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Ward

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(54) **AMMONIA DETECTION**

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

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(22) Filed: **Oct. 5, 2010**

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B64G 1/36 (2006.01)

(52) **U.S. Cl.**
USPC **701/13**

(58) **Field of Classification Search**
None
See application file for complete search history.

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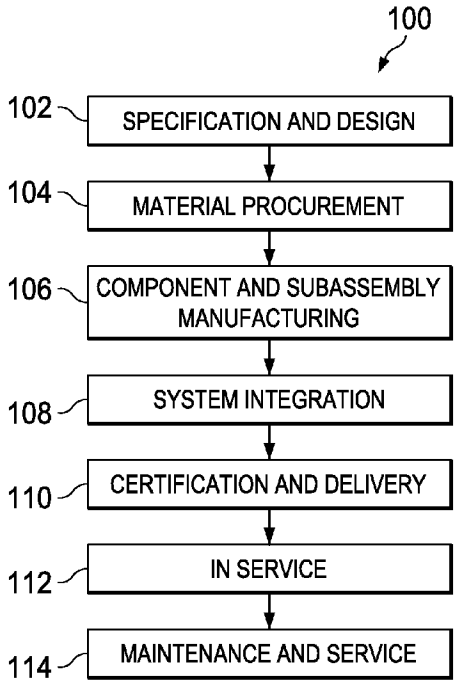
(57) **ABSTRACT**

The different advantageous embodiments provide for identifying gas leakage in a platform. A processor unit identifies a rate of the gas of the substance leaking from a container in a first compartment for a platform. The processor unit also identifies an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time. The processor unit identifies an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments. The processor unit determines whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas.

20 Claims, 6 Drawing Sheets



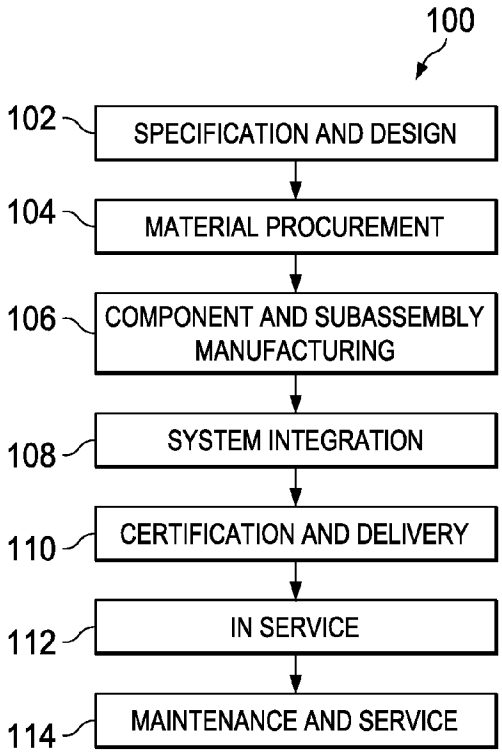

100
102
SPECIFICATION AND DESIGN
104
MATERIAL PROCUREMENT
106
COMPONENT AND SUBASSEMBLY MANUFACTURING
108
SYSTEM INTEGRATION
110
CERTIFICATION AND DELIVERY
112
IN SERVICE
114
MAINTENANCE AND SERVICE

