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Lutke et al.

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(45) **Date of Patent: Aug. 20, 2013**

(54) **UNMANNED AERIAL VEHICLE BASE STATION**

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(73) Assignee: **The Boeing Company**, Chicago, IL (US)

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(22) Filed: **Dec. 9, 2009**

(51) **Int. Cl.**
B64D 41/00 (2006.01)

(52) **U.S. Cl.**
USPC .... **244/58**; 244/100 R; 320/109

(58) **Field of Classification Search**
USPC .... 244/58, 100 R, 110 R, 110 G, 117 R, 244/1 R, 190, 12.3, 53 R, 172.2, 172.9; 320/109, 108; 701/3, 13; 414/227; 191/10
See application file for complete search history.

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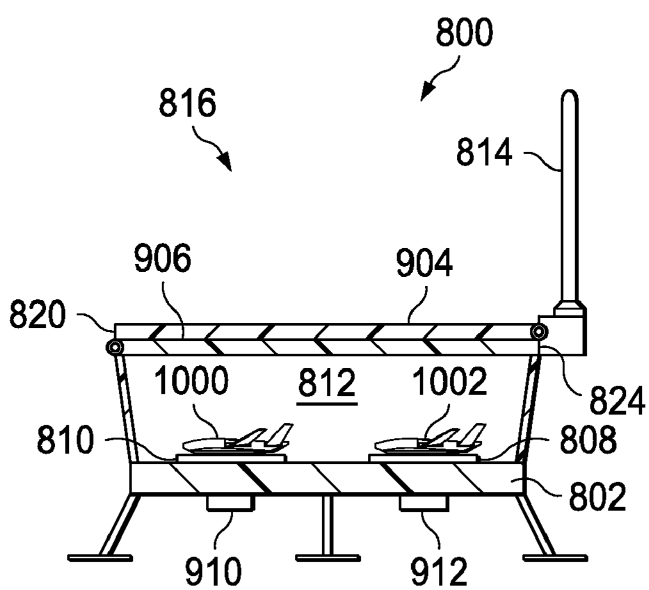
(57) **ABSTRACT**

A method and apparatus comprising a platform, a battery system, a power generation system, a number of charging stations, and a controller. The platform is configured to house a number of unmanned aerial vehicles. The power generation system is connected to the battery system. The power generation system is configured to generate electrical energy from an environment in which the platform is located, and store the electrical energy in the battery system. The number of charging stations is connected to the battery system. The controller is connected to the battery system and is configured to receive sensor data from the number of unmanned aerial vehicles, generate information from the sensor data, and send the information to a remote location.

19 Claims, 16 Drawing Sheets



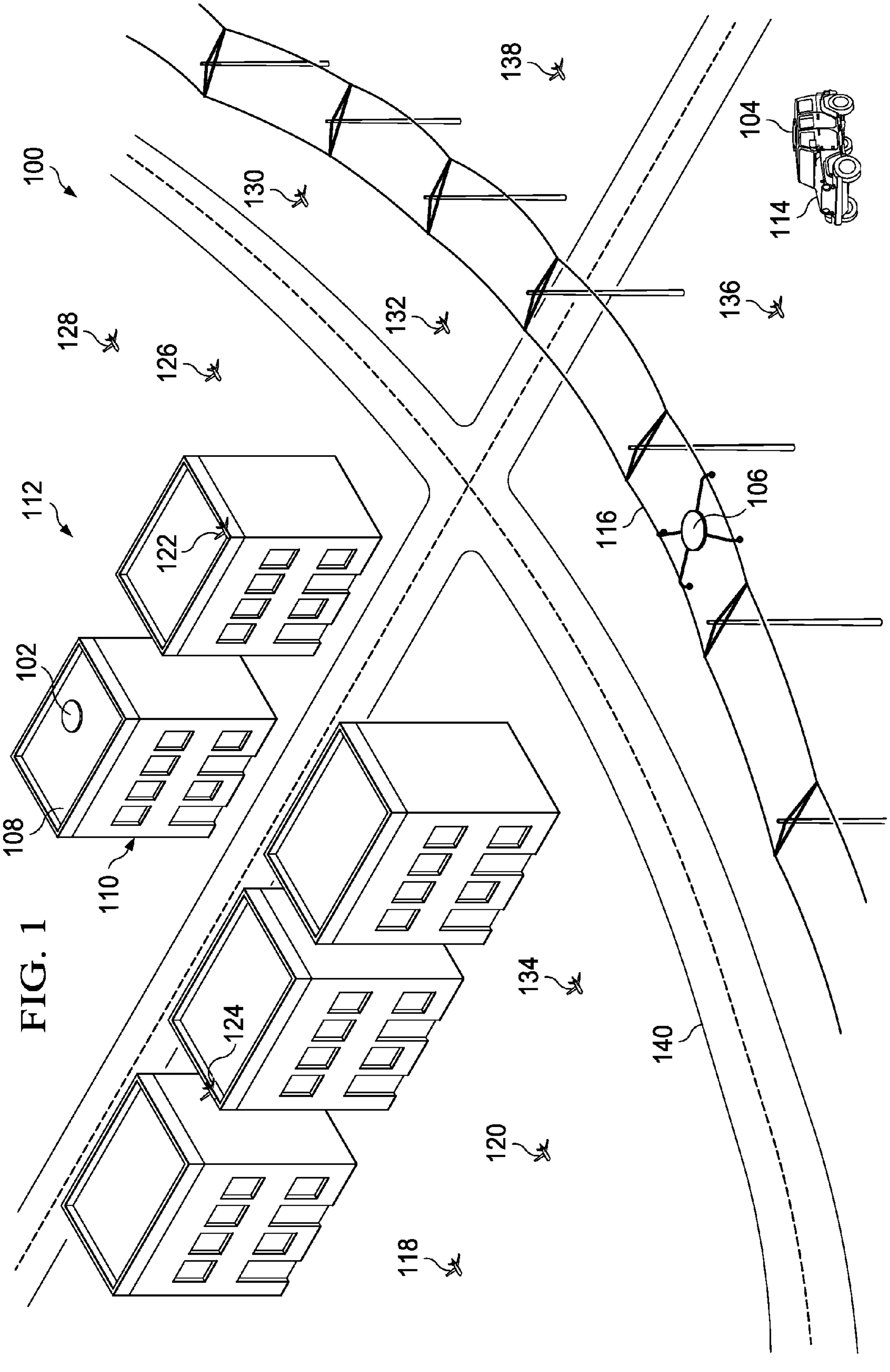

100
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FIG. 1

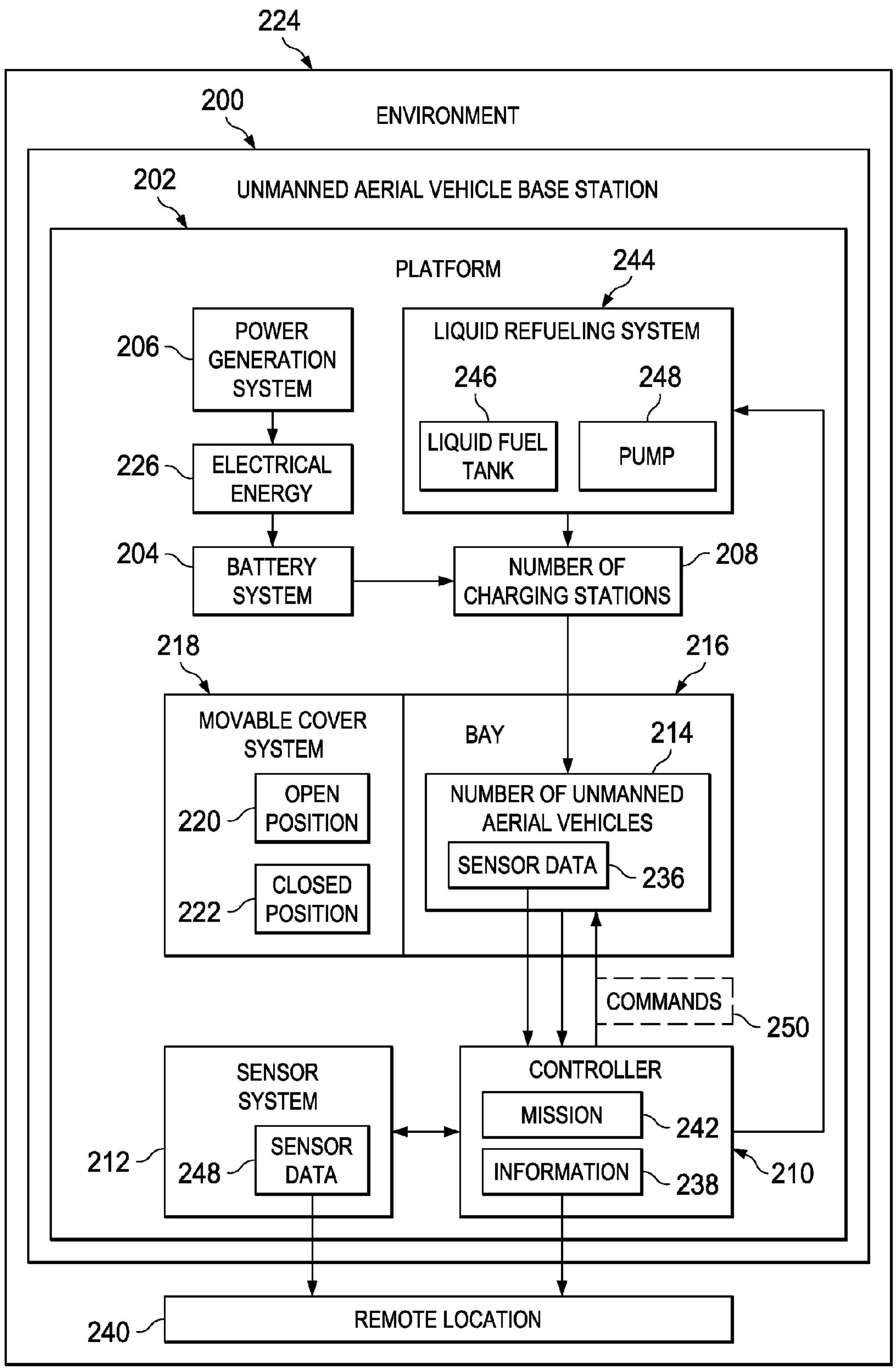
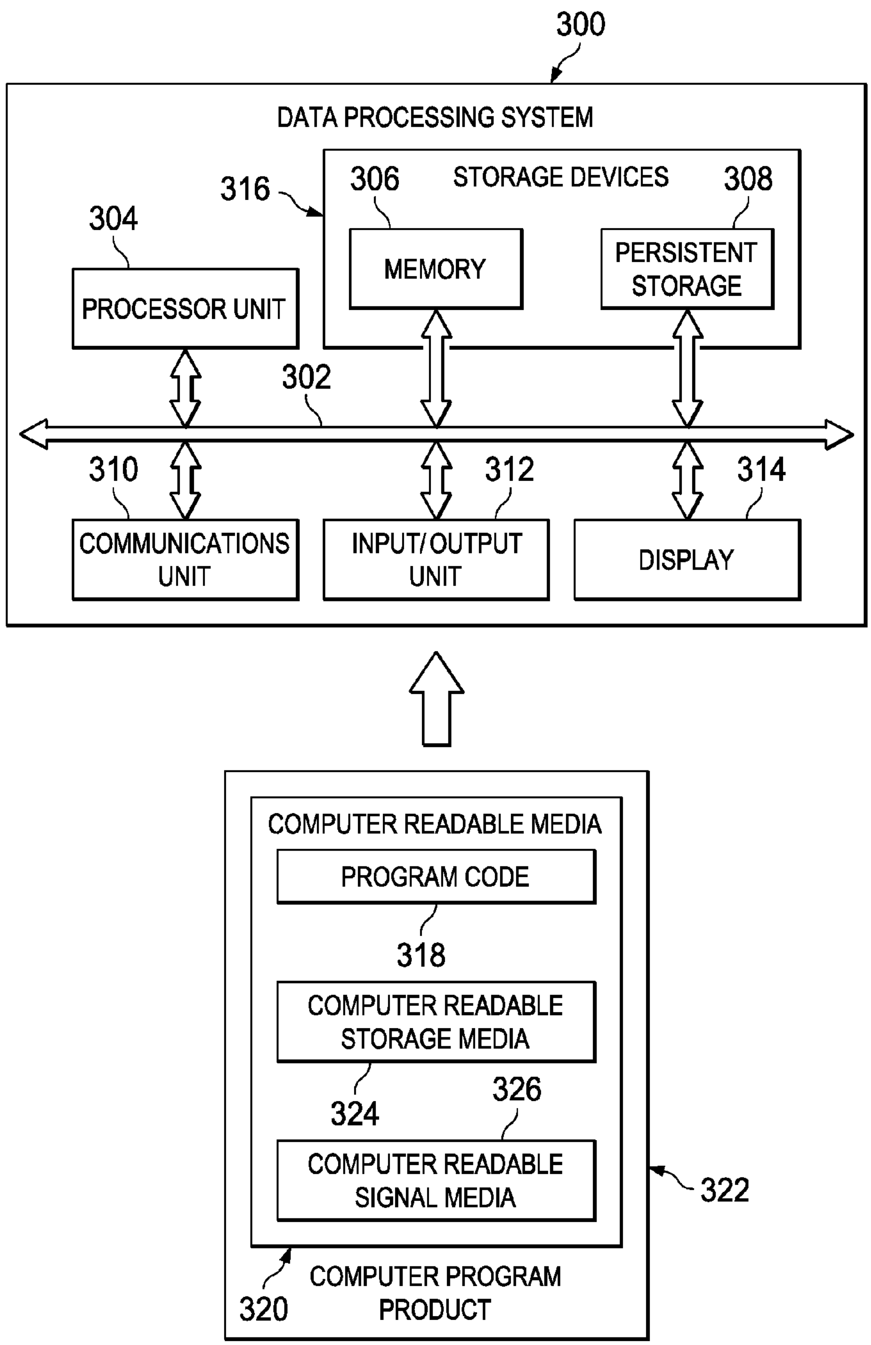

224
200
ENVIRONMENT
202
UNMANNED AERIAL VEHICLE BASE STATION
PLATFORM
244
206
POWER GENERATION SYSTEM
LIQUID REFUELING SYSTEM
246
248
LIQUID FUEL TANK
PUMP
226
ELECTRICAL ENERGY
204
BATTERY SYSTEM
NUMBER OF CHARGING STATIONS
208
218
216
MOVABLE COVER SYSTEM
BAY
214
OPEN POSITION
220
NUMBER OF UNMANNED AERIAL VEHICLES
SENSOR DATA
236
222
CLOSED POSITION
COMMANDS
250
SENSOR SYSTEM
CONTROLLER
MISSION
242
212
248
SENSOR DATA
INFORMATION
238
210
240
REMOTE LOCATION

