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Mozer

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(54) **DRONE AIRCRAFT LANDING AND DOCKING SYSTEMS**

(71) Applicant: **Reese A. Mozer**, Pittsburgh, PA (US)

(72) Inventor: **Reese A. Mozer**, Pittsburgh, PA (US)

(73) Assignee: **American Robotics, Inc.**, Marlborough, MA (US)

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(51) **Int. Cl.**

B64F 1/36	(2017.01)
B64C 39/02	(2006.01)
B64F 1/00	(2006.01)

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

CPC ***B64F 1/36*** (2013.01); ***B64C 39/024*** (2013.01); *B64C 2201/042* (2013.01); *B64C 2201/108* (2013.01); *B64C 2201/18* (2013.01); *B64C 2201/182* (2013.01); *B64F 1/007* (2013.01)

(58) **Field of Classification Search**

CPC B64F 1/36; B64F 1/007; B64C 2201/18

See application file for complete search history.

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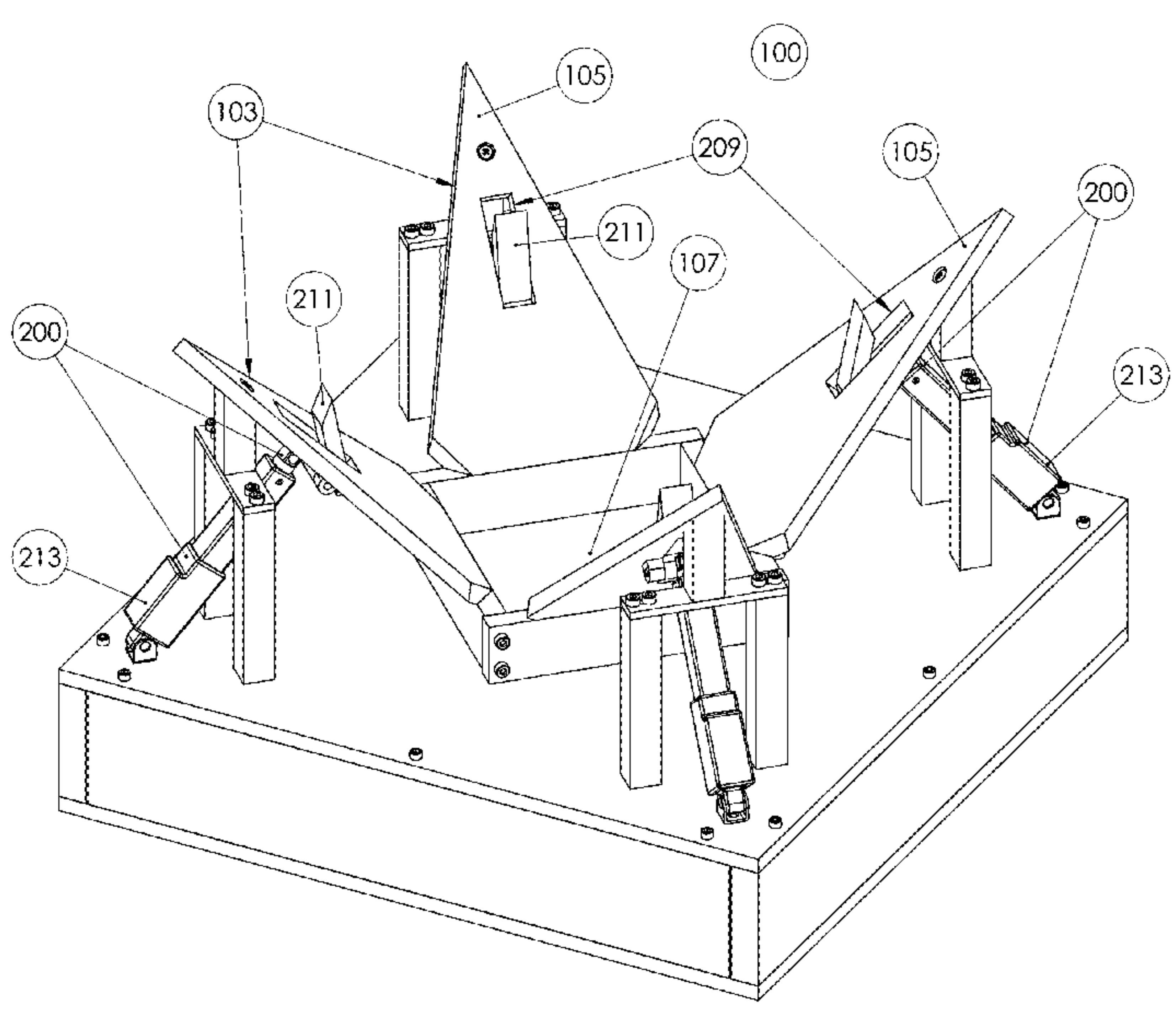
Primary Examiner — Philip J Bonzell

(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Daniel J. Fiorello; Georgi Korobanov

(57) **ABSTRACT**

A docking station for an aircraft includes a base portion and an alignment system disposed on the base portion configured to orient the aircraft relative to the base portion. The alignment system can include a plurality of protrusions extending away from the base portion in a vertical direction. The plurality of protrusions can extend away from the base portion in both the vertical direction and a horizontal direction such that the protrusions can extend from the base portion at an angle.

