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AN UNMANNED AERIAL DELIVERY SYSTEM COMPRISING PRIMARY AND SECONDARY AIRCRAFT

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(71) Applicant(s)
Chung-Kiak Poh;Chung-How Poh

(72) Inventor(s)
Poh, Chung-Kiak;Poh, Chung-How

(74) Agent / Attorney
Chung-How Poh, PO Box 839, Port Melbourne, VIC, 3207, AU

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AN UNMANNED AERIAL DELIVERY SYSTEM COMPRISING PRIMARY AND SECONDARY AIRCRAFT

ABSTRACT

The present invention relates to an unmanned aerial delivery system comprising a primary aircraft (100), and at least one secondary aircraft (200). The idea is to have the primary aircraft (100) away from populated areas and having the smaller and safer secondary aircraft (200) performing the aerial deliveries to the respective destinations on the ground.

Most Illustrative Diagram: FIG. 2

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AN UNMANNED AERIAL DELIVERY SYSTEM COMPRISING PRIMARY AND SECONDARY AIRCRAFT

FIELD OF INVENTION

The present invention relates to an unmanned aerial delivery system, and in particular, it relates to a system of plurality of aircraft that delivers payloads to delivery locations.

BACKGROUND OF INVENTION

E-commerce is on the rise globally and delivery service plays a central role in E-commerce. A delivery service such as courier service, and shipping service offers delivery of letters, packages, and parcels (hereinafter referred to as "items") to and from its customers using various means. An emerging means to efficiently deliver the items to respective delivery locations or destinations is via an unmanned aerial vehicle (UAV). The UAV is often a part of a larger system known as an unmanned aerial delivery system (UADS).

While the potential and efficiency of aerial delivery system are well recognized, there are safety concerns with respect to operations of large and heavy delivery unmanned aerial vehicles (UAVs) in populated areas. An obvious solution is to use lighter and smaller delivery UAVs in the form of multirotors when operating in these areas. The safety advantage of a multirotor stems from the fact that multirotors use propellers in contrary to a rotorcraft having rotating main blades with rotor diameter that often exceeds 1 meter. Furthermore, propeller guards can be installed on multirotors to enhance operational safety. However, propellers of a multirotor are inherently less efficient in lift generation compared to the much larger rotor of a rotorcraft, and this limits the travel range and payload capacity of a multirotor.

There are numerous developments of UAVs for aerial delivery, however, these aircraft are often based on multirotor design whose vertical thrusts are provided by propellers.

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Thus, there remains a need to develop an unmanned aerial delivery system that addresses both the safety concern relating to UAV operation in densely populated areas, and the ability to transport multiple items of realistic weight across large distances.

SUMMARY OF INVENTION

An object of the present invention is an attempt to mitigate risks associated with large and heavy unmanned aerial vehicles (UAVs) with rotating rotor blades operating in populated areas.

The present invention relates to an unmanned aerial delivery system comprising a primary aircraft, and at least one secondary aircraft. The idea is to have the primary aircraft located outside of populated areas and having the smaller and safer secondary aircraft to perform the aerial delivery from the primary aircraft to the delivery locations or destinations on the ground.

In the present invention, a payload comprises a custom-built container, and the custom-built container further comprises at least an item to be delivered to a delivery location on the ground. In an alternative embodiment, the custom-built container may be empty and does not comprise an item.

In embodiments of the present invention, the primary aircraft comprises at least one payload region to accommodate at least one payload, and the main role of the secondary aircraft is to unload the payload from the primary aircraft and to deliver the payload to destinations. In accordance with the presence invention, the secondary aircraft may also retrieve a payload from a location on the ground and load said payload onto the primary aircraft.

In accordance with the present invention, several types of aircraft may be able serve as the primary aircraft, such as rotorcraft, fixed-wing airplane, and ground-effect vehicle. The key requirement for the primary aircraft is to have a relatively large payload capacity and the ability to cruise efficiently. An example of a primary aircraft is a rotocraft having tandem rotors. Similarly, several types of aircraft may serve as the secondary aircraft but they should preferably have vertical takeoff and landing (VTOL) capability to facilitate delivery of payloads to residential areas and

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offices in urban settings. An example of aircraft suitable as the secondary aircraft is multirotor. This is because multirotors have VTOL capability, and propeller guards can be installed to prevent damages to properties and also to prevent bodily injuries to people and pets during delivery. Another possible example of secondary aircraft is an airplane comprising horizontal and vertical propulsors as described in Malaysian Patent Application No. PI 2020000674, wherein the airplane is able to perform hovering and VTOL flight.

In embodiments, the secondary aircraft may be ground-based, or said secondary aircraft may be docked on a docking station on board the primary aircraft during non-delivery phase, such as transit. An example of ground-based secondary aircraft would be a multirotor plus with its dedicated docking station to receive and store the payload(s). The dedicated docking station may be placed at a residence or roof-top of an office building.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1(a) is a perspective view of an exemplary primary aircraft in the form of an unmanned rotorcraft which comprises a tandem rotors and a chassis in accordance with the present invention.

FIG. 1(b) is a side view of the primary aircraft as shown in FIG. 1(a) which comprises at least one payload region to accommodate at least one payload.

FIG. 1(c) is a perspective view showing a secondary unmanned aircraft unloading a payload from the primary aircraft while said primary aircraft is airborne in accordance with the present invention.

FIG. 1(d) is a perspective view of a secondary aircraft in the form of a multirotor.

FIG. 2 is a perspective view showing an embodiment wherein the secondary aircraft dock on board the primary aircraft during transit or non-delivery phase in accordance with the present invention.

FIG. 3(a) is a perspective view showing locking means being present on the chassis of a rotorcraft as well as on the exterior of a custom-built container.

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FIG. 3(b) is a perspective view of the custom-built container which is cuboid in shape and comprises six faces in accordance with the present invention.

FIG. 3(c) is a perspective view of the custom-built container with its cover in open position revealing an interior to accommodate at least an item in accordance with the present invention.

FIG. 3(d) is a perspective view of the custom-built container wherein the interior comprises a power source and an electronic circuit board in accordance with the present invention.

FIG. 4 is a perspective view of an embodiment of the secondary aircraft.

FIG. 5 is a perspective view of an embodiment of the primary aircraft in the form of a canard biplane wherein there are two pairs of fore wings and two pairs of rear wings.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The present invention relates to an unmanned aerial delivery system comprising a primary aircraft, and at least one secondary aircraft.

FIG. 1(a) is a perspective view of an exemplary unmanned rotorcraft serving as the primary aircraft (100) in accordance with the present invention. The rotorcraft comprises a chassis (102); two pairs of landing skids (104), one pair towards the front of the rotorcraft and the other pair towards the back of the rotorcraft; and two rotors (106A, 106B) arranged in tandem configuration, *i.e.*, one in front of the other. The rotors generate lift and provide cyclic control to the rotorcraft.

