US 20230206165A1

(19) **United States**

(12) **Patent Application Publication**

Luckay et al.

(10) **Pub. No.: US 2023/0206165 A1**

(43) **Pub. Date: Jun. 29, 2023**

(54) **SYSTEMS FOR AUTONOMOUS ITEM DELIVERY**

(71) Applicant: **United States Postal Service**, Washington, DC (US)

(72) Inventors: **Ryan Luckay**, Washington, DC (US); **Robert E. Dixon, JR.**, Washington, DC (US); **Gregory Cooil**, Washington, DC (US)

(21) Appl. No.: **18/169,539**

(22) Filed: **Feb. 15, 2023**

Related U.S. Application Data

(63) Continuation of application No. 15/832,245, filed on Dec. 5, 2017.

(60) Provisional application No. 62/430,304, filed on Dec. 5, 2016.

Publication Classification

(51) **Int. Cl.**

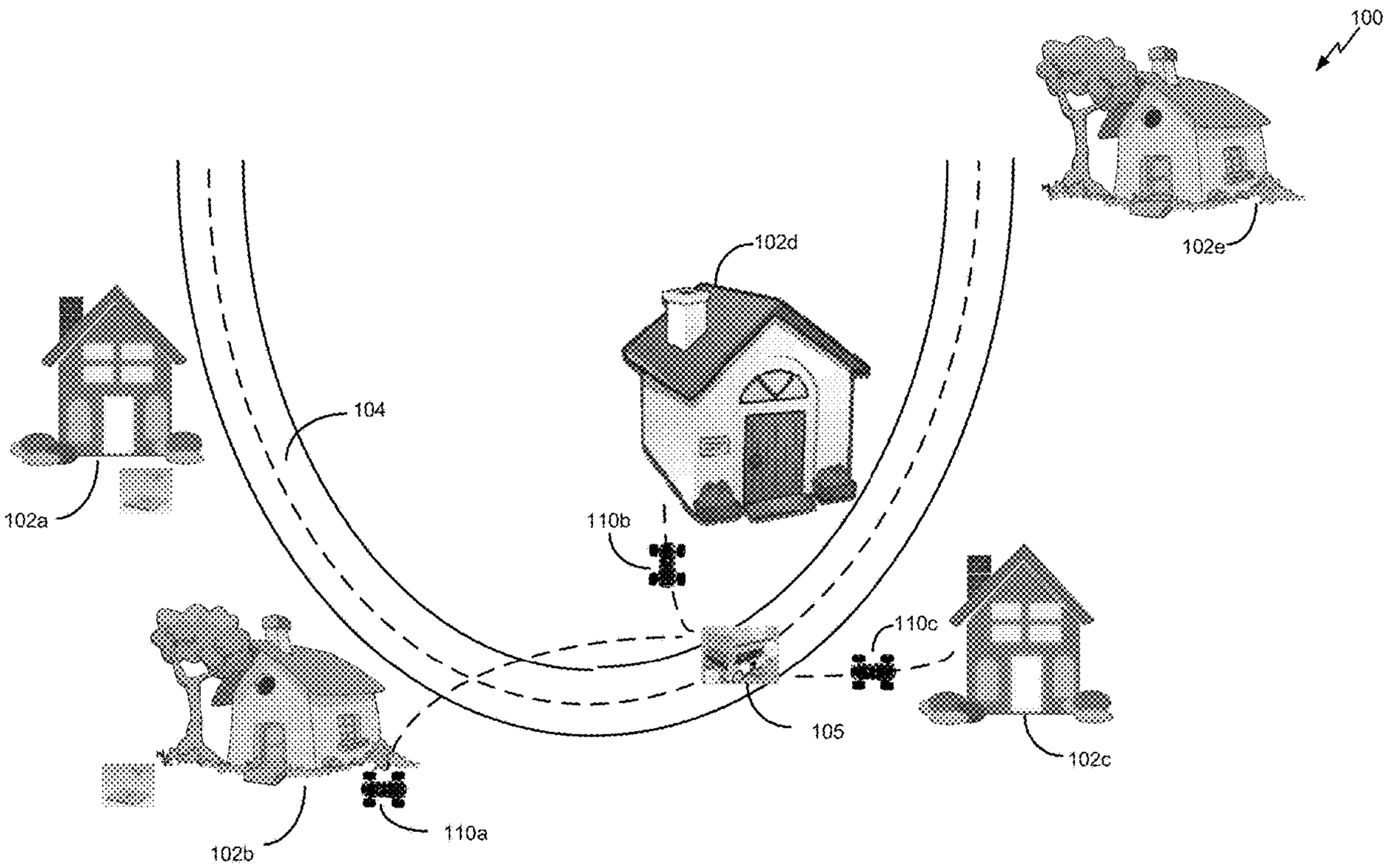
G06Q 10/0832	(2006.01)
G05D 1/00	(2006.01)
G05D 1/02	(2006.01)
B64C 39/02	(2006.01)
G05D 1/10	(2006.01)
G01C 21/34	(2006.01)

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

CPC ***G06Q 10/0832*** (2013.01); ***G05D 1/0088*** (2013.01); ***G05D 1/0027*** (2013.01); ***G05D 1/0217*** (2013.01); ***B64C 39/024*** (2013.01); ***G05D 1/104*** (2013.01); ***G01C 21/343*** (2013.01); *G01C 21/3469* (2013.01); *G05D 2201/0213* (2013.01); *B64U 80/86* (2023.01)

(57) **ABSTRACT**

Methods and systems for autonomous item delivery and/or pick up are provided. IN some aspects, a mothership travels along an item route. One or more autonomous delivery vehicles may be dispatched from the mothership as the mothership progresses along the route. Each of the autonomous delivery vehicles may deliver and/or pick-up one or more items at one or more item locations. In addition, as the mothership progresses along its route, it may also stop to facilitate the manual delivery and/or pick-up of additional items via a human operator. Upon completing their delivery and/or pick up tasks, the autonomous delivery vehicles return to the mothership, either at the point at which they dispatched from the mothership, or at a different location along the item delivery route.