15 Claims, 7 Drawing Sheets



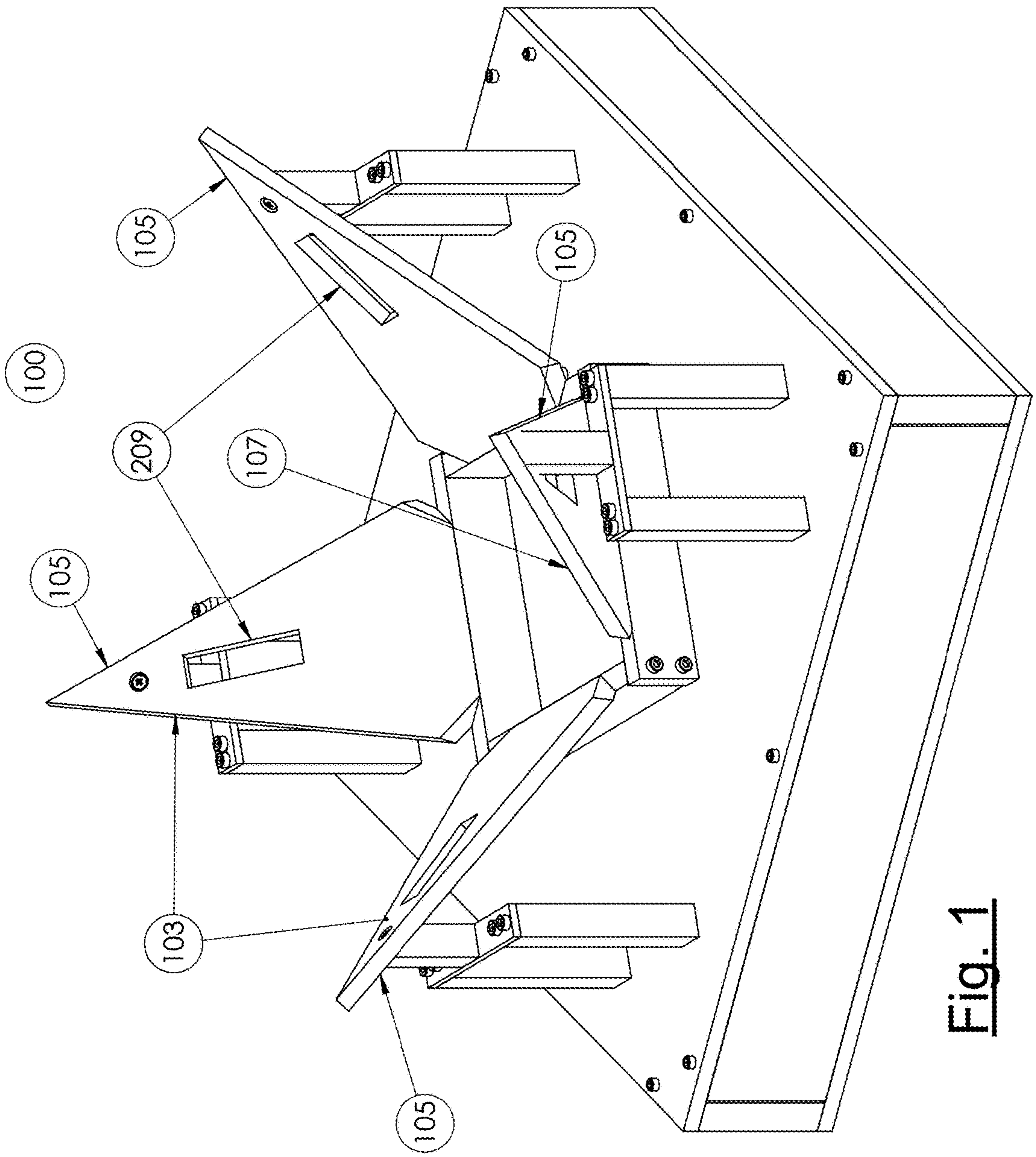


Fig. 1