The primary aircraft (100) comprises at least one payload region (108) to accommodate at least one payload (110) as shown in a side view in FIG. 1(b). The payload region (108) is enclosed by the dashed lines in FIG. 1(b) and the payload region (108) is located above the chassis (102).

Each payload (110) further comprises a custom-built container (111), and the custom-built container (111) is designed to hold at least an item in its interior in accordance with the present invention. In an alternative embodiment, the interior of the custom-built container (111) may be empty and does not contain any item, and

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one such scenario is when an empty custom-built container (111) is being retrieved from a residential home.

In this exemplary embodiment, two secondary unmanned aircraft (200) unload the payloads (110) from the rotorcraft while the rotorcraft is airborne, as shown in a perspective view in FIG. 1(c). In the present invention, the main role of the secondary aircraft (200) is to unload at least one payload (110) from the primary aircraft (100) and to deliver the payload (110) to its destination. In this example, the secondary aircraft (200) are multirotors. FIG. 1(d) shows a perspective view of a multirotor comprising four rotors. Some heavy-lift multirotors may have eight rotors known as a 'octacopter'.

In the present invention, the secondary aircraft (200) may be ground-based or the secondary aircraft (200) can be docked on the primary aircraft (100) during non-delivery phase, such as transit. FIG. 2 shows the primary aircraft (100), in this case being exemplified by the rotorcraft, further comprising at least a docking station (112) that allows the secondary aircraft (200), in this case being exemplified by at least one multirotor, to dock on the docking station (112) during transit or non-delivery phase. In case of the secondary aircraft being a multirotor, the surface of the docking station may be tilted forward at an angle in the range of 2° to 60° against the surface of the chassis (102) to optimize launching and docking performance of the multirotor in the presence of forward airspeed.

The two rotors (106A, 106B) are disposed below the chassis (102) to minimize accidental collision with the secondary aircraft (200), and to facilitate docking station (112) to be disposed on the upper side of the chassis (102) so as to make docking and launching of secondary aircraft (200) easier.

To increase payload density, an additional payload region (108) may be located below the chassis (102), as shown in FIG. 2. Locking means may be used to help achieve a so-called "open-air" configuration in which the payloads are exposed and subjected to air flow during flight. An advantage of "open-air" configuration is that it is easier for the secondary aircraft (200) to load and unload the payloads from the primary aircraft (100) while the primary aircraft (100) is airborne.

The chassis (102) comprises at least a locking means (114) as shown in FIG. 3(a). The custom-built container (111) comprises an exterior, and the exterior

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comprises a locking means (114') that complements the locking means (114) on the chassis (102) such that custom-built container (111) is secured to the chassis (102) of the rotorcraft during transit or non-delivery phase. Possible examples of locking means (114, 114') are mechanical and electro-mechanical approach.

The custom-built container (111) is substantially cuboid in external shape with rounded edges (111R) and comprises six flat faces (111F) as indicated by straight arrows in FIG. 3(b). The purpose of having rounded edges (111R) is to reduce aerodynamic drag during transit. The top flat face (111F) of the custom-built container (111) also form part of a cover (111C) which can be removed to reveal an interior (111N) which is designed to hold at least an item for aerial delivery as shown in FIG. 3(c).

A way to realize locking means (114') based on electro-mechanical approach on the custom-built container (111) is to have a small power source (116) such as a supercapacitor or battery pack that is arranged such that it is substantially flushed with the wall(s) (111W) of the interior (111N) of the custom-built container (111), as shown in FIG. 3(d). The power source (116) may be designed to be rechargeable via inductive charging or piezoelectric effect or other suitable means such as traditional wired charging. An advantage of electro-mechanical approach is that wireless smart-lock system may be used in which the custom-built container (111) is disengaged from the chassis (102) when the secondary aircraft (200) is ready to unload it from the primary aircraft (100).

Additionally, at least a flat face (111F) of the custom-built container (111) may comprise at least a locking means (114') such that plurality of custom-built containers (111) are secured to each other in horizontal and vertical directions during transit or non-delivery phase. Furthermore, the custom-built container (111) may also comprise at least an electronic circuit board (117) that controls the locking and unlocking processes of the locking means (114') in the present invention. The electronic circuit board (117) may also comprise a wireless module to enable wireless communication to take place.

It would also be advantageous if the custom-built container (111) is watertight so that aerial delivery can still be carried out under rainy condition. A way to achieve watertight is to use rubber seal strips.

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The following aerial delivery-and-retrieving scheme may be envisioned in accordance with the present invention for a primary aircraft (100) having the upper and lower payload regions (108): the upper payload region (108) is used to hold custom-built containers (111) with items and secondary aircraft (200) unload and deliver them to destinations on the ground; and the same group or different group of secondary aircraft (200) pick up empty custom-built containers (111) (without items) from the ground and load them onto the lower payload region (108), and these processes take place while the primary aircraft (100) *i.e.*, the rotorcraft, is airborne.

In an exemplary embodiment, the secondary aircraft (200) comprises a fuselage (202), at least a pair of fixed-wings (204), at least a horizontal propulsor (206), at least a pair of vertical propulsors (208A, 208B), and an attachment terminal (210) as shown in FIG 4. The attachment terminal (210) is used as the airplane's landing gear while docking and at the same time it is used as a terminal to attach the airplane to a custom-built container (111). The attachment terminal (210) is tiltable from a vertical position to 45° to the back.

In another embodiment of the present invention, the primary aircraft (100) is in the form of a fixed-wing airplane and it is generally expected to have a more efficient cruising than a rotorcraft though runway is needed for taking off and landing and so it is suitable for destinations which are much farther away from the dispatch center. FIG. 5 shows an example of such airplane. The fixed-wing airplane comprises at least a pair of fore wings (302A), and at least a pair of rear wings (302B). The biplane configuration shown in FIG. 5 allows the wingspan to be made shorter compared to a monoplane, making ground handling easier to manage. At least one pair of fore wings (302A) and at least one pair of back wings (302B) comprise ailerons (304) which may be used to control roll, and pitch of the airplane. The airplane also comprises at least a vertical stabilizer (306) and a horizontal propulsor (308). The wing airfoil can be of high-lift type such as EPPLER E423 or SELIG S1223.

In yet another embodiment of the present invention, the primary aircraft (100) is in the form of a ground-effect vehicle. Distinct advantages of this embodiment are that it has efficient cruising and therefore has good range, and during delivery phase

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the primary aircraft (100) can settle on the surface of the water instead of expending energy to remain airborne.