FIG. 1

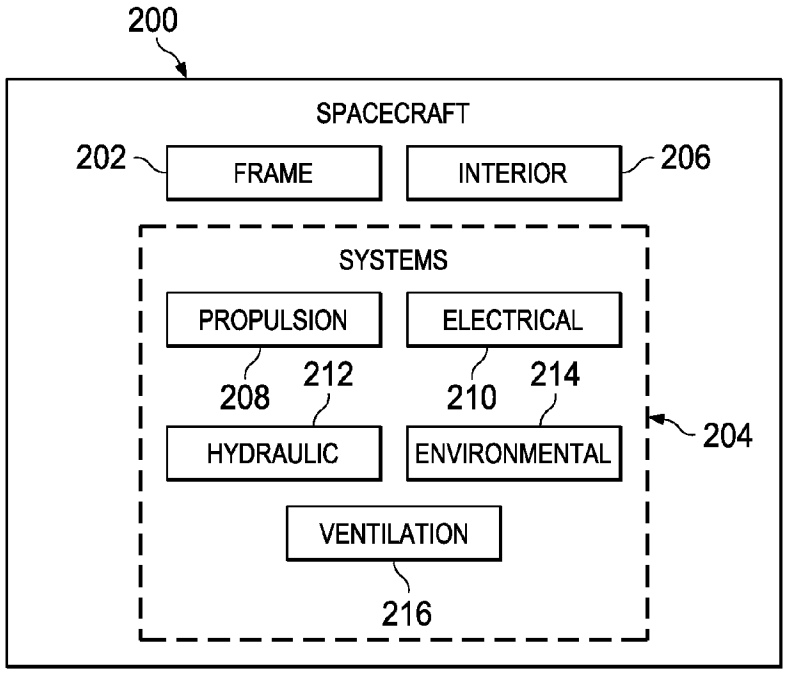
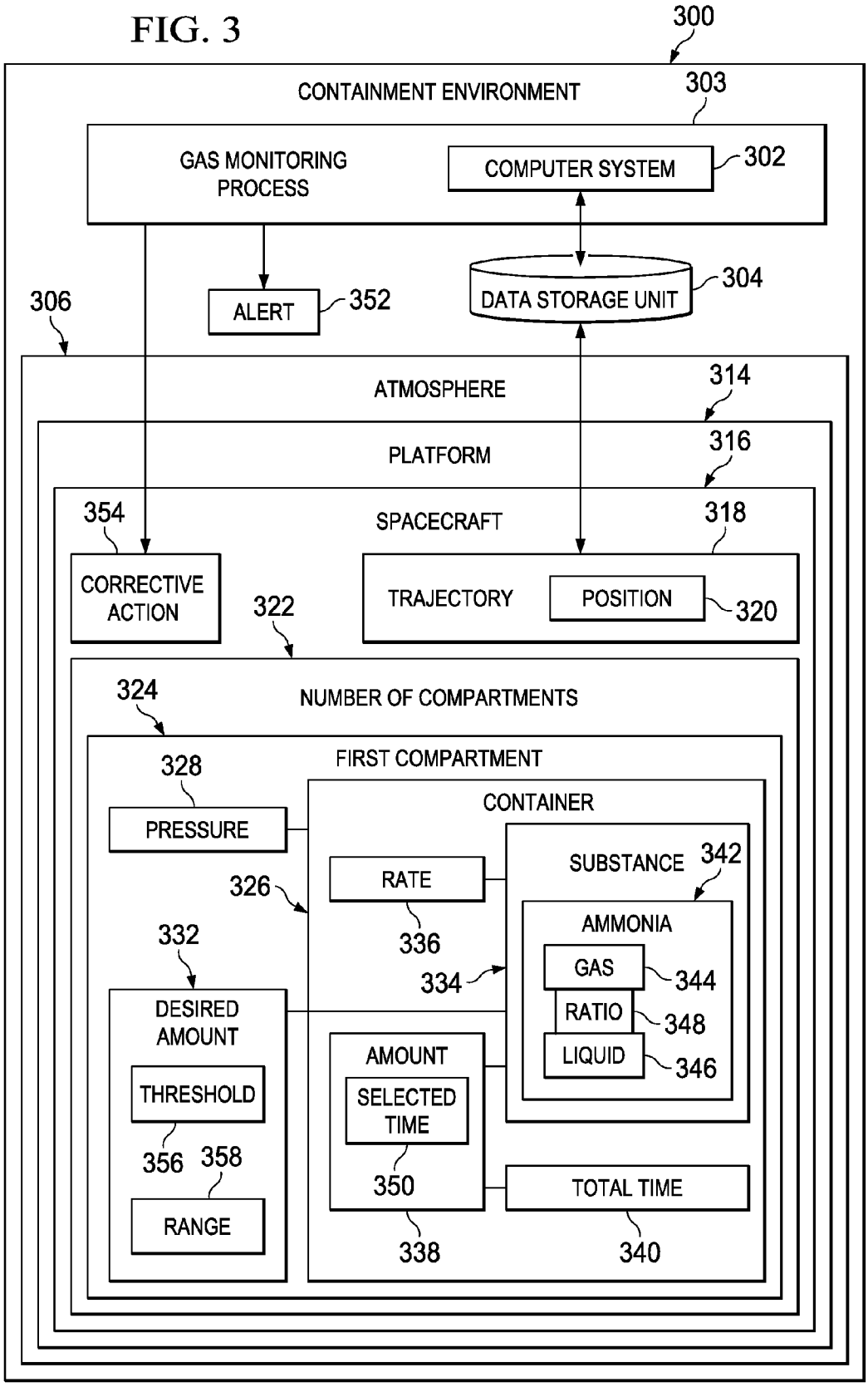

200
SPACECRAFT
202
FRAME
INTERIOR
206
SYSTEMS
PROPULSION
ELECTRICAL
208
212
210
214
HYDRAULIC
ENVIRONMENTAL
204
VENTILATION
216

FIG. 2

FIG. 3


300
CONTAINMENT ENVIRONMENT
303
GAS MONITORING PROCESS
COMPUTER SYSTEM
302
ALERT
352
DATA STORAGE UNIT
304
306
ATMOSPHERE
314
PLATFORM
316
354
SPACECRAFT
318
CORRECTIVE ACTION
TRAJECTORY
POSITION
320
322
324
NUMBER OF COMPARTMENTS
328
FIRST COMPARTMENT
CONTAINER
PRESSURE
SUBSTANCE
342
RATE
326
AMMONIA
332
336
GAS
344
334
RATIO
348
DESIRED AMOUNT
LIQUID
346
AMOUNT
THRESHOLD
SELECTED TIME
356
358
350
TOTAL TIME
RANGE
338
340