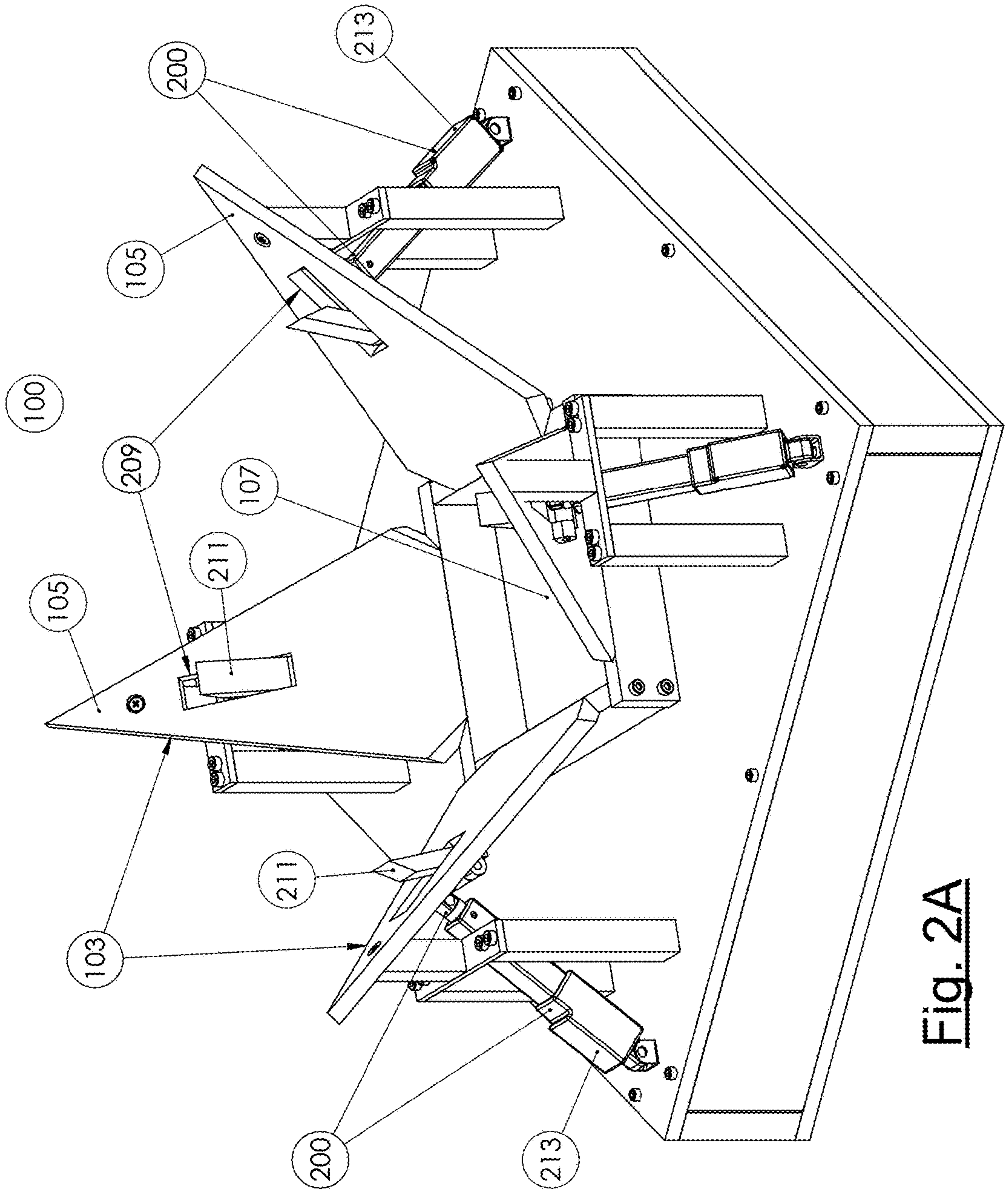


Fig. 2A

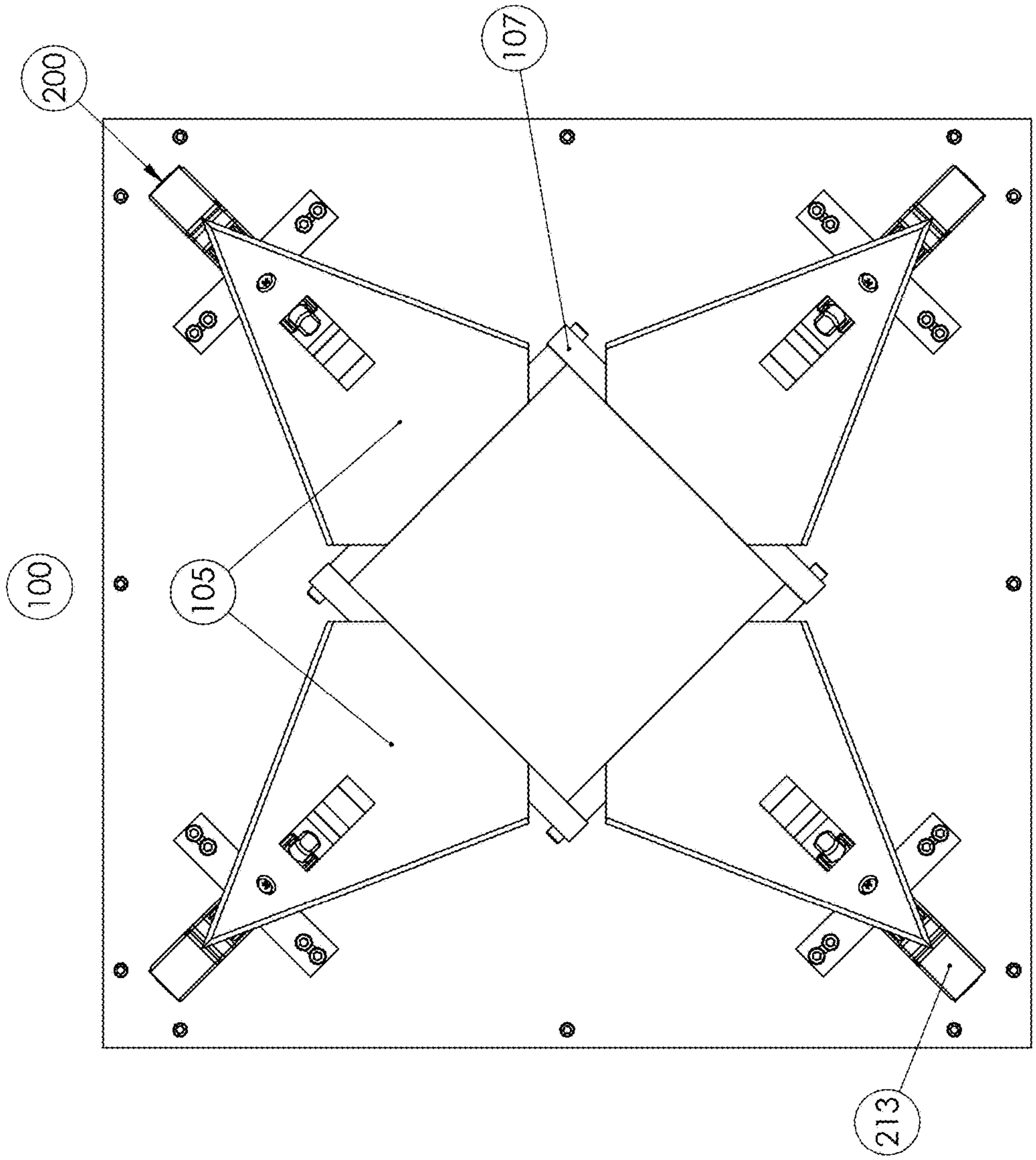