The foregoing description of the present invention has been presented for purpose of illustration and description. Furthermore, the description is not intended to limit the invention to the form disclosed herein. Consequently, variations and modifications commensurate with the above teachings, and skill and knowledge of the relevant art, are within the scope of the present invention. The embodiments described hereinabove are further intended to explain best modes known of practicing the invention and to enable other skilled in the art to utilize the invention in such or other embodiments and with various modifications required by the particular application(s) or use(s) of the present invention. It is intended that the appended claims be construed to include alternative embodiments to the extent permitted by the prior art.

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CLAIM:

1. An unmanned aerial delivery system comprising:

a primary aircraft (100); said primary aircraft (100) further comprises a chassis (102), and at least a payload region (108) to accommodate at least a payload (110); and

at least one secondary aircraft (200); said secondary aircraft (200) unloads the payload (110) from the primary aircraft (100) and delivers the payload (110) to destination, wherein:

the chassis (102) comprises at least a locking means (114); further wherein the payload (110) comprises a custom-built container (111); the custom-built container (111) comprises an exterior, wherein said exterior comprises a locking means (114') such that the custom-built container (111) is secured to the chassis (102) of the primary aircraft (100) during non-delivery phase.

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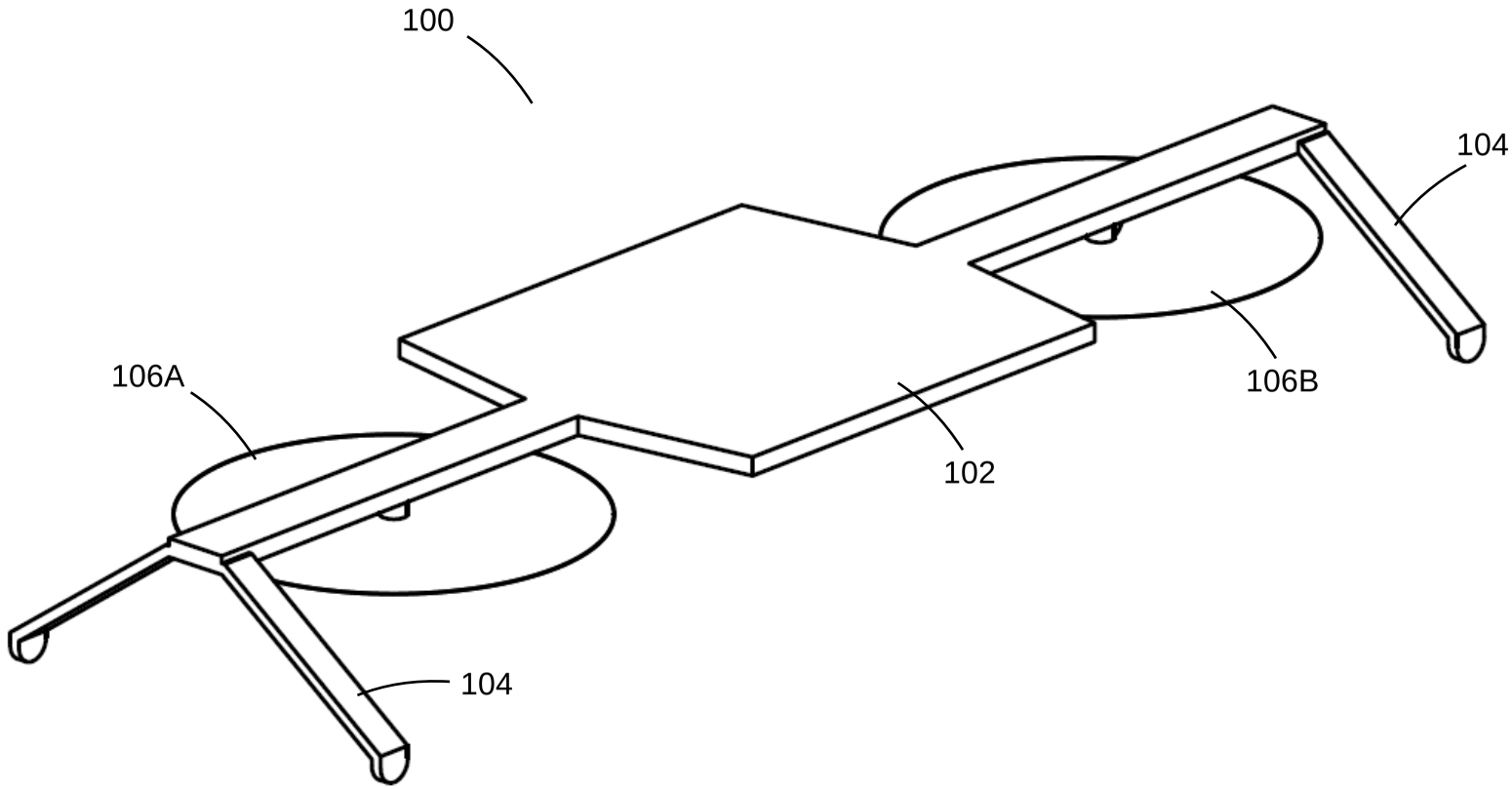


FIG. 1(a)