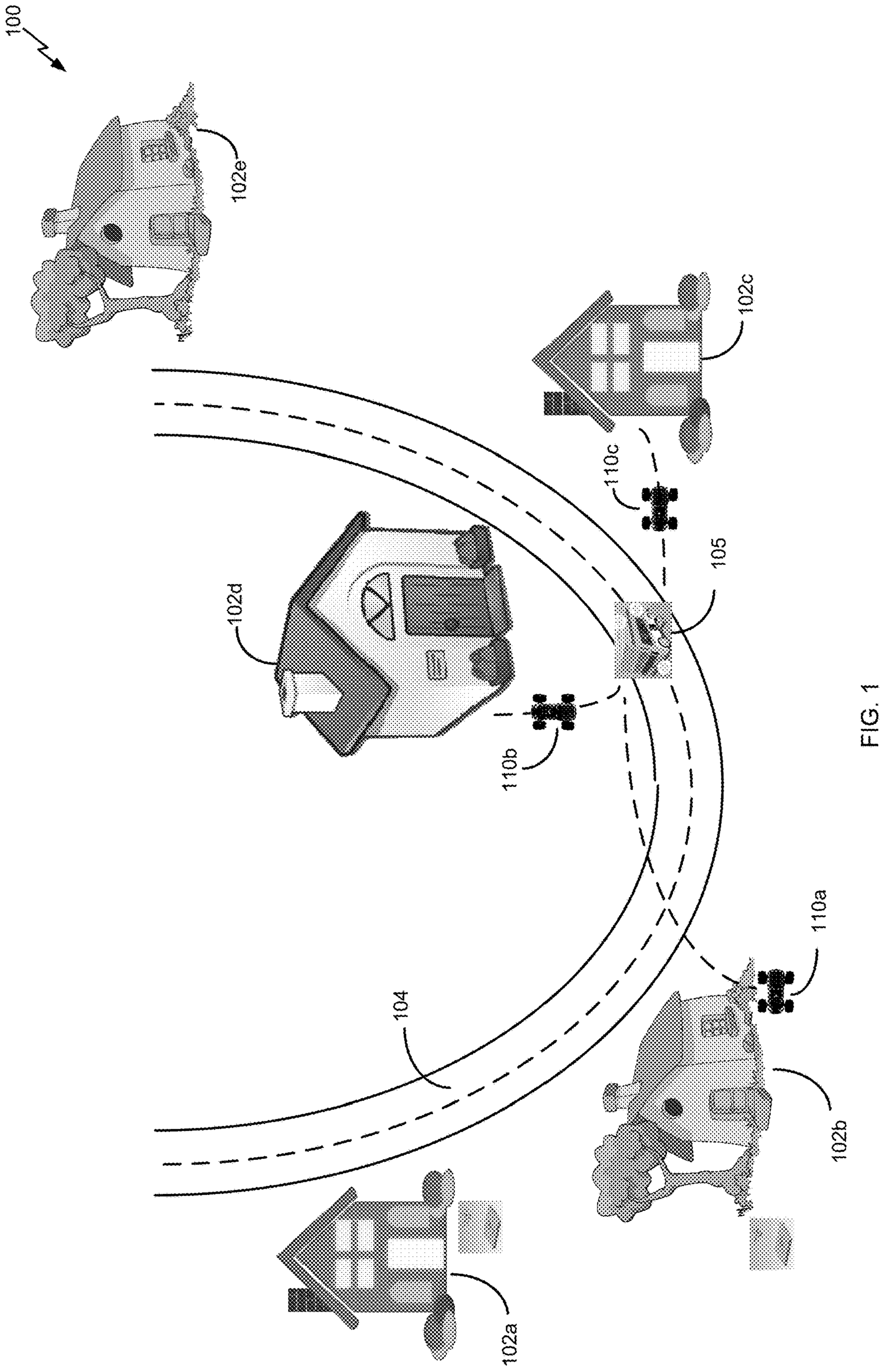


FIG. 1

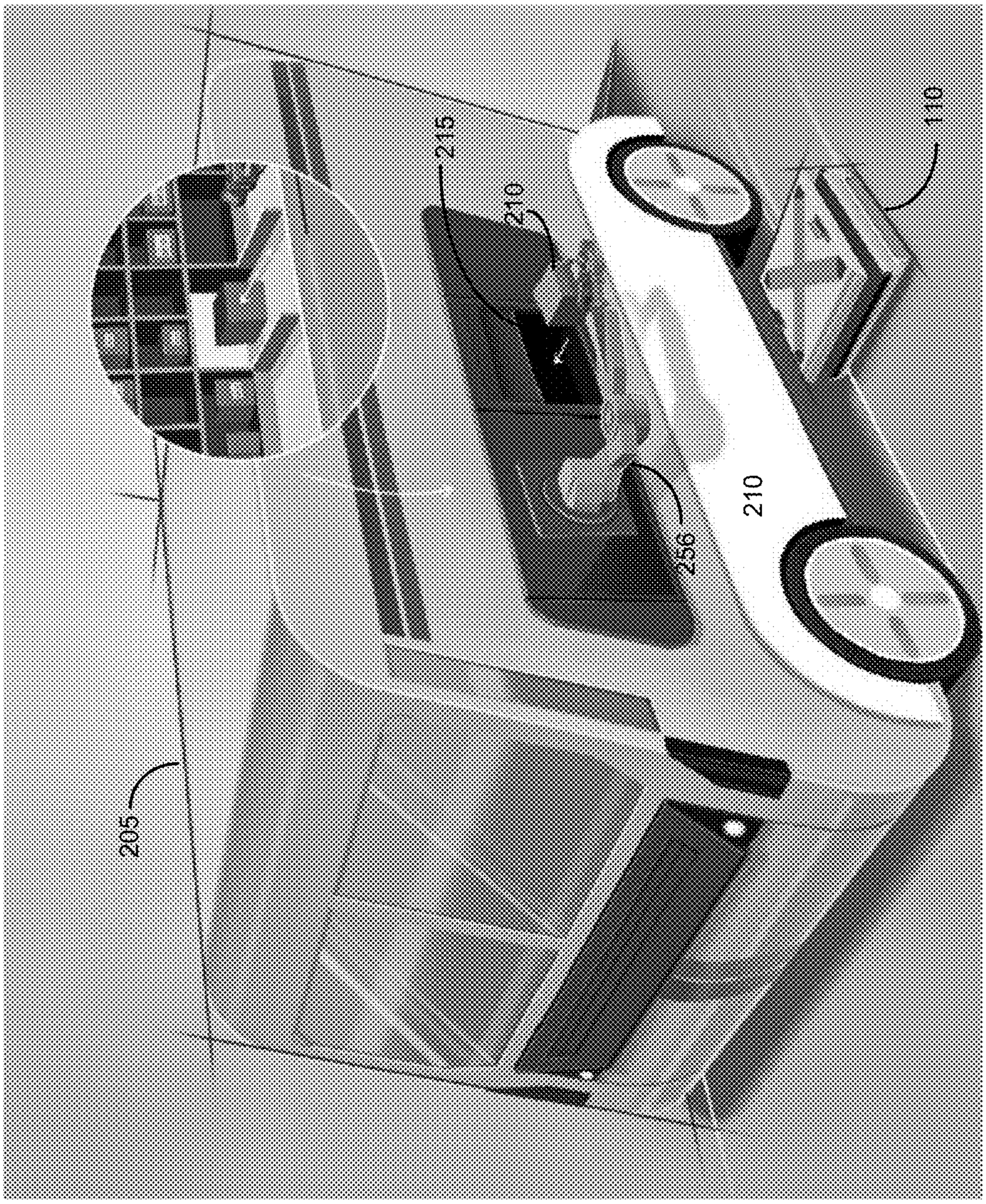


FIG. 2A

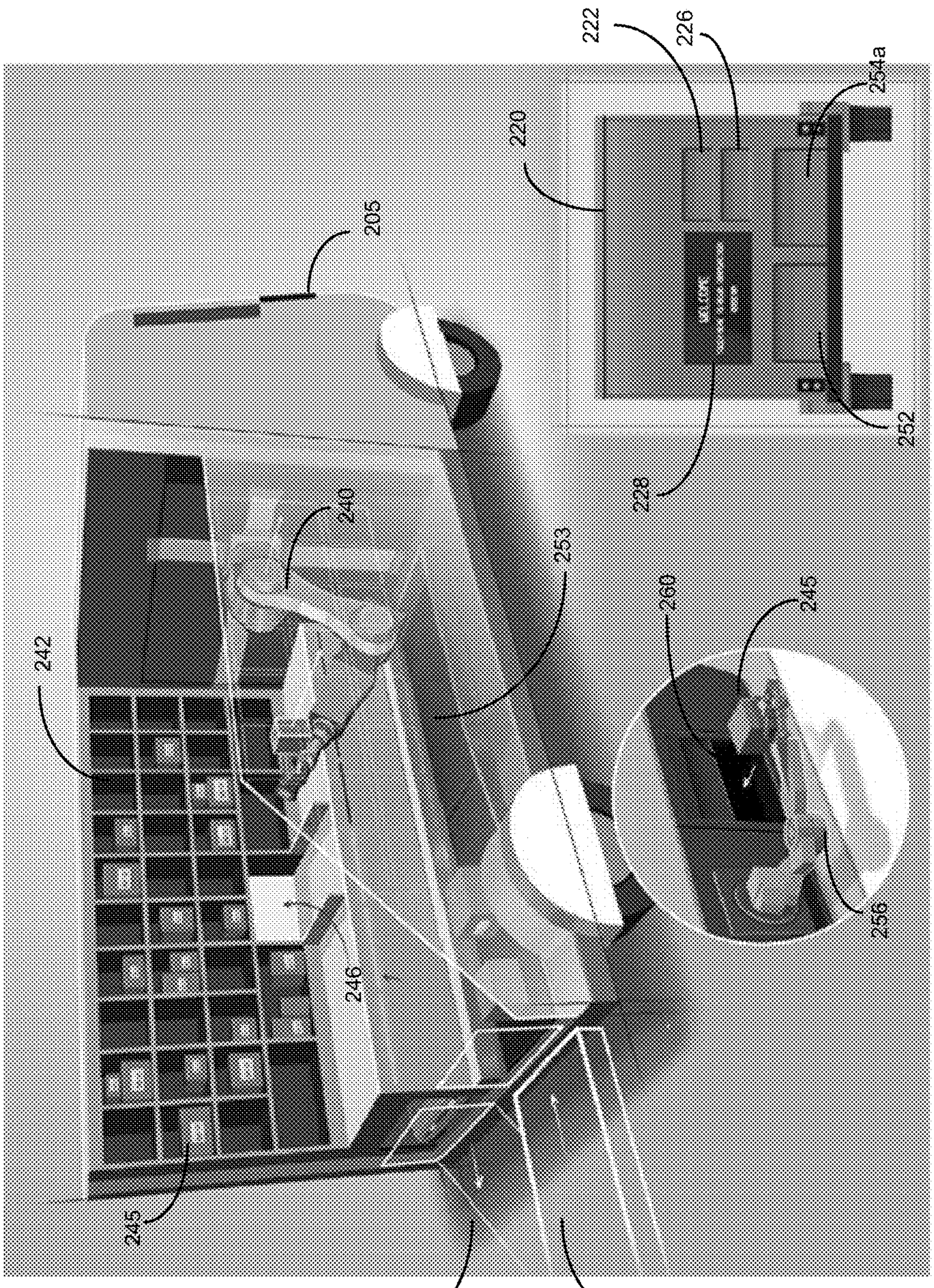


FIG. 2B

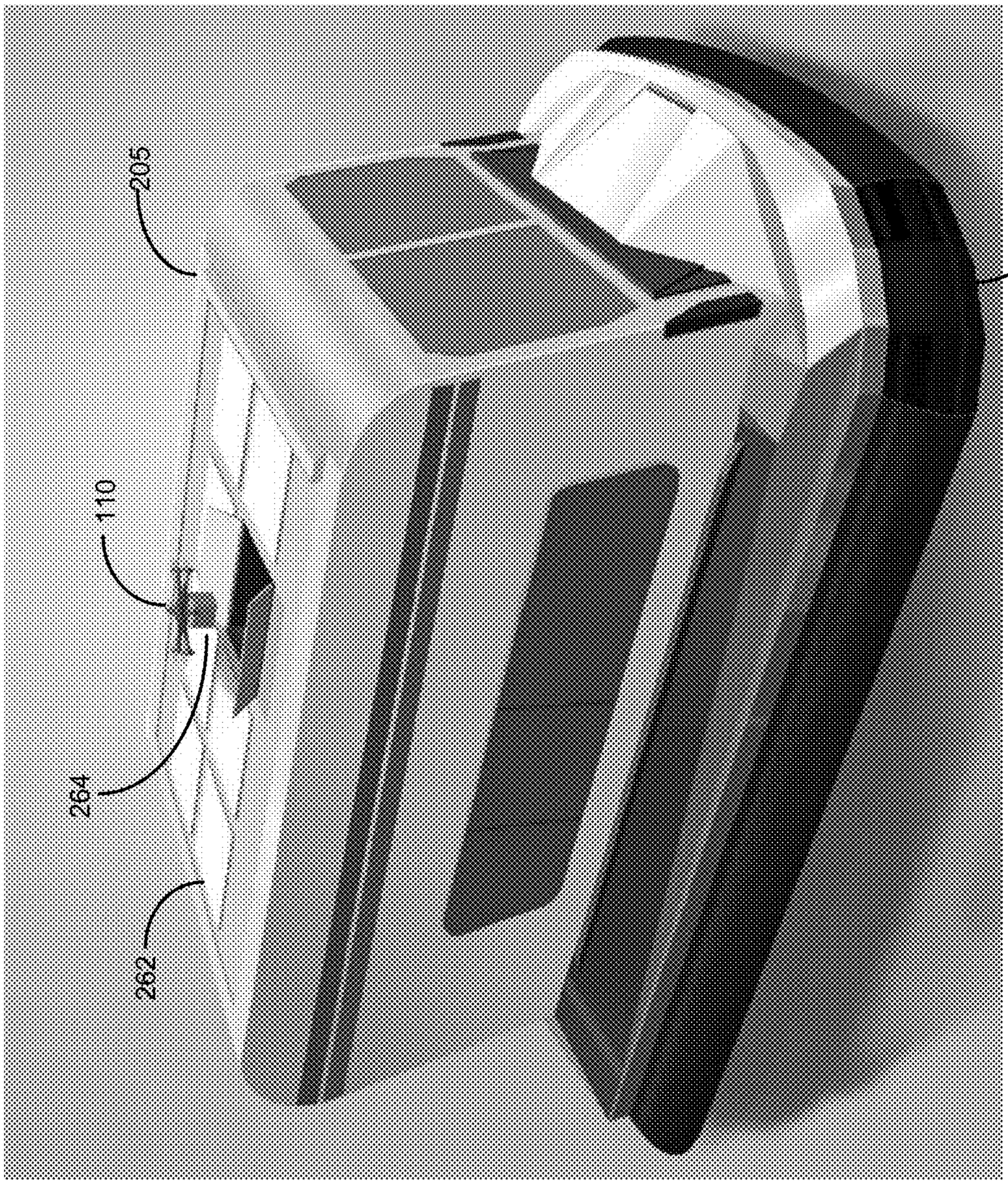


FIG. 2C

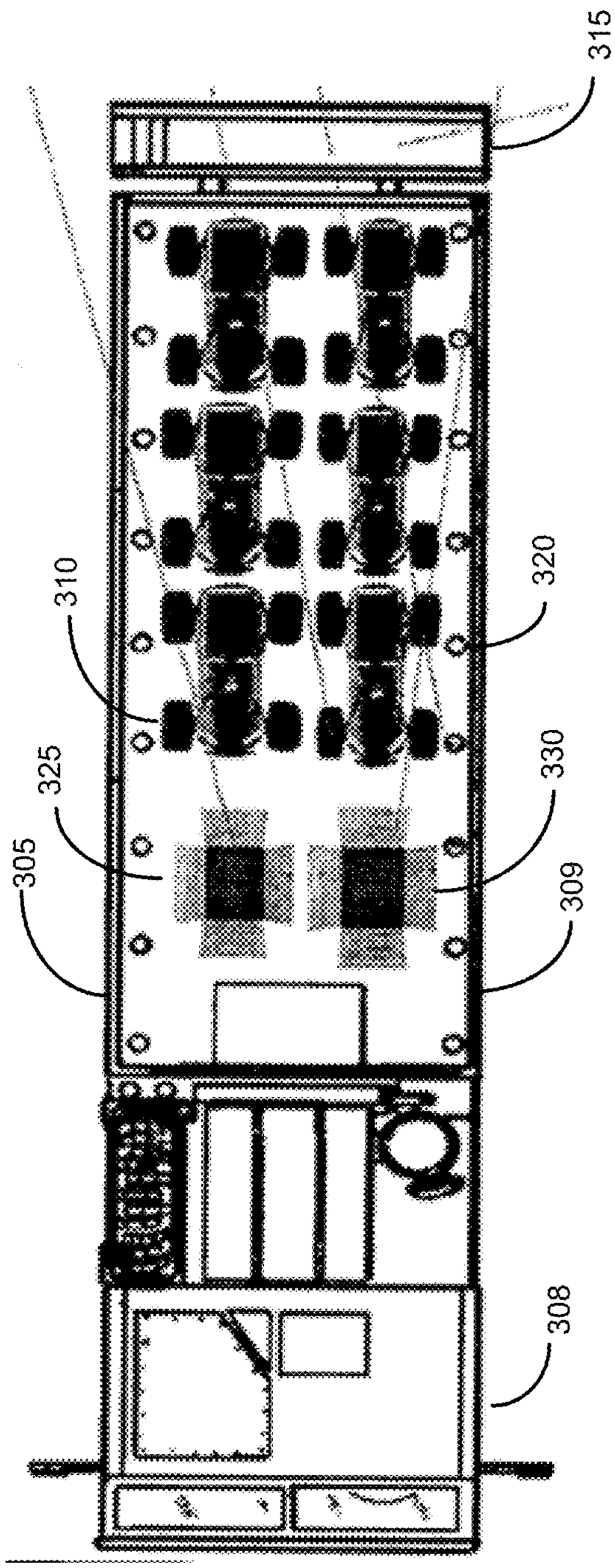


FIG. 3

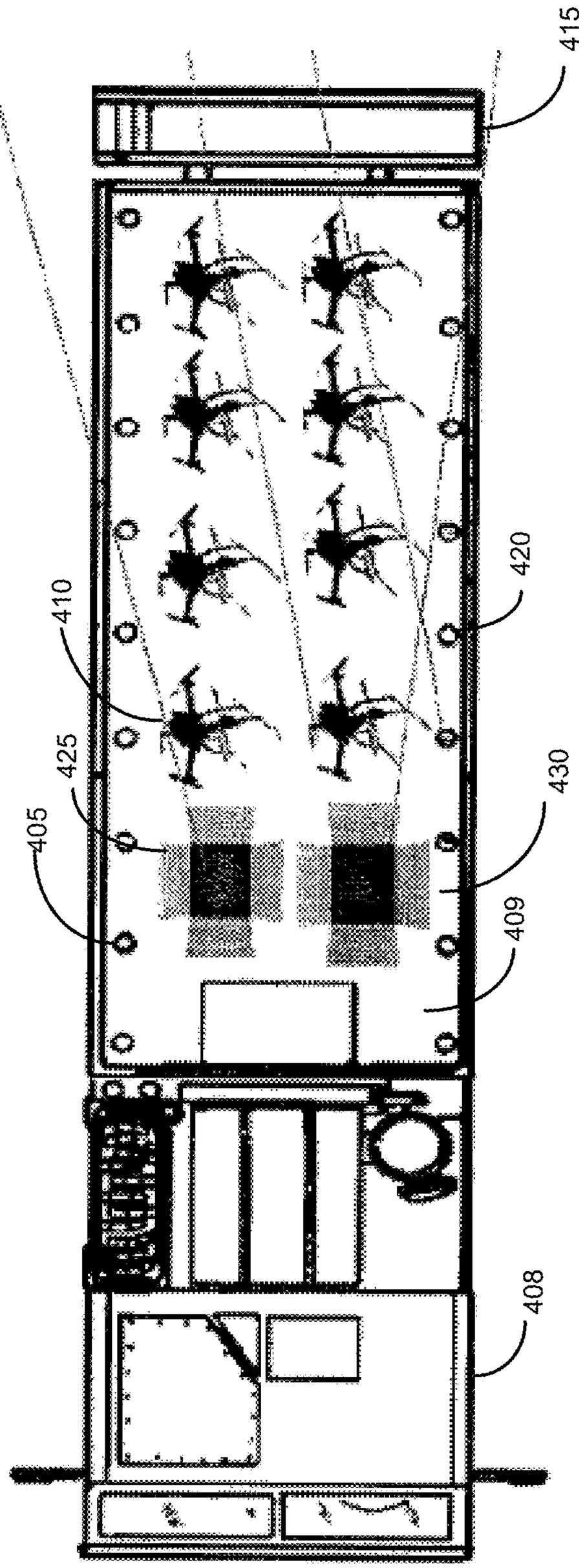


FIG. 4

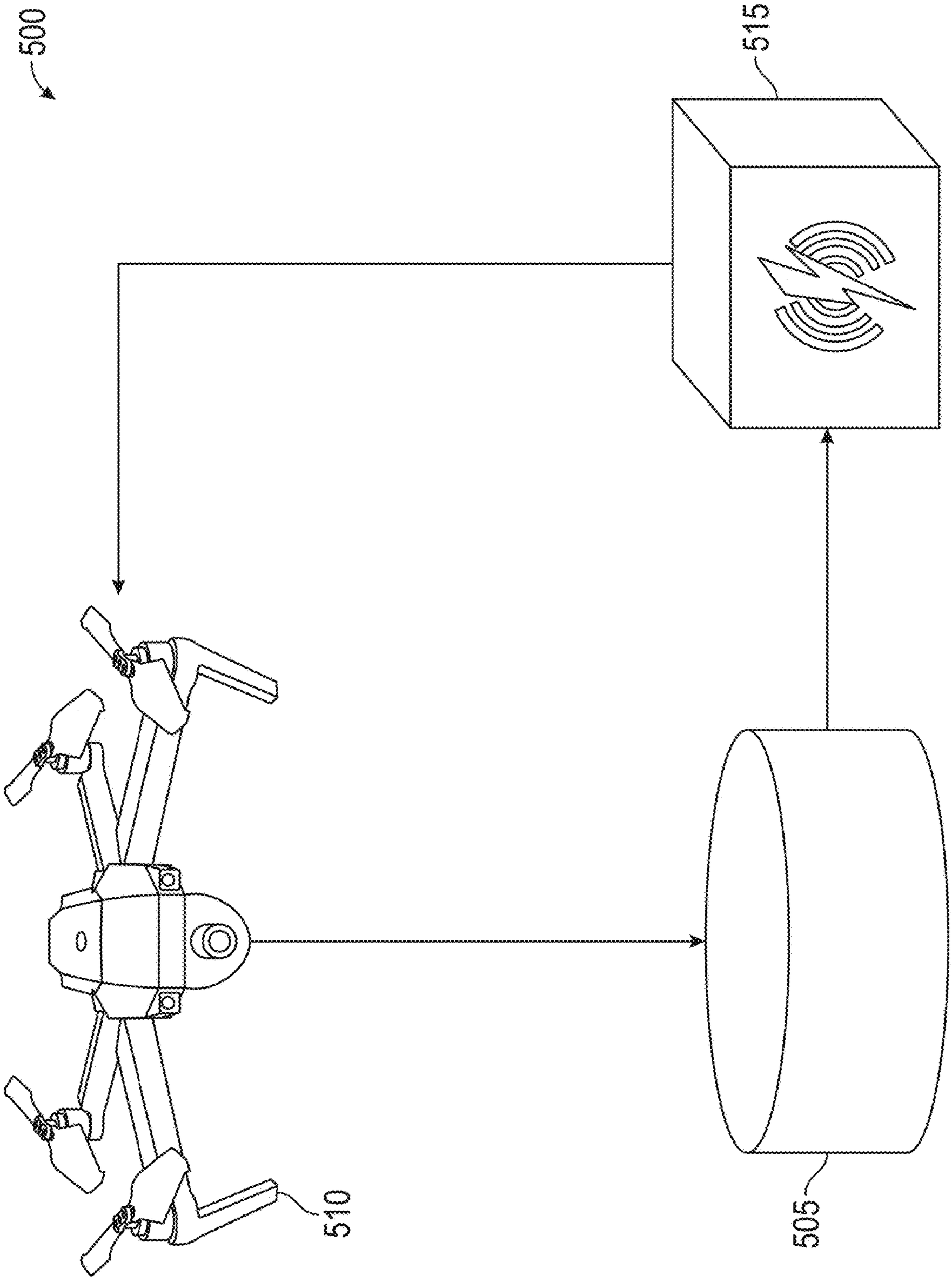


FIG. 5

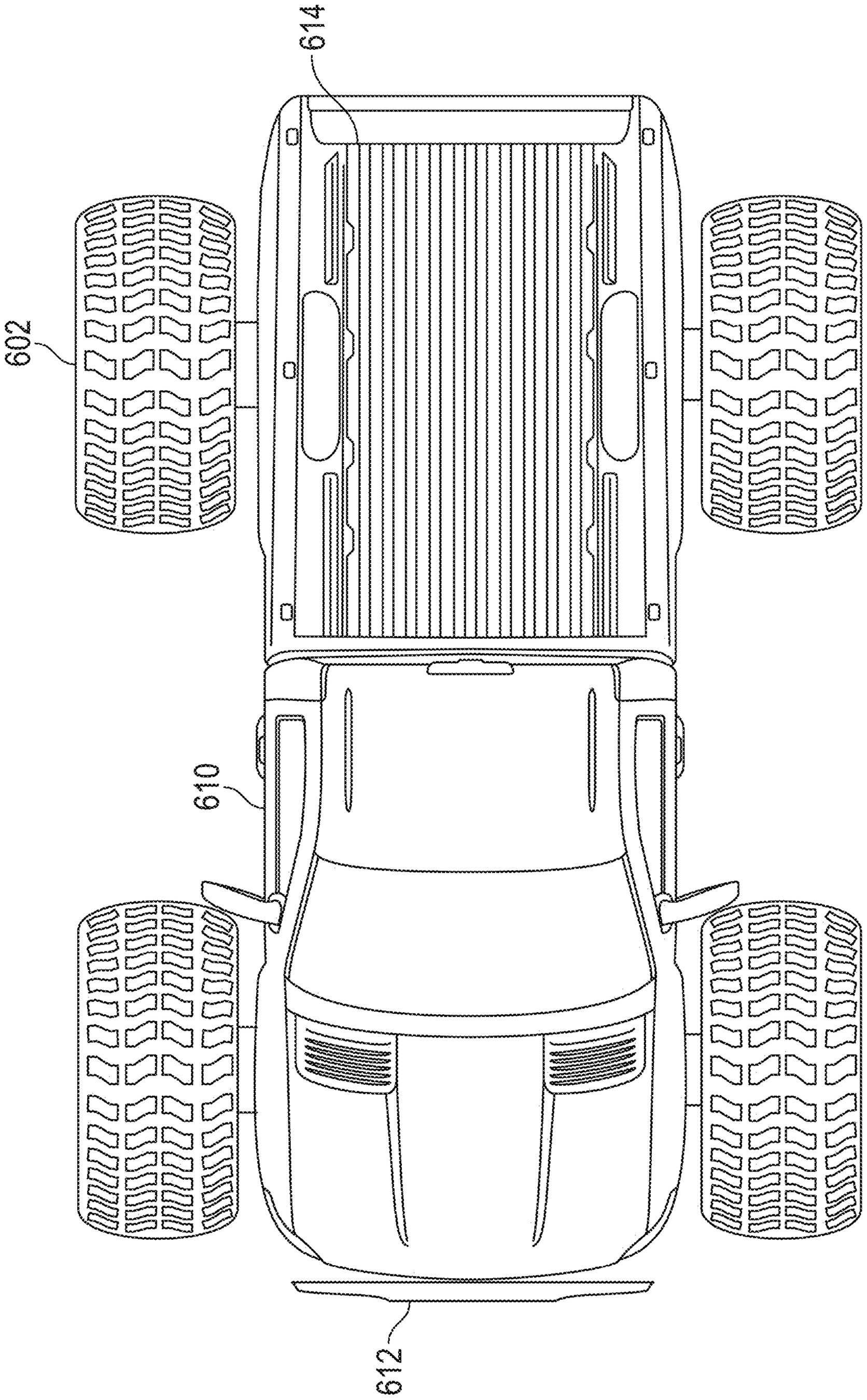


FIG. 6A