FIG. 2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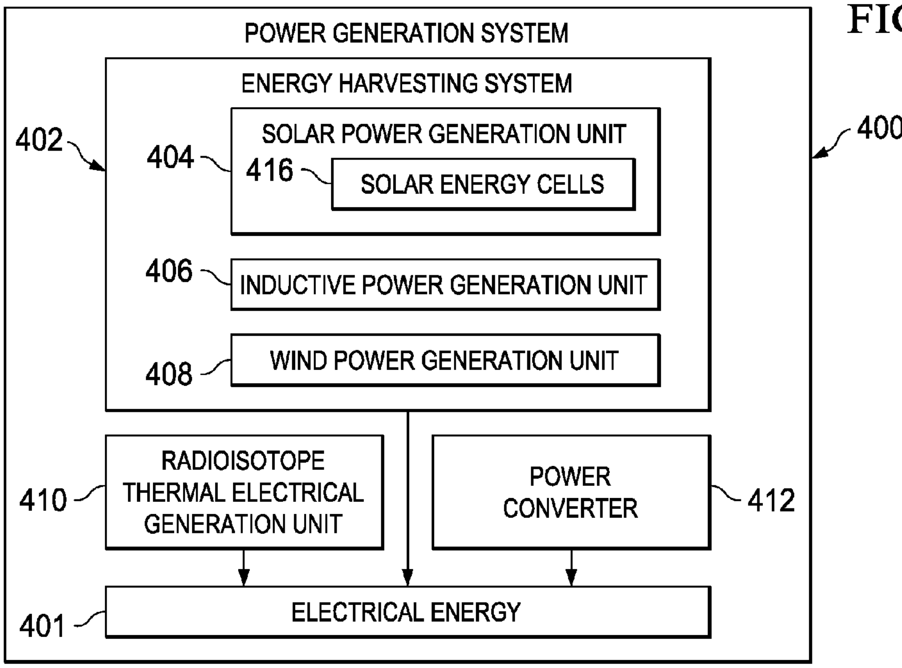
DATA PROCESSING SYSTEM
316
306
STORAGE DEVICES
308
304
MEMORY
PERSISTENT STORAGE
PROCESSOR UNIT
302
310
312
314
COMMUNICATIONS UNIT
INPUT/OUTPUT UNIT
DISPLAY
COMPUTER READABLE MEDIA
PROGRAM CODE
318
COMPUTER READABLE STORAGE MEDIA
324
326
COMPUTER READABLE SIGNAL MEDIA
322
320
COMPUTER PROGRAM PRODUCT

FIG. 3


POWER GENERATION SYSTEM
ENERGY HARVESTING SYSTEM
SOLAR POWER GENERATION UNIT
SOLAR ENERGY CELLS
INDUCTIVE POWER GENERATION UNIT
WIND POWER GENERATION UNIT
RADIOISOTOPE THERMAL ELECTRICAL GENERATION UNIT
POWER CONVERTER
ELECTRICAL ENERGY
400
402
404
416
406
408
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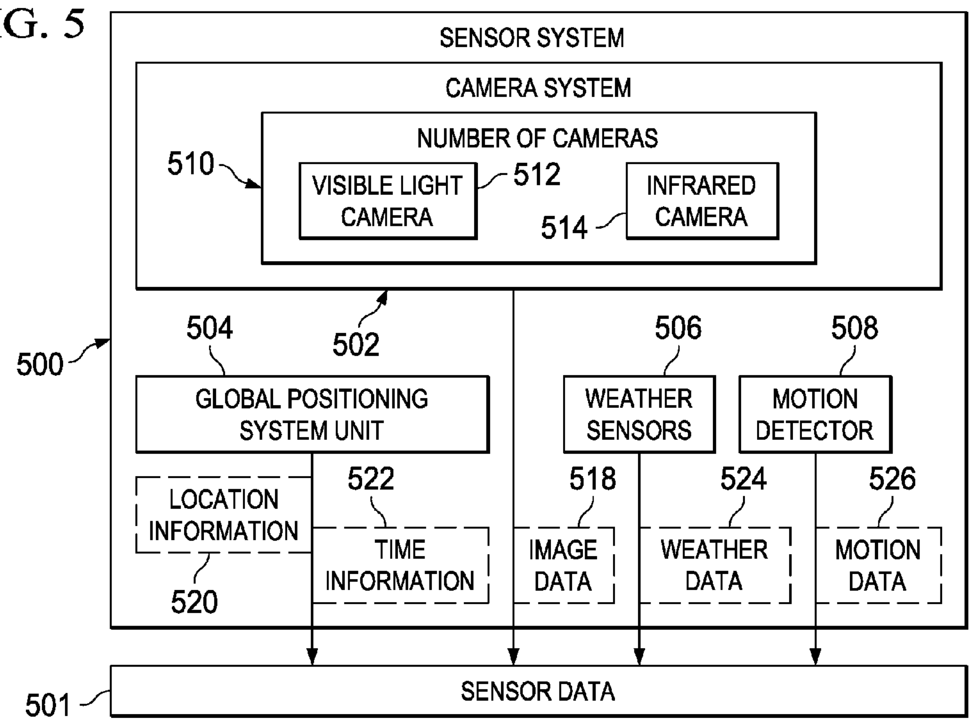
412
401

FIG. 4

FIG. 5


SENSOR SYSTEM
CAMERA SYSTEM
NUMBER OF CAMERAS
VISIBLE LIGHT CAMERA
INFRARED CAMERA
GLOBAL POSITIONING SYSTEM UNIT
WEATHER SENSORS
MOTION DETECTOR
LOCATION INFORMATION
TIME INFORMATION
IMAGE DATA
WEATHER DATA
MOTION DATA
SENSOR DATA
500
510
512
514
502
504
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508
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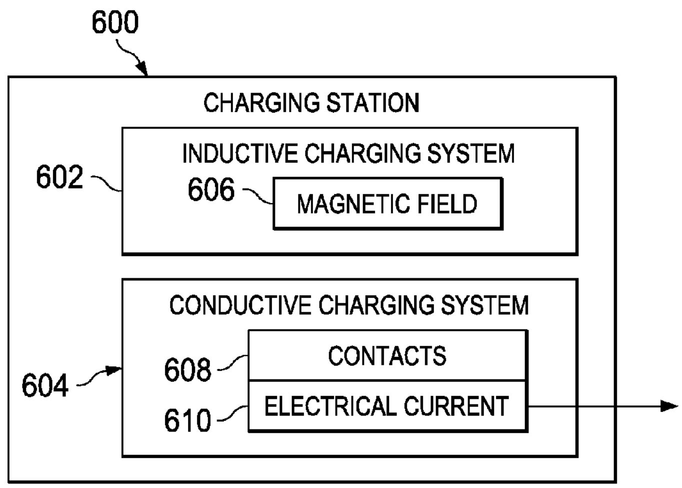
520
522
524
526
501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CHARGING STATION
602
INDUCTIVE CHARGING SYSTEM
606
MAGNETIC FIELD
604
CONDUCTIVE CHARGING SYSTEM
608
CONTACTS
610
ELECTRICAL CURRENT

FIG. 6

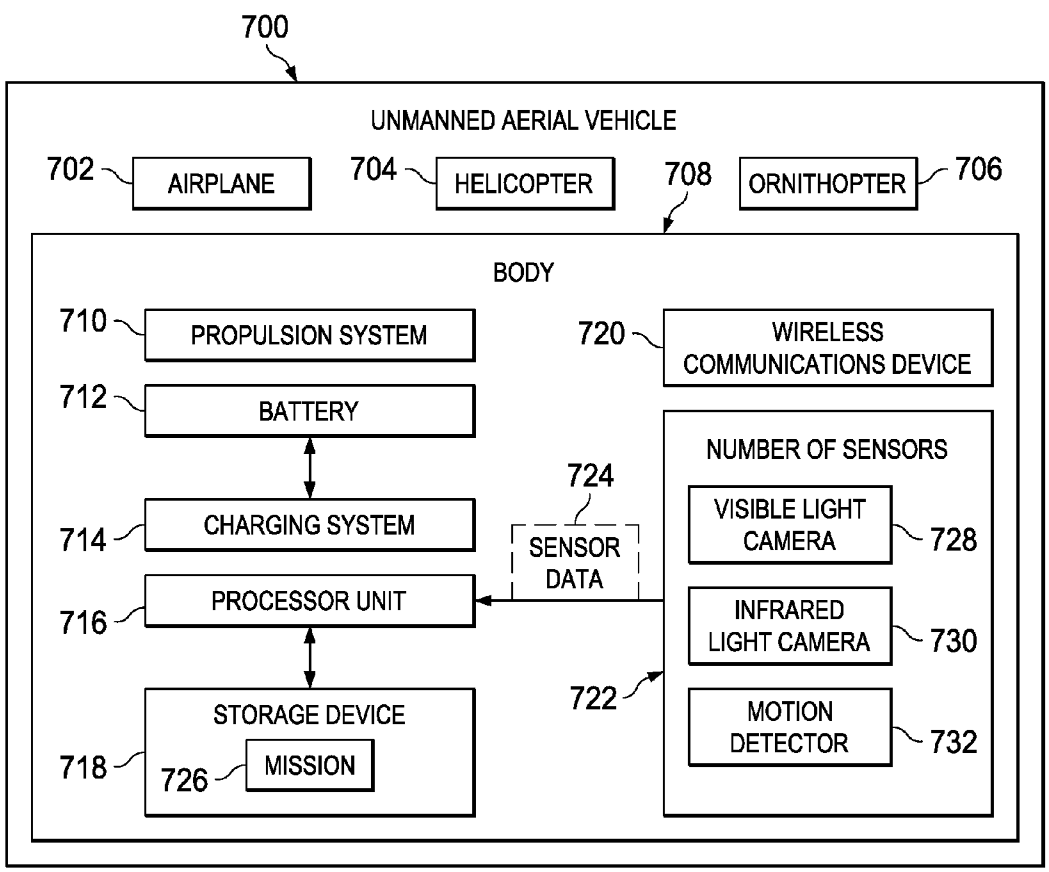
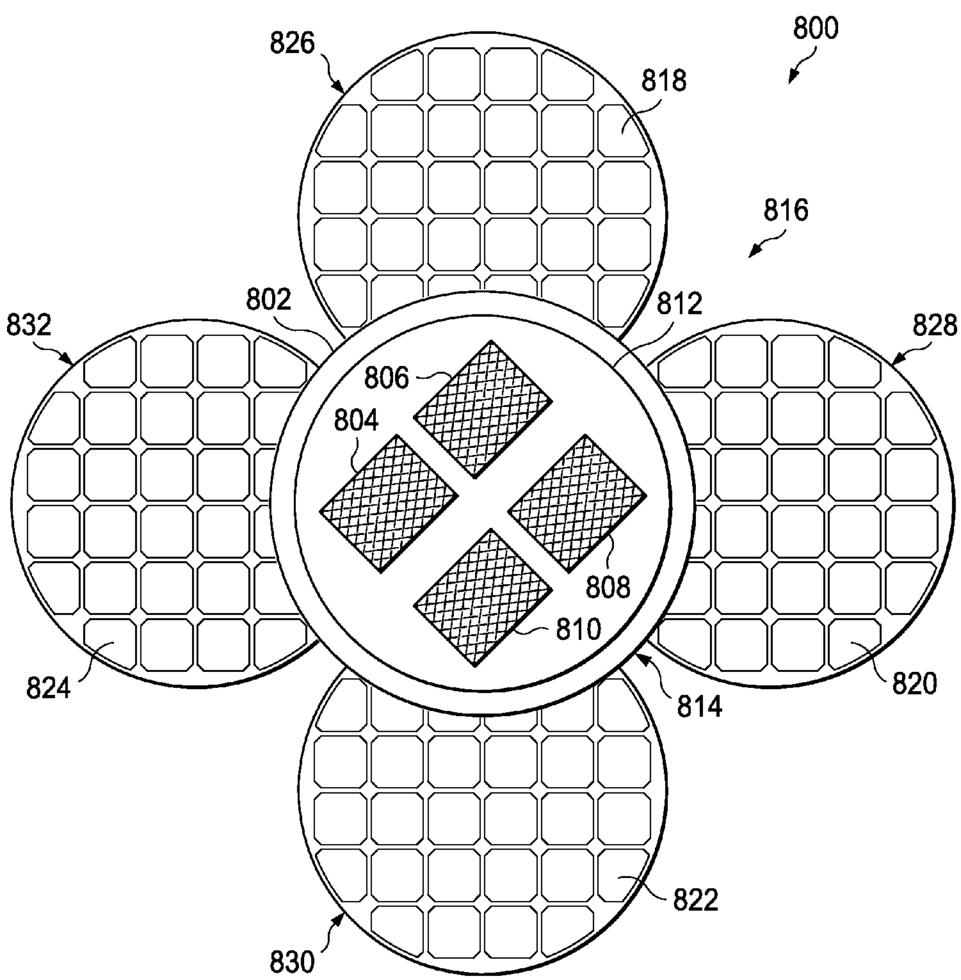

700
UNMANNED AERIAL VEHICLE
702
AIRPLANE
704
HELICOPTER
708
ORNITHOPTER
706
BODY
710
PROPULSION SYSTEM
720
WIRELESS COMMUNICATIONS DEVICE
712
BATTERY
NUMBER OF SENSORS
724
714
CHARGING SYSTEM
SENSOR DATA
VISIBLE LIGHT CAMERA
728
716
PROCESSOR UNIT
INFRARED LIGHT CAMERA
730
722
STORAGE DEVICE
MOTION DETECTOR
732
718
726
MISSION

FIG. 7

FIG. 8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804
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820
822
830