Fig. 2B

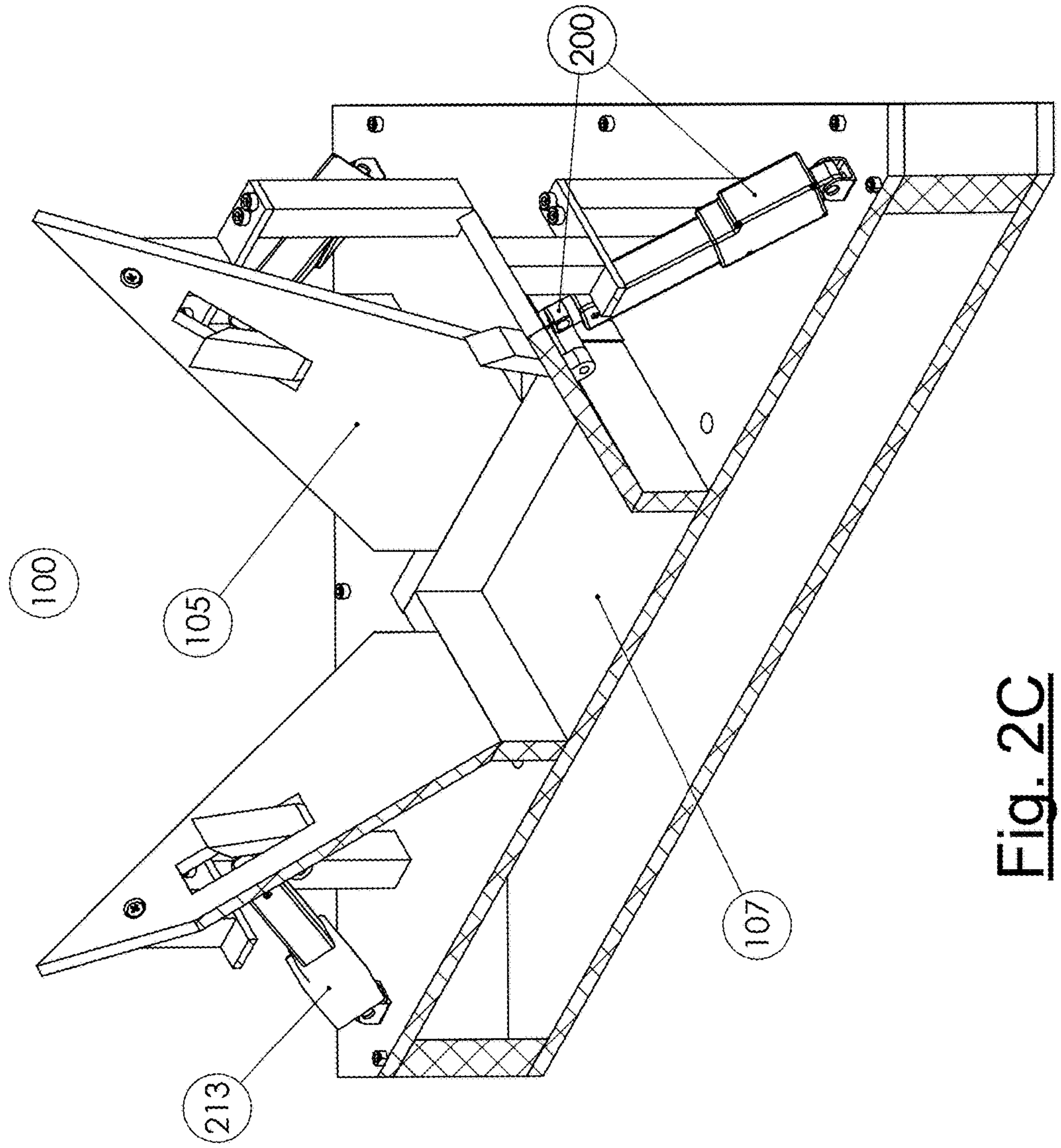


Fig. 2C