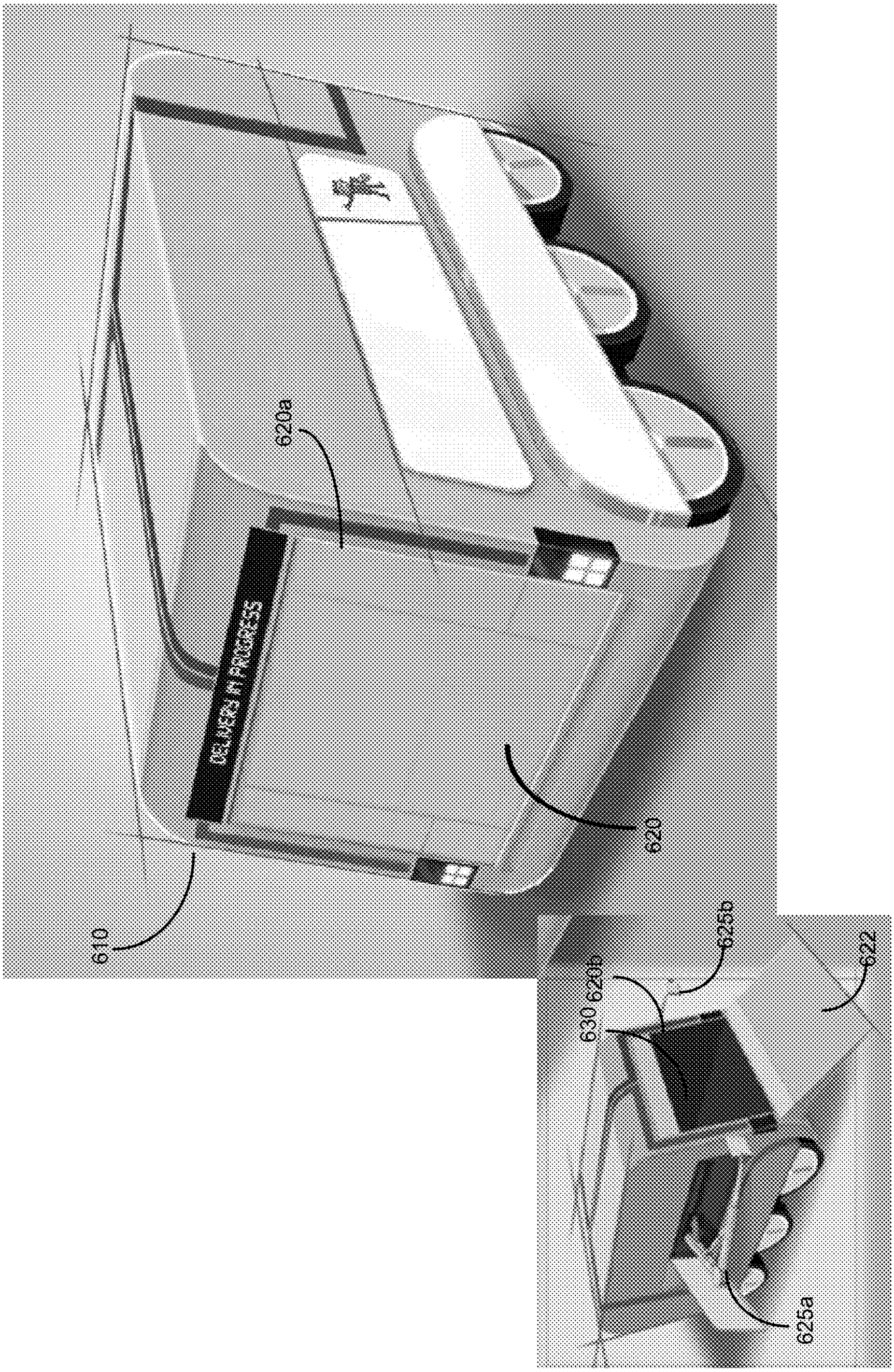


FIG. 6B

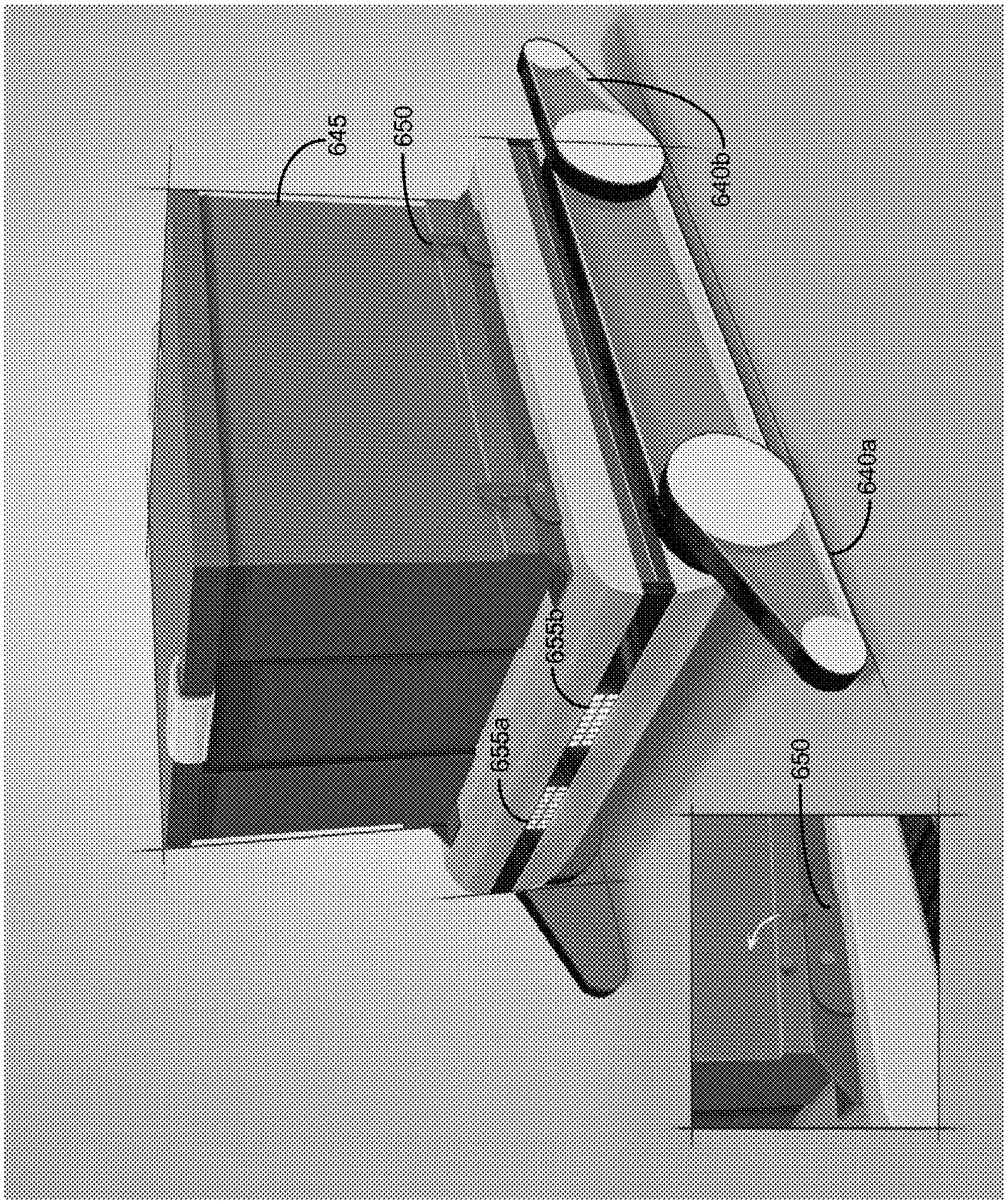


FIG. 6C

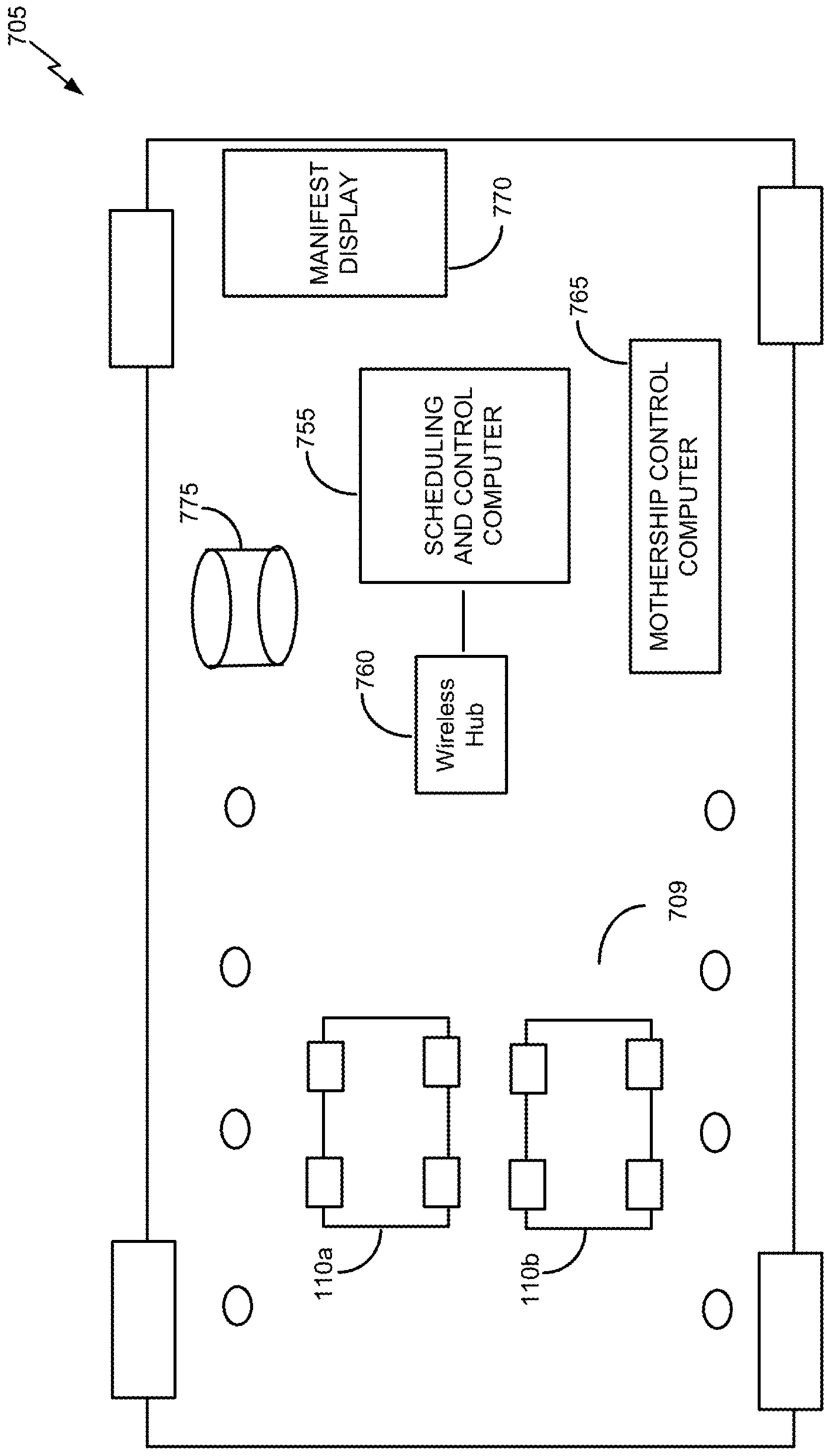

705
MANIFEST DISPLAY
770
765
MOTHERSHIP CONTROL COMPUTER
755
SCHEDULING AND CONTROL COMPUTER
775
760
Wireless Hub
709
110a
110b

FIG. 7

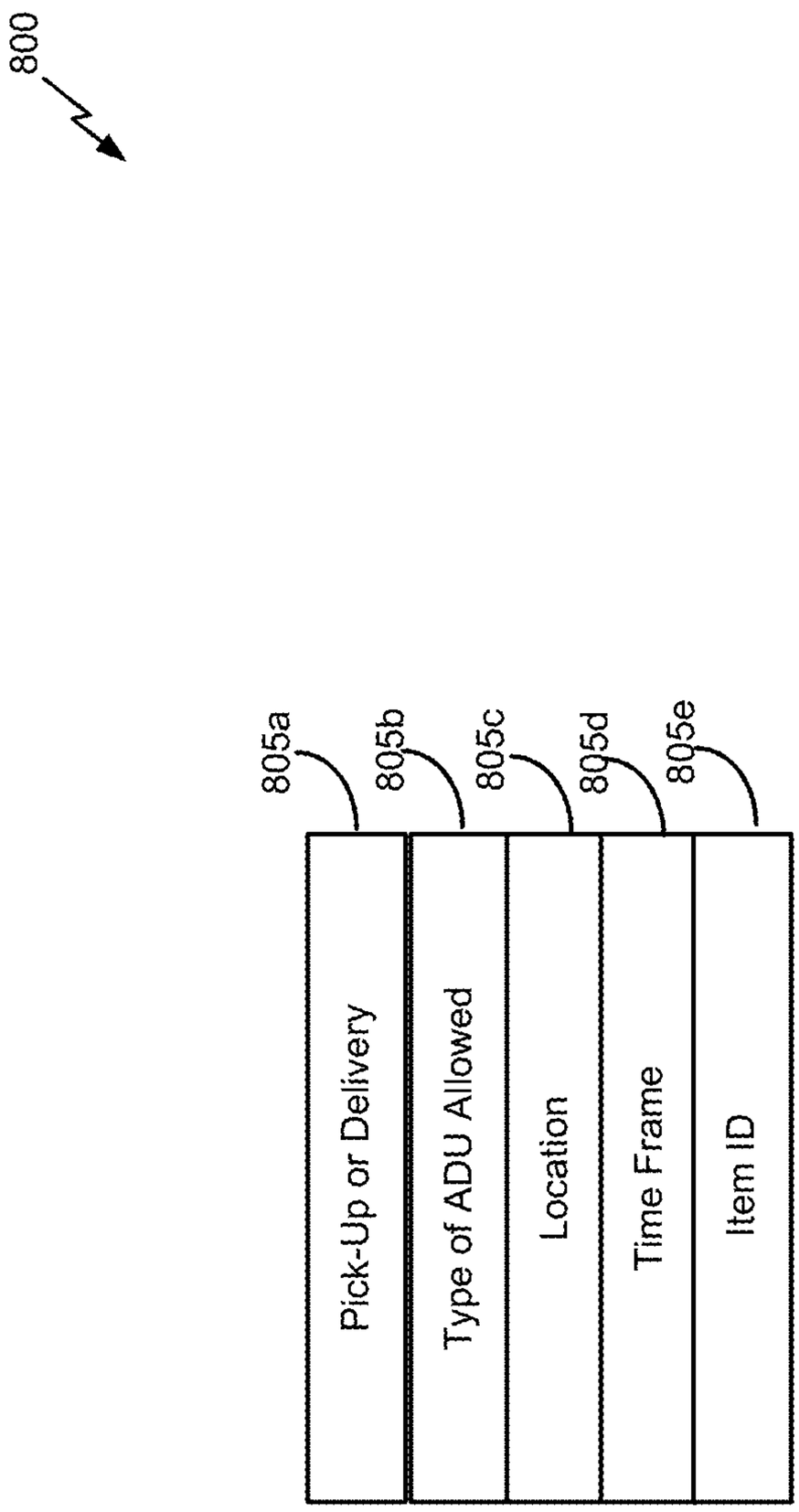

800
805a
805b
805c
805d
805e
Pick-Up or Delivery
Type of ADU Allowed
Location
Time Frame
Item ID