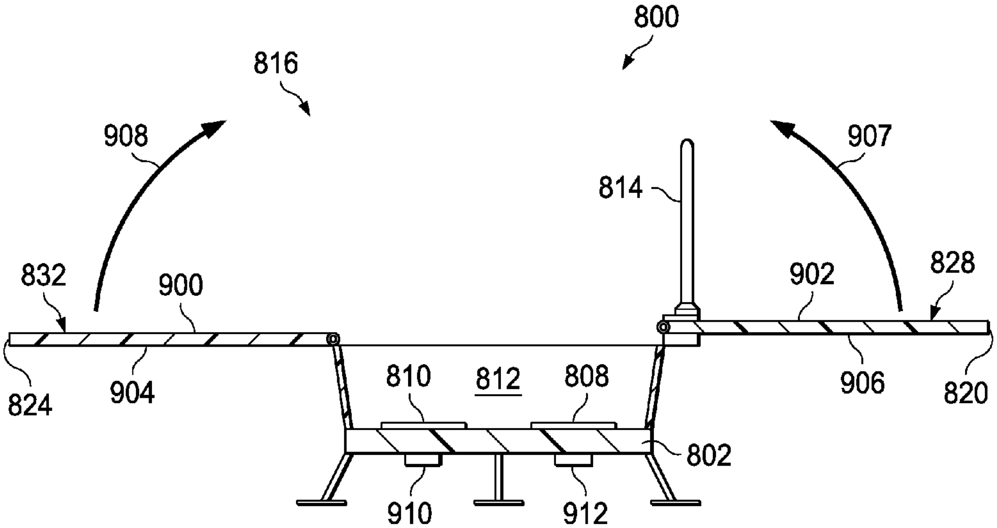
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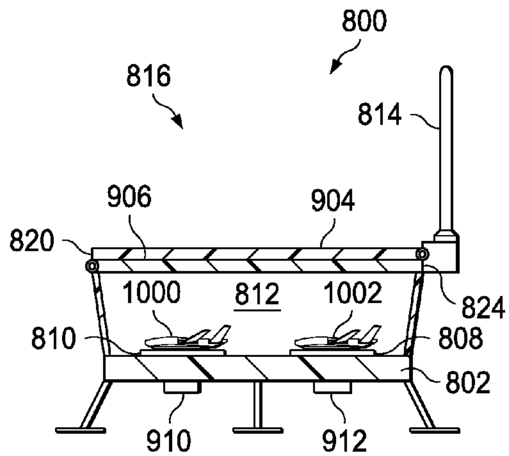
FIG. 9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1002
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910
912

FIG. 10

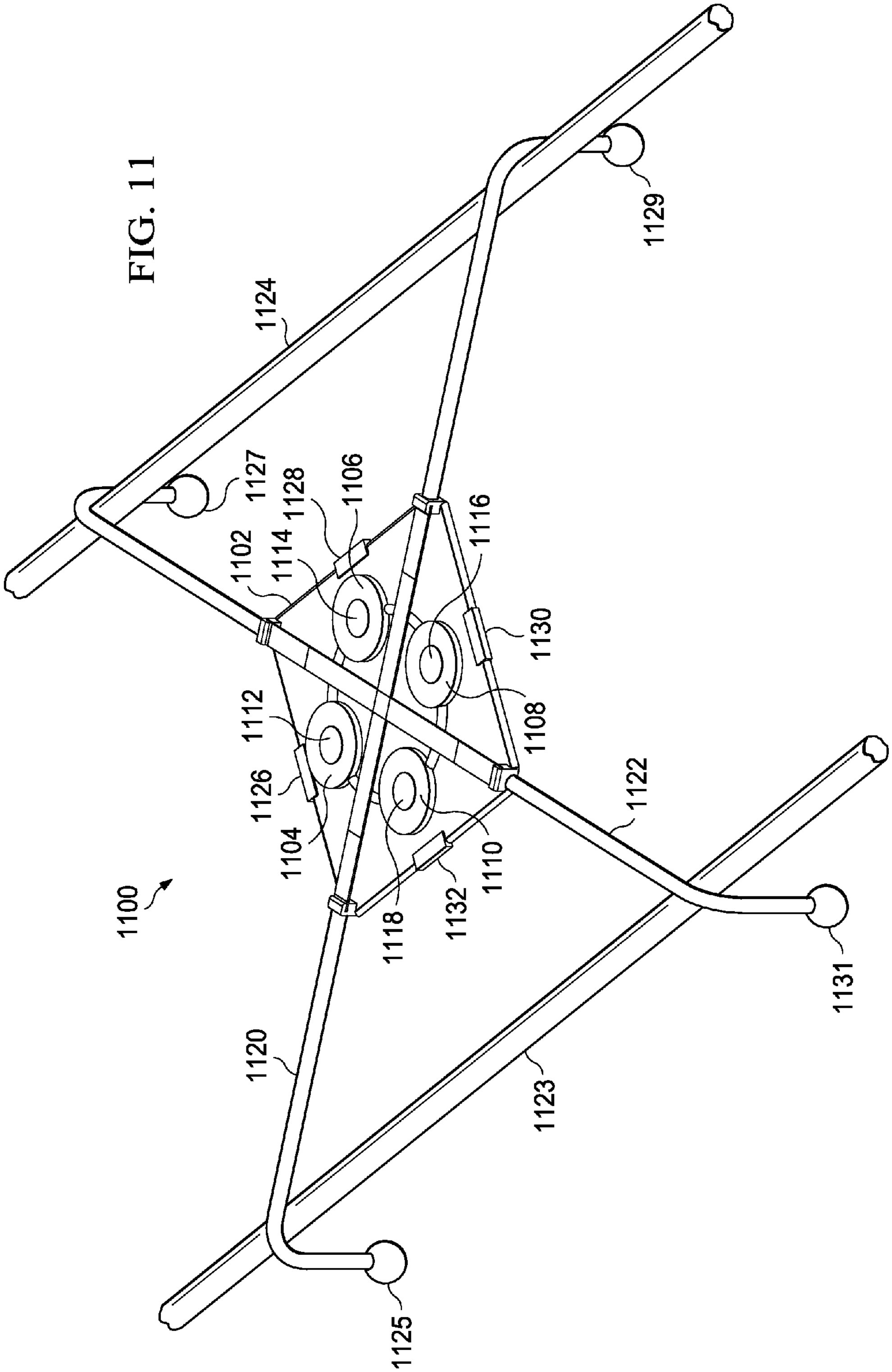
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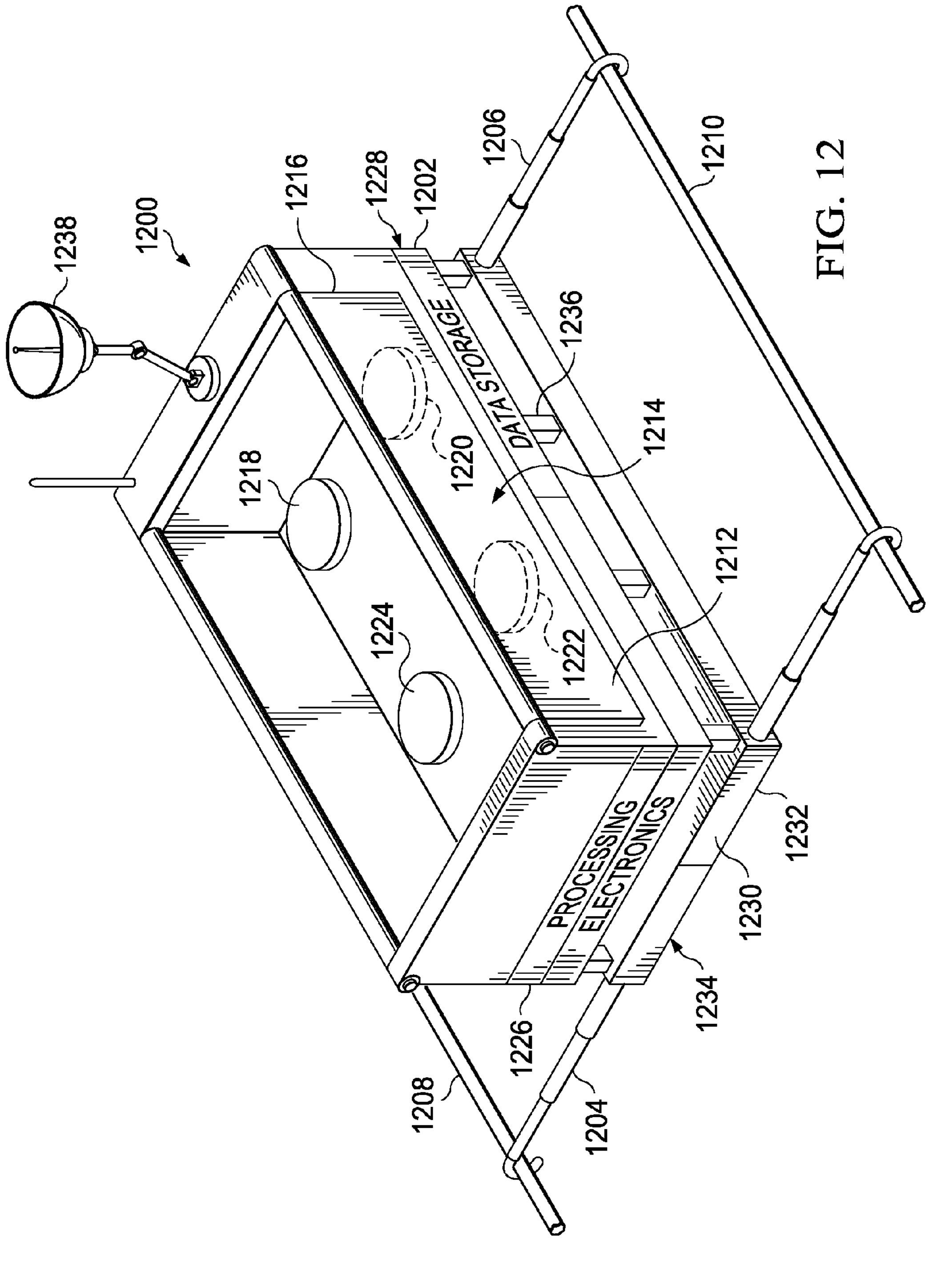
FIG. 11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DATA STORAGE
1236
1214
1220
1218
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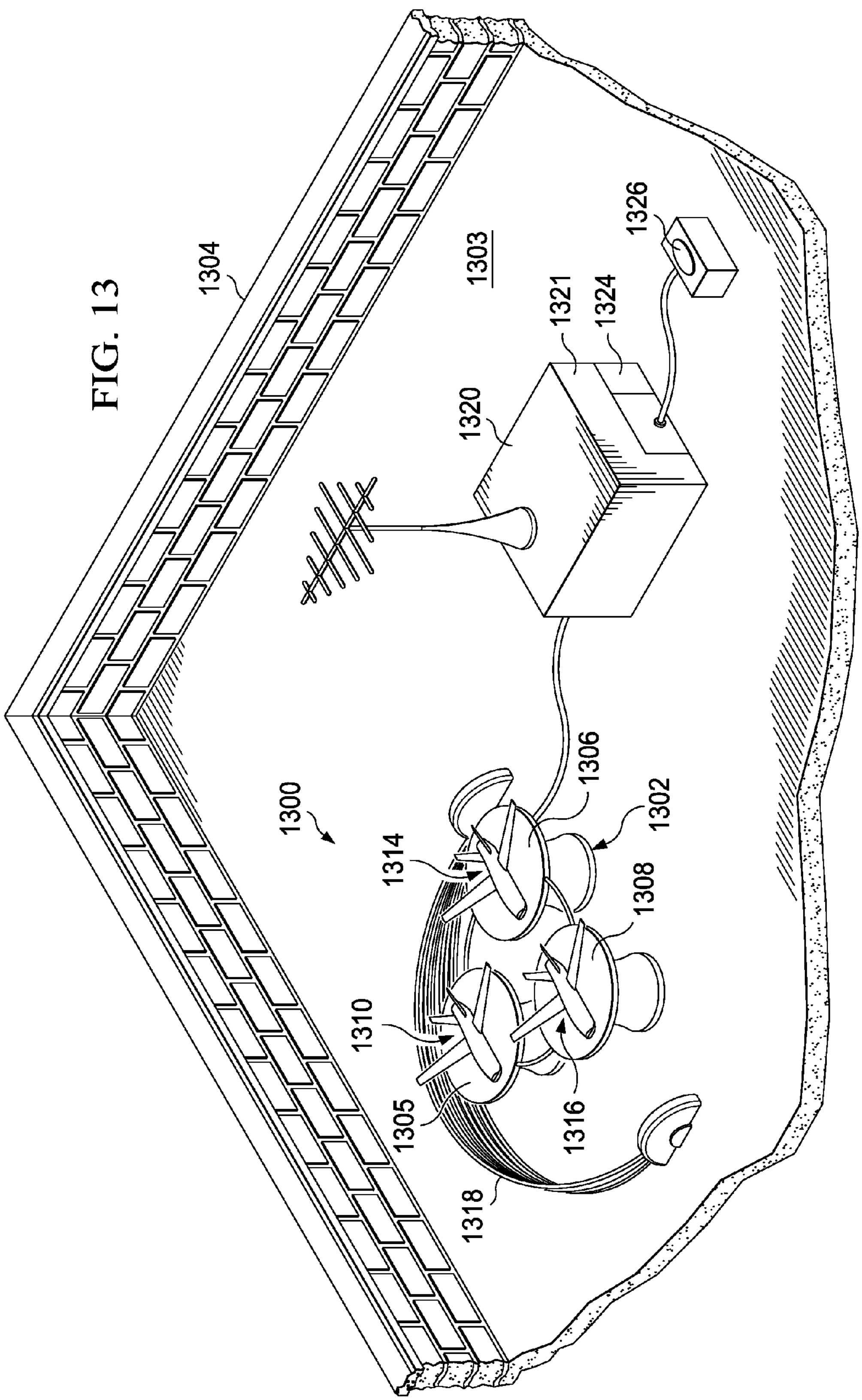
1222
1212
PROCESSING
ELECTRONICS
1232
1230
1234
1226
1208
1204