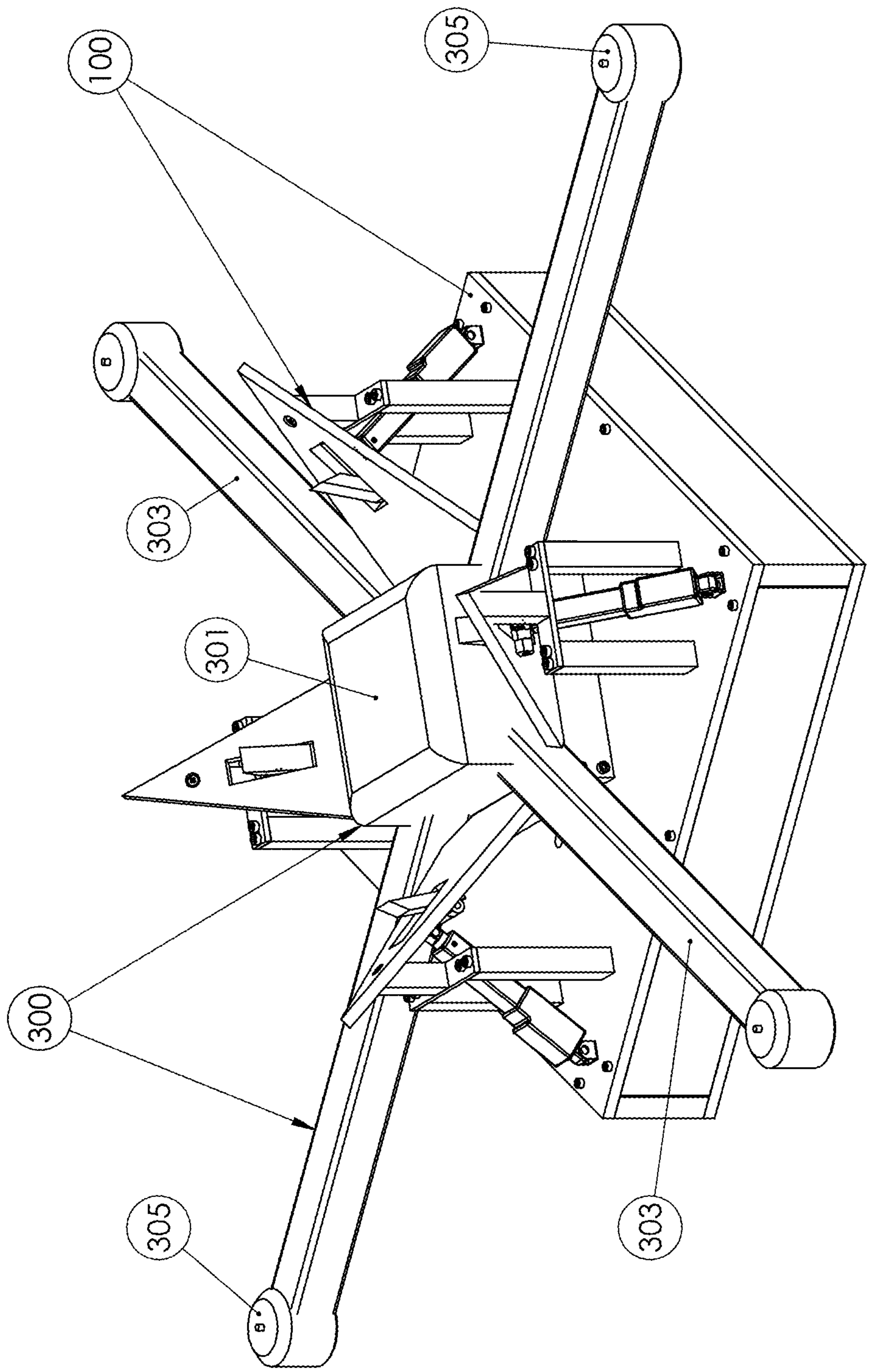
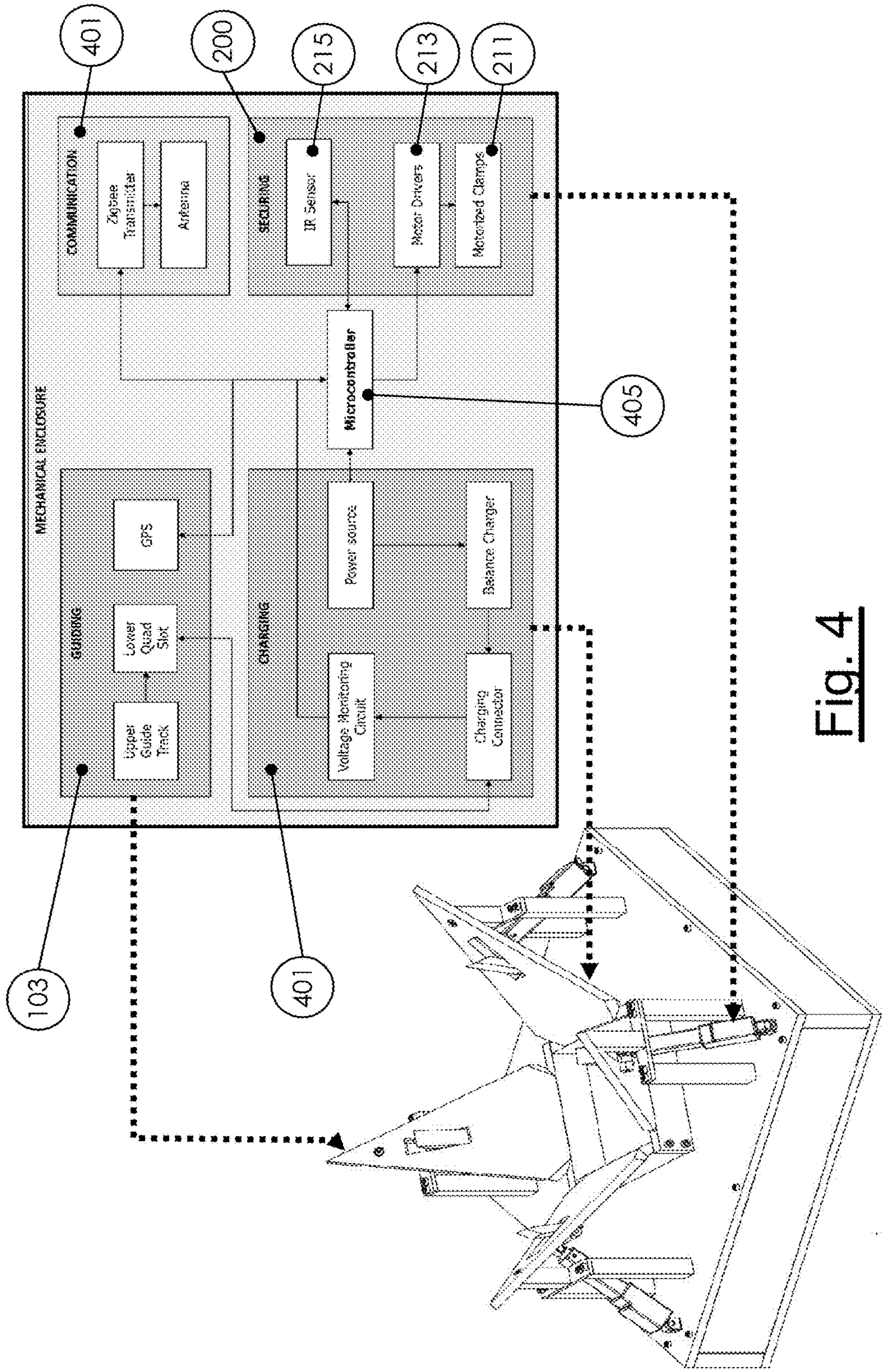