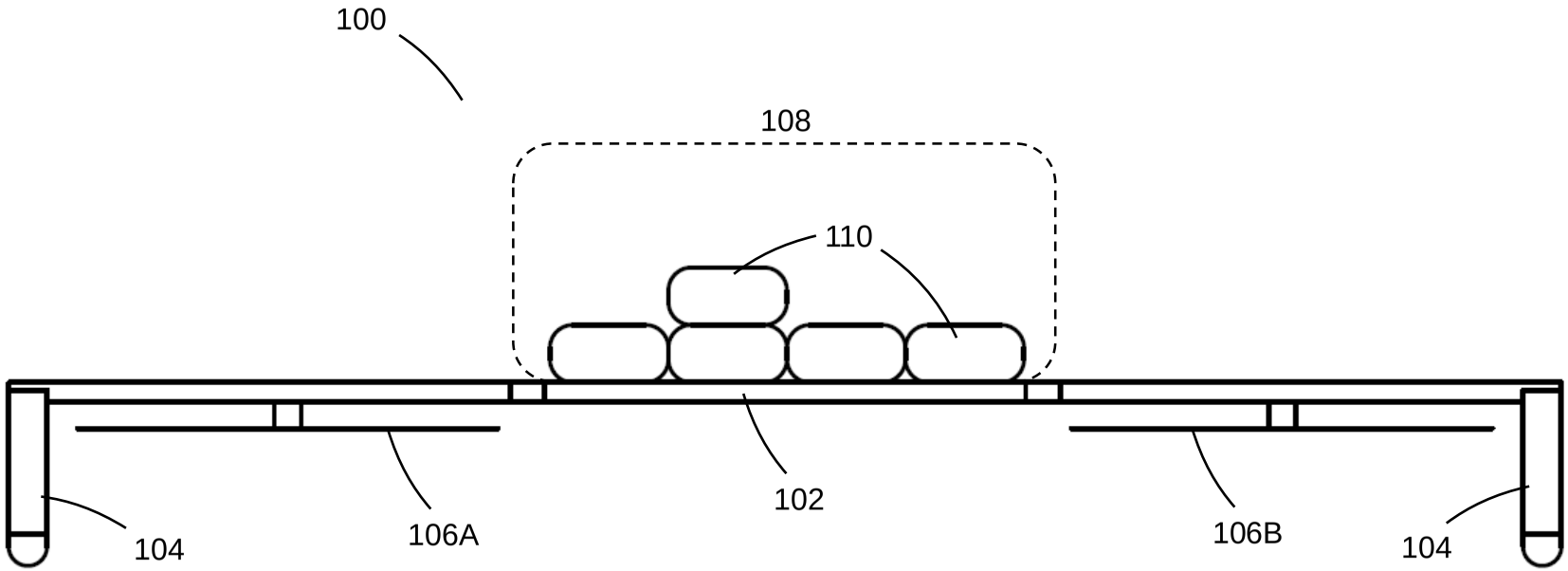


FIG. 1(b)

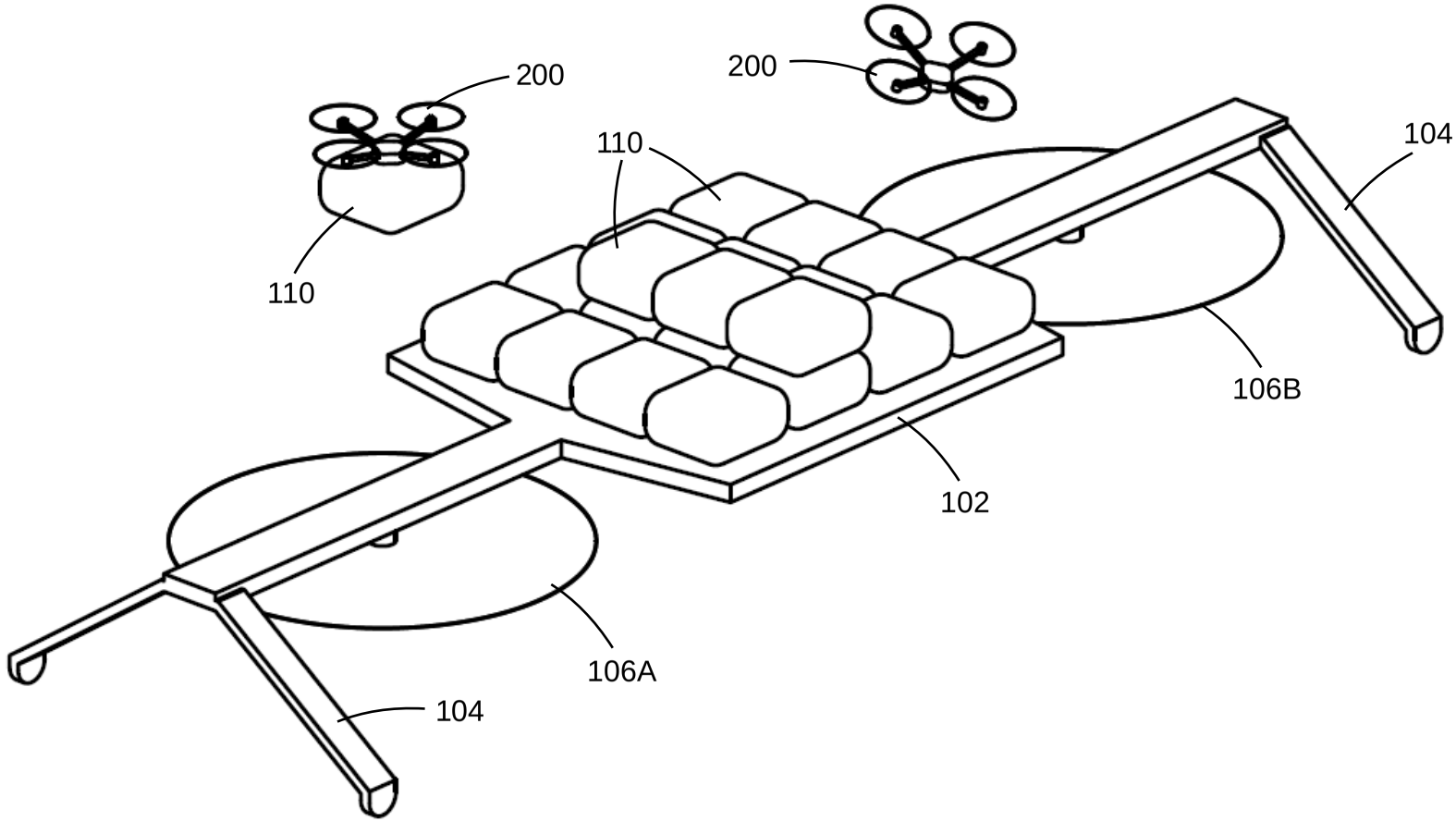


FIG. 1(c)