FIG. 12

FIG. 13



1304
1303
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1321
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1300
1306
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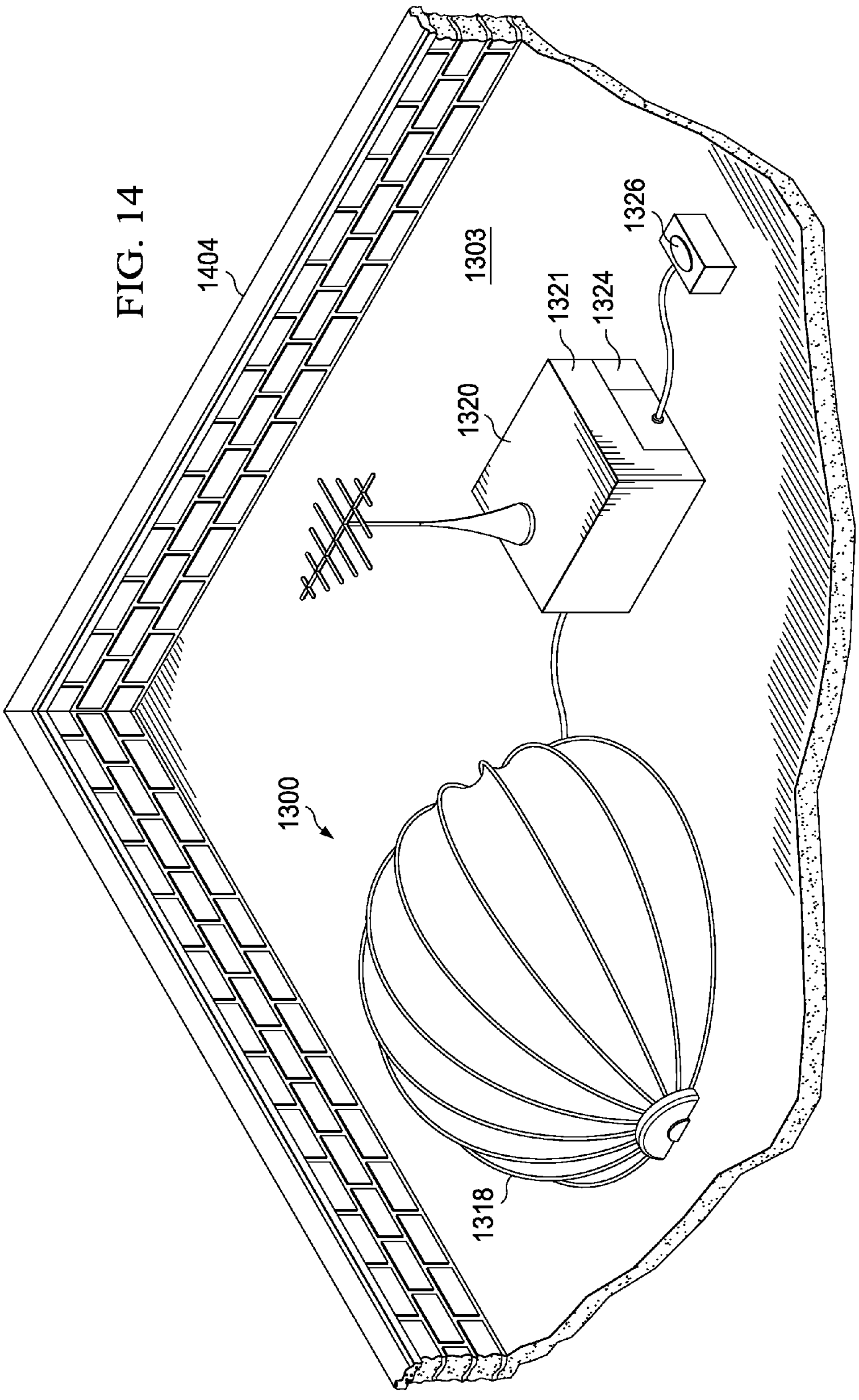
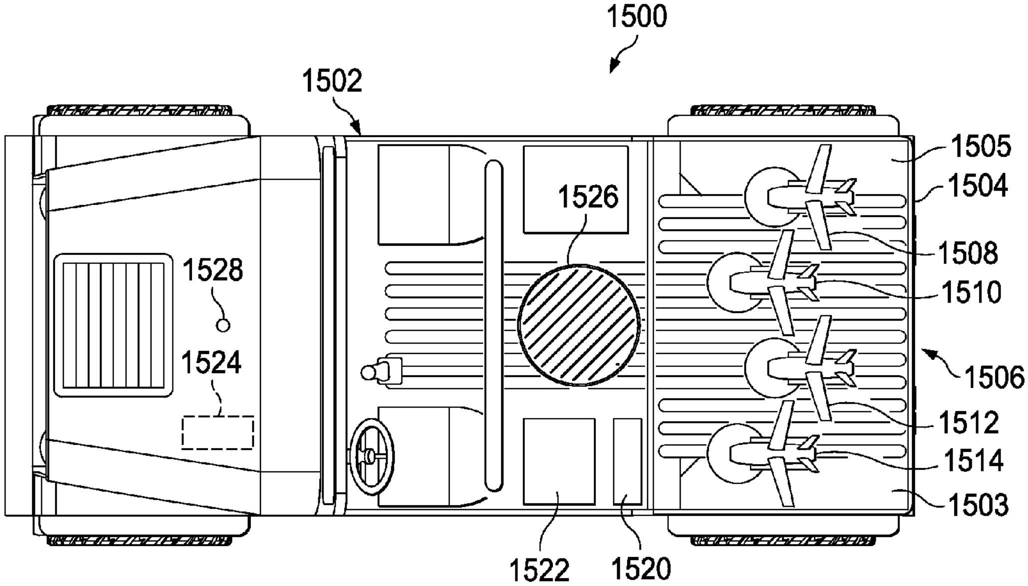
FIG. 14

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1502
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FIG. 15

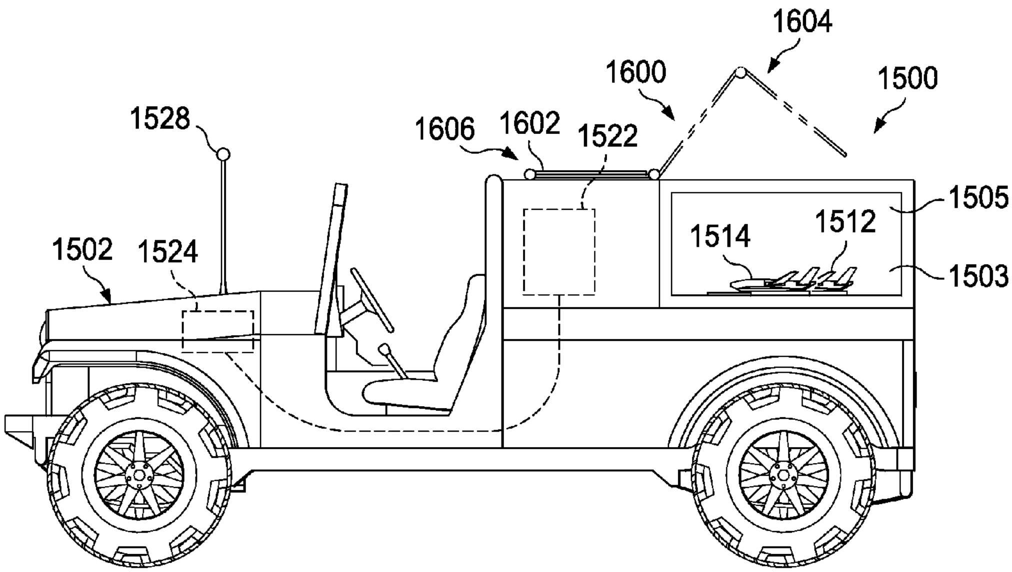

1604
1600
1500
1528
1606
1602
1522
1505
1502
1524
1514
1512
1503

FIG. 16

FIG. 17

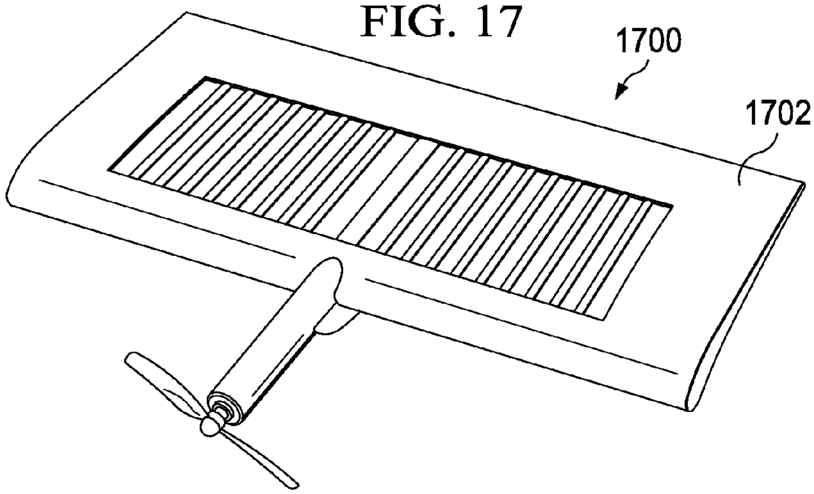


FIG. 18

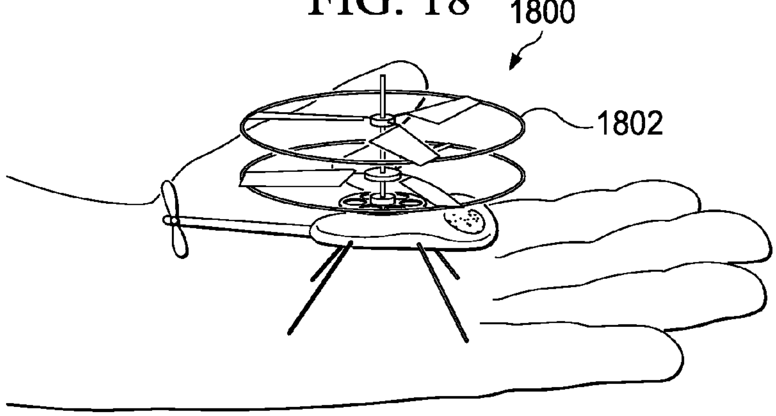
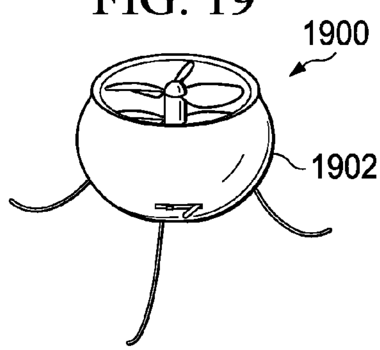


FIG. 19



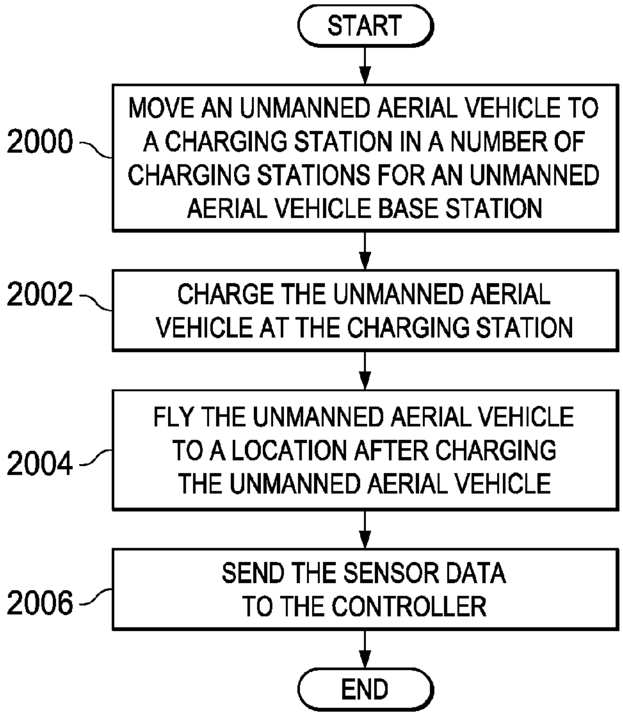

START
2000
MOVE AN UNMANNED AERIAL VEHICLE TO A CHARGING STATION IN A NUMBER OF CHARGING STATIONS FOR AN UNMANNED AERIAL VEHICLE BASE STATION
2002
CHARGE THE UNMANNED AERIAL VEHICLE AT THE CHARGING STATION
2004
FLY THE UNMANNED AERIAL VEHICLE TO A LOCATION AFTER CHARGING THE UNMANNED AERIAL VEHICLE
2006
SEND THE SENSOR DATA TO THE CONTROLLER
END

FIG. 20

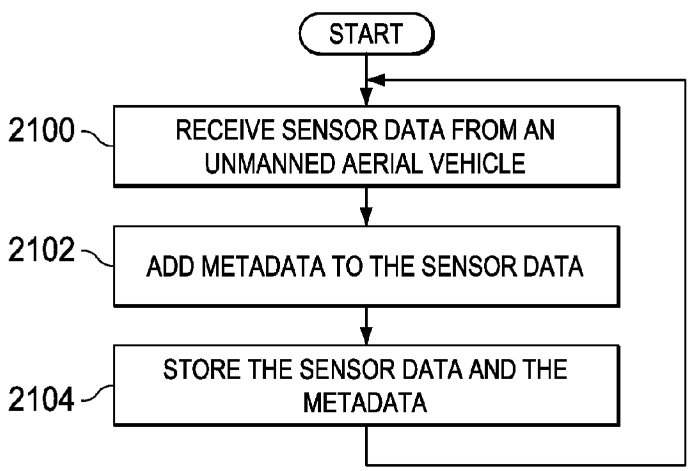
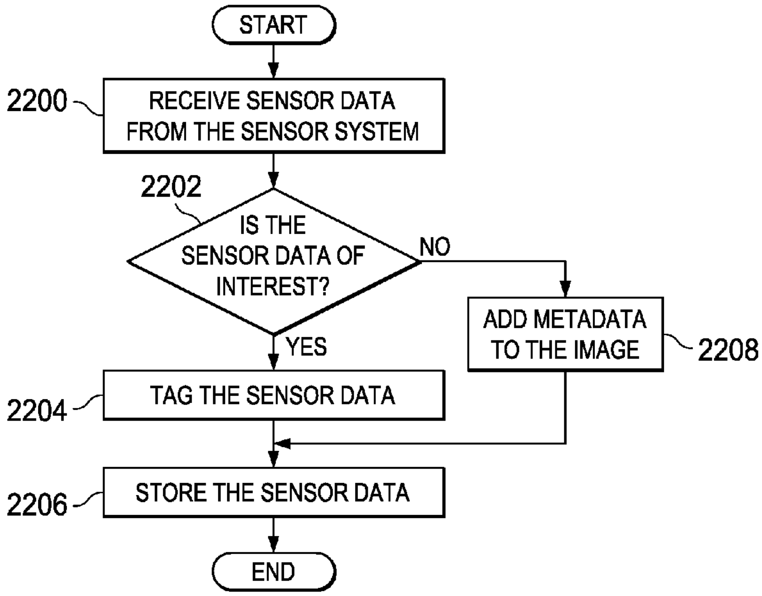
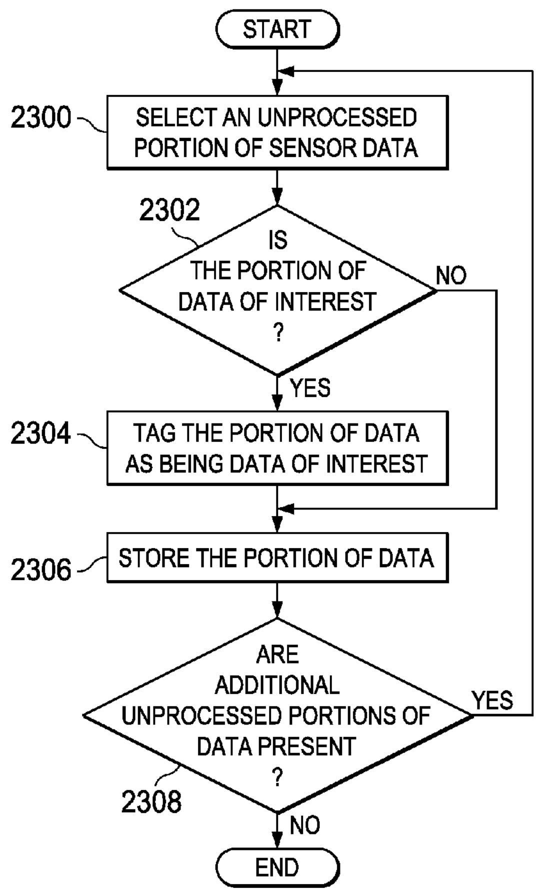