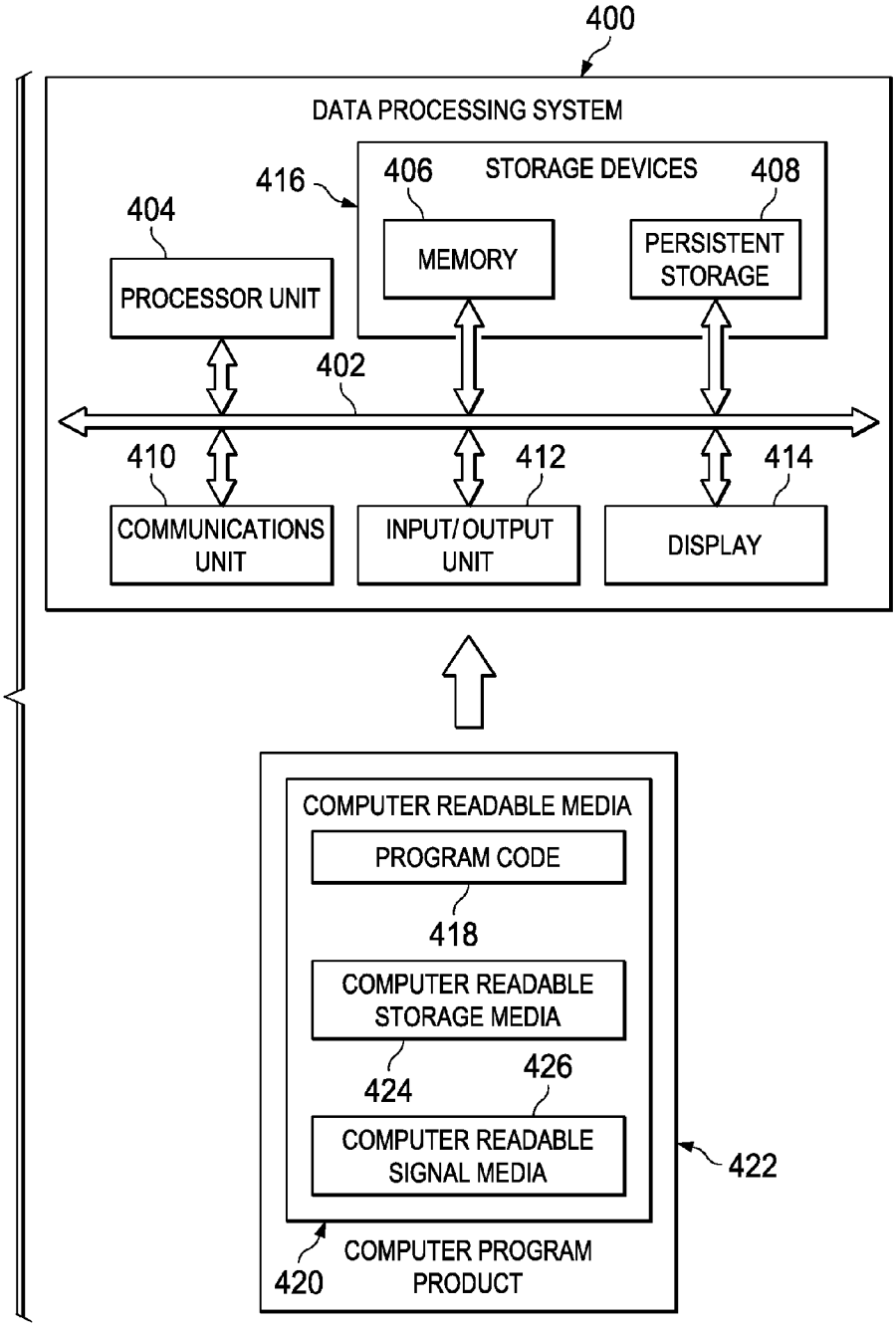

400
DATA PROCESSING SYSTEM
416
406
STORAGE DEVICES
408
404
MEMORY
PERSISTENT STORAGE
PROCESSOR UNIT
402
410
412
414
COMMUNICATIONS UNIT
INPUT/OUTPUT UNIT
DISPLAY
COMPUTER READABLE MEDIA
PROGRAM CODE
418
COMPUTER READABLE STORAGE MEDIA
424
426
COMPUTER READABLE SIGNAL MEDIA
422
420
COMPUTER PROGRAM PRODUCT