Fig. 3


MECHANICAL ENCLOSURE
COMMUNICATION
Zigbee Transmitter
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SECURING
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Motor Drivers
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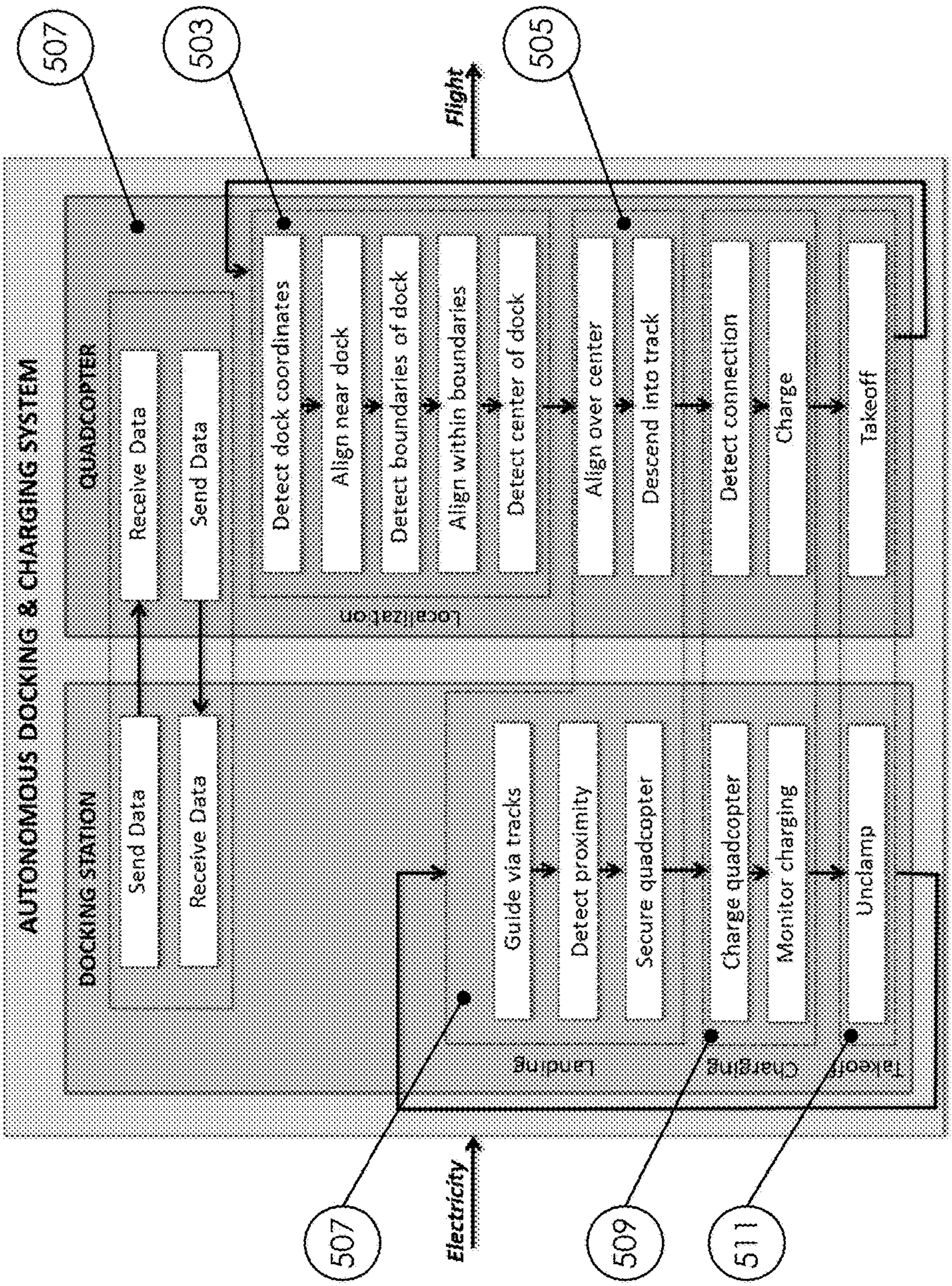
Microcontroller
GUIDING
GPS
Lower Quad Slot
Upper Guide Track
CHARGING
Power source
Balance Charger
Voltage Monitoring Circuit
Charging Connector
401
200
215
213
211
405
103
401

Fig. 4



AUTONOMOUS DOCKING & CHARGING SYSTEM
QUADCOPTER
Receive Data
Send Data
Detect dock coordinates
Align near dock
Detect boundaries of dock
Align within boundaries
Detect center of dock
Localization
Align over center
Descend into track
Detect connection
Charge
Takeoff
DOCKING STATION
Send Data
Receive Data
Guide via tracks
Detect proximity
Secure quadcopter
Landing
Charge quadcopter
Monitor charging
Charging
Unclamp
Takeoff
Flight
Electricity
507
503
505
507
509
511

Fig. 5

DRONE AIRCRAFT LANDING AND DOCKING SYSTEMS

CROSS REFERENCE TO RELATED APPLICATIONS

The subject invention claims the benefit of priority from U.S. Provisional Patent Application Ser. No. 62/126,764, the disclosure of which is herein incorporated by reference in its entirety.

BACKGROUND

1. Field

The present disclosure relates to unmanned and drone aircraft, more specifically to landing and docking systems for unmanned aircraft (e.g., quad copters).

2. Description of Related Art

Quad-copters and similar aircraft can be configured to charge and/or transfer data through a suitable docking station. Such aircraft can be manually flown to and/or placed onto such a docking station for charging/data transfer. Certain types of these aircraft can be configured as autonomous drones that include software such that the drone can perform one or more functions on its own (e.g., flying a particular route, taking off, landing). These systems can employ GPS navigational mechanisms, vision sensors, distance sensors, or the like.

However, such software, sensors, and related systems inherently include positional errors that lead to misalignment of the drone relative to the docking station. Such misalignment can prevent the drone from making a physical or electromagnetic connection with the docking station, thereby preventing data transfer, object retrieval (e.g., for package delivery), and/or charging of the drone's battery without manual intervention.

Such conventional methods and systems have generally been considered satisfactory for their intended purpose. However, there is still a need in the art for improved landing and docking systems. The present disclosure provides a solution for this need.