FIG. 8

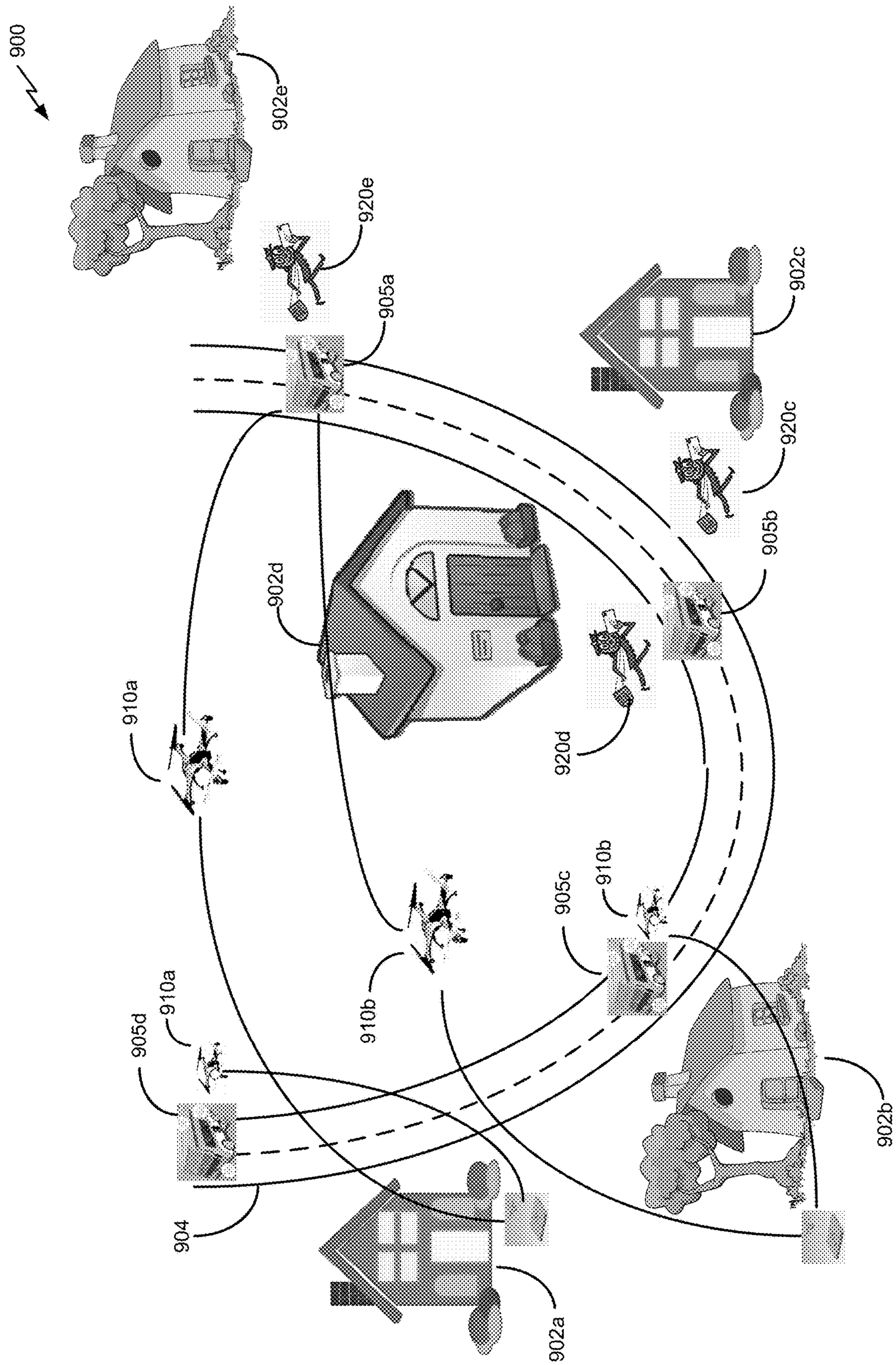

900
902e
920e
905a
902c
920c
905b
902d
910a
920d
910b
905c
905d
904
902a
902b

FIG. 9

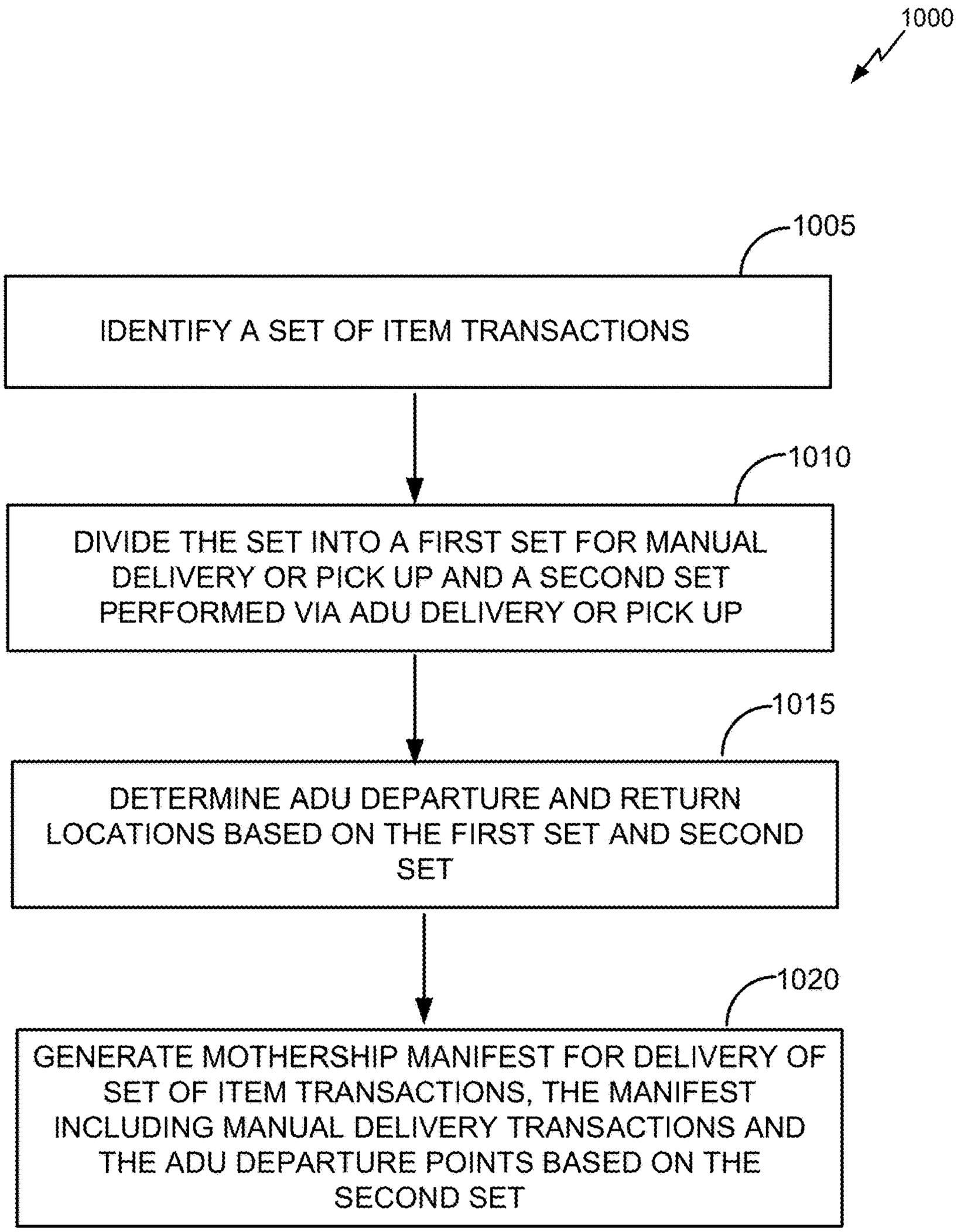

1000
1005
IDENTIFY A SET OF ITEM TRANSACTIONS
1010
DIVIDE THE SET INTO A FIRST SET FOR MANUAL DELIVERY OR PICK UP AND A SECOND SET PERFORMED VIA ADU DELIVERY OR PICK UP
1015
DETERMINE ADU DEPARTURE AND RETURN LOCATIONS BASED ON THE FIRST SET AND SECOND SET
1020
GENERATE MOTHERSHIP MANIFEST FOR DELIVERY OF SET OF ITEM TRANSACTIONS, THE MANIFEST INCLUDING MANUAL DELIVERY TRANSACTIONS AND THE ADU DEPARTURE POINTS BASED ON THE SECOND SET

FIG. 10

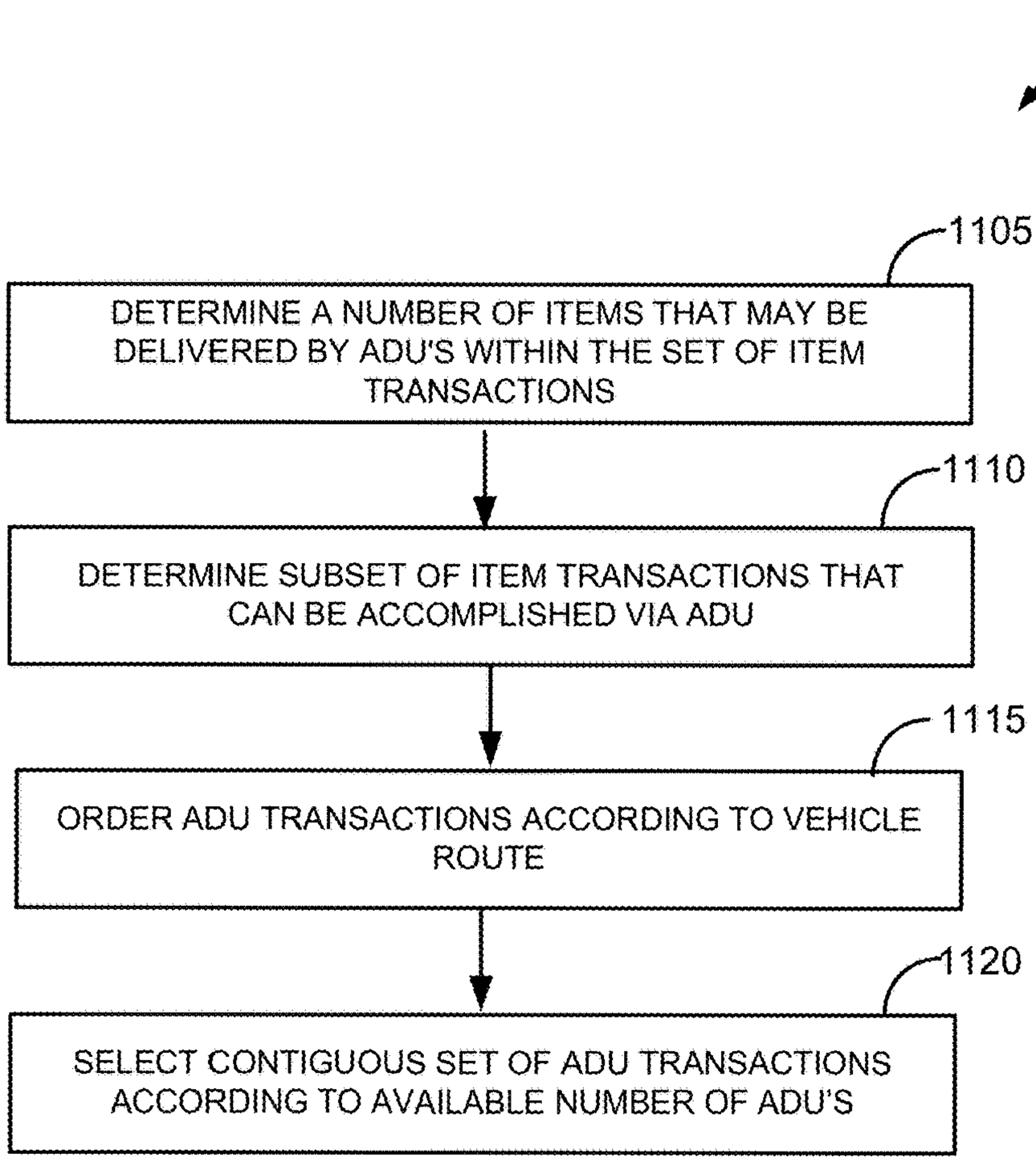

1100
1105
DETERMINE A NUMBER OF ITEMS THAT MAY BE DELIVERED BY ADU'S WITHIN THE SET OF ITEM TRANSACTIONS
1110
DETERMINE SUBSET OF ITEM TRANSACTIONS THAT CAN BE ACCOMPLISHED VIA ADU
1115
ORDER ADU TRANSACTIONS ACCORDING TO VEHICLE ROUTE
1120
SELECT CONTIGUOUS SET OF ADU TRANSACTIONS ACCORDING TO AVAILABLE NUMBER OF ADU'S