FIG. 4

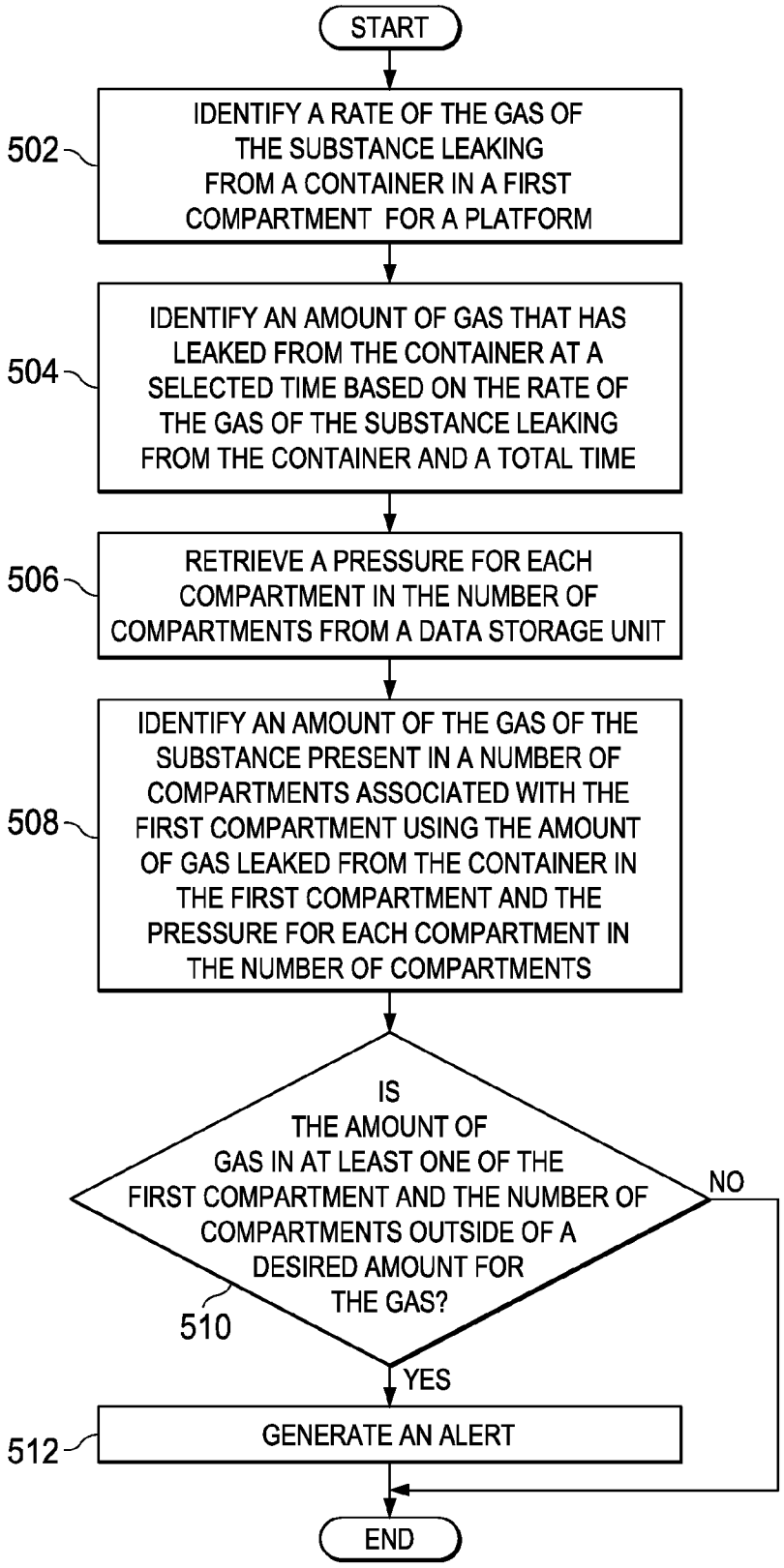
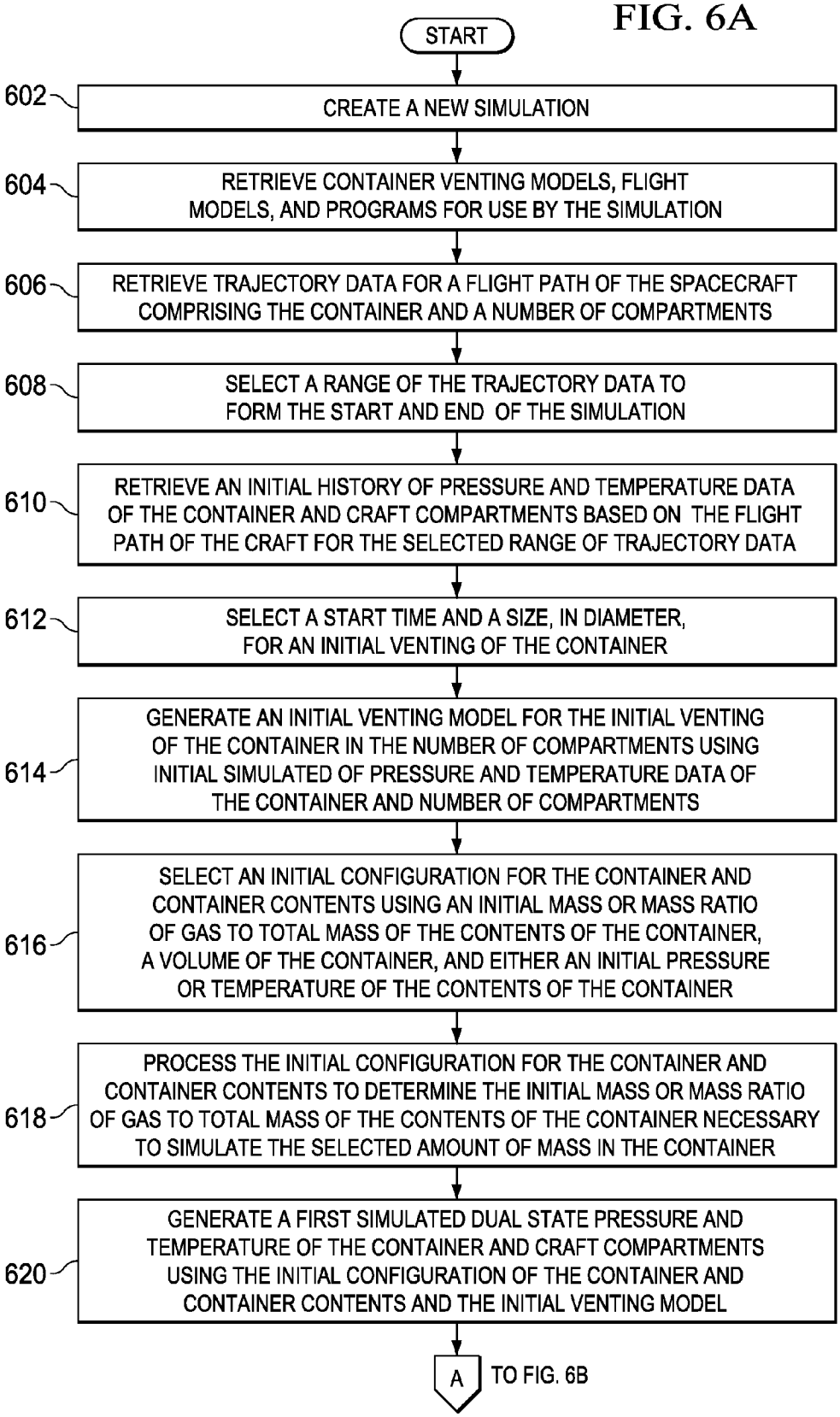