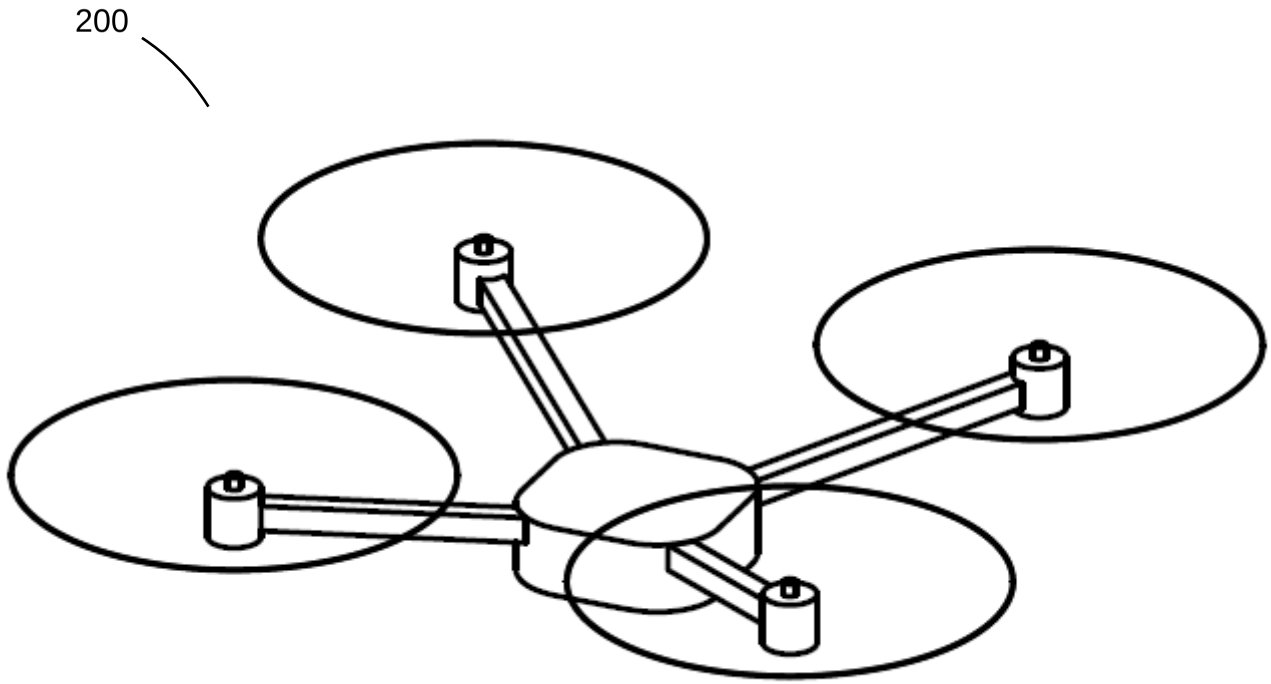


FIG. 1(d)