FIG. 11

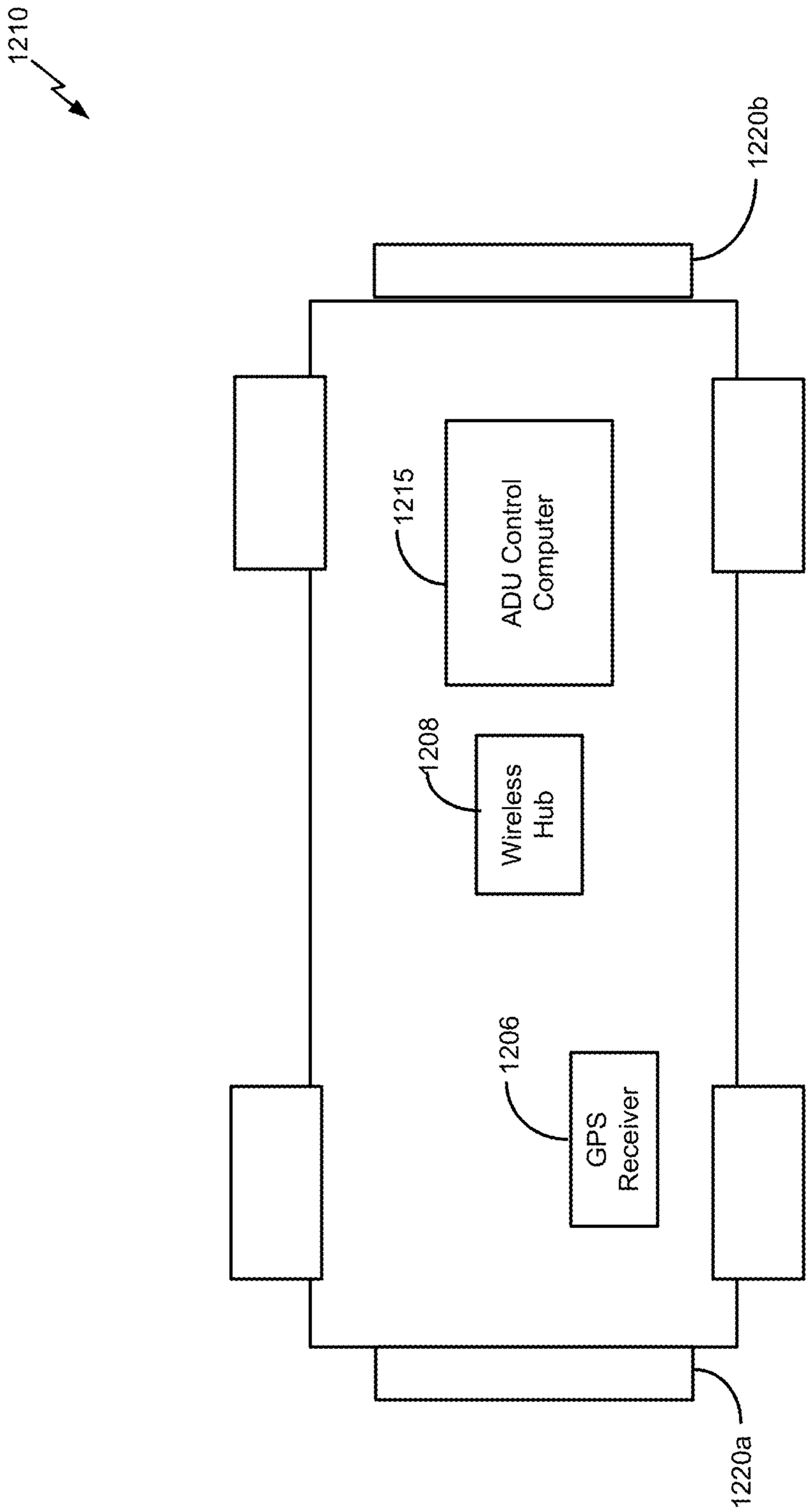

1210
1220b
1215
ADU Control Computer
1208
Wireless Hub
1206
GPS Receiver
1220a

FIG. 12

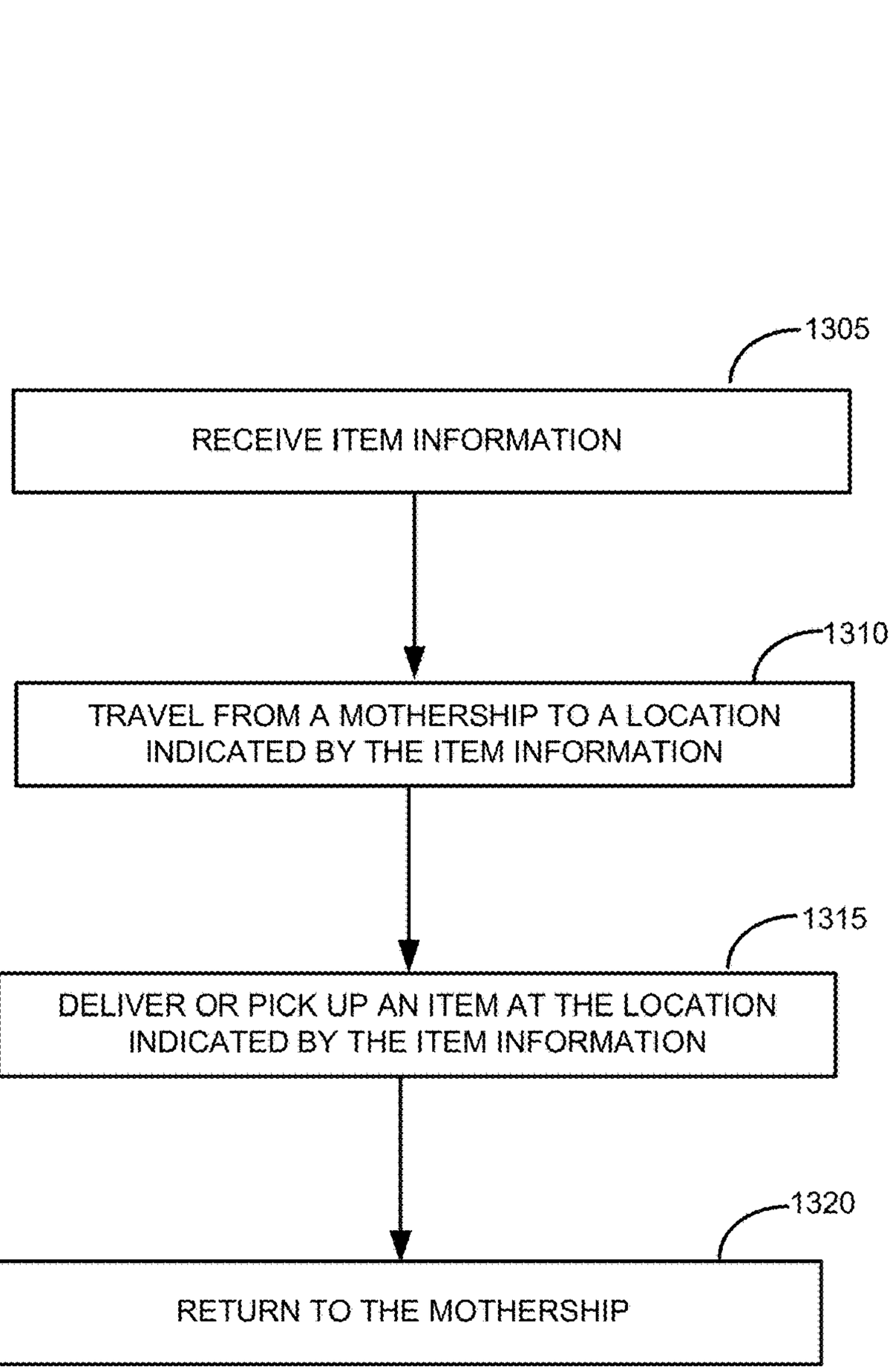

1300
1305
RECEIVE ITEM INFORMATION
1310
TRAVEL FROM A MOTHERSHIP TO A LOCATION INDICATED BY THE ITEM INFORMATION
1315
DELIVER OR PICK UP AN ITEM AT THE LOCATION INDICATED BY THE ITEM INFORMATION
1320
RETURN TO THE MOTHERSHIP

FIG. 13

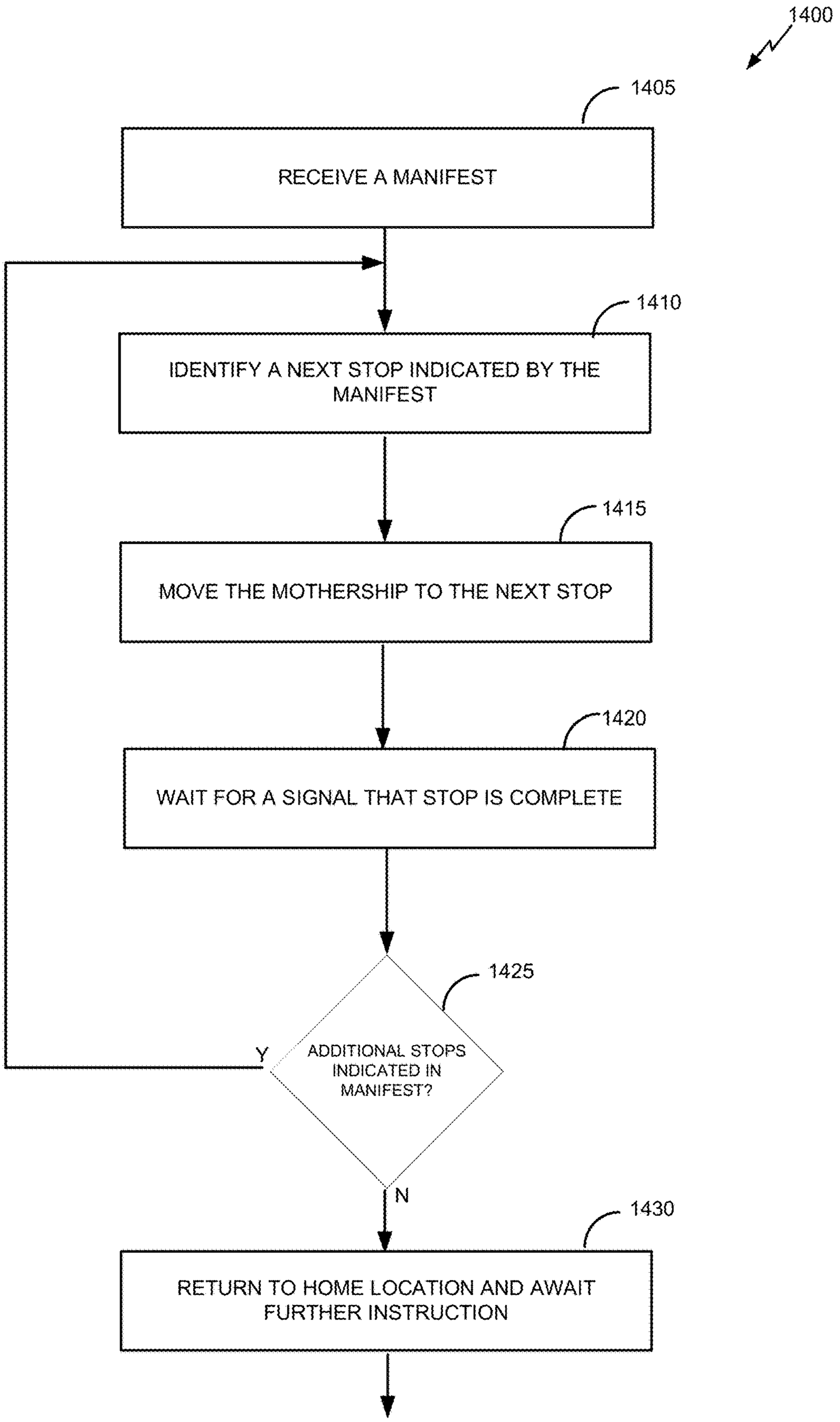

1400
1405
RECEIVE A MANIFEST
1410
IDENTIFY A NEXT STOP INDICATED BY THE MANIFEST
1415
MOVE THE MOTHERSHIP TO THE NEXT STOP
1420
WAIT FOR A SIGNAL THAT STOP IS COMPLETE
1425
ADDITIONAL STOPS INDICATED IN MANIFEST?
Y
N
1430
RETURN TO HOME LOCATION AND AWAIT FURTHER INSTRUCTION

FIG. 14

SYSTEMS FOR AUTONOMOUS ITEM DELIVERY

INCORPORATION BY REFERENCE OF ANY PRIORITY APPLICATIONS

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet as filed with the present application are hereby incorporated by reference under 37 CFR 1.57. This application is a continuation of U.S. application Ser. No. 15/832,245, filed on Dec. 5, 2017, which claims the benefit of U.S. Provisional Application Ser. No. 62/430,304, filed Dec. 5, 2016, entitled "SYSTEMS FOR AUTONOMOUS ITEM DELIVERY" the entirety of which is incorporated by reference herein.

FIELD

[0002] Embodiments relate generally to automated movement and delivery of items that uses unmanned delivery or pick-up transportation devices.

DESCRIPTION OF THE RELATED TECHNOLOGY

[0003] Personnel expenses can be a major source of expense for item distribution networks. Personnel expenses include not only direct salaries of personnel, but also their benefits, such as health insurance, work space costs, pension benefits, and the like.

[0004] The sophistication of computer programs continues to expand, enabling greater and greater capabilities with respect to automating tasks previously performed by human operators. Computer automation provides several advantages over the use of humans to perform similar tasks. When properly configured, computers may perform routine and conventional activities more reliability than humans and at a much reduced cost. In addition, cost trends for computer based automation are favorable, whereas costs for maintaining a workforce based on manual performance of tasks is becoming less and less competitive. Therefore, there is a need to automate additional tasks performed by a distribution network to reduce costs, increase reliability and overall quality.

SUMMARY

[0005] Methods and systems disclosed provide for automation of item delivery and or pick-up via the use of autonomous delivery units (ADUs), and/or a "mothership" that can deliver the ADUs to locations from which the ADUs may perform their delivery and/or pick-up functions. Items transferred and/or delivered by the systems and methods described herein can be various types of items, for example, parcels, packages, crates, boxes, envelopes, flats, cards, or other items transported by a distribution network such as a postal network, a delivery service, or the like.

[0006] The mothership may include a location for storage of one or more ADUs. While stored on the mothership, the ADUs may receive power for recharging their batteries. The ADUs may also interface with a computer on-board the mothership, from which the ADUs may receive instructions for performing one or more item deliveries and/or pick-ups. The mothership may be equipped with a loading ramp, from which the ADUs may exit the mothership and travel to their assigned item pick-up and/or drop off locations. Upon completion of their assignments, the ADUs may return to the mothership. In some aspects, while the ADUs are out performing their assignments, the mothership may continue along an item delivery route, for example, to facilitate delivery of other items via either autonomous or manual means. Thus, in some aspects, the ADUs may return to the mothership by transiting to a location different from the location from which they departed the mothership.

[0007] The disclosed methods and systems may receive a set of item delivery transactions and divide the transactions into those that will be delivered by a human item carrier and those that will be delivered and/or picked-up by an ADU. The ADU transactions may then be ordered, and a contiguous set of ADU transactions within the order may be selected for execution via an ADU. In some aspects, the set of transactions to be executed by an ADU may be based on a number of ADUs available in the mothership.

[0008] In one aspect, a system for autonomous item delivery, comprises a mothership, comprising: a freight bay, configured to store one or more autonomous delivery units (ADUs); a scheduling and control computer, configured to: identify a set of item transactions along an item route, each item transaction comprising a delivery or a pick-up of an item at an item location; divide the set into a first set of manual item transactions and a second set of autonomous item transactions for execution by the one or more ADUs; determine ADU departure and return locations based on the first set and the second set; generate a mothership manifest indicating the transactions in the first and second set; and communicate the item transactions in the second set to the one or more ADUs; and the one or more ADUs, each ADU configured to automatically: receive item information from the mothership; travel from the mothership to a location indicated by the item information; deliver or pick-up an item at the location indicated by the item information; and return to the mothership.

[0009] In some embodiments, the one or more ADUs comprise a GPS receiver.

[0010] In some embodiments, the mothership further comprises a mothership control computer, configured to autonomously control the mothership along the item route.

[0011] In some embodiments, the manifest indicates stop locations for item transactions in the first and second sets, and wherein the mothership control computer is further configured to stop the mothership at the stop locations associated with the first set and second set of item transactions.

[0012] In some embodiments, the mothership further comprises manual driving controls to provide a means for an operator to operate the mothership along the item route.

[0013] In some embodiments, the mothership further comprises a ramp configured to allow ingress and egress by the ADUs to and from the freight bay.

[0014] In some embodiments, the mothership comprises automated loading means for loading an item onto an ADU.

[0015] In some embodiments, one or more of the ADUs comprises item loading means or item drop off means.

[0016] In some embodiments, the item loading means comprises a scoop.

[0017] In some embodiments, at least one of the autonomous delivery vehicles comprises a bed, and wherein the item drop off means comprises a bed lifting means.

[0018] In some embodiments, the mothership further comprises an item storage system located within the freight bay, and a robotic arm configured to retrieve and store items in the item storage system.

[0019] In some embodiments, the mothership further comprises a roof structure substantially enclosing the freight bay, and wherein the roof comprises an access portal to provide ingress and egress of aerial ADUs.

[0020] In some embodiments, the robotic arm is further configured to position an item for pick-up by an ADU via the access portal.

[0021] In some embodiments, the robotic arm is further configured to retrieve an item from an ADU via the access portal and store the item in the item storage system.

[0022] In another aspect, a computer-implemented method for automated transfer of items, the method comprises under control of one or more processors of a mothership, identifying a set of item transactions along an item route, each item transaction comprising a delivery or a pick-up of an item at an item location; dividing the set into a first set of manual item transactions and a second set of autonomous item transactions for execution by one or more autonomous delivery units (ADUs) located within the mothership; determining ADU departure and return locations based on the first set and the second set; generating a mothership manifest indicating the transactions in the first and second set; communicating a first item transaction of the second set to a first ADU of the one or more ADUs; at a first ADU departure location, causing the first ADU to leave the mothership to execute the first item transaction; and at a first ADU return location, causing the mothership to receive the first ADU subsequent to execution of the first item transaction.

[0023] In some embodiments, the first ADU return location is different from the first ADU departure location, and the method further comprises receiving, from the first ADU, a signal indicating that the first item transaction is complete; and sending a signal to the first ADU indicating the first ADU return location.