START
502
IDENTIFY A RATE OF THE GAS OF THE SUBSTANCE LEAKING FROM A CONTAINER IN A FIRST COMPARTMENT FOR A PLATFORM
504
IDENTIFY AN AMOUNT OF GAS THAT HAS LEAKED FROM THE CONTAINER AT A SELECTED TIME BASED ON THE RATE OF THE GAS OF THE SUBSTANCE LEAKING FROM THE CONTAINER AND A TOTAL TIME
506
RETRIEVE A PRESSURE FOR EACH COMPARTMENT IN THE NUMBER OF COMPARTMENTS FROM A DATA STORAGE UNIT
508
IDENTIFY AN AMOUNT OF THE GAS OF THE SUBSTANCE PRESENT IN A NUMBER OF COMPARTMENTS ASSOCIATED WITH THE FIRST COMPARTMENT USING THE AMOUNT OF GAS LEAKED FROM THE CONTAINER IN THE FIRST COMPARTMENT AND THE PRESSURE FOR EACH COMPARTMENT IN THE NUMBER OF COMPARTMENTS
IS THE AMOUNT OF GAS IN AT LEAST ONE OF THE FIRST COMPARTMENT AND THE NUMBER OF COMPARTMENTS OUTSIDE OF A DESIRED AMOUNT FOR THE GAS?
510
NO
YES
512
GENERATE AN ALERT
END