START
2100
RECEIVE SENSOR DATA FROM AN UNMANNED AERIAL VEHICLE
2102
ADD METADATA TO THE SENSOR DATA
2104
STORE THE SENSOR DATA AND THE METADATA

FIG. 21



START
2200
RECEIVE SENSOR DATA FROM THE SENSOR SYSTEM
2202
IS THE SENSOR DATA OF INTEREST?
NO
ADD METADATA TO THE IMAGE
2208
YES
2204
TAG THE SENSOR DATA
2206
STORE THE SENSOR DATA
END

FIG. 22



START
2300
SELECT AN UNPROCESSED PORTION OF SENSOR DATA
2302
IS THE PORTION OF DATA OF INTEREST ?
NO
YES
2304
TAG THE PORTION OF DATA AS BEING DATA OF INTEREST
2306
STORE THE PORTION OF DATA
ARE ADDITIONAL UNPROCESSED PORTIONS OF DATA PRESENT ?
YES
2308
NO
END

FIG. 23

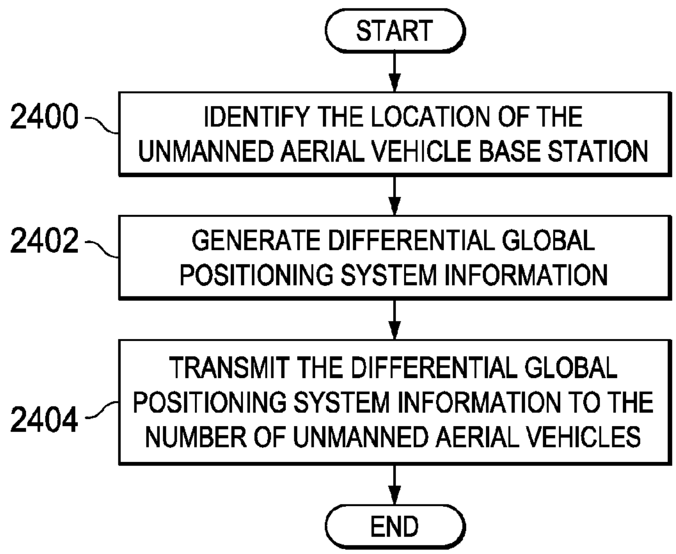

START
2400
IDENTIFY THE LOCATION OF THE UNMANNED AERIAL VEHICLE BASE STATION
2402
GENERATE DIFFERENTIAL GLOBAL POSITIONING SYSTEM INFORMATION
2404
TRANSMIT THE DIFFERENTIAL GLOBAL POSITIONING SYSTEM INFORMATION TO THE NUMBER OF UNMANNED AERIAL VEHICLES
END

FIG. 24

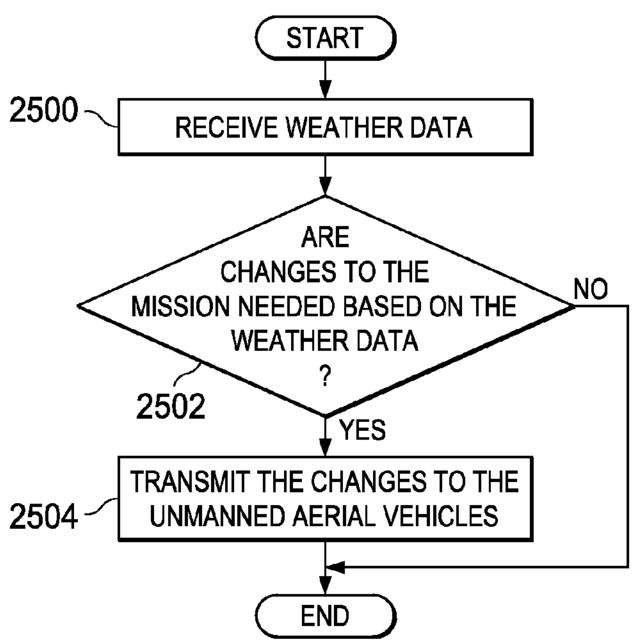

START
2500
RECEIVE WEATHER DATA
ARE CHANGES TO THE MISSION NEEDED BASED ON THE WEATHER DATA ?
2502
NO
YES
2504
TRANSMIT THE CHANGES TO THE UNMANNED AERIAL VEHICLES
END

FIG. 25

UNMANNED AERIAL VEHICLE BASE STATION

BACKGROUND INFORMATION

1. Field:

The present disclosure relates generally to aircraft and, in particular, to unmanned aerial vehicles. Still more particularly, the present disclosure relates to a method and apparatus for operating unmanned aerial vehicles in different locations.

2. Background:

An unmanned aerial vehicle (UAV) is an aircraft that flies without human operators being present in the aircraft. Unmanned aerial vehicles may be controlled from a remote location. At this remote location, a human operator or a program executed by a computer generates commands for the unmanned aerial vehicle. Unmanned aerial vehicles also may be controlled using a program running on a computer or other controller on the unmanned aerial vehicle.

Unmanned aerial vehicles are used for a number of different purposes. Currently, the largest use is for military applications. Unmanned aerial vehicles may be used to perform missions that may include, for example, without limitation, reconnaissance missions, attack missions, and/or other suitable types of missions. Unmanned aerial vehicles also may be used in a number of civilian applications. For example, without limitation, unmanned aerial vehicles may be used to perform surveying, firefighting, and/or other suitable types of missions.

Unmanned aerial vehicles may come in a number of different sizes and shapes. Unmanned aerial vehicles may, for example, take the form of fixed wing aircraft, helicopters, and/or ornithopters. For example, without limitation, an unmanned aerial vehicle may take the form of an airplane, a helicopter, or some other suitable type of device capable of flying. The size of an unmanned aerial vehicle may vary greatly. For example, an unmanned aerial vehicle may have a wing span from about a few inches to about 200 feet, depending on the type of unmanned aerial vehicle.

Smaller unmanned aerial vehicles are referred to as micro air vehicles. These types of air vehicles may be configured to be carried by a person and may be launched by the person. For example, the micro air vehicles may be launched by the person throwing the micro air vehicles in the air. The small size of these types of air vehicles allows this type of launching method to provide sufficient velocity for these air vehicles to begin flight.

The size of unmanned aerial vehicles has been reduced in part because of a reduction in the sizes of sensors, motors, power supplies, and controllers for these types of vehicles.

These reduced sizes and reductions in cost make it desirable to operate these vehicles in large numbers. For example, micro air vehicles (MAVs) may be operated in numbers that are about the size of a squad or platoon, as compared to operating one or two larger unmanned aerial vehicles. This type of operation increases the monitoring that can be performed for a particular area.

These types of unmanned aerial vehicles also may land on a perch, a building, or another location. In this manner, a micro air vehicle may monitor a particular location without having to continue flight. The micro air vehicle may be repositioned if the area of interest changes.

For example, a micro air vehicle may land on a building in a city or town. The micro air vehicle may monitor a particular road or building in the city.

Micro air vehicles, however, have limitations with their smaller size, as compared to larger unmanned aerial vehicles.

For example, the processing power and data transmission ranges may be more limited for micro air vehicles, as compared to larger unmanned aerial vehicles. Further, the range of these micro air vehicles may be shorter, as compared to the larger unmanned aerial vehicles.

Therefore, it would be advantageous to have a method and apparatus that takes into account one or more of the issues discussed above, as well as other possible issues.

SUMMARY

In one advantageous embodiment, an apparatus comprises a platform, a battery system, a power generation system, a number of charging stations, and a controller. The platform is configured to house a number of unmanned aerial vehicles. The power generation system is connected to the battery system. The power generation system is configured to generate electrical energy from an environment in which the platform is located, and store the electrical energy in the battery system. The number of charging stations is connected to the battery system. The controller is connected to the battery system and configured to receive sensor data from the number of unmanned aerial vehicles, generate information from the sensor data, and send the information to a remote location.

In another advantageous embodiment, an apparatus comprises a platform, a number of charging stations, and a controller. The platform is configured to house a number of unmanned aerial vehicles. Each charging station in the number of charging stations is configured to charge the number of unmanned aerial vehicles. The controller is configured to receive sensor data from the number of unmanned aerial vehicles.

In yet another advantageous embodiment, a method is present for operating an unmanned aerial vehicle. The unmanned aerial vehicle is charged at a charging station for an unmanned aerial vehicle base station. The unmanned aerial vehicle base station comprises a platform configured to house a number of unmanned aerial vehicles, a battery system connected to the charging station, a power generation system connected to the battery system, and a controller connected to the battery system. The power generation system is configured to generate electrical energy from an environment in which the platform is located. The power generation system is configured to store the electrical energy in the battery system. The controller is connected to the battery system and is configured to receive sensor data from the number of unmanned aerial vehicles, generate information from the sensor data, and send the information to a remote location. The unmanned aerial vehicle is flown to a location after charging the unmanned aerial vehicle. The sensor data is sent to the controller.

The features, functions, and advantages can be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the advantageous embodiments are set forth in the appended claims. The advantageous embodiments, however, as well as a preferred mode of use, further objectives, and advantages thereof, will best be understood by reference to the following detailed description of an advantageous embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

FIG. **1** is an illustration of an unmanned aerial vehicle environment in accordance with an advantageous embodiment;

FIG. **2** is an illustration of a block diagram of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **3** is an illustration of a block diagram of a data processing system in accordance with an advantageous embodiment;

FIG. **4** is an illustration of a block diagram of a power generation system in accordance with an advantageous embodiment;

FIG. **5** is an illustration of a block diagram of a sensor system in accordance with an advantageous embodiment;

FIG. **6** is an illustration of a block diagram of a charging station in accordance with an advantageous embodiment;

FIG. **7** is an illustration of a block diagram of an unmanned aerial vehicle in accordance with an advantageous embodiment;

FIG. **8** is an illustration of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **9** is a cross-sectional side view of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **10** is an illustration of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **11** is an illustration of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **12** is an illustration of a perspective view of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **13** is another illustration of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **14** is an illustration of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **15** is an illustration of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **16** is an illustration of a side view of an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **17** is an illustration of an unmanned aerial vehicle in accordance with an advantageous embodiment;

FIG. **18** is an illustration of an unmanned aerial vehicle in accordance with an advantageous embodiment;

FIG. **19** is an illustration of an unmanned aerial vehicle in accordance with an advantageous embodiment;

FIG. **20** is an illustration of a flowchart of a process for operating an unmanned aerial vehicle base station in accordance with an advantageous embodiment;

FIG. **21** is an illustration of a flowchart of a process for processing sensor data in accordance with an advantageous embodiment;

FIG. **22** is an illustration of a flowchart for processing sensor data in accordance with an advantageous embodiment;

FIG. **23** is an illustration of a flowchart for processing sensor data to form information in accordance with an advantageous embodiment;

FIG. **24** is an illustration of a flowchart of a process for sending information to an unmanned aerial vehicle in accordance with an advantageous embodiment; and

FIG. **25** is an illustration of a flowchart of a process for changing a mission in accordance with an advantageous embodiment.

DETAILED DESCRIPTION

The different advantageous embodiments recognize and take into account a number of considerations. For example, the different advantageous embodiments recognize and take into account that unmanned aerial vehicles may be more susceptible to environmental conditions as the size of the unmanned aerial vehicles decreases. For example, a micro air vehicle having a wing span of about 13 inches and a weight of about six ounces may be more susceptible to wind gusts, rain, hail, and/or other conditions, as compared to an unmanned aerial vehicle having a wing span of about 84 feet and a weight of about 7,000 pounds.

The different advantageous embodiments also recognize and take into account that having human operators launch, retrieve, and/or maintain unmanned aerial vehicles during a mission may be time-consuming and/or expensive. The different advantageous embodiments also recognize and take into account that with the use of human operators, the mission being performed by the unmanned aerial vehicles may be more likely detected when such detection is undesirable.

Further, as the size of an unmanned aerial vehicle decreases, the range and complexity of the components in the unmanned aerial vehicle also may decrease. As a result, more maintenance of these types of unmanned aerial vehicles may be required.

Thus, the different advantageous embodiments provide a method and apparatus for performing a mission using unmanned aerial vehicles. In one advantageous embodiment, an apparatus comprises a platform, a battery system, a power generation system, a number of charging stations, and a controller. The platform is configured to house a number of unmanned aerial vehicles. The battery system is configured to store electrical energy in the form of chemical energy.

The battery system is configured to generate electrical current as needed to provide power to the various components in the apparatus. The power generation system is connected to the battery system. The power generation system is configured to generate electrical energy from an environment in which the platform is located. The power generation system is also configured to store the electrical energy in the battery system. The number of charging stations is connected to the battery system in which each charging station in the number of charging stations is configured to charge an unmanned aerial vehicle. The controller is configured to receive sensor data from a number of unmanned aerial vehicles and generate information from the data and send the information to a remote location.

With reference now to FIG. **1**, an illustration of an unmanned aerial vehicle environment is depicted in accordance with an advantageous embodiment. Unmanned aerial vehicle environment **100** includes unmanned aerial vehicle base station **102**, unmanned aerial vehicle base station **104**, and unmanned aerial vehicle base station **106**.

In this illustrative example, unmanned aerial vehicle base station **102** is located on rooftop **108** of building **110** within town **112**. Unmanned aerial vehicle base station **104** is associated with vehicle **114**. A first component may be considered to be associated with a second component by being secured to the second component, bonded to the second component, fastened to the second component, and/or connected to the second component in some other suitable manner. The first component also may be connected to the second component by a third component. The first component may be considered to be associated with the second component by being formed as part of and/or an extension of the second component.

Unmanned aerial vehicle base station **106** is located on power lines **116**. Unmanned aerial vehicle base stations **102**, **104**, and **106** may be deployed in a number of different ways. Unmanned aerial vehicle base station **102** may be dropped off by helicopter on rooftop **108**. The location of unmanned aerial vehicle base station **102** on rooftop **108** may result in unmanned aerial vehicle base station **102** being less observable. Further, this location may provide a better line of sight between unmanned aerial vehicle base station **102** and communication arrays. In this manner, the range at which unmanned aerial vehicle base station **102** may communicate with unmanned aerial vehicles may be increased.

Unmanned aerial vehicle base station **104** is associated with vehicle **114**. By being associated with vehicle **114**, unmanned aerial vehicle base station **104** may be moved periodically or constantly. This type of deployment may reduce the discoverability of unmanned aerial vehicle base station **104**. Further, by providing mobility to unmanned aerial vehicle base station **104**, greater flexibility may be present for performing missions. In addition, unmanned aerial vehicle base station **104** may be removed from vehicle **114** and placed on the ground or in some other suitable location.