[0024] In some embodiments, the first item transaction comprises a delivery, and the method further comprises based at least in part on the mothership manifest, causing an automated loading mechanism of the mothership to retrieve a first item from a storage location within the mothership; and causing the automated loading mechanism to load the item onto the first ADU.

[0025] In some embodiments, the first item transaction comprises a pick-up, and the method further comprising, subsequent to the mothership receiving the first ADU causing an automated loading mechanism of the mothership to retrieve a first item from the first ADU; and causing the automated loading mechanism to place the first item into a storage location within the mothership.

[0026] In some embodiments, the first ADU is selected from the one or more ADUs based at least in part on a battery charge status of the first ADU.

[0027] In some embodiments, the method further comprises, subsequent to causing the mothership to receive the first ADU:

[0028] determining that a battery charge level of the first ADU is greater than or equal to a predetermined threshold; communicating a second item transaction of the second set to the first ADU; and at a second ADU departure location, causing the first ADU to leave the mothership to execute the second item transaction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] In the figures, similar components and/or features can have the same reference label. Further, various components of the same type can be distinguished by following the reference label by a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

[0030] FIG. **1** is an overview diagram of an exemplary automated delivery system.

[0031] FIG. **2**A is a perspective view of an exemplary mothership.

[0032] FIG. **2**B is partial cutaway view of an exemplary mothership.

[0033] FIG. **2**C is a perspective view of an exemplary mothership.

[0034] FIG. **3** is a schematic view of an exemplary mothership having ground based ADUs.

[0035] FIG. **4** is a schematic view of an exemplary mothership having flying ADUs.

[0036] FIG. **5** is a schematic view of an exemplary wireless charging system.

[0037] FIG. **6**A is a top view of an exemplary embodiment of an ADU.

[0038] FIG. **6**B is a perspective view of an exemplary ADU.

[0039] FIG. **6**C is a perspective view of an exemplary ADU.

[0040] FIG. **7** is a block diagram of an exemplary mothership.

[0041] FIG. **8** is an exemplary database table showing the format of an item transaction.

[0042] FIG. **9** is an illustration of a mothership on an item delivery and pick-up route employing a combination of ADUs and manual item delivery and pick up to execute a set of item transactions.

[0043] FIG. **10** is a flowchart of a method of scheduling and executing delivery of a set of item transactions.

[0044] FIG. **11** is a flowchart of a method for dividing a set of item transactions into a first manual set of transactions and a second ADU-assisted set of transactions.

[0045] FIG. **12** is a block diagram of an exemplary ADU.

[0046] FIG. **13** is a flowchart of an exemplary method for delivering or picking up an item.

[0047] FIG. **14** is a flowchart of an exemplary method for autonomously controlling a mothership.

DETAILED DESCRIPTION

[0048] In the following description, numerous specific details are set forth to provide a thorough understanding of the present disclosure. However, one having ordinary skill in the art should recognize that the disclosure can be practiced without these specific details. In some instances, circuits, structures, and techniques have not been shown in detail to avoid obscuring the present disclosure.

[0049] FIG. **1** is an overview diagram of an exemplary automated delivery system **100**. The environment shown in FIG. **1** includes several item origins or delivery points **102***a-e* (e.g. in FIG. **1** shown as dwellings) along an item delivery route **104**. A mothership **105** travels along the item delivery route **104**. In some aspects, the mothership **105** may drive to the item delivery route **104** in response to receiving

a request for an item delivery or pick-up. In some aspects, a wireless communication link between the mothership **105** and a pick-up/delivery management system may enable information regarding item delivery and/or pick-up requests to be transmitted to the mothership **105** in real time. In some aspects, the pick-up and/or delivery requests transmitted to the mothership may be selected by the pick-up/delivery management system based on a location of the mothership **105**. For example, the pick-up/delivery management system may select a mothership nearest a requested pick-up/delivery location. Other mothership selection parameters are also contemplated.

[0050] Along the item delivery route **104**, the mothership **105** may deploy one or more autonomous delivery units **110***a-c*. For example, the mothership **105** may come to a stop at a predetermined location along the item delivery route **104** for deployment. In some embodiments, the mothership **105** may stop at the first delivery point and deploy the ADUs **110***a-c* along the delivery route **104**. In some embodiments, the mothership **105** may stop at an intermediate delivery point, such as at delivery point **102***c*, and deploy the ADUs **110***a-c* behind and forward along the delivery route **104**. In some embodiments, the mothership **105** may stop at the end point, for example, at delivery point **102***e*, and deploy the ADUs **110***a-c* back along the delivery route **104**. In another example, one or more autonomous delivery units **110***a-c* may be deployed while the mothership **105** continues moving along the item delivery route **104** so as to reduce or eliminate starting and stopping by the mothership **105** along the item delivery route **104**. The autonomous delivery units **110***a-c* may then drive autonomously from a storage position within the mothership **105**, to a delivery point or pick up point associated with the item origins or delivery points **102***a-e*. Upon either delivering an item or picking up an item at the item origins/destinations **102***a-c*, the autonomous delivery units **110***a-c* may return to the mothership **105** and return to a storage location (not shown) within the mothership **105**.

[0051] While the example of FIG. **1** shows autonomous delivery units that drive over the ground, in some aspects, the autonomous delivery units may fly from the mothership **105** to the item origins/destinations **102***a-e*, as described elsewhere herein. For example, the autonomous delivery units may include wheeled or tracked ground-based vehicles, aircraft such as autonomous helicopters, or a combination of ground-based vehicles and aircraft.

[0052] FIG. **2**A shows an exemplary mothership, with an inset depicting a portion of the internals of the mothership **205**, which is described elsewhere herein The mothership **205** includes an ability to load and unload items to/from an autonomous delivery unit (ADU) **110** while the ADU **110** is positioned outside the mothership **205**. The ADU **110** can be stored in the mothership **205** until they are ready to be used, and can be summoned by the mothership **205** to receive an item **210** as required. The ADU **110** will be described in greater detail elsewhere herein, for example, with reference to FIG. **6**C. The loading and unloading of the ADU **110** may be accomplished in some aspects, via a loading arm **256**. The loading arms **205** may access an item **210**, which is stored internally to the mothership **205**, via an access portal **215**. After the loading arm **205** places the item **210** on the ADU **110**, the ADU may autonomously move to an item destination, such as one of the item origins or delivery points **102***a-e* shown in FIG. **1**. In some aspects, the mothership **205** may include one or more charging bays (not shown) internally.

[0053] The mothership **205** may be capable of either manual control and/or automated control. In some cases, the mothership may be controlled by a human operator, and thus may be equipped with traditional driving controls such as a steering wheel, accelerator, brake pedal, and the like. In some aspects, the mothership **205** may be configured into a separate autonomous mode, where input from the steering wheel, accelerator, and brake are given less than 100% control of the mothership **205**, and control of the mothership **205** is at least partially controlled by an autonomous driving controller (not shown).

[0054] In some aspects, the mothership **205** may be electrically powered, and may not rely on the use of carbon based fuels for propulsion. In other aspects, the mothership **205** may be equipped with a hybrid drivetrain or a traditional internal combustion engine based drive train (gas or diesel for example).

[0055] FIG. **2**B is a partial cutaway view of the mothership **205** with insets depicting the exterior of the mothership **205** and the rear of the mothership **205**. The mothership **205** includes an item storage system **242** that provides for internal storage of items that are to be delivered by the mothership **205** or picked up by the mothership **205**. A first robotic arm **240** is positioned internally to the mothership with access to the item storage system **242**, including a plurality of item storage bins **245**. The first robotic arm **240** can be articulated and include a picking mechanism attached to an end of the first robotic arm **240**. The picking mechanism can pick an item **245** from the item storage system **242**, and place the item **245** on a staging area **246** inside the mothership **205**.

[0056] FIG. **2**B also illustrates the loading arm **256** attached to the mothership **205** but also positioned external to the mothership **205**. The loading arm **256** may be configured to move the item **245** from a position external to the mothership **205** through an access portal **260** in the case of an item pick-up. The access portal **260** may provide access to the conveyer system **253** within the mothership **205**. After the item **245** is deposited on the conveyer system **253** via the access portal **260** by the loading arm **256**, the first robotic arm **240** may store the item **258** in the item storage system **242**. Similarly, the loading arm **256** may be configured to retrieve an item from the conveyer system **253**, or from the staging area **246** and deposit the item outside the mothership **205**, for example, onto an ADU **110**, in the case of delivery. The loading arm **256** may be similar to the robotic arm.

[0057] In some embodiments, the first robotic arm **240** may be configured to dispense items for delivery from the item storage system **242** to the outbound portion **252** of a conveyer system **253**. The first robotic arm **240** may be configured to receive items from pick-up via an inbound portion **254** of the conveyer system **253**, and store the item in the item storage system **242**. The outbound portion **252** can include a storage area within the mothership **205** where ADUs **110** await receipt of an item from the first robotic arm **240**, which can place the item on the ADU **110** while the ADU **110** is inside the mothership **205**. The ADU **110** then departs the mothership **205** via a ramp on the outbound portion **252**. When the ADU **110** has picked up an item, the

ADU returns to the mothership by driving up a ramp extending from the ground to the mothership **205** in the inbound portion **245**.

[0058] In some embodiments, the first robotic arm **240** picks the item **245** from the ADU **110** while the ADU **110** is near the inbound portion **254**, but without the ADU **110** driving into the mothership **205**. In some embodiments, the ADU **110** drives to the inbound portion **254**, and aligns with an inbound access door **254***a*. The ADU uses a conveyor belt on the ADU **110** (not shown) to move the item **245** through the inbound access door **254***a* and onto the conveyor belt **253**. The first robotic arm **240** then picks the item **245** from the conveyor system **253**, and places the item **245** in the item storage system **242**.

[0059] FIG. **2**B also shows an embodiment of an automated retail hotspot **220** that can be integrated into the mothership **205**. This embodiment of the automated retail hotspot **220** is positioned at the rear of the mothership **205**. Other embodiments integrating the automated retail hotspot **220** into a side or front portion of the mothership **205** are also contemplated. The hotspot **220** includes an item drop off slot **222** and an item pick up dispenser **226**. The automated retail hotspot **220** also includes a touch screen display **228**. Via the touch screen display **228**, a user may indicate an item for drop off, and use the drop off slot **222** to deposit the item within the mothership **205**. In some aspects, the first robotic arm **240** may retrieve the deposited item from the drop off slot **222**, based on input received from the touch screen **228**. The first robotic arm **240** may be configured to store the item in the item storage system **242** based on input received from the touch screen **228**. The touch screen display **228** may also be configured to display a user interface soliciting input from a user. The input may identify an item for pick up by the user. Based on input received via the touch screen display, the first robot arm **240** may be configured to retrieve the specified item from the item storage system **242** and dispense the item via the item pick up dispenser **226** to the user.

[0060] FIG. **2**C shows an exemplary mothership. The exemplary mothership **205** of FIG. **2**C is a hovercraft, including a skirt **261**. A person of skill in the art will understand that the mothership **205** configured for aerial ADU **110** use can be a land based vehicle, without departing from the scope of this disclosure. The mothership **205** of FIG. **2**C also includes a plurality of top hatches **262** and is configured for use with aerial ADUs **110**. FIG. **2**C illustrates how an item **264** may be picked-up from or delivered to the mothership **205** via an aerial ADU **110**. The mothership **205** of FIG. **2**C may be equipped with the robotic item delivery system illustrated in FIG. **2**B. For example, the first robotic arm **240** may be configured to retrieve the item **264** from the ADU **110** via a top hatch **262**. The first robotic arm **240** may then store the retrieved item **264** in the item storage system **242**, which may be integrated within the mothership of FIG. **2**C in a similar manner to that shown in FIG. **2**B. The first robotic arm **240** may also be configured to retrieve an item **264** from the item storage system **242**, and position the item **264** at a location in proximity to the top hatch **262**, such that the ADU **110** may pick-up the item **264** for delivery from the location.

[0061] Although the mothership embodiments depicted in FIGS. **2**A-**2**C individually include a variety of components and functions, a mothership can include any combination or subset of the components and functionalities described above with reference to FIGS. **2**A-**2**C without departing from the scope of the present disclosure.

[0062] FIG. **3** is a schematic view of an exemplary mothership. The mothership **305** includes a cab **308** and a freight bay **309**. The freight bay **309** may be configured to provide storage locations for one or more ADUs **310**. The mothership **105** may also include a deployable ramp **315**. The deployable ramp **315** may be configured to allow one or more of the ADUs **310** to exit the mothership **305**. The deployable ramp **315** may be deployed via a push of a button positioned within the cab **305** or other control input by an operator in the cab **305**, or automatically. This may allow an operator of the mothership **305** to deploy the ADUs **310** without exiting the cab **308**, and in some aspects, without leaving a driving seat positioned within the cab **308**.

[0063] In some aspects, the mothership **105** may also be equipped with power units **320**, such as wireless power units. The power units **320** may be configured to recharge batteries in one or more of the ADUs **310** stored in the freight bay **309**. The mothership **305** may also include one or more pick up boxes **325** in the freight bay **309**. The pick-up boxes **325** may be utilized for storage of items until the items are loaded onto one of the ADUs **310**.

[0064] The mothership **305** may also include one or more drop-off boxes **330** in the freight bay **309** where items to be delivered are stored. In some embodiments, the drop-off boxes **330** and pick-up boxes **325** can be storage areas within the freight bay **309**. The mothership **305** may be dispatched to a location within a range of an ADU **310** to a delivery point. The item may then be loaded from the drop off box **330** to one of the ADUs **310**. This loading operation may be performed manually by a human operator, or in some aspects, the mothership **105** may be equipped with automated loading apparatus to move the item from the drop off box **330** to the ADU **310** without human assistance, similar to that described with reference to FIGS. **2**A-**2**C. For example, the mothership **305** of FIG. **3** may be equipped with a robotic arm **240** and item storage system **245**, and optionally a conveyer system **253** as described above with respect to FIG. **2**B in some aspects. The loaded ADU **310** may then exit the mothership **305** via the loading ramp **315**, and transit to the delivery point. After delivery of the item, the ADU **110** may return to the mothership **105**, and re-enter the freight bay **309** via the loading ramp **315**. The ADU **110** may be configured to then autonomously place itself in a storage position within the freight bay **309**, and may enable power recharging, such as wireless charging, via the power unit(s) **320**.

[0065] The drop off boxes **330** may also provide a storage location for items available for a "drop off on demand" service. For example, a customer may place an order for an item after the mothership **305** has left a logistics center and is already loaded. However, the mothership **305** may be preloaded with high demand items, such as newly released electronics items, or other popular or high volume items, in one or more of the drop off boxes **330**. Upon receipt of the order in real-time, the mothership may be pre-configured, due to the item being preloaded on the mothership **305**, to fulfill the order without returning to a logistics center to obtain the item. Instead, the mothership **305** may be dispatched directly to a location in proximity to a delivery location specified in the received order.

[0066] FIG. **4** is a view of an exemplary mothership. The mothership of FIG. **4** shares some features of the mothership

of FIG. **3**. In particular, the mothership of FIG. **4** includes a cab **408**, a freight bay **409**, a loading ramp **415**, power units **420**, and pick-up and drop-off boxes **425** and **430**. In some aspects, these features may provide similar functions as those described with respect to their respective counterparts described above with respect to FIG. **3**. In contrast to the mothership of FIG. **3**, the mothership of FIG. **4** includes automated delivery units (ADUs) **410** that are capable of airborne flight. Thus, whereas the ground based ADUs **310** of FIG. **3** must transit from the mothership **305** to a delivery or pick-up location via the ground, the ADUs **410** of FIG. **4** may fly from the mothership **405** to the delivery or pick-up location. In some aspects, the mothership **405** may include an opening to allow egress and ingress of the ADUs **410** via openings (not shown) in the top of the mothership **405**. In some embodiments, the openings may be positioned in proximity to the loading ramp **415**. In some aspects, the opening may be in a top or roof of the mothership **405**. In some aspects, the freight bay **409** does not include a roof and, in some aspects, does not include sides, or the sides are of a height less than three feet. By exposing the freight bay **409** to the open air, the mothership **405** provides for easier ingress and egress of the ADUs **410**. The ADUs **410** may be configured in some aspects to recognize the configuration of the mothership **405**, and to alter their approach course to the mothership **405** based on its configuration. For example, if an embodiment of a mothership includes an opening on one side of the mothership **405**, the aerial ADUs **410** may be configured to approach the mothership **405** from that side. If the mothership **405** includes a freight bay that does not have a roof, the ADUs **410** may be configured to approach the mothership **405** from more than one side, for example, from any position 360 degrees around the mothership. For example, the ADUs **410** approach to the mothership **405** may be based on a direction of travel of the ADU **410** from its drop-off or pick-up location to the mothership **405**.