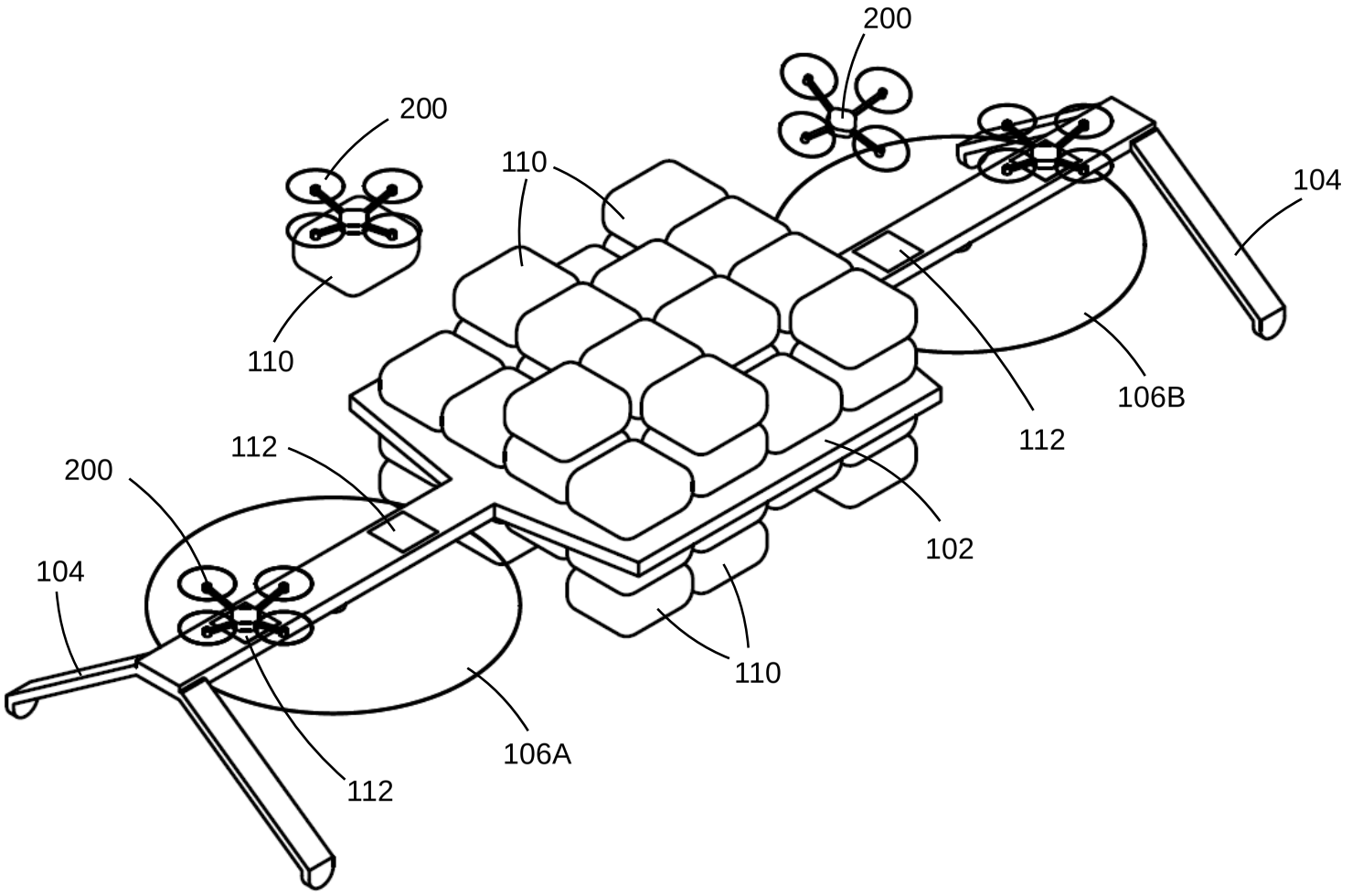


FIG. 2

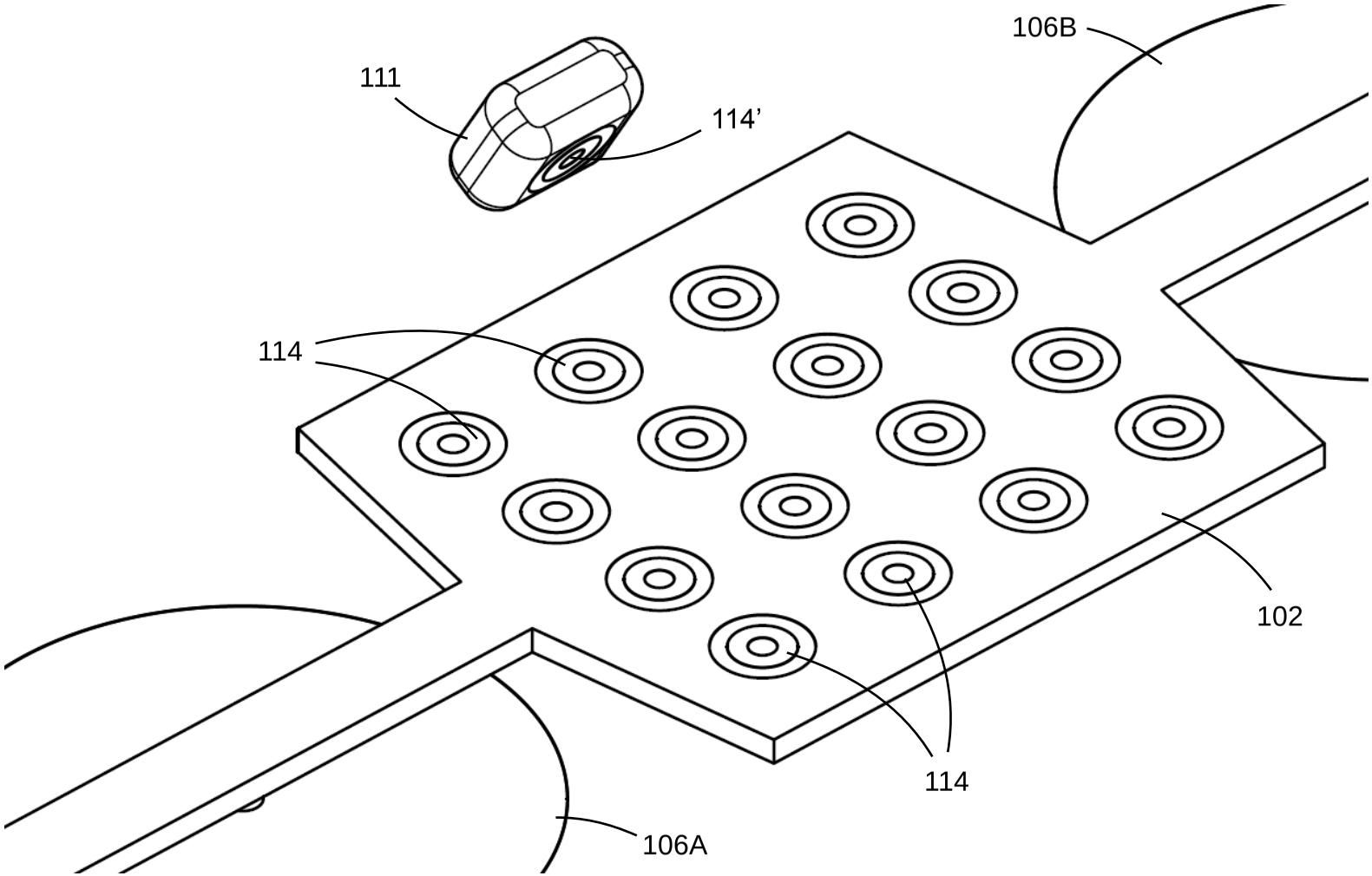


FIG. 3(a)

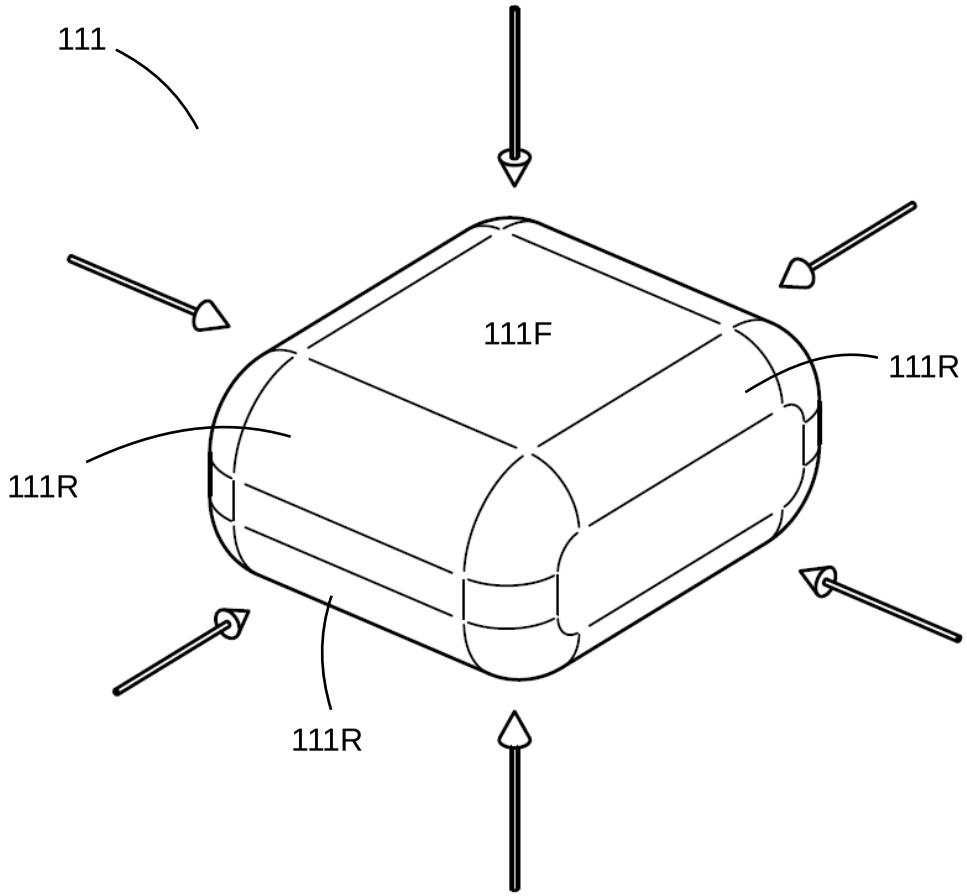


FIG. 3(b)