Unmanned aerial vehicle base station **106** may be deployed onto power lines **116** by being dropped by a helicopter, on a parachute, or some other suitable mechanism. Unmanned aerial vehicle base station **106** may be less observable on power lines **116**. As depicted, unmanned aerial vehicles, such as unmanned aerial vehicles **118**, **120**, **122**, **124**, **126**, **128**, **130**, **132**, **134**, **136**, and **138** may operate from unmanned aerial vehicle base stations **102**, **104**, and **106**.

In these illustrative examples, unmanned aerial vehicle base stations **102**, **104**, and **106** provide a base from which the different unmanned aerial vehicles may transmit data, receive instructions, recharge, be stored, and/or perform other operations.

Additionally, unmanned aerial vehicles may travel from base station to base station. In other words, unmanned aerial vehicle base stations **102**, **104**, and **106** may provide a network to extend the range of unmanned aerial vehicles. Having multiple unmanned aerial vehicle base stations also may provide backup in case one unmanned aerial vehicle base station malfunctions or fails to perform as needed.

As can be seen in this depicted example, unmanned aerial vehicle base stations **102**, **104**, and **106** may be placed in locations where detection of those base stations may be reduced. These locations may include other locations other than those illustrated in this particular example. For example, unmanned aerial vehicle base stations **102**, **104**, and **106** may be placed in trees, in brush, and/or in other suitable locations.

The unmanned aerial vehicles may be used to perform a number of different missions in unmanned aerial vehicle environment **100**. In this illustrative example, the unmanned aerial vehicles may monitor for undesired activity. For example, the undesired activity may be the placement of an improvised explosive device in roadway **140**. In another illustrative example, the unmanned aerial vehicles may monitor for movement of vehicles or people. In still other examples, unmanned aerial vehicles may be used to monitor for construction of structures.

With reference now to FIG. **2**, an illustration of a block diagram of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. Unmanned aerial vehicle base station **200** is an example of an unmanned aerial vehicle base station that may be used to implement unmanned aerial vehicle base stations **102**, **104**, and **106** in FIG. **1**.

In this illustrative example, unmanned aerial vehicle base station **200** comprises platform **202**, battery system **204**, power generation system **206**, number of charging stations **208**, controller **210**, sensor system **212**, and/or other suitable components.

Platform **202** is configured to house number of unmanned aerial vehicles **214**. In other words, number of unmanned aerial vehicles **214** may be placed in and/or stored in or on platform **202**. For example, platform **202** may have bay **216** in which number of unmanned aerial vehicles **214** may land. Bay **216** may be an area of platform **202** surrounded by walls with an opening on the top side of platform **202**. In other advantageous embodiments, bay **216** may have walls and a roof with an opening on the side of platform **202**. An unmanned aerial vehicle is considered to be housed when the unmanned aerial vehicle enters into or lands on platform **202**.

Additionally, platform **202** may be configured to provide protection from environment **224** for number of unmanned aerial vehicles **214** when number of unmanned aerial vehicles **214** is housed in platform **202**.

Platform **202** also may have movable cover system **218** that is configured to move between open position **220** and closed position **222**. Movable cover system **218** may cover bay **216**. When movable cover system **218** is in open position **220**, number of unmanned aerial vehicles **214** may take off from and/or land in or on platform **202**.

When movable cover system **218** is in closed position **222**, number of unmanned aerial vehicles **214** located in bay **216** of platform **202** may be protected from environment **224**. Further, closed position **222** also provides a configuration for transporting number of unmanned aerial vehicles **214** in unmanned aerial vehicle base station **200**.

Battery system **204** and power generation system **206** provide electrical energy **226** for unmanned aerial vehicle base station **200** and number of unmanned aerial vehicles **214**. Battery system **204** stores electrical energy **226** generated by power generation system **206**. Power generation system **206** generates electrical energy **226** from environment **224** in which unmanned aerial vehicle base station **200** is located.

Number of charging stations **208** is connected to battery system **204**. Number of charging stations **208** is configured to charge number of unmanned aerial vehicles **214** using electrical energy **226**. Further, number of charging stations **208** provides electrical energy **226** to controller **210** and sensor system **212** in unmanned aerial vehicle base station **200**.

In some advantageous embodiments, number of unmanned aerial vehicles **214** may take the form of liquid fueled unmanned aerial vehicles. In these illustrative examples, number of charging stations **208** is configured to refuel these liquid fueled unmanned aerial vehicles. For example, unmanned aerial vehicle base station **200** may have liquid refueling system **244**. Liquid refueling system **244** has liquid fuel tank **246** containing liquid fuel. The liquid fuel may be, for example, gasoline or diesel fuel. Pump **248** in liquid refueling system **244** transfers the liquid fuel in liquid fuel tank **246** to number of charging stations **208**. Number of charging stations **208** is configured to provide liquid fuel to the liquid fuel unmanned aerial vehicles.

In these illustrative examples, controller **210** may be configured to control the pumping of liquid fuel from liquid refueling system **244**. In some advantageous embodiments, liquid refueling system **244** may deliver liquid fuel to number of unmanned aerial vehicles **214** at number of charging stations **208** using a syringe injection system.

In these illustrative examples, controller **210** is configured to receive sensor data **236** from number of unmanned aerial vehicles **214**. Additionally, controller **210** is configured to generate information **238** from sensor data **236**. Information **238** may then be sent to remote location **240**. Remote location **240** is a location remote to unmanned aerial vehicle base station **200**. Controller **210** is also configured to program each of number of unmanned aerial vehicles **214** with mission **242**. Mission **242** may be the same or different for each of number of unmanned aerial vehicles **214**.

Sensor system **212** generates sensor data **248** from environment **224**. Sensor data **248** may be sent to remote location **240** or may be used to send commands **250** to number of unmanned aerial vehicles **214** or to program number of unmanned aerial vehicles **214** with mission **242**.

The illustration of unmanned aerial vehicle base station **200** in FIG. **2** is not meant to imply physical or architectural limitations to the manner in which different advantageous embodiments may be implemented. Other components in addition to and/or in place of the ones illustrated may be used. Some components may be unnecessary in some advantageous embodiments. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined and/or divided into different blocks when implemented in different advantageous embodiments.

For example, in some advantageous embodiments, different forms of energy may be stored in storage devices for conversion into electrical energy for number of unmanned aerial vehicles **214**. These storage devices may be devices other than battery system **204**. These devices may include, for example, without limitation, capacitors, flywheels, compressed air devices, and/or other suitable energy storage devices. One or more of these devices may be connected to number of charging stations **208**.

Turning now to FIG. **3**, an illustration of a block diagram of a data processing system is depicted in accordance with an advantageous embodiment. Data processing system **300** is an example of an implementation for controller **210** in FIG. **2**. In this illustrative example, data processing system **300** includes communications fabric **302**, which provides communications between processor unit **304**, memory **306**, persistent storage **308**, communications unit **310**, and input/output (I/O) unit **312**.

Processor unit **304** serves to execute instructions for software that may be loaded into memory **306**. Processor unit **304** may be a set of one or more processors or may be a multi-processor core, depending on the particular implementation. Further, processor unit **304** may be implemented using one or more heterogeneous processor systems in which a main processor is present with secondary processors on a single chip. As another illustrative example, processor unit **304** may be a symmetric multi-processor system containing multiple processors of the same type.

Memory **306** and persistent storage **308** are examples of storage devices **316**. A storage device is any piece of hardware that is capable of storing information, such as, for example, without limitation, data, program code in functional form, and/or other suitable information either on a temporary basis and/or a permanent basis. Memory **306**, in these examples, may be, for example, a random access memory or any other suitable volatile or non-volatile storage device.

Persistent storage **308** may take various forms, depending on the particular implementation. For example, persistent storage **308** may contain one or more components or devices. For example, persistent storage **308** may be a hard drive, a flash memory, a rewritable optical disk, a rewritable magnetic tape, or some combination of the above. The media used by persistent storage **308** may be removable. For example, a removable hard drive may be used for persistent storage **308**.

Communications unit **310**, in these examples, provides for communication with other data processing systems or devices. In these examples, communications unit **310** is a network interface card. Communications unit **310** may provide communications through the use of either or both physical and wireless communications links.

Communications unit **310** is configured to provide wireless communications links. These wireless communications links may include, for example, without limitation, a satellite communications link, a microwave frequency communications link, a radio frequency communications link, and/or other suitable types of wireless communication links.

Input/output unit **312** allows for the input and output of data with other devices that may be connected to data processing system **300**. For example, input/output unit **312** may provide a connection for user input through a keyboard, a mouse, and/or some other suitable input device. Further, input/output unit **312** may send output to a printer. Display **314** provides a mechanism to display information to a user.

Instructions for the operating system, applications, and/or programs may be located in storage devices **316**, which are in communication with processor unit **304** through communications fabric **302**. In these illustrative examples, the instructions are in a functional form on persistent storage **308**. These instructions may be loaded into memory **306** for execution by processor unit **304**. The processes of the different embodiments may be performed by processor unit **304** using computer implemented instructions, which may be located in a memory, such as memory **306**.

These instructions are referred to as program code, computer usable program code, or computer readable program code that may be read and executed by a processor in processor unit **304**. The program code, in the different embodiments, may be embodied on different physical or computer readable storage media, such as memory **306** or persistent storage **308**.

Program code **318** is located in a functional form on computer readable media **320** that is selectively removable and may be loaded onto or transferred to data processing system **300** for execution by processor unit **304**. Program code **318** and computer readable media **320** form computer program product **322**. In one example, computer readable media **320** may be computer readable storage media **324** or computer readable signal media **326**.

Computer readable storage media **324** may include, for example, an optical or magnetic disk that is inserted or placed into a drive or other device that is part of persistent storage **308** for transfer onto a storage device, such as a hard drive, that is part of persistent storage **308**. Computer readable storage media **324** also may take the form of a persistent storage, such as a hard drive, a thumb drive, or flash memory that is connected to data processing system **300**. In some instances, computer readable storage media **324** may not be removable from data processing system **300**.

Alternatively, program code **318** may be transferred to data processing system **300** using computer readable signal media **326**. Computer readable signal media **326** may be, for example, a propagated data signal containing program code **318**. For example, computer readable signal media **326** may be an electromagnetic signal, an optical signal, and/or any other suitable type of signal. These signals may be transmitted over communications links, such as wireless communications links, an optical fiber cable, a coaxial cable, a wire, and/or any other suitable type of communications link. In other words, the communications link and/or the connection may be physical or wireless in the illustrative examples.

In some illustrative embodiments, program code **318** may be downloaded over a network to persistent storage **308** from another device or data processing system through computer readable signal media **326** for use within data processing system **300**. For instance, program code stored in a computer readable storage media in a server data processing system may be downloaded over a network from the server to data processing system **300**. The data processing system providing program code **318** may be a server computer, a client computer, or some other device capable of storing and transmitting program code **318**.

The different components illustrated for data processing system **300** are not meant to provide architectural limitations to the manner in which different embodiments may be implemented. The different illustrative embodiments may be implemented in a data processing system, including components in addition to or in place of those illustrated for data processing system **300**. Other components shown in FIG. **3** can be varied from the illustrative examples shown. The different embodiments may be implemented using any hardware device or system capable of executing program code. As one example, data processing system **300** may include organic components integrated with inorganic components and/or may be comprised entirely of organic components excluding a human being. For example, a storage device may be comprised of an organic semiconductor.

As another example, a storage device in data processing system **300** is any hardware apparatus that may store data. Memory **306**, persistent storage **308**, and computer readable media **320** are examples of storage devices in a tangible form.

In another example, a bus system may be used to implement communications fabric **302** and may be comprised of one or more buses, such as a system bus or an input/output bus. Of course, the bus system may be implemented using any suitable type of architecture that provides for a transfer of data between different components or devices attached to the bus system. Additionally, a communications unit may include one or more devices used to transmit and receive data, such as a modem or a network adapter. Further, a memory may be, for example, memory **306** or a cache such as found in an interface and memory controller hub that may be present in communications fabric **302**.

With reference now to FIG. **4**, an illustration of a block diagram of a power generation system is depicted in accordance with an advantageous embodiment. Power generation system **400** is an example of one implementation for power generation system **206** in FIG. **2**. Power generation system **400** generates electrical energy **401** in these illustrative examples.

Power generation system **400** may include energy harvesting system **402**. Energy harvesting system **402** may comprise at least one of solar power generation unit **404**, inductive power generation unit **406**, wind power generation unit **408**, and/or other suitable types of energy harvesting units. Power generation system **400** also may include radioisotope thermal electrical generation unit **410**, power converter **412**, and/or other suitable types of power generation devices.

As used herein, the phrase "at least one of", when used with a list of items, means that different combinations of one or more of the listed items may be used and only one of each item in the list may be needed. For example, "at least one of item A, item B, and item C" may include, for example, without limitation, item A or item A and item B. This example also may include item A, item B, and item C, or item B and item C. In other examples, "at least one of" may be, for example, without limitation, two of item A, one of item B, and 10 of item C; four of item B and seven of item C; and other suitable combinations.

Solar power generation unit **404** generates electrical energy **401** from exposure to sunlight or other light in the environment. Solar power generation unit **404** may comprise solar energy cells **416**. In the different illustrative examples, solar energy cells **416** may take the form of photovoltaic units.

Solar energy cells **416** may be located on, for example, without limitation, movable cover system **218** in FIG. **2**.

Inductive power generation unit **406** generates power inductively when an alternating current source is present, such as in power lines. This power may be used to provide electrical energy **401**. Wind power generation unit **408** may include a number of wind power turbines that generate electrical energy **401** from wind that may be present in the environment.

Radioisotope thermal electrical generation unit **410** generates electrical energy **401** from radioactive material that decays. The decay of the radioactive material generates heat used by radioisotope thermal electrical generation unit **410** to generate electrical energy **401**. This radioactive material is carried by the unmanned aerial vehicle base station in these examples.

Power converter **412** converts electrical power from one form to another form. For example, power converter **412** may convert alternating current (AC) energy into direct current (DC) energy. Power converter **412** also may change the frequency of alternating current energy as another example. In yet another example, power converter **412** may change the current flow. Power converter **412** may be used when a power source, such as an electrical outlet, is present. In these illustrative examples, power converter **412** converts energy into electrical energy **401** for use by an unmanned aerial vehicle.

Turning now to FIG. **5**, an illustration of a block diagram of a sensor system is depicted in accordance with an advantageous embodiment. Sensor system **500** is an example of one implementation for sensor system **212** in FIG. **2**. In these illustrative examples, sensor system **500** generates sensor data **501**. Sensor system **500**, in this example, includes camera system **502**, global positioning system unit **504**, weather sensors **506**, and motion detector **508**.