SUMMARY

A docking station for an aircraft includes a base portion and an alignment system disposed on the base portion configured to orient the aircraft relative to the base portion. The alignment system can include a plurality of protrusions extending away from the base portion in a vertical direction. The plurality of protrusions can extend away from the base portion in both the vertical direction and a horizontal direction such that the protrusions can extend from the base portion at an angle.

The protrusions can include a wedge shape. The plurality of protrusions can include four wedge shape protrusions. The four wedge shape protrusions can be oriented to extend outwardly from a center of the base portion 90 degrees relative to each other. The wedge shape protrusions can each include a triangular plate shape.

The docking station can include a latching system operatively associated with the alignment system for selectively latching the aircraft to the docking station. The wedge shape protrusions can include at least one latch orifice for receiving a latching member of a latching system. The docking station can include the latching member extending through the latching orifice and configured to move relative to the wedge shape protrusion.

The docking station can include a charging system operatively associated with the base portion and configured to electrically couple to the aircraft to charge a battery of the aircraft. The docking station can also include a data transfer system operatively associated with the base portion and configured to communicate with the aircraft.

The docking station can be configured for use with a quad-copter such that it is a quad-copter docking station.

A method for charging and/or securing an autonomous aircraft to a docking station can include determining if the aircraft has landed in the docking station, and latching the aircraft to the docking station if the aircraft is determined to have landed in the docking station.

These and other features of the systems and methods of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

FIG. **1** is a perspective view of an embodiment of a docking station in accordance with this disclosure, showing a plurality of protrusions extending therefrom;

FIG. **2**A is a perspective view of the docking station of FIG. **1**, showing a locking system operatively disposed thereon;

FIG. **2**B is a plan view of the docking station of FIG. **2**A;

FIG. **2**C is a perspective cross-sectional view of the docking station of FIG. **2**A;

FIG. **3** is a perspective view of the docking station of FIG. **1**, showing a quad-copter disposed therein;

FIG. **4** is a schematic of an embodiment of system internals of the docking station of FIG. **2**A; and

FIG. **5** is a schematic of an embodiment of algorithmic architecture of the docking system and an aircraft relative to each other.

DETAILED DESCRIPTION

Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, an illustrative view of an embodiment of a docking station in accordance with the disclosure is shown in FIG. **1** and is designated generally by reference character **100**. Other embodiments and/or aspects of this disclosure are shown in FIGS. **2**A-**5**. The systems and methods described herein can be used to improve aircraft alignment when landing at a docking station (e.g., for autonomous quad-copters or the like).

Referring to FIGS. **1** and **3**, a docking station **100** for an aircraft (e.g., quad-copter **300**) includes a base portion **101** and an alignment system **103** disposed on the base portion **101**. The alignment system **103** is configured to orient the aircraft relative to the base portion **103**, for example, to facilitate coordinated landing on the base portion **101**. This can allow for aircraft (e.g., unmanned and/or autonomous aircraft) to properly land on a docking station **100** in a predetermined orientation and/or position so that the aircraft can receive energy and/or data from through the docking station **100**.

The alignment system **103** can include a plurality of protrusions **105** extending away from the base portion **101** in at least a vertical direction. As shown, the plurality of protrusions **105** can extend away from the base portion **101** in both the vertical direction and a horizontal direction such that the protrusions **105** can extend from the base portion **101** at a non-right angle. The angle at which protrusions **105** extend can be the same for each or different for one or more protrusions **105**.

At least one of the protrusions **105** can include a wedge shape. As shown, the docking station **100** can include four wedge shape protrusions **105** configured for guiding a quad copter. The four protrusions **105** can be oriented to extend outwardly from a center **107** of the base portion **101** at about 90 degrees relative to each other. It is contemplated that the docking station **100** can be configured to have less than four protrusions (e.g., for a tri-copter) or more than four protrusions (e.g., for a hexacopter, octocopter, or any other suitable multi-rotor craft). Generally, any suitable number of protrusions **105** is contemplated herein and each protrusion **105** can be placed at $360/N_p$ degrees relative to each other, where N_p is the total number of protrusions **105**.

As shown, the wedge shaped protrusions **105** can be defined by a triangular plate shape or any other suitable shape that allows the aircraft to be medialised to the center **107** of the docking station **100**. The protrusions **105** can have any suitable angle with a sufficient vertical component to overcome frictional and/or other resistance forces of from the aircraft to allow the aircraft to slide on the protrusions **105** toward the center **107**.

Referring to FIGS. **2A-2C**, the docking station **100** can include a latching system **200** operatively associated with the alignment system **103** for selectively latching the aircraft to the docking station **100**. For example, the protrusions **105** can include at least one latch orifice **209** for receiving a latching member **211** of a latching system **200**.

The latching member **211** can extend through the latching orifice **209** and be configured to move relative to the protrusion **105**. The latching member **211** can be actuated by any suitable motor or other mechanism (e.g., piston member **213**) to extend toward the center **107** and hold the aircraft to the docking station **100**. Referring to FIG. **4**, the latching system **200** can include a sensor **215** in communication with a controller **405** configured to sense when the aircraft is present in the docking station **100**.

With continued reference to FIG. **4**, the docking station **100** can include a charging system **401** operatively associated with the base portion **101** and configured to electrically couple to the aircraft to charge a battery of the aircraft. For example, the charging system **410** can include an inductive charger or any other suitable charger with contact terminals. The docking station **100** can also include a data transfer system **403** operatively associated with the base portion **101** and configured to communicate with the aircraft via any suitable connection (e.g., an antenna, a wired connection). It is also contemplated that an object retrieval system (not shown) can be included to retrieve or add packages or other payload from the aircraft. These components can be disposed in the center **107** or any other suitable portion of the docking station **100** (e.g., base **101**).