FIG. 5

FIG. 6A


START
602
CREATE A NEW SIMULATION
604
RETRIEVE CONTAINER VENTING MODELS, FLIGHT MODELS, AND PROGRAMS FOR USE BY THE SIMULATION
606
RETRIEVE TRAJECTORY DATA FOR A FLIGHT PATH OF THE SPACECRAFT COMPRISING THE CONTAINER AND A NUMBER OF COMPARTMENTS
608
SELECT A RANGE OF THE TRAJECTORY DATA TO FORM THE START AND END OF THE SIMULATION
610
RETRIEVE AN INITIAL HISTORY OF PRESSURE AND TEMPERATURE DATA OF THE CONTAINER AND CRAFT COMPARTMENTS BASED ON THE FLIGHT PATH OF THE CRAFT FOR THE SELECTED RANGE OF TRAJECTORY DATA
612
SELECT A START TIME AND A SIZE, IN DIAMETER, FOR AN INITIAL VENTING OF THE CONTAINER
614
GENERATE AN INITIAL VENTING MODEL FOR THE INITIAL VENTING OF THE CONTAINER IN THE NUMBER OF COMPARTMENTS USING INITIAL SIMULATED OF PRESSURE AND TEMPERATURE DATA OF THE CONTAINER AND NUMBER OF COMPARTMENTS
616
SELECT AN INITIAL CONFIGURATION FOR THE CONTAINER AND CONTAINER CONTENTS USING AN INITIAL MASS OR MASS RATIO OF GAS TO TOTAL MASS OF THE CONTENTS OF THE CONTAINER, A VOLUME OF THE CONTAINER, AND EITHER AN INITIAL PRESSURE OR TEMPERATURE OF THE CONTENTS OF THE CONTAINER
618
PROCESS THE INITIAL CONFIGURATION FOR THE CONTAINER AND CONTAINER CONTENTS TO DETERMINE THE INITIAL MASS OR MASS RATIO OF GAS TO TOTAL MASS OF THE CONTENTS OF THE CONTAINER NECESSARY TO SIMULATE THE SELECTED AMOUNT OF MASS IN THE CONTAINER
620
GENERATE A FIRST SIMULATED DUAL STATE PRESSURE AND TEMPERATURE OF THE CONTAINER AND CRAFT COMPARTMENTS USING THE INITIAL CONFIGURATION OF THE CONTAINER AND CONTAINER CONTENTS AND THE INITIAL VENTING MODEL
A
TO FIG. 6B