Camera system **502** may comprise number of cameras **510**. Number of cameras **510** may include at least one of visible light camera **512**, infrared camera **514**, and other suitable types of cameras. In some advantageous embodiments, visible light camera **512** and infrared camera **514** are combined as part of a multispectral camera.

Camera system **502** generates sensor data **501** in the form of image data **518**. Global positioning system unit **504** generates location information **520** in sensor data **501**. Location information **520** may include, for example, latitude, longitude, and an elevation. Additionally, time information **522** also may be generated by global positioning system unit **504**.

Weather sensors **506** generate weather data **524** in sensor data **501** that may be used to identify weather conditions. For example, weather sensors **506** may generate information about wind speed, pressure, wind direction, humidity, temperature, and/or other suitable information.

Motion detector **508** generates motion data **526** in sensor data **501**. Motion detector **508** generates motion data **526** when motion in an area monitored by motion detector **508** is detected.

Turning now to FIG. **6**, an illustration of a block diagram of a charging station is depicted in accordance with an advantageous embodiment. Charging station **600** is an example of an implementation for a charging station within number of charging stations **208** in FIG. **2**.

Charging station **600** may comprise at least one of inductive charging system **602** and conductive charging system **604**. Inductive charging system **602** generates magnetic field **606**. Magnetic field **606** may induce another magnetic field in a coil located within the device being charged. In this manner, the current may be caused to flow in the device being charged without contact between inductive charging system **602** and the device.

Conductive charging system **604** includes contacts **608**. Contacts **608** may be placed in physical contact with contacts on the device being charged. This contact allows for electrical current **610** to flow from conductive charging system **604** to the device being charged by charging station **600**. In this manner, the device may be charged and/or recharged to perform additional operations or missions.

Turing now to FIG. **7**, an illustration of a block diagram of an unmanned aerial vehicle is depicted in accordance with an advantageous embodiment. Unmanned aerial vehicle **700** is an example of one implementation for number of unmanned aerial vehicles **214** in FIG. **2**.

In this illustrative example, unmanned aerial vehicle **700** may take a number of forms. For example, unmanned aerial vehicle **700** may be, for example, without limitation, airplane **702**, helicopter **704**, ornithopter **706**, or some other suitable type of aircraft.

As illustrated, unmanned aerial vehicle **700** comprises body **708**, propulsion system **710**, battery **712**, charging system **714**, processor unit **716**, storage device **718**, wireless communications device **720**, and number of sensors **722**. Body **708** provides a structure in which the different components of unmanned aerial vehicle **700** may be associated with each other. For example, without limitation, body **708** may be a fuselage. Further, body **708** may include aerodynamic surfaces, such as wings or other types of surfaces.

Propulsion system **710** is configured to move unmanned aerial vehicle **700** in the air. Propulsion system **710** may be, for example, without limitation, an electric motor configured to rotate a propeller or other type of blade. In other advantageous embodiments, propulsion system **710** may be configured to move wings on body **708** when unmanned aerial vehicle **700** takes the form of ornithopter **706**. Battery **712** provides electrical energy for unmanned aerial vehicle **700**.

Charging system **714** is connected to battery **712** and allows battery **712** to be recharged at a charging station. Charging system **714** may include inductive coils for an inductive charging system or conductive contacts for a conductive charging system. In some advantageous embodiments, charging system **714** also may be used to transfer data. As one illustrative example, charging system **714** may provide a modulated charge as a carrier frequency. This modulated charge allows for the transfer of data in addition to the providing of power.

As another illustrative example, conductive contacts in charging system **714** may be used to transfer data. In other advantageous embodiments, power may be provided wirelessly by charging system **714** using microwaves or a laser.

Processor unit **716** runs a number of programs for missions in these illustrative examples. Storage device **718** may store sensor data **724** generated by number of sensors **722**. Additionally, storage device **718** may store mission **726** that is executed or run by processor unit **716**. Mission **726** may be, for example, without limitation, a program, an identification of a target, and/or other suitable types of information.

Wireless communication device **720** is configured to provide communications between unmanned aerial vehicle **700** and a remote location, such as unmanned aerial vehicle base station **200** or remote location **240** in FIG. **2**. In these illustrative examples, number of sensors **722** may include, for example, at least one of visible light camera **728**, infrared light camera **730**, motion detector **732**, and/or other suitable types of sensors used to generate sensor data **724** for processing by processor unit **716**.

The illustration of unmanned aerial vehicle base station **200** and its components in FIGS. **2-6** and unmanned aerial vehicle **700** in FIG. **7** are not meant to imply physical or architectural limitations to the manner in which different advantageous embodiments may be implemented. Other components in addition to and/or in place of the ones illustrated may be used. Some components may be unnecessary in some advantageous embodiments. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined and/or divided into different blocks when implemented in different advantageous embodiments.

For example, in some advantageous embodiments, unmanned aerial vehicle base station **200** may not include movable cover system **218**. Instead, bay **216** may be configured to provide protection from environment **224** without moving parts. For example, bay **216** may be a cavity in platform **202** with an opening configured to protect number of unmanned aerial vehicles **214** from environment **224**. Additionally, in some advantageous embodiments, unmanned aerial vehicle **700** may not have wireless communications device **720**. Instead, a wired contact may be used to transfer data from unmanned aerial vehicle **700** to unmanned aerial vehicle base station **200** when unmanned aerial vehicle **700** lands on platform **202**.

With reference now to FIG. **8**, an illustration of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. In this illustrative example, unmanned aerial vehicle base station **800** is an example of one implementation for unmanned aerial vehicle base station **200** in FIG. **2**. A top view of unmanned aerial vehicle base station **800** is depicted in this figure.

In this depicted example, unmanned aerial vehicle base station **800** has platform **802**. In this illustrative example, platform **802** has a circular shape. In other advantageous embodiments, platform **802** may have some other suitable shape. Charging stations **804**, **806**, **808**, and **810** are located in bay **812** in platform **802**. Charging stations **804**, **806**, **808**, and **810** take the form of inductive charging stations in this illustrative example. Platform **802** is also associated with antenna **814**. Antenna **814** transmits information over a wireless communications link.

As depicted, unmanned aerial vehicle base station **800** has movable cover system **816**. Movable cover system **816** comprises panels **818**, **820**, **822**, and **824**. In this illustrative example, movable cover system **816** is in an open configuration.

As depicted, photovoltaic arrays **826**, **828**, **830**, and **832** are present on panels **818**, **820**, **822**, and **824**, respectively. These arrays form part of a power generation system for unmanned aerial vehicle base station **800**.

With reference now to FIG. **9**, a cross-sectional side view of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. In this illustrative example, a cross-sectional side view of unmanned aerial vehicle base station **800** is depicted. As illustrated, unmanned aerial vehicle base station **800** is shown in an open configuration.

As seen in this view, photovoltaic array **832** is on top side **900** of panel **824**. Photovoltaic array **828** is on top side **902** of panel **820**.

Side **904** of panel **824** and side **906** of panel **820** provide a protective shell for bay **812** when these panels are in a closed configuration. In this illustrative example, panel **820** may move in the direction of arrow **907**, and panel **824** may move in the direction of arrow **908** to cover bay **812** when these panels are moved into the closed configuration. The movement of these panels and the other panels (not shown) may be performed using a number of actuators, a gear system, or some other suitable device.

In this illustrative example, battery **910** and controller **912** are located within platform **802**. In these examples, battery **910** and controller **912** are located under bay **812**.

With reference now to FIG. **10**, an illustration of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment.

In this illustrative example, unmanned aerial vehicle base station **800** is shown in a cross-sectional side view with movable cover system **816** in a closed configuration. As can be seen in this example, unmanned aerial vehicles **1000** and **1002** are located within bay **812**. These unmanned aerial vehicles are protected from the environment with movable cover system **816** in the closed position.

With reference now to FIG. **11**, an illustration of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. In this illustrative example, unmanned aerial vehicle base station **1100** is an example of another implementation for unmanned aerial vehicle base station **200** in FIG. **2**.

In this illustrative example, unmanned aerial vehicle base station **1100** comprises platform **1102**. Platform **1102** has unmanned aerial vehicle platforms **1104**, **1106**, **1108**, and **1110**. These unmanned aerial vehicle platforms are configured to allow unmanned aerial vehicles to land and recharge. In this example, charging stations **1112**, **1114**, **1116**, and **1118** are present on unmanned aerial vehicle platforms **1104**, **1106**, **1108**, and **1110**, respectively.

In this illustrative example, platform **1102** has support members **1120** and **1122**. Support member **1120** and support member **1122** are configured to support platform **1102** on power line **1123** and power line **1124**. These members may take the form of legs that bend in one direction but not the reverse direction. In this manner, the legs bend over power line **1123** and power line **1124** in one direction to provide stability for platform **1102** on one side of platform **1102**. However, by not bending in the reverse direction, the legs provide rigidity to platform **1102** on the other side. These members also may include weights **1125**, **1127**, **1129**, and **1131** to reduce tipping of platform **1102**. Support member **1120** and support member **1122** also may be adjustable in length. In this manner, platform **1102** may be placed between power lines with different spacing between the power lines.

Further, in these illustrative examples, coils **1126**, **1128**, **1130**, and **1132** are present. These coils are configured to generate a magnetic field and current in response to alternating current flowing through power lines **1123** and **1124**. These coils are part of a power generation system for unmanned aerial vehicle base station **1100**. More specifically, these coils may be part of an inductive power generation unit, such as inductive power generation unit **406** in FIG. **4**.

Turning now to FIG. **12**, an illustration of a perspective view of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. In this illustrative example, unmanned aerial vehicle base station **1200** is an example of yet another implementation for unmanned aerial vehicle base station **200** in FIG. **2**.

In this illustrative example, unmanned aerial vehicle base station **1200** is depicted in a partially-exposed view. Unmanned aerial vehicle base station **1200** comprises platform **1202**. Platform **1202** may have members **1204** and **1206**. These members provide support for unmanned aerial vehicle base station **1200** on power lines **1208** and **1210**.

In this exposed view, bay **1212** can be seen inside platform **1202**. Bay **1212** has opening **1214**, which may be covered by door **1216**. Door **1216** may open and close to protect unmanned aerial vehicles from the environment. In these illustrative examples, door **1216** may be opened and closed using an actuator system, a gear system, and/or some other suitable device capable of moving door **1216**.

Additionally, in this exposed view, charging stations **1218**, **1220**, **1222**, and **1224** may be seen inside bay **1212**. In this illustrative example, controller **1226** may be located in section **1228** of platform **1202**. Additionally, battery **1230** and inductive power generation unit **1232** may be located in section **1234** of platform **1202**. Section **1234** may be isolated from section **1228** using insulators **1236**. Electrical connections between battery **1230** and charging stations **1218**, **1220**, **1222**, and **1224** and controller **1226** may be made through wires extending through insulators **1236**.

Satellite communications array **1238** is an example of an antenna that is part of controller **1226** and used to establish wireless communications links.

With reference now to FIG. **13**, another illustration of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. In this illustrative example, unmanned aerial vehicle base station **1300** is an example of another implementation for unmanned aerial vehicle base station **200** in FIG. **2**.

In this illustrative example, unmanned aerial vehicle base station **1300** is deployed on rooftop **1303** of building **1304**. Unmanned aerial vehicle base station **1300** has platform **1302** with unmanned aerial vehicle platforms **1305**, **1306**, and **1308**. Charging stations **1310**, **1314** and **1316** are located on unmanned aerial vehicle platforms **1305**, **1306**, and **1308**, respectively.

Additionally, unmanned aerial vehicle base station **1300** has movable cover **1318**. In this illustrative example, unmanned aerial vehicle base station **1300** also has controller **1320**. Controller **1320** is in housing **1321**, which is a separate structure from platform **1302**.

In this illustrative example, unmanned aerial vehicle base station **1300** may not require a battery system or power generation system. Instead, unmanned aerial vehicle base station **1300** has transformer **1324** located inside of controller **1320**. Transformer **1324** may be connected to electrical connection **1326** on rooftop **1303** of building **1304**. Electrical connection **1326** is used by transformer **1324** to provide power to unmanned aerial vehicle base station **1300**.

Turning now to FIG. **14**, an illustration of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. In this illustrative example, movable cover **1318** for unmanned aerial vehicle base station **1300** is in a closed position, providing shelter to any unmanned aerial vehicles that may be on platforms **1305**, **1306**, and/or **1308** (not shown).

With reference now to FIG. **15**, an illustration of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. In this example, a top-exposed view of unmanned aerial vehicle base station **1500** is depicted. Unmanned aerial vehicle base station **1500** is an example of yet another implementation for unmanned aerial vehicle base station **200** in FIG. **2**. Unmanned aerial vehicle base station **1500** is shown as being integrated into vehicle **1502**.

In this illustrative example, platform **1503** has charging station **1504** located within bay **1505**. As depicted, charging station **1504** comprises conductive lines **1506**.

Unmanned aerial vehicles **1508**, **1510**, **1512**, and **1514** in bay **1505** are located on charging station **1504**. Conductive lines **1506** provide for charging through contact between conductive lines **1506** and contacts on unmanned aerial vehicles **1508**, **1510**, **1512**, and **1514**.

In this illustrative example, unmanned aerial vehicle base station **1500** also includes controller **1520**. Battery system **1522** provides power to charging station **1504**. Battery system **1522** is charged by alternator **1524** in vehicle **1502** in these illustrative examples. Antenna **1526** provides for transmission of signals by controller **1520** to exchange information with a remote location. Antenna **1528** provides for communications with unmanned aerial vehicles **1508**, **1510**, **1512**, and **1514**.

In other illustrative examples, unmanned aerial vehicle base station **1500** may have side panels associated with bay **1505**. These side panels may be used to provide additional landing space for unmanned aerial vehicles **1508**, **1510**, **1512**, and **1514** and/or reduce the number of collisions between these unmanned aerial vehicles.

Turning now to FIG. **16**, an illustration of a side view of an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. In this example, a partially-exposed side view of unmanned aerial vehicle base station **1500** is illustrated. In some advantageous embodiments, unmanned aerial vehicle base station **1500** also may include an energy harvesting system. Unmanned aerial vehicle base station **1500** also may be designed to be removable from vehicle **1502** for deployment in the field.

As depicted in this illustrative example, unmanned aerial vehicle base station **1500** has movable cover system **1600**. Movable cover system **1600** takes the form of movable door **1602**. Movable door **1602** is seen in partially open position **1604** and fully open position **1606**. Movable door **1602** may be closed to cover bay **1505**.

Next, FIGS. **17-19** are illustrative examples of implementations for number of unmanned aerial vehicles **214** in FIG. **2**. Turning now to FIG. **17**, an illustration of an unmanned aerial vehicle is depicted in accordance with an advantageous embodiment. In this illustrative example, unmanned aerial vehicle **1700** is an example of one implementation for one of number of unmanned aerial vehicles **214** in FIG. **2**. In this depicted example, unmanned aerial vehicle **1700** takes the form of airplane **1702**.