As described above, the docking station can be configured for use with a quad-copter **300** (e.g., an autonomous quad-copter) such that it is a quad-copter docking station. For example, quad-copter **300** can include a body portion **301** and four arms **303** extending therefrom, each arm **303** configured to hold a motor **305** and propeller (not shown) for lifting and controlling the quad-copter **300**.

During landing, the quad-copter **300** positions itself or is positioned by a user over the docking station imperfectly due to inherent errors in the precision of autonomous navigation and/or control software and/or or manual user error. Also, the orientation of the arms **303** relative to the docking station **100** can be misaligned. When descending toward the docking station **100** when out of alignment with the center **107**, the arms **303** and/or the body **101** contact the protrusions **105** and are directed toward the center **107**. If the arms **303** are out of alignment, the quad-copter **300** will also be rotated as it descends. When the quad-copter reaches its lowest point at the center **107**, it can be put into communication with the charging system **401** and/or data transfer system **403** by being medialised and/or oriented properly. The locking system **200** can then selectively retain the quad-copter **200** to the docking station **100** according to any predetermined criteria or algorithm.

A method for charging and/or securing an autonomous aircraft to a docking station **100** can include determining if the aircraft has landed in the docking station **100**, and latching the aircraft to the docking station **100** if the aircraft is determined to have landed in the docking station **100**. In an autonomous example, referring to FIG. **5**, when flying or during any other suitable operation, the docking station **100** and the quad-copter **300** can communicate with each other via one or more embodiments of a communication subroutine **501**. When the quad-copter **300** software decides to land at the docking station **100**, the quad-copter can be configured to execute one or more embodiments of a localization subroutine **503** and attempt to align with the center **107** of the docking station **100**. In one or more embodiments of a landing subroutine **505**, the quad-copter **300** can descend into the docking station **100**/alignment system **103** after attempting to align itself using its own navigation (e.g., GPS).

The docking station **100** can execute one or more embodiments of a docking subroutine **507** to detect when the quad-copter **300** has descended into the docking station **100**. After the quad-copter **300** has landed, the quad-copter **300** and/or the docking station can execute one or more embodiments of a charging subroutine **509** (e.g., to detect a suitable electrical coupling and/or to monitor charging) and/or to transfer data. After suitable charging/data transfer, the docking station **100** and the quad-copter **300** can execute one or more embodiments of a take-off subroutine **511** (e.g., the docking station **100** can release locking system **200** and allow the quad-copter **300** to take off).

The methods and systems of the present disclosure, as described above and shown in the drawings, provide for aircraft docking stations with superior properties including alignment systems for guiding aircraft into the docking stations. While the apparatus and methods of the subject disclosure have been shown and described with reference to embodiments, those skilled in the art will readily appreciate that changes and/or modifications may be made thereto without departing from the spirit and scope of the subject disclosure.

What is claimed is:

1. A docking station for an aircraft, comprising:

a base portion;

an alignment system disposed on the base portion configured to orient the aircraft relative to the base portion; and

a latching system operatively associated with the alignment system for selectively latching the aircraft to the docking station, wherein the alignment system includes a plurality of protrusions, wherein the protrusions include at least one latch orifice for receiving a latching member of the latching system, wherein the latching system includes the latching member extending through the latching orifice and configured to move relative to the protrusion.

2. The docking station of claim **1**, further including a charging system operatively associated with the base portion and configured to electrically couple to the aircraft to charge a battery of the aircraft.

3. The docking station of claim **1**, further including a data transfer system operatively associated with the base portion and configured to communicate with the aircraft.

4. The docking station of claim **1**, wherein the plurality of protrusions extending away from the base portion in a vertical direction.

5. The docking station of claim **4**, wherein the plurality of protrusions extend away from the base portion in both the vertical direction and a horizontal direction such that the protrusions extend from the base portion at an angle.

6. The docking station of claim **5**, wherein the protrusions include a wedge shape.

7. The docking station of claim **6**, wherein the plurality of protrusions includes four wedge shape protrusions.

8. The docking station of claim **7**, wherein the four wedge shape protrusions are oriented to extend outwardly from a center of the base portion 90 degrees relative to each other.

9. The docking station of claim **8**, wherein the wedge shape protrusions each include a triangular plate shape.

10. A quad-copter docking station, comprising:

a base portion; and

an alignment system disposed on the base portion configured to orient the aircraft relative to the base portion, wherein the alignment system includes a plurality of protrusions extending away from the base portion in both the vertical direction and a horizontal direction such that the protrusions extend from the base portion at an angle; and

a latching system operatively associated with the alignment system for selectively latching the aircraft to the docking station, wherein the protrusions include at least one latch orifice for receiving a latching member of the latching system, wherein the latching system includes the latching member extending through the latching orifice and configured to move relative to the protrusion.

11. The docking station of claim **10**, wherein the protrusions include a wedge shape.

12. The docking station of claim **11**, wherein the plurality of protrusions includes four wedge shape protrusions.

13. The docking station of claim **12**, wherein the four wedge shape protrusions are oriented to extend outwardly from a center of the base portion 90 degrees relative to each other.

14. The docking station of claim **13**, wherein the wedge shape protrusions include a triangular plate shape.

15. A method for charging and/or securing an autonomous aircraft to a docking station, comprising:

determining if the aircraft has landed in the docking station, wherein the docking station includes:

a base portion; and

an alignment system disposed on the base portion configured to orient the aircraft relative to the base portion, wherein the alignment system includes a plurality of protrusions extending away from the base portion in both the vertical direction and a horizontal direction such that the protrusions extend from the base portion at an angle; and

a latching system operatively associated with the alignment system for selectively latching the aircraft to the docking station, wherein the protrusions include at least one latch orifice for receiving a latching member of the latching system, wherein the latching system includes the latching member extending through the latching orifice and configured to move relative to the protrusion; and

latching the aircraft to the docking station if the aircraft is determined to have landed in the docking station using the latching system.

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