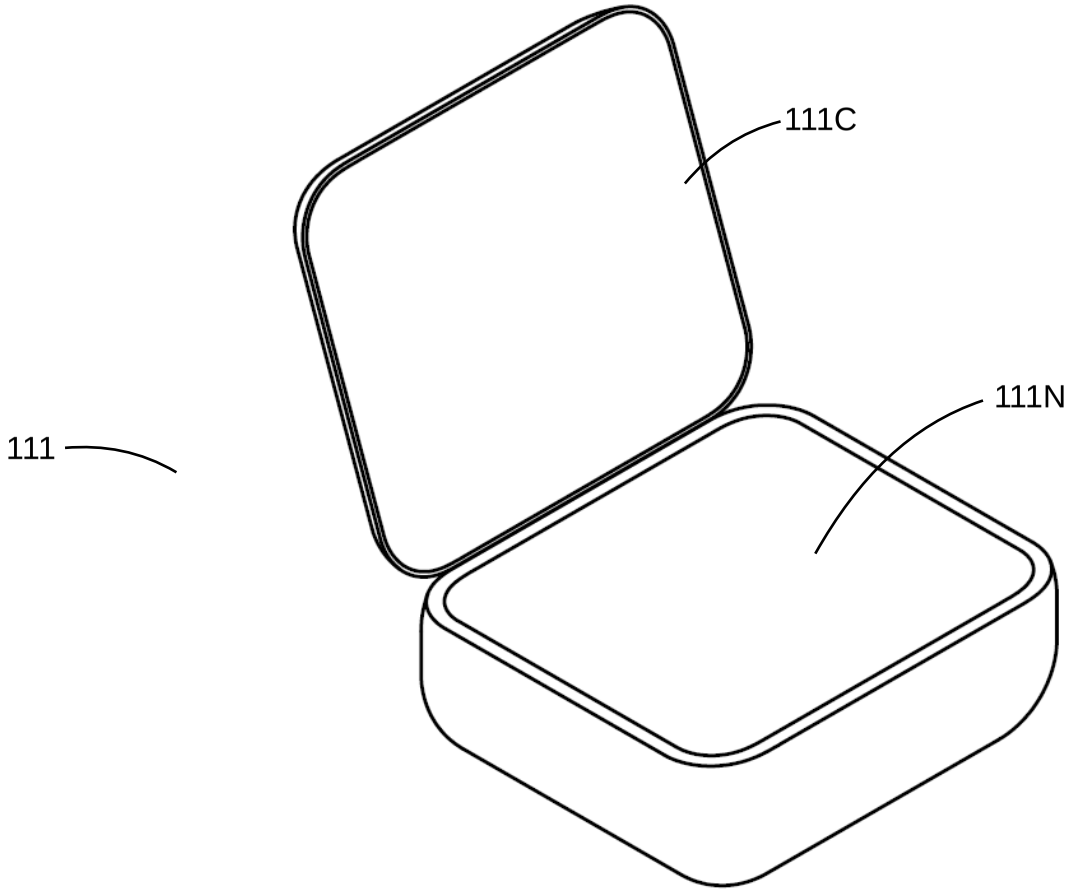


FIG. 3(c)

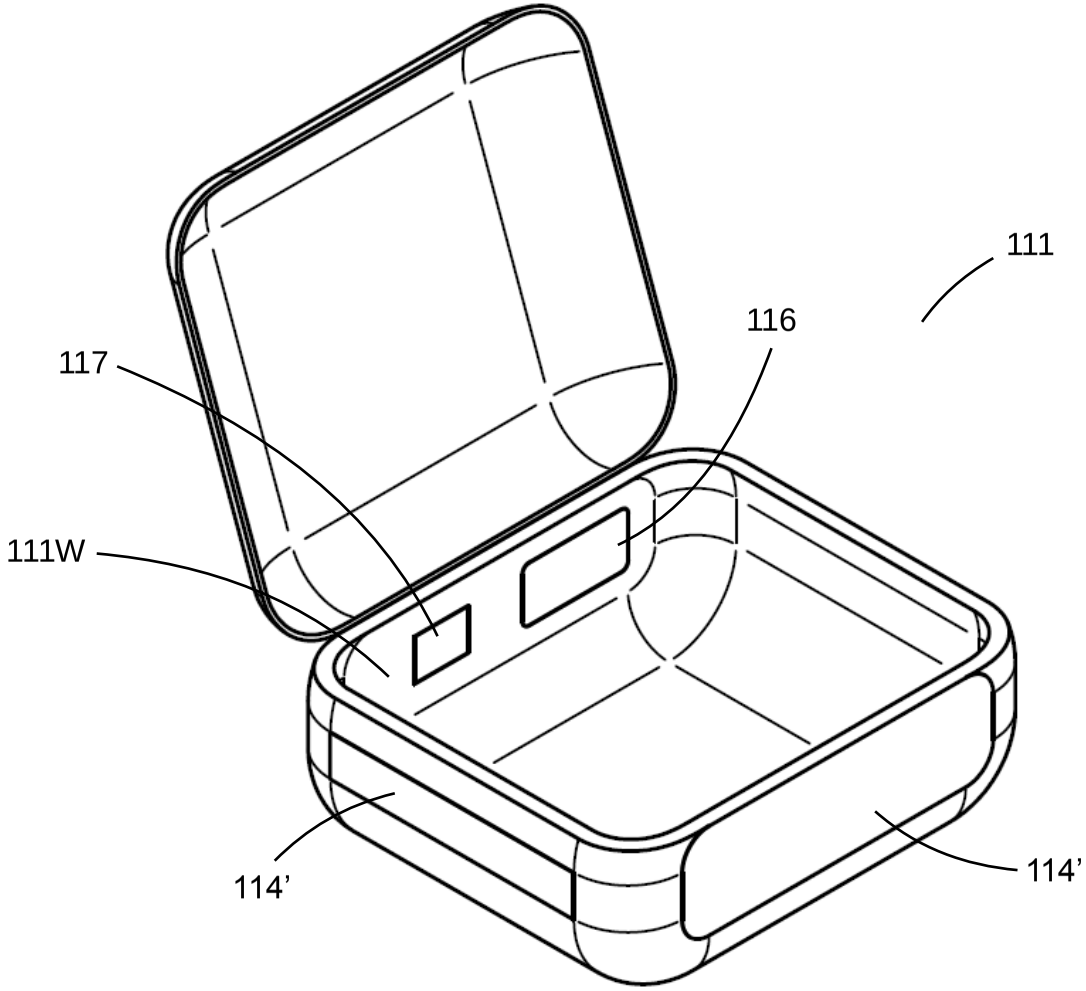


FIG. 3(d)

