerial delivery system **100** may be “pointed” in a particular orientation. Moreover, aerial delivery system **100** may be “re-pointed” at a different orientation if desired, via further operation of brake **316**. In various embodiments, aerial delivery system **100** may be “re-pointed” any desired number of times, provided further rotation of nut **314** with respect to lead screw **312** is still possible (i.e., provided that nut **314** has not traversed to the end of lead screw **312**).

[0058] As will be appreciated, the above-illustrated principles regarding attitude and/or azimuth orientation, adjustment, and control for an aerial delivery system **100** may be applied in various settings, configurations, combinations, and/or the like, such that a particular aerial delivery system **100** and associated payload (e.g., one or more releasable items **199**) may be rotated, translated, and/or otherwise moved and/or “pointed” in any desired direction relative to the associated stabilization system (e.g., a streamer, a ballute, a drogue parachute, a primary parachute, a recovery parachute, and/or the like). In this manner, an extended loiter time for rockets, cameras, and other useful items over a target area can be achieved.

[0059] As will be appreciated by one of ordinary skill in the art, principles of the present disclosure may be reflected in a computer program product on a tangible computer-readable program storage medium having computer-readable program code means embodied in the storage medium. Any suitable computer-readable storage medium may be utilized, including magnetic storage devices (hard disks, floppy disks, and the like), optical storage devices (CD-ROMs, DVDs, Blu-Ray discs, and the like), flash memory, and/or the like. These computer program instructions may be loaded onto a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions that execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart block or blocks. These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means which implement the function specified in the flowchart block or blocks. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer-implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart block or blocks.

[0060] While the principles of this disclosure have been shown in various embodiments, many modifications of structure, arrangements, proportions, the elements, materials and components, used in practice, which are particularly adapted for a specific environment and operating requirements may be

used without departing from the principles and scope of this disclosure. These and other changes or modifications are intended to be included within the scope of the present disclosure and may be expressed in the following claims.

[0061] In the foregoing specification, the invention has been described with reference to various embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the present invention as set forth in the claims below. Accordingly, the specification is to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present invention. Likewise, benefits, other advantages, and solutions to problems have been described above with regard to various embodiments. However, benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature or element of any or all the claims. As used herein, the terms “comprises,” “comprising,” or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Also, as used herein, the terms “coupled,” “coupling,” or any other variation thereof, are intended to cover a physical connection, an electrical connection, a magnetic connection, an optical connection, a communicative connection, a functional connection, and/or any other connection. When language similar to “at least one of A, B, or C” is used in the claims, the phrase is intended to mean any of the following: (1) at least one of A; (2) at least one of B; (3) at least one of C; (4) at least one of A and at least one of B; (5) at least one of B and at least one of C; (6) at least one of A and at least one of C; or (7) at least one of A, at least one of B, and at least one of C.

What is claimed is:

1. An aerial delivery system, comprising:
 - a platform;
 - a first linear guidance device coupled to the platform; and
 - a releasable securing mechanism, wherein the releasable securing mechanism is configured to couple a releasable item to the first linear guidance device.
2. The aerial delivery system of claim 1, further comprising two side sections coupled to the platform.
3. The aerial delivery system of claim 2, further comprising a rear section coupled to the platform and to the two side sections.
4. The aerial delivery system of claim 1, further comprising a plurality of sling attachment fittings.
5. The aerial delivery system of claim 4, wherein the sling attachment fittings are configured to cause the aerial delivery system to exhibit a horizontal attitude when the aerial delivery system is suspended beneath a parachute.
6. The aerial delivery system of claim 1, wherein the first linear guidance device is configured to permit the release of a releasable item having an extended control surface.
7. The aerial delivery system of claim 1, wherein the first linear guidance device is a monorail.
8. The aerial delivery system of claim 1, wherein the releasable securing mechanism is a reefing cutter.
9. The aerial delivery system of claim 1, wherein the releasable securing mechanism is configured to impart a force to a

releasable item to at least partially eject the releasable item from the aerial delivery system.

10. The aerial delivery system of claim 1, further comprising a second linear guidance device coupled to the platform.

11. The aerial delivery system of claim 4, further comprising a rotation mechanism coupled to a parachute and coupled to the plurality of sling attachment fittings, wherein the rotation mechanism is configured to allow the azimuth of the aerial delivery system to be varied.

12. The aerial delivery system of claim 11, wherein the rotation mechanism comprises a lead screw, a nut, and a brake.

13. The aerial delivery system of claim 11, wherein the rotation mechanism comprises a motor.

14. The aerial delivery system of claim 11, wherein the rotation mechanism is configured to be controlled from a remote location.

15. A method, comprising:

- coupling a first releasable item to an aerial delivery system comprising a first releasable securing mechanism;
- deploying a drogue parachute to cause the aerial delivery system to exit an aircraft; and
- activating the first releasable securing mechanism to separate the first releasable item from the aerial delivery system, wherein the releasable item separates from the aerial delivery system under the influence of a linear guidance device.

16. The method of claim 15, further comprising deploying a guided parachute to control the descent of the aerial delivery system.

17. The method of claim 15, further comprising activating a rotation mechanism to modify the azimuth orientation of the aerial delivery system.

18. The method of claim 15, further comprising coupling a second releasable item to the aerial delivery system.

19. The method of claim 18, further comprising activating a second releasable securing mechanism to separate the second releasable item from the aerial delivery system.

20. The method of claim 15, wherein the linear guidance device is a monorail.

21. The method of claim 15, wherein the linear guidance device is a tube.

22. The method of claim 21, wherein the first releasable item and the second releasable item are located within the tube prior to the aerial delivery system exiting the aircraft.

23. A method for controlling the attitude of a payload, the method comprising:

- coupling a first strap having a first length to the payload;
- coupling a second strap having a second length to the payload, wherein the second length is different from the first length;
- coupling the first strap and the second strap to a parachute;
- deploying the payload from an aircraft; and
- deploying the parachute to cause the payload to achieve a predetermined orientation responsive to the weight of the payload.

24. A method for controlling the azimuth of a payload, the method comprising:

- coupling a payload to a rotation mechanism;
- coupling the rotation mechanism to a parachute;
- deploying the payload from an aircraft;

deploying the parachute to cause the payload to be suspended beneath the parachute; and activating the rotation mechanism to cause the payload to rotate with respect to the parachute.

25. A method for controlling the azimuth of a payload, the method comprising:

issuing a first move command to a motor, wherein the motor is coupled to a payload and to a parachute;

moving, responsive to the first move command, a motor shaft a first time to rotate the payload with respect to the parachute to bring the payload into a desired azimuth orientation;

issuing, responsive to a change in the azimuth orientation of the payload, a second move command to the motor,

moving, responsive to the second move command, a motor shaft a second time to rotate the payload with respect to the parachute to restore the payload to a desired azimuth orientation.

26. A computer-readable medium having stored thereon, computer-executable instructions that, if executed by a system, cause the system to perform a method comprising:

issuing a first move command to a motor, wherein the motor is coupled to a payload and to a parachute;

moving, responsive to the first move command, a motor shaft a first time to rotate the payload with respect to the parachute to bring the payload into a desired azimuth orientation;

issuing, responsive to a change in the azimuth orientation of the payload, a second move command to the motor,

moving, responsive to the second move command, a motor shaft a second time to rotate the payload with respect to the parachute to restore the payload to a desired azimuth orientation.

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