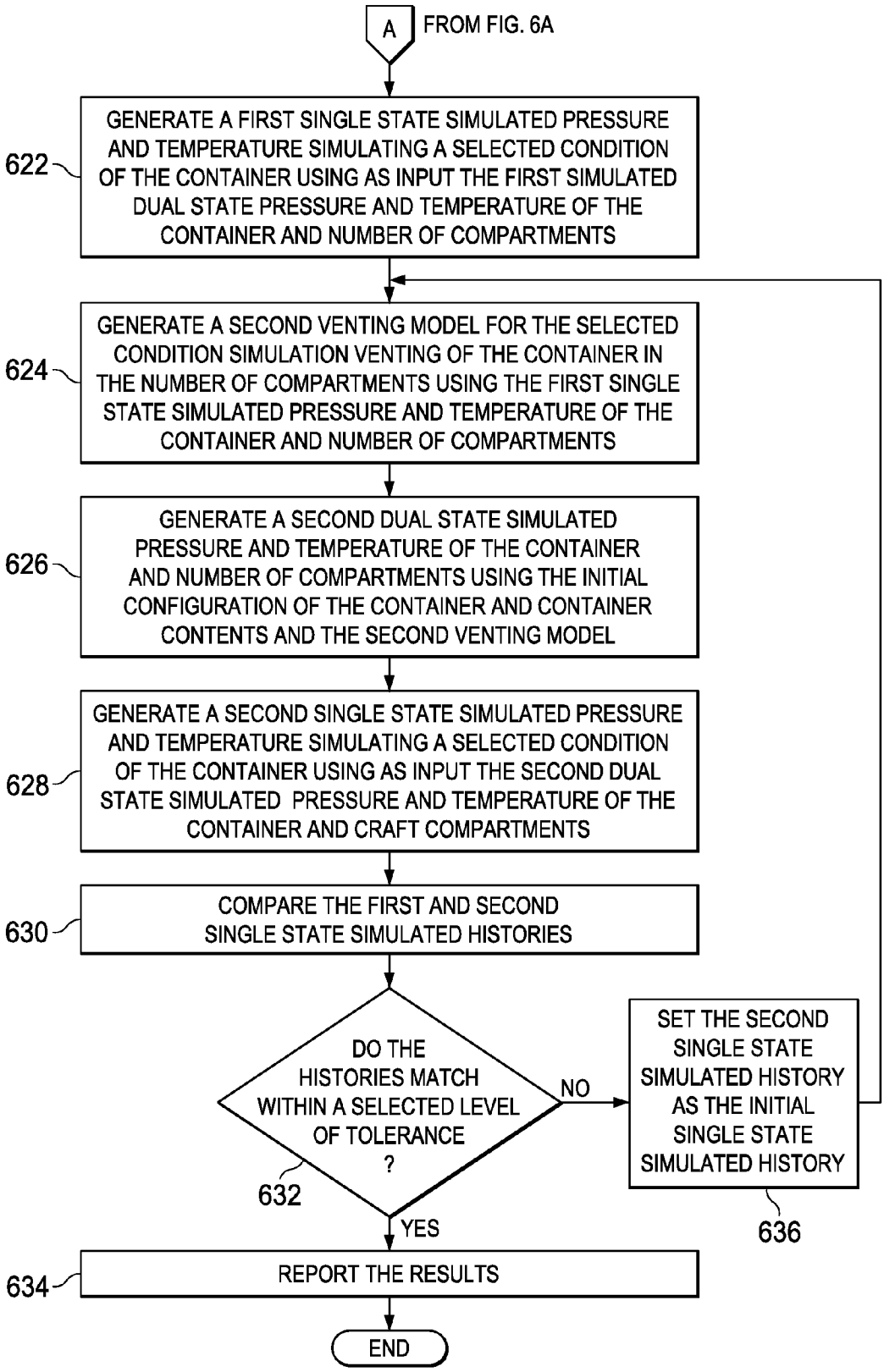

A
FROM FIG. 6A
622
GENERATE A FIRST SINGLE STATE SIMULATED PRESSURE AND TEMPERATURE SIMULATING A SELECTED CONDITION OF THE CONTAINER USING AS INPUT THE FIRST SIMULATED DUAL STATE PRESSURE AND TEMPERATURE OF THE CONTAINER AND NUMBER OF COMPARTMENTS
624
GENERATE A SECOND VENTING MODEL FOR THE SELECTED CONDITION SIMULATION VENTING OF THE CONTAINER IN THE NUMBER OF COMPARTMENTS USING THE FIRST SINGLE STATE SIMULATED PRESSURE AND TEMPERATURE OF THE CONTAINER AND NUMBER OF COMPARTMENTS
626
GENERATE A SECOND DUAL STATE SIMULATED PRESSURE AND TEMPERATURE OF THE CONTAINER AND NUMBER OF COMPARTMENTS USING THE INITIAL CONFIGURATION OF THE CONTAINER AND CONTAINER CONTENTS AND THE SECOND VENTING MODEL
628
GENERATE A SECOND SINGLE STATE SIMULATED PRESSURE AND TEMPERATURE SIMULATING A SELECTED CONDITION OF THE CONTAINER USING AS INPUT THE SECOND DUAL STATE SIMULATED PRESSURE AND TEMPERATURE OF THE CONTAINER AND CRAFT COMPARTMENTS
630
COMPARE THE FIRST AND SECOND SINGLE STATE SIMULATED HISTORIES
DO THE HISTORIES MATCH WITHIN A SELECTED LEVEL OF TOLERANCE ?
632
NO
SET THE SECOND SINGLE STATE SIMULATED HISTORY AS THE INITIAL SINGLE STATE SIMULATED HISTORY
636
YES
634
REPORT THE RESULTS
END

FIG. 6B

AMMONIA DETECTION

GOVERNMENT LICENSE RIGHTS

This invention was made with Government support under Boeing subcontract 6000132079 awarded by United Space Alliance under prime contract NNJ06VA01C awarded by NASA. The Government has certain rights in this invention.

BACKGROUND INFORMATION

1. Field

The present disclosure relates generally to substance detection and more particularly to identifying concentrations of ammonia. Still more particularly, the present disclosure provides a method and system for determining when an amount of ammonia is in a selected amount for a number of compartments.

2. Background

A spacecraft is a craft or machine designed for spaceflight. Spacecraft are used for a variety of purposes, including communications, earth observation, meteorology, navigation, planetary exploration and space tourism. Spacecraft are used to deliver materials and retrieve materials from the space station. Different materials may be retrieved for different reasons. However, one example is when the spacecraft is used to retrieve a container that is not working properly. The container may be an ammonia container. Containers of ammonia are used to supply cooling to different modules of the space station.

Each container has an attachment piece used to extract the ammonia. The attachment piece may allow ammonia to exit when not connected. The attachment piece may also allow ammonia to exit to an outside area even when connected. The ammonia that has exited the container may accumulate in different compartments of the spacecraft. The ammonia is not desirable when accumulated in a compartment with a certain concentration.

Current systems for determining the concentrations of ammonia only identify the concentration in the compartment where the container is located. These systems take the amount of ammonia that has been leaked and determine a concentration in the compartment. However, ammonia flows to other compartments as well. Therefore, the current systems do not have an accurate measurement of ammonia in the compartment.

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

SUMMARY

An advantageous embodiment of the present disclosure provides a method for identifying gas leakage in a platform. A processor unit identifies a rate of the gas of the substance leaking from a container in a first compartment for a platform. The processor unit also identifies an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time. The processor unit identifies an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments. The processor unit determines whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas.

Another advantageous embodiment of the present disclosure provides a data processing system for identifying gas leakage in a platform. The data processing system comprises a bus system, a storage device connected to the bus system, and a processing unit connected to the bus system. The storage device includes a set of instructions. The processor executes the set of instructions to identify a rate of the gas of the substance leaking from a container in a first compartment for a platform. The processor executes the set of instructions to identify an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time. The processor executes the set of instructions to identify an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments. The processor executes the set of instructions to determine whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas.