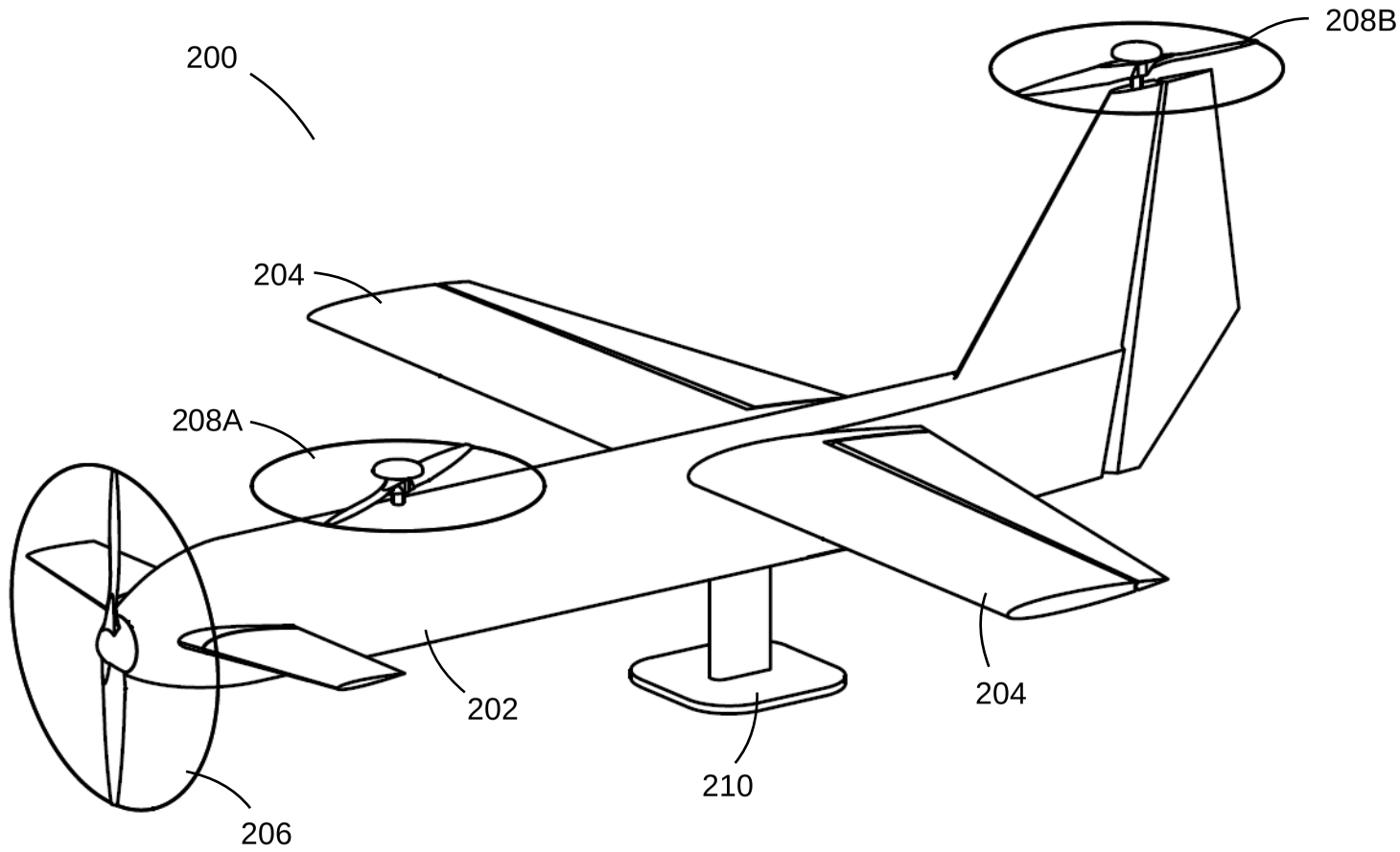
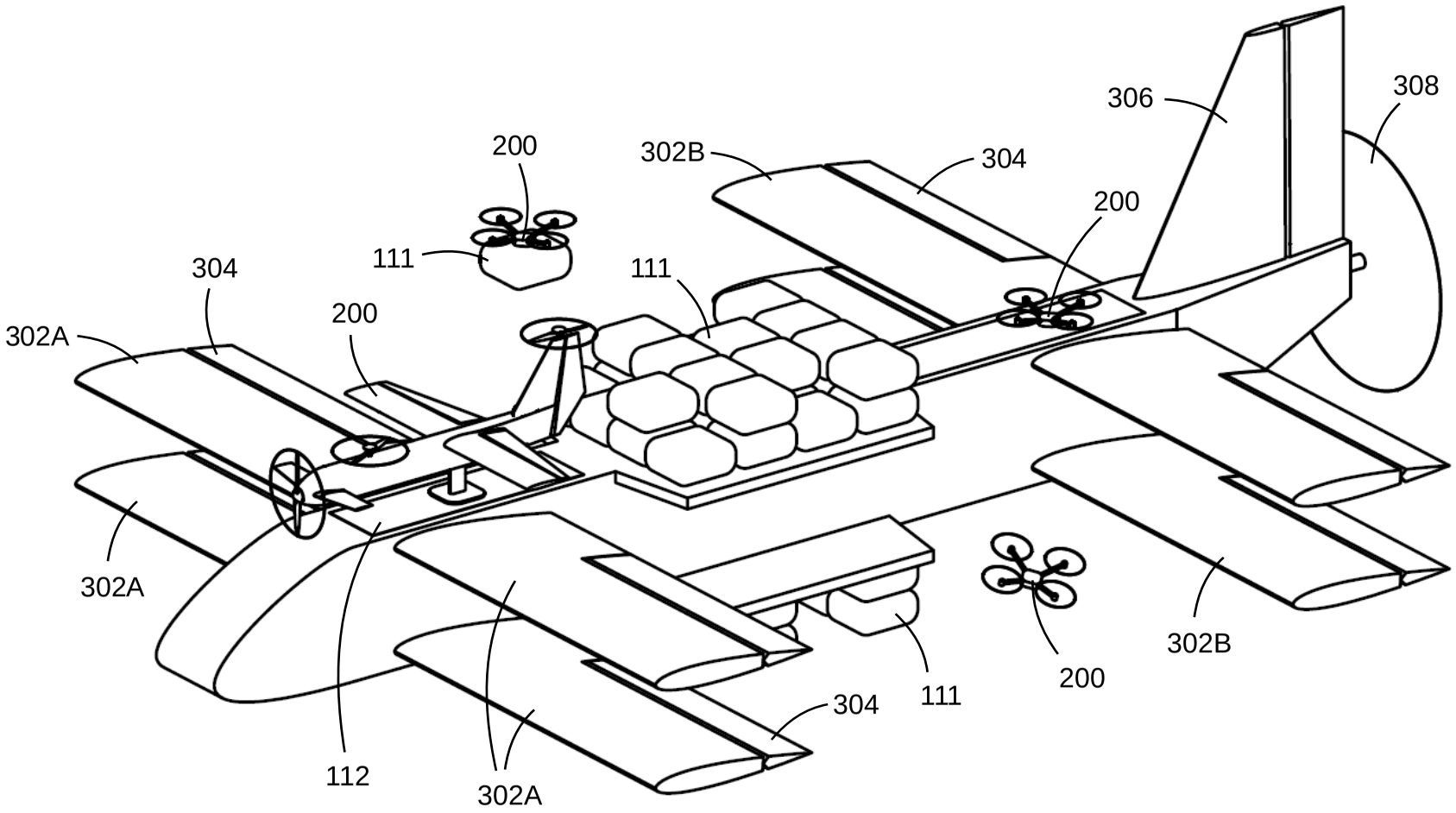


FIG. 4


306
308
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302B
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304
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302A
302A
112
302A
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302B

FIG. 5