Turning now to FIG. **18**, an illustration of an unmanned aerial vehicle is depicted in accordance with an advantageous embodiment. Unmanned aerial vehicle **1800** is an example of another implementation of an unmanned aerial vehicle in number of unmanned aerial vehicles **214** in FIG. **2**. In this illustrative example, unmanned aerial vehicle **1800** takes the form of helicopter **1802**.

Turning now to FIG. **19**, an illustration of an unmanned aerial vehicle is depicted in accordance with an advantageous embodiment. Unmanned aerial vehicle **1900** is an example of yet another implementation of an unmanned aerial vehicle in number of unmanned aerial vehicles **214** in FIG. **2**. In this illustrative example, unmanned aerial vehicle **1900** may take the form of direct lift vehicle **1902**.

The illustrations of unmanned aerial vehicles in FIGS. **17-19** are not meant to imply physical or architectural limitations to the manner in which different unmanned aerial vehicles may be implemented for use with an unmanned aerial vehicle base station. Other types of unmanned aerial vehicles may be used in addition to or in place of the ones illustrated.

For example, in some advantageous embodiments, an ornithopter may be employed for an unmanned aerial vehicle. In still other advantageous embodiments, the unmanned aerial vehicles may be larger or smaller than the ones illustrated in these examples.

Further, the number of unmanned aerial vehicles may be heterogeneous or homogeneous. In other words, the same type of unmanned aerial vehicles may be present in an unmanned aerial vehicle base station or different types of unmanned aerial vehicles may be used.

In some advantageous embodiments, heterogeneous unmanned aerial vehicles are launched sequentially, as compared to simultaneously. For example, different types of micro air vehicles may be launched sequentially or one at a time. The type of micro air vehicles launched in this example may be based on data to be collected at a ground station in some illustrative examples.

With reference now to FIG. **20**, an illustration of a flowchart of a process for operating an unmanned aerial vehicle base station is depicted in accordance with an advantageous embodiment. The process in FIG. **20** may be implemented using unmanned aerial vehicle base station **200** and number of unmanned aerial vehicles **214** in FIG. **2**.

The process begins by moving an unmanned aerial vehicle to a charging station in a number of charging stations for an unmanned aerial vehicle base station (operation **2000**). In these examples, the unmanned aerial vehicle base station comprises a platform configured to house a number of unmanned aerial vehicles, a battery system configured to store electrical energy, a power generation system connected to the battery system and configured to generate the electrical energy stored in the battery system, the number of charging stations connected to the battery system, and a controller connected to the battery system.

The controller is configured to receive sensor data from the number of unmanned aerial vehicles, generate information from the sensor data, and send the information to a remote location. The power generation system is configured to generate electrical energy from an environment in which the platform is located. Each charging station in the number of charging stations is configured to charge the number of unmanned aerial vehicles.

The unmanned aerial vehicle is charged at the charging station (operation **2002**). The unmanned aerial vehicle is flown to a location after charging the unmanned aerial vehicle (operation **2004**). The sensor data is sent to the controller (operation **2006**), with the process terminating thereafter. In these illustrative examples, the process illustrated in FIG. **20** may be performed each time the unmanned aerial vehicle needs to be recharged.

With reference now to FIG. **21**, an illustration of a flowchart of a process for processing sensor data is depicted in accordance with an advantageous embodiment. The process in FIG. **21** may be implemented using unmanned aerial vehicle base station **200** in FIG. **2**.

The process begins by receiving sensor data from an unmanned aerial vehicle (operation **2100**). The process adds metadata to the sensor data (operation **2102**). This metadata may be, for example, without limitation, an identification of the unmanned aerial vehicle submitting the data, a location of the unmanned aerial vehicle, a time stamp, and/or other suitable information. In some advantageous embodiments, this operation may be optional if the unmanned aerial vehicle provides this information in the sensor data.

The process then stores the sensor data and the metadata (operation **2104**), with the process then returning to operation **2100** to receive more sensor data from the unmanned aerial vehicle.

With reference now to FIG. **22**, an illustration of a flowchart for processing sensor data is depicted in accordance with an advantageous embodiment. The process illustrated in FIG. **22** is an example of a process that may be implemented in an unmanned aerial vehicle, such as unmanned aerial vehicle **700** in FIG. **7**. In particular, this process may be implemented in processor unit **716** in FIG. **7**. In some advantageous embodiments, this process may be implemented in unmanned aerial vehicle base station **200** using controller **210** in FIG. **2**.

The process begins by receiving sensor data from the sensor system (operation **2200**). This sensor data may be, for example, an image or video stream. A determination is made as to whether the sensor data is of interest (operation **2202**). This determination may be made on the unmanned aerial vehicle and/or at the unmanned aerial vehicle base station. This determination may be made in a number of different ways. For example, the unmanned aerial vehicle may be programmed to look for a particular object, such as a particular vehicle type with a particular color. This information may be part of the mission programmed into the unmanned aerial vehicle.

In other advantageous embodiments, this determination may be made by comparing the image with a prior image from a prior flyover of the location. For example, a change in pixels between the current image and a prior image of the same road may indicate that the sensor data is sensor data of interest.

If the sensor data is sensor data of interest, the sensor data is tagged (operation **2204**). In this example, some sort of indicator may be added to the sensor data to identify the image as one of interest. In addition, other information may be added including, for example, an identification of the unmanned aerial vehicle, the location at which the image was taken, and/or the attitude and relative position of the unmanned aerial vehicle relative to the location where the image was taken.

The process then stores the sensor data (operation **2206**), with the process terminating thereafter. With reference again to operation **2202**, if the sensor data is not sensor data of interest, the process may add metadata to the image (operation **2208**). This metadata may include, for example, metadata as described above, with respect to operation **2204**. The process then proceeds to operation **2206**.

In some advantageous embodiments, the information may also be transmitted to the unmanned aerial vehicle base station from the unmanned aerial vehicle instead of being stored on the unmanned aerial vehicle, depending on the particular implementation. In some advantageous embodiments, if the sensor data is not of interest, the sensor data may be discarded.

With reference now to FIG. **23**, an illustration of a flowchart for processing sensor data to form information is depicted in accordance with an advantageous embodiment. The process illustrated in FIG. **23** may be implemented in unmanned aerial vehicle base station **200** in FIG. **2**. In particular, the process may be implemented in controller **210** in FIG. **2**. This process may be used by controller **210** to process data as the data is received from the unmanned aerial vehicle. In other advantageous embodiments, this processing of data may be performed at a later time.

The process begins by selecting an unprocessed portion of sensor data (operation **2300**). The size of the unprocessed portion of sensor data may vary, depending on the particular implementation. For example, the unprocessed portion may be a single image or may be several minutes of video data. The process determines whether the portion of data is of interest (operation **2302**). This operation may be performed using various processes or programs. For example, processes looking for changes in images that indicate the presence of improvised explosive devices may be used. The initial data flagged by the unmanned aerial vehicle can be processed to determine whether the change indicates that an improvised explosive device may be present.

Further, processes such as optical moving target indications used to find vehicles also may be used in this operation. Of course, other processes may be used, depending on the particular data that is desired to be identified.

If the portion of data is of interest, the process tags the portion of data as being data of interest (operation **2304**). Thereafter, the process stores the portion of data (operation **2306**). A determination is made as to whether additional unprocessed portions of data are present (operation **2308**). If additional unprocessed portions of data are present, the process returns to operation **2300**. Otherwise, the process terminates.

With reference again to operation **2302**, if the portion of data is not of interest, the process then proceeds to operation **2306** as discussed above. In some advantageous embodiments, in operation **2306**, the process may also transmit the data over a communications link to a remote location in addition to or in place of storing the data.

With reference now to FIG. **24**, an illustration of a flowchart of a process for sending information to an unmanned aerial vehicle is depicted in accordance with an advantageous embodiment. The process illustrated in FIG. **24** may be implemented in unmanned aerial vehicle base station **200** in FIG. **2**. In particular, the process may be implemented in controller **210** in FIG. **2**.

The process begins by identifying the location of the unmanned aerial vehicle base station (operation **2400**). Thereafter, the process generates differential global positioning system information (operation **2402**). Differential global positioning system information is information that may be used by the unmanned aerial vehicle to identify the location of the unmanned aerial vehicle based on the location of the unmanned aerial vehicle base station.

The process then transmits the differential global positioning system information to the number of unmanned aerial vehicles (operation **2404**), with the process terminating thereafter.

With reference now to FIG. **25**, an illustration of a flowchart of a process for changing a mission is depicted in accordance with an advantageous embodiment. The process illustrated in FIG. **25** may be implemented in unmanned aerial vehicle base station **200** in FIG. **2** and in particular, in controller **210** in FIG. **2**.

The process begins by receiving weather data (operation **2500**). A determination is made as to whether changes to the mission are needed based on the weather data (operation **2502**). This determination may include, for example, without limitation, whether different flight paths should be used to take advantage of tail winds or to avoid undesirable conditions.

Additionally, this determination in operation **2502** also may include changing the mission, such as recalling the number of unmanned aerial vehicles if the analysis determines that the weather conditions may affect the capability of the

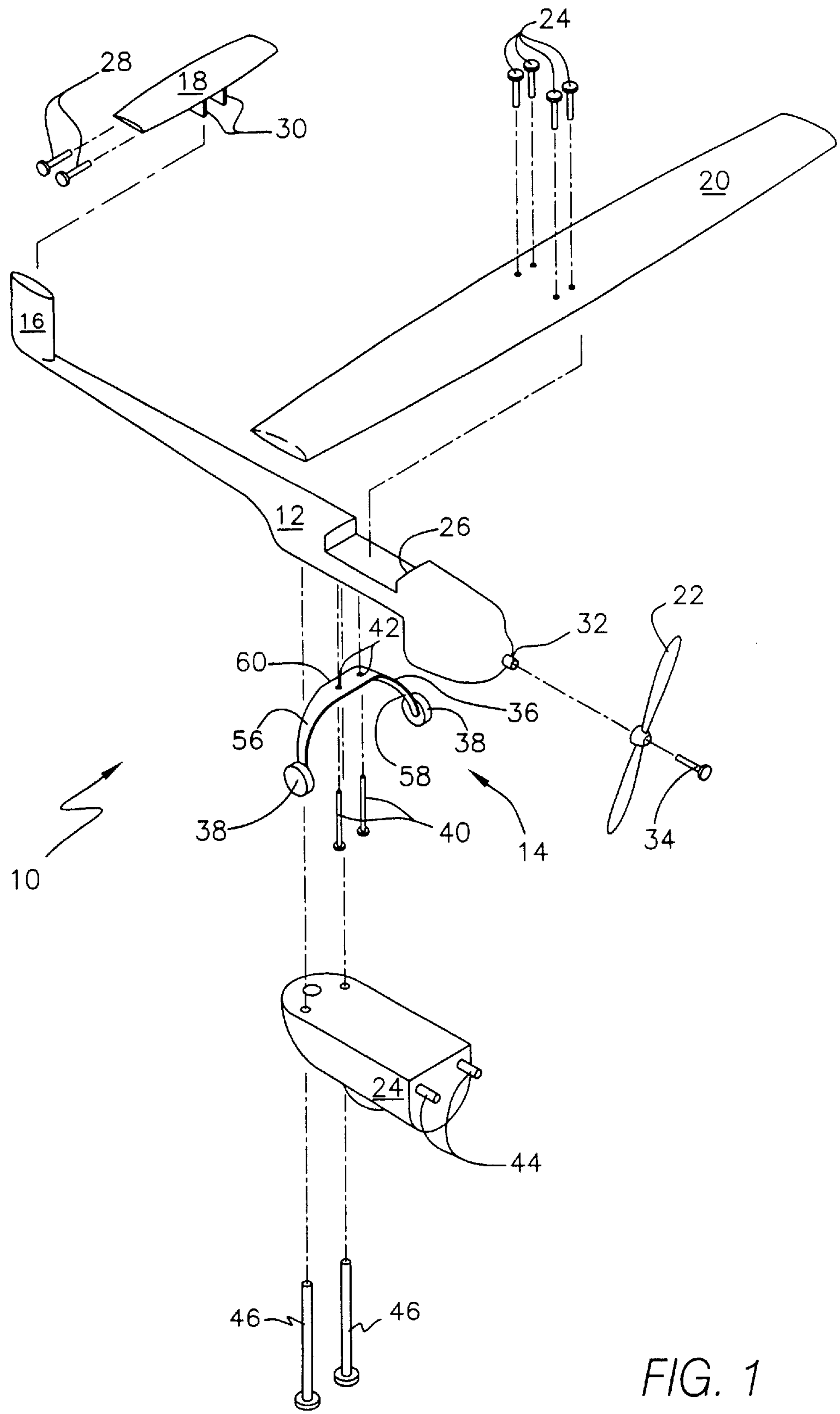

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FIG. 1

11. The apparatus of claim **1** further comprising:

a sensor system associated with the platform.

12. The apparatus of claim **1**, wherein the platform is configured to be associated with a structure selected from one of a set of power lines and a vehicle.

13. The apparatus of claim **1**, wherein the platform, the battery system, the power generation system, the number of charging stations, and the controller form an unmanned aerial vehicle base station and further comprising:

a number of additional unmanned aerial vehicle base stations.

14. An apparatus comprising:

a platform configured to house a plurality of unmanned aerial vehicles;

a number of charging stations, wherein each charging station in the number of charging stations is configured to charge the plurality of unmanned aerial vehicles; and

a controller configured to receive sensor data from the plurality of unmanned aerial vehicles;

wherein the number of charging stations comprises at least one of a number of inductive coupling systems configured to generate a magnetic field that cause a current to flow in a coil in an unmanned aerial vehicle that charges a battery in the unmanned aerial vehicle and a number of electrical pads configured to make electrical contact with a pad on the unmanned aerial vehicle.

15. The apparatus of claim **14** further comprising:

a battery system connected to the number of charging stations and the controller; and

a power generation system connected to the battery system, wherein the power generation system is configured to generate electrical energy from an environment in which the platform is located, and store the electrical energy in the battery system.

16. The apparatus of claim **14**, wherein the number of charging stations and the controller are connected to an external source power electrical energy.

17. The apparatus of claim **14**, wherein the controller is configured to generate information from the sensor data and send the information to a remote location.

18. The apparatus of claim **14** further comprising:

a liquid refueling system connected to the number of charging stations, wherein the liquid refueling system provides liquid fuel to the number of charging stations to charge the plurality of unmanned aerial vehicles.

19. The apparatus of claim **14** further comprising:

an energy storage device connected to the number of charging stations and selected from at least one of a battery system, a capacitor, a flywheel, and a compressed air device.

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