Another advantageous embodiment of the present disclosure provides a computer program product for identifying gas leakage in a platform. The computer program product comprises a computer recordable storage medium. The computer program product comprises program code, stored on the computer recordable storage medium, for identifying a rate of the gas of the substance leaking from a container in a first compartment for a platform. The computer program product comprises program code, stored on the computer recordable storage medium, for identifying an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time. The computer program product comprises program code, stored on the computer recordable storage medium, for identifying an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments. The computer program product comprises program code, stored on the computer recordable storage medium, for determining whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas.

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 a spacecraft manufacturing and service method in which an advantageous embodiment may be implemented;

FIG. **2** is an illustration of a spacecraft in accordance with an advantageous embodiment;

FIG. **3** is an illustration of a containment environment depicted in accordance with an advantageous embodiment;

FIG. **4** is an illustration of a data processing system depicted in accordance with an advantageous embodiment;

FIG. **5** is an illustration of a flowchart illustrating a process for identifying a concentration of a substance within a number of compartments depicted in accordance with an advantageous embodiment; and

FIGS. **6**A-**6**B are an illustration of a flowchart illustrating a process for identifying a concentration of a substance within a number of compartments depicted in accordance with an advantageous embodiment.

DETAILED DESCRIPTION

Referring more particularly to the drawings, embodiments of the disclosure may be described in the context of spacecraft manufacturing and service method **100** as shown in FIG. **1** and spacecraft **200** as shown in FIG. **2**. Turning first to FIG. **1**, an illustration of an spacecraft manufacturing and service method is depicted in accordance with an advantageous embodiment. During pre-production, spacecraft manufacturing and service method **100** may include specification and design **102** of spacecraft **200** in FIG. **2** and material procurement **104**.

During production, component and subassembly manufacturing **106** and system integration **108** of spacecraft **200** in FIG. **2** takes place. Thereafter, spacecraft **200** in FIG. **2** may go through certification and delivery **110** in order to be placed in service **112**. While in service by a customer, spacecraft **200** in FIG. **2** is scheduled for routine maintenance and service **114**, which may include modification, reconfiguration, refurbishment, and other maintenance or service.

Each of the processes of spacecraft manufacturing and service method **100** may be performed or carried out by a system integrator, a third party, and/or an operator. In these examples, the operator may be a customer. For the purposes of this description, a system integrator may include, without limitation, any number of spacecraft manufacturers and major-system subcontractors; a third party may include, without limitation, any number of venders, subcontractors, and suppliers; and an operator may be an airline, leasing company, military entity, service organization, and so on.

With reference now to FIG. **2**, an illustration of a spacecraft is depicted in which an advantageous embodiment may be implemented. In this example, spacecraft **200** is produced by spacecraft manufacturing and service method **100** in FIG. **1** and may include frame **202** with a plurality of systems **204** and interior **206**. Examples of plurality of systems **204** include one or more of propulsion system **208**, electrical system **210**, hydraulic system **212**, environmental system **214**, and ventilation system **216**. Any number of other systems may be included. One or more of these systems may be integrated and/or used in conjunction with one or more other systems. For example, ventilation system **216** may be powered by electrical system **210**, in one illustrative example. Although an aerospace example is shown, different advantageous embodiments may be applied to other industries, such as the automotive industry, marine vessel industry, military, and/or any other suitable industry.

Apparatus and methods embodied herein may be employed during at least one of the stages of spacecraft manufacturing and service method **100** in FIG. **1**. For example, the different advantageous embodiments may be implemented during routine maintenance and service **114** of spacecraft **200** in FIG. **2**.

In one illustrative example, components or subassemblies produced in component and subassembly manufacturing **106** in FIG. **1** may be fabricated or manufactured in a manner similar to components or subassemblies produced while spacecraft **200** is in service **112** in FIG. **1**. As yet another example, a number of apparatus embodiments, method embodiments, or a combination thereof may be utilized during production stages, such as component and subassembly manufacturing **106** and system integration **108** in FIG. **1**. As used herein, the phrase "a number of", when referring to items means, one or more items. For example, a number of apparatus embodiments is one or more apparatus embodiments. A number of apparatus embodiments, method embodiments, or a combination thereof may be utilized while spacecraft **200** is in service **112** and/or during maintenance and service **114** in FIG. **1**. The use of a number of the different advantageous embodiments may substantially expedite the assembly of and/or reduce the cost of spacecraft **200**.

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 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.

As used herein, when a first component is connected to a second component, the first component may be connected to the second component without any additional components. The first component also may be connected to the second component by one or more other components. For example, one electronic device may be connected to another electronic device without any additional electronic devices between the first electronic device and the second electronic device. In some cases, another electronic device may be present between the two electronic devices connected to each other.

The different advantageous embodiments recognize and take into account a number of different considerations. For example, the different advantageous embodiments recognize and take into account that current systems and methods for identifying ammonia leakage in a spacecraft do not account for the different compartments and areas in the spacecraft. The ammonia leaks to the different compartments which have different pressurizations.

The different advantageous embodiments further recognize and take into account that current methods of identifying flow rate