[0067] In aspects utilizing a mothership without a substantial roof structure or wind shielding structure for the freight bay **409**, the ADUs **410** may be secured to the freight bay **409** via a hard coupling device, such as one or more chains, latches, ropes, or other hard coupling device, so as to prevent the displacement of the ADUs **410** from their respective storage locations within the freight bay **409** during high speed travel of the mothership.

[0068] FIG. **5** is an exemplary wireless charging system which may be, for example, the charging systems **320**, **420** depicted in FIGS. **3** and **4**. The wireless charging system **500** is configured to charge an ADU **510**, and includes an active proxy **505** and a wireless power emitter **515**. While the ADU **510** depicted in FIG. **5** is an aerial ADU, in some other aspects, the ADU **510** may be ground based. For example, the ADU **510** may be equipped with tires, treads, or tracks for transport over the ground. The ADU **510** may be configured to use an internal sensor to locate the active proxy **505** via a signal emitted by the active proxy **505**. For example, in some aspects, the active proxy **505** may be configured to emit an RFID signal that the ADU **510** receives, and uses to locate a position of the active proxy **505**. In some aspects, the ADU **110** may be in communication with a database of active proxy locations, and may determine an active proxy within a proximity of a current location of the ADU **510**, or within a range reachable by the ADU **510** at the ADUs **510** state of charge. The ADU **510** may then autonomously fly to a location of one of the active proxies **505** indicated in the database. In some aspects, the accuracy of the location information in the database, and/or the accuracy of the ADU's **510** ability to determine its own location, may limit the ability of the ADU **510** to identify an exact location of the active proxy **505**, for example, so that the ADU **510** may physically land on top of the active proxy **505** in some aspects. Alternatively, the accuracy limitations discussed above may prevent the ADU **510** from reliability positioning itself within a near enough proximity to one or more of the active proxy **505** and/or the wireless emitter **510**, such that the ADU **510** may efficiently receive a charging signal from the wireless emitter **515**.

[0069] The ADU **510** may communicate to the active proxy that it needs power and the ADU **510** may then enter a low power mode so as to configure itself to accept power. The active proxy **505** may then transmit a signal to the wireless power emitter **515** to command the wireless power emitter to emit power and thus recharge the ADU **510**.

[0070] The ADU **510** may be configured such that when its charging level reaches a threshold, e.g. 80% or 100%, the ADU **510** sends a signal to the active proxy **505** that charging is complete. The active proxy **505** may then, in response to the signal from the ADU **510**, send a separate signal to the wireless power emitter **515** to stop emitting a charging signal.

[0071] FIG. **6**A is an exemplary embodiment of an ADU **610**. The ADU **610** of FIG. **6**A is a point to point autonomous, ground-based vehicle, capable of traveling over land. As such, the ADU **510** of FIG. **6**A may include tires **602** and an electric motor (not shown) coupled, in some cases via gears, to one or more of the tires **602**.

[0072] The ADU **610** of FIG. **6**A may also include an item loading apparatus **612**. In some aspects, the item loading apparatus **612** may be configured as a scoop that is positionable so as to enable the ADU **610** to lift an item from a ground location to a storage position **614** for transport by the ADU **110**. In some aspects, the storage position is the scoop itself.

[0073] The ADU **610** of FIG. **6**A may also include an item storage area or bed **610**. The item storage area or bed **614** may be substantially flat in the horizontal dimension and be sized to accommodate items of particular dimensions. In some aspects, the bed **614** may be raised or lowered relative to the ADU **610** to facilitate loading or unloading of items. For example, in some aspects, the bed **614** may function in a manner similar to a dump truck, in that one end of the bed may be liftable to cause an item positioned on the bed to slide off the bed during an unloading operation.

[0074] The ADU **610** is capable of autonomous driving, and configured to perform item delivery and/or item drop-off after being provided with item origin/destination information. In some aspects, the ADU **610** may be equipped with a wireless network connection that allows it to receive commands from a mothership **505** (see FIG. **6**B). For example, either before or after reaching a location proximate to a particular item drop-off or pick-up location, the ADU **610** may be loaded with one or more items. The loading may be accomplished via a human operator or an automated loading apparatus within the mothership **505**, or in some aspects, via the systems described above with respect to FIG. **2**. The mothership **505** may send one or more commands to the ADU **610**, the one or more commands indicating an item drop-off or pick-up location, and details of the item operation, such as whether an item is to be dropped at

the location or picked-up at the location. In some aspects, the ADU **610** may be configured to deliver more than one item in one trip. For example, the mothership **505** may load the ADU **610** with one or more items, and send one or more commands, for example, via a wireless network, to the ADU **610** indicating two or more separate item origin/delivery points, and whether each of the two or more separate item origins or delivery points locations are for an item drop off or pickup. The ADU **610** may then be configured to autonomously carry out the item drop off(s) and/or pick-up operations indicated by the mothership's commands.

[0075] FIG. **6**B is a perspective view of an exemplary ADU. The ADU **610** of FIG. **6**B includes a rear door **620**, shown in both a closed position **620***a* and an open position **620***b*. The ADU **610** may also include loading arms **625***a-b*. The loading arms **625***a-b* may operate so as to load an item into an internal storage bay **630** within the ADU **610**. In the open position **620***b*, a ramp **622** can be deployed.

[0076] FIG. **6**C is a perspective view of an exemplary ADU. The ADU **610** of FIG. **6**C may provide for delivery and/or pick up of items over more rugged terrain than some other embodiments of the ADU **610**. This more robust delivery and pick-up capability is provided, at least in part, by the asymmetric tracked wheels **640***a-b*. The ADU **610** may secure an item **645** to the top of the ADU **610** via hooks **650**.

[0077] In some aspects, the ADU **610** of FIG. **6**C includes a waterproof seal to protect internal components from the weather. The ADU **610** of FIG. **6**C utilizes the hooks **650** in concert with an item casing configured to be secured by the hooks **650**.

[0078] The ADU **610** is configured to operate in an autonomous manner. The ADU **610** can include ultrasound sensors (not shown). One ultrasound sensor may be positioned at a location closer to the bottom of a frame of the ADU **610** while a second ultrasound sensor may be positioned at a location further from the bottom of the frame than the first ultrasound sensor. The different positions of the ultrasound sensor allows the ADU **610** to detect differences in distance between the two sensors, and as a result of the detection, determine that the ADU may need to deploy arms (not shown) or other maneuvering structures in order to rotate to a 90 degree angle relative to the floor.

[0079] Upon touching a stair, a pressure sensor in the ADU **610** (not shown) may provide a signal indicating the ADU **610** should elevate itself so as to make contact with the stair. The ADU **610** then moves up the steps using the angle of the stairs. The ADU may also be equipped with sensors to detect a passive proximity sensor. Upon receiving a signal from the proximity sensor, the ADU **610** may disengage the hooks from the item **645**. In some aspects, the hooks **650** may act to push the item **645** off the ADU **610**. The ADU **610** may then return to the mothership **205**. The ADU **610** may also include lights **655***a-b*.

[0080] FIG. **7** is an exemplary block diagram of a mothership **705**. The mothership **705** of FIG. **7** includes a freight bay **709** including two ADUs **710***a-b*. The mothership **705** also includes a scheduling and control computer **755**, wireless hub **760**, mothership control computer **765**, a manifest display **770**, and a memory **775**.

[0081] In some aspects, the scheduling and control computer **755** is configured to facilitate scheduling and dispatching of the ADUs **710***a-b* to item delivery and/or pick-up in order to execute one or more item transactions. The scheduling and control computer **755** may communicate with the ADUs **710***a-b* via the wireless hub **760**. The scheduling and control computer **755** may be configured to display a manifest on the manifest display **770**. The scheduling and control computer may communicate with the mothership control computer **765** in some aspects. For example, the scheduling and control computer **755** may indicate to the mothership control computer **765**, one or more stop locations to facilitate pick-up and/or delivery of items as indicated by one or more item transactions. The mothership control computer **765** may be configured to autonomously move the mothership **705** according to the indicated stop locations along an item pick-up/delivery route.

[0082] The memory **775** can store item and manifest information, including delivery point information for delivery points along a route, or to which item son the mothership **705** are to be delivered; information regarding which items are located on the mothership **705** which are to be delivered and their location within the mothership **705** and the associated delivery points. The memory **775** can also store item information regarding items which have been picked up, including manifest information for these items, including origin, intended destination, item characteristics, etc. The scheduling and control computer **755** and the mothership control computer **765** can be in communication with the memory **775** in order to plan routes, load ADUs **710** and dispatch ADUs **710** to the proper delivery points.

[0083] In some aspects, one or more of the scheduling and control computer **755** and/or the mothership control computer **765** may be configured to perform one or more of the functions attributed to it as described herein via instructions that are stored in the memory **775**.

[0084] FIG. **8** is an exemplary database table showing the format of an item transaction. The item transaction **800** may include a pick-up or delivery indication **805**, a type of ADU allowed indication **805***b*, a location **805***c*, and a timeframe **805***d*. The pick-up or delivery indication may indicate whether the transaction is to deliver an item to an address or to pick-up an item from the address, or must be performed by a human postal carrier. The type indication **805***b* indicates the type of ADU allowed to perform the delivery and/or pickup. For example, the type indication **805***b*, via a series of predetermined values, may indicate one of 1) the transaction must be performed by a human operator, no ADU is allowed for this transaction, 2) only a ground based ADU may be utilized, 3) a ground or flying ADU may be utilized, or 4) only a flying ADU may be utilized.

[0085] The location **805***c* may indicate the location for the item transaction **800**. In some aspects, the location **805***c* may indicate one or more of an item address, and geographic coordinates.

[0086] The time frame **805***d* indicates a time period in which the item transaction should be performed. The item identification **805***e* may indicate an identification number for the item of the transaction. In some aspects, the item identification **805** may be indicated via a barcode affixed to the item. The barcode on the item may be utilized by, for example, ADUs to identify the item for pick-up. In some aspects, the barcode may be utilized within the mothership **105** to load the appropriate item on an ADU for delivery, or to provide the item to a human item carrier for delivery.

[0087] FIG. **9** is an depiction of a mothership on an item delivery and pick-up route employing a combination of ADUs and manual item delivery and pick up to execute a set

of item transactions. The system **900** shows a delivery route **904** for a set of item transactions for delivery and/or pick-up at the delivery points **902***a-e*. The mothership **905** begins the route at positon **905***a*. Positon **905***a* may be indicated in the manifest generated by block **1020** of FIG. **10**, which will be described elsewhere herein.

[0088] In some aspects, the manifest may be a human readable display, either in paper form or on an electronic display. In these aspects, the manifest may assist a human operator of the mothership **905** to position the mothership **905** at positions indicated by the manifest. In some other aspects, the manifest may be in a computer readable form. In these aspects, the manifest may be provided as input to the mothership control computer **765** of FIG. **7**. The mothership control computer **765** may then autonomously steer the mothership **105** to various locations indicated by the manifest.

[0089] At position **905***a*, in some aspects, a human operator of the mothership **905** may load two ADUs **910***a* and **910***b* with items destined for delivery points **902***a* and **902***b*, which can be farther along the route than the delivery points nearer position **905***a*. In other aspects, the two ADUs **910***a-b* may be loaded via automated means, such as illustrated in FIGS. **2**A-**2**C. The ADUs **910***a-b* may then depart from the mothership **905** and position **905***a* for their item intended delivery points, **102***a* and *b*, respectively. The position **905***a* is also a stopping point for manual delivery and/or pick-up of items **920***e* at delivery point **902***e*. Thus, delivery point **902***e* may be included in the first set of item transactions determined in block **1010** of FIG. **10**, as will be described below.

[0090] After the manual delivery and/or pick up of items **920***e* at dwelling **902***e* is completed, and the ADUs **910***a-b* have departed the location **910***a*, the mothership **905** may move, either by human operator or autonomously, to position **905***b*. Position **905***b* may be indicated in the manifest generated in block **1020** of FIG. **10**. Position **905***b* may facilitate manual pick-up and/or delivery **920***c* of one or more items at the delivery point **102***c*. After the manual delivery and/or pick-up of items **920***c* at delivery point **102***c* is completed, the mothership **905** may move, either autonomously or under control of a human operator, to position **905***c*. Position **905***c* may also be indicated in the manifest produced by block **1020** of FIG. **10**. Position **905***c* may be a pick-up location for the ADU **910***b*, after it makes a delivery and/or picks up an item at delivery point **902***b*. After the ADU **910***b* and in some aspects, its item, have been recovered in the mothership at position **905***c*, the mothership **905** moves to position **905905***d*, which may also be indicated in the manifest generated by block **1020** of FIG. **10**. At position **905***d*, the ADU **910***a*, and any items it may have picked-up at dwelling **902***a*, is recovered and returned to a storage location inside the freight bay of the mothership **905**.

[0091] Employing a system of ADUs **910** and human carriers can improve the efficiency of completing a delivery route by enabling ADUs **910** to deliver to points along the route that would be more costly or time consuming for a human carrier to reach. In some embodiments, the human carrier can deliver items which are too heavy or bulky for an ADU **910**, and the ADUs **910** can deliver items which are smaller or lighter. In some embodiments, although FIG. **9** depicts human carriers, the ADUs **910** and the mothership **905** can complete a delivery route in a similar manner to that shown and described in FIG. **9** without human carriers.

[0092] FIG. **10** is a flowchart of one method of scheduling and executing delivery of a set of item transactions. In some aspects, process **1000** discussed with respect to FIG. **8** may be performed by the scheduling and control computer **755**, discussed above with respect to FIG. **7**.

[0093] In block **1005**, a set of item transactions is identified. In some aspects, each transaction in the set of item transactions may include the item transaction record **800** of FIG. **8**. In some aspects, the set of item transactions may be identified based on a location of a mothership and origins and/or delivery points for items associated with the set of item transactions. For example, in some aspects, the set of item transactions may be transactions with an origin/destination location within a threshold distance of the mothership location, or a scheduled mothership location.

[0094] In block **1010**, the set of item transactions is divided into a first set of item transactions to be performed via manual or human delivery and/or pick-up methods, and a second set of item transactions to be performed by ADU delivery or pick-up.

[0095] In block **1015**, ADU departure and return locations are determined. These may be determined based on the first set and second set of item transactions. In some aspects, block **1015** may determine a first set of mothership stop locations that facilitate completion of the set of manual pick-up and delivery locations. In some aspects, the mothership stop locations may be determined so as to optimize a walkable distance between the transactions in the first set. For example, in aspects where the mothership is driven by a human operator, as the number of stops increases, the amount of time necessary for the human operator to return to the driving controls and move the mothership increases. Furthermore, as the number of stops increases, the amount of time necessary for the human operator to execute the first set of item transactions may decrease, when the time required to drive the mothership is not considered. Furthermore, the position of the stops of the mothership for delivery or pick up of the first set of transactions may seek to provide for reduced time for the human operator to walk to the item origin/destination locations specified in the item transactions of the first set.

[0096] Once the stop locations for the first set of item transactions is identified, block **1015** may determine a second set of stops for the second set of item transactions based on a number of parameters. The second set of stops may be based on the first set of stops. For example, it may provide for time savings if a stop for the first set of item transactions is also utilized as a stop for an ADU departure to execute at least one of the item transactions in the second set of item transactions.

[0097] The second set of stop locations is also based on the item transactions in the second set. As was the case with determining stops for the first set of item transactions, as the number of stops increases for the second set of item transactions, travel distance for each ADU performing a transaction may be decreased.

[0098] The second set of stop locations may be further based on a range of one or more ADUs included in the mothership. The range of each ADU may depend on the ADU model, battery capacity, battery charge state, weight of item to be delivered by the ADU, and the type of ground expected between the stop location of the mothership and the item origin/destination specified in the item transaction.

For example, traveling over concrete or asphalt may provide for longer range than traveling over a dirt or grass surface for example.

[0099] In block **1020**, a manifest is generated for delivery of the set of item transactions, including items in the first and second sets. Portions of the manifest may be displayed on the manifest display **720**, discussed above with respect to FIG. **7**. For example, the portions of the manifest relating to the first set of item transactions may be displayed, to provide guidance to the human operator as to which items should be manually delivered and where. The manifest may also provide indications of the stop locations discussed above, including stop locations to facilitate delivery/pick up of items in the first set of transactions, and also in some aspects to facilitate drop-off or pick-up of ADUs to facilitate execution of item transactions in the second set. In aspects that rely on the human operator to manually drive the mothership to each stop position. The manifest may also provide indications that allow the human operator to manually load one or more of the ADUs with their appropriate items as indicated by the second set of item transactions.

[0100] FIG. **11** is a flowchart depicting a process **1100** for dividing a set of item transactions into a first manual set of transactions and a second ADM assisted set of transactions.

[0101] In block **1105** a number of ADUs available for delivery is determined. In some aspects, this information may be entered into the scheduling and control computer via a human interface such as a keyboard and/or mouse. In some aspects, the scheduling and control computer **755** may automatically sense the number of ADUs available. For example, ADUs in the freight bay **760** for example may periodically transmit a wireless signal allowing their presence in the freight bay to be detected. In some aspects, this wireless signal (or another) may further indicate the ADU's battery charge level and/or model number, and/or an indication of the ADU's range. These wireless signals transmitted by the ADUs in the freight bay **760** may be received by the wireless hub **760** and forwarded to the scheduling and control computer **755**. The scheduling and control computer **755** may then utilize the signals to determine the number of ADUs available for delivery.

[0102] In block **1110**, a subset of item transactions that can be performed by an ADU is determined. In some aspect, block **1110** receives an input the set of item transactions from block **1005** of FIG. **10**. In some aspects, each item transaction may include one or more characteristics associated with the item origin/destination associated with the transactions. In some aspects, the characteristics may indicate whether an ADU may provide delivery/pick-up services at that location. For example, some customers of the distribution network may prefer not to have ADUs perform pick-ups and/or deliveries at their locations, and this may be indicated by the item transaction.

[0103] In some aspects, each item transaction record may indicate one or more characteristics of the item origin/destination location. For example, these characteristics may include a number of steps that must be climbed or descended to reach the origin/destination, whether the origin/destination is wheel chair accessible, whether reaching the origin/destination requires manually or automatically opening of a gate, or other characteristics. In some aspects, block **1110** may determine whether the item transaction can be accomplished via an ADU based on one or more of these characteristics.

[0104] In block **1115**, the ADU capable transactions determined in block **1110** are ordered according to a mothership route of delivery for the set of item transactions of block **1005** of FIG. **10**. For example, the ADU capable transactions may be ordered according to a distance from the start of the route. Alternatively, they may be ordered according to a distance from the end of the route.

[0105] In block **1120**, a contiguous set of ADU transactions from the ordered transactions of block **1115** is selected. In some aspects, the contiguous set of ADU transactions is selected from the portion of the ordered transactions that are closest to the start of the mothership route. In some aspects, the contiguous set of ADU transactions is selected from the portion of the ordered transactions furthest from the start of the mothership route. In some aspects, the contiguous set of ADU transactions is selected from the middle of the ordered list of transactions. The selected set of contiguous ADU transactions is placed in the second set of transactions. The other item transactions from block **1005** of FIG. **10** are included in the first set of transactions, and will be executed via a manual delivery process in some aspects.

[0106] FIG. **12** is a block diagram of an exemplary autonomous delivery unit. The autonomous delivery unit **1210** of FIG. **12** includes a GPS receiver **1206**, a wireless hub **1208**, and an ADU control computer **1215**. The ADU **1210** also include proximity sensors **1220***a* and **1220***b*, positioned at the front and rear of the ADU **1210** respectively.

[0107] The ADU control computer **1215** may be configured to autonomously deliver and/or pick-up one or more items from an item location, for example, as indicated in the location field **805***c* discussed above with respect to FIG. **8**. The ADU control computer **1215** may receive input from one or more of the GPS receiver **1205** and/or the proximity sensor **1220***a-b*.

[0108] The ADU control computer **1215** may communicate with the scheduling and control computer **755** of FIG. **7**A in some aspects. For example, the scheduling and control computer **755** may transmit information to the ADU control computer **1215** regarding a particular item transaction, such as the item transaction **800** shown above in FIG. **8**. The ADU control computer **1215** may receive location information for delivery or pick up of an item. The ADU control computer **1215** may then control the ADU **1210** to travel to the location indicated in the item transaction record **800** to deliver or pick up an item. The ADU control computer **1215** may then cause the ADU **1200** to return to the mothership.

[0109] FIG. **13** is a flowchart of an exemplary process for delivering or picking up an item. In some aspects, the process **1300** discussed with respect to FIG. **13** may be performed by the ADU control computer **1315**, discussed above with respect to FIG. **12**.

[0110] In block **1305**, item information is received. In some aspects, the item information received in block **1305** may include one or more portions of the item transaction record **800**, discussed above with respect to FIG. **8**. In some aspects, the item information may be received from the scheduling and control computer **755** by the ADU control computer **1215**, for example, via the wireless hubs **760** and **1210**.

[0111] In block **1310**, the ADU travels from a mothership to a location indicated by the item information. In some aspects, block **1310** may be performed by the ADU control computer **1315**. For example, the ADU control computer **1315** may receive input from the GPS receiver indicating its

current position. The ADU control computer **1315** may then command the ADU **110** to travel a route between the current position and the location indicated in the item information received in block **1305**.

[0112] In block **1315**, the item is delivered or picked up from the location. In some aspects, the item may be delivered by activation of a bed tilting mechanism that causes the item to slide from a position on top of the ADU into an item delivery location. In some aspects, an item pick up may be accomplished by the item loading apparatus **612**, discussed above with respect to FIG. **6**.

[0113] In block **1320**, the ADU returns to the mothership. In some aspects, block **1320** includes the ADU control computer **1315** receiving GPS location information from the GPS receiver **1205**, and navigating the ADU back to a mothership location. In some aspects, the mothership location may be the same location from which the ADU departed the mothership in block **1310**. In some aspects, the location may be different. For example, in some aspects, the ADU may receive second location information indicating a location for rendezvous with the mothership. Block **1320** may include navigating the ADU to that location if provided.

[0114] FIG. **14** is a flowchart of a process **1400** for autonomously controlling a mothership. In some aspects, the process **1300** discussed with respect to FIG. **13** may be performed by the mothership control computer **765**.

[0115] In block **1405**, a manifest is received. In some aspects, the manifest may be received from the scheduling and control computer **755**, discussed above with respect to FIG. **7**. The manifest may indicate a first and second set of item transactions, with the first set to be performed manually, or via a human item carrier, and a second set to be performed by an ADU. The manifest may also include a number of stops associated with the set of item transactions. The indicated stops may facilitate execution of the item transactions, by placing the mothership within a certain proximity of a location associated with each of the item transactions.

[0116] In block **1410** a next stop indicated by the manifest is identified. In some aspects, the item transactions within the manifest may have a particular order corresponding to an order in which the item transactions should be executed. The next stop may correspond to a first stop the first time block **1410** is executed, a second stop the second time block **1410** is executed, and so on.

[0117] In block **1415**, the mothership is moved to the next stop identified in block **1410**. In some aspects, moving the mothership may include autonomously moving the mothership under the control of the mothership control computer **765**. In other aspects, moving the mothership may include displaying instructions on a display viewable by a human operator of the mothership. For example, block **1415** may include displaying indications of the next stop to the operator of the mothership via an electronic display. The human operator may then manually move, via traditional controls such as a steering wheel and/or brake and accelerator pedal, to the new location. Block **1420** waits for a signal that the stop is complete. For example, in some aspects, the manifest may indicate one or more item transactions are to be executed at a particular stop. In some aspects, the item transactions to be executed at a particular stop are manual. Thus, block **1420** may wait for a human operator to signal that the stop is complete (for example, after the human operator executes all of the manual item deliveries and/or pickups at this particular stop).

[0118] After the stop is completed, process **1400** moves to decision block **1425**, where it is determined whether there are additional stops indicated in the manifest. If there are additional stops, process **1400** moves from decision block **1425** to block **1410**, where the next stop is identified and processing continues. If there are no additional stops, in some aspects, process **1400** moves to block **1430**. In block **1430**, the ADU may return to a home location and await further instruction. After block **1430** is completed, processing continues. Block **1430** may not be implemented in some aspects.

[0119] The methods disclosed herein include one or more actions for achieving the described method. The method and/or actions can be interchanged with one another without departing from the scope of the claims. In other words, unless a specific order of actions is specified, the order and/or use of specific actions can be modified without departing from the scope of the claims.

[0120] The functions described can be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions can be stored as one or more instructions on a tangible computer-readable medium. A storage medium can be any available tangible medium that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can include RAM, ROM, EEPROM, CD-ROM, or other optical disk storage, magnetic disk storage, or other magnetic storage devices, or any other tangible medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Disk and disc, as used herein, include compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk, and Blu-ray® disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers.

[0121] A computer program product can perform certain operations presented herein. For example, such a computer program product can be a computer readable tangible medium having instructions tangibly stored (and/or encoded) thereon, the instructions being executable by one or more processors to perform the operations described herein. The computer program product can include packaging material. Software or instructions can also be transmitted over a transmission medium. For example, software can be transmitted from a website, server, or other remote source using a transmission medium such as a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technology such as infrared, radio, or microwave.

[0122] Further, modules and/or other appropriate means for performing the methods and techniques described herein can be downloaded and/or otherwise obtained by suitable terminals and/or coupled to servers, or the like, to facilitate the transfer of means for performing the methods described herein. Alternatively, various methods described herein can be provided via storage means (e.g., RAM, ROM, a physical storage medium such as a CD or floppy disk, etc.), such that a user terminal and/or base station can obtain the various methods upon coupling or providing the storage means to the device. Moreover, any other suitable technique for providing the methods and techniques described herein to a device can be utilized. Features implementing functions can also be physically located at various positions, including

being distributed such that portions of functions are implemented at different physical locations.

[0123] In describing the present invention, the following terminology will be used: The singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to an item includes reference to one or more items. The term "ones" refers to one, two, or more, and generally applies to the selection of some or all of a quantity. The term "plurality" refers to two or more of an item. The term "about" means quantities, dimensions, sizes, formulations, parameters, shapes and other characteristics need not be exact, but can be approximated and/or larger or smaller, as desired, reflecting acceptable tolerances, conversion factors, rounding off, measurement error and the like and other factors known to those of skill in the art. The term "substantially" means that the recited characteristic, parameter, or value need not be achieved exactly, but that deviations or variations including, for example, tolerances, measurement error, measurement accuracy limitations and other factors known to those of skill in the art, can occur in amounts that do not preclude the effect the characteristic was intended to provide. Numerical data can be expressed or presented herein in a range format. It is to be understood that such a range format is used merely for convenience and brevity and thus should be interpreted flexibly to include not only the numerical values explicitly recited as the limits of the range, but also interpreted to include all of the individual numerical values or sub-ranges encompassed within that range as if each numerical value and sub-range is explicitly recited. As an illustration, a numerical range of "about 1 to 5" should be interpreted to include not only the explicitly recited values of about 1 to about 5, but also include individual values and sub-ranges within the indicated range. Thus, included in this numerical range are individual values such as 2, 3 and 4 and sub-ranges such as 1-3, 2-4 and 3-5, etc. This same principle applies to ranges reciting only one numerical value (e.g., "greater than about 1") and should apply regardless of the breadth of the range or the characteristics being described. A plurality of items can be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. Furthermore, where the terms "and" and "or" are used in conjunction with a list of items, they are to be interpreted broadly, in that any one or more of the listed items can be used alone or in combination with other listed items. The term "alternatively" refers to selection of one of two or more alternatives, and is not intended to limit the selection to only those listed alternatives or to only one of the listed alternatives at a time, unless the context clearly indicates otherwise. The term "coupled" as used herein does not require that the components be directly connected to each other. Instead, the term is intended to also include configurations with indirect connections where one or more other components can be included between coupled components. For example, such other components can include amplifiers, attenuators, isolators, directional couplers, redundancy switches, and the like. Also, as used herein, including in the claims, "or" as used in a list of items prefaced by "at least one of" indicates a disjunctive list such that, for example, a list of "at least one of A, B, or C" means A or B or C or AB or AC or BC or ABC (i.e., A and B and C). Further, the term "exemplary" does not mean that the described example is preferred or better than other examples. As used herein, a "set" of elements is intended to mean "one or more" of those elements, except where the set is explicitly required to have more than one or explicitly permitted to be a null set.

[0124] Various changes, substitutions, and alterations to the techniques described herein can be made without departing from the technology of the teachings as defined by the appended claims. Moreover, the scope of the disclosure and claims is not limited to the particular aspects of the process, machine, manufacture, composition of matter, means, methods, and actions described above. Processes, machines, manufacture, compositions of matter, means, methods, or actions, presently existing or later to be developed, that perform substantially the same function or achieve substantially the same result as the corresponding aspects described herein can be utilized. Accordingly, the appended claims include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or actions.

What is claimed is:

1. A system for autonomous item drop off and pick up, comprising:

a vehicle, comprising:

a freight bay,

an access portal formed in an exterior portion of the vehicle, the access portal providing ingress and/or egress of items between the freight bay and the exterior of the vehicle; and

an item storage system located in the freight bay, the item storage system configured to handle items;

a user interface on the vehicle configured to allow users to interact with the item storage system.

2. The system of claim **1**, wherein the user interface is further configured to receive a request for an item retrieval or a request to designate an item drop off.

3. The system of claim **2**, wherein the item storage system comprises a plurality of storage locations and a robotic arm configured to move items between the plurality of storage locations and the access portal.

4. The system of claim **3**, wherein the robotic arm is further configured to retrieve an item designated for drop off via the user interface from the access portal and store the item in the plurality of storage locations.

5. The system of claim **3**, wherein the robotic arm is further configured to retrieve an item requested for pick up via the user interface from the plurality of storage locations and dispense the item via the access portal.

6. The system of claim **3**, wherein the robotic arm further comprises a picking mechanism configured to lift and move items.

7. The system of claim **1**, wherein the item storage system further comprises a staging area proximate the access portal, wherein items can be dispensed and retrieved.

8. The system of claim **7**, wherein the staging area comprises a conveyer system located within the freight bay, configured to move items between the access portal and the interior of the freight bay.

9. The system of claim **3**, wherein the system further comprises a processor, the processor configured to receive a request for item drop off or pick up.

10. The system of claim **9**, wherein the processor is further configured to send a signal to the item storage system indicating an empty storage location for item drop off.

11. The system of claim **9**, wherein the processor is further configured to send a signal to the item storage system indicating a storage location containing an item requested for pick up.

12. The system of claim **1**, wherein the vehicle is an autonomous vehicle.

13. A method for automatically storing and dispensing items, comprising:

receiving an item designation, via a processor, from a user interface on a vehicle, wherein the vehicle comprises:

a freight bay,

an access portal formed in the vehicle, the access portal providing ingress and/or egress of items between the freight bay and the exterior of the vehicle; and

an item storage system located in the freight bay configured to handle items; and

transporting, via the item storage system, an item between the freight bay and the access portal based on the item designation received.

14. The method of claim **13**, wherein the item designation comprises an item retrieval designation or an item drop off designation.

15. The method of claim **14**, further comprising moving, via a robotic arm, the item between a plurality of storage locations in the item storage system and the access portal.

16. The method of claim **15**, wherein moving the item between the plurality of storage locations and the access portal comprises picking, via a picking mechanism on the robotic arm, the item.

17. The method of claim **13**, wherein the vehicle further comprises a staging area proximate the access portal where items can be dispensed and retrieved.

18. The method of claim **17**, wherein the staging area further comprises a conveyer system located within the freight bay, configured to move items between the access portal and the interior of the freight bay.

19. The method of claim **15**, wherein transporting between the freight bay and the access portal comprises:

upon receiving an item retrieval designation, sending a signal to the item storage system, indicating a storage location within the plurality of storage locations that contains an item to be picked up;

retrieving the item designated for retrieval, via the robotic arm, from the indicated storage location; and

dispensing the item via the access portal.

20. The method of claim **15**, wherein transporting between the freight bay and the access portal comprises:

upon receiving an item drop off designation, sending a signal to the item storage system, indicating an empty storage location within the plurality of storage locations;

retrieving the item designated for drop off, via the robotic arm, from the access portal; and

storing the item in the empty storage location.

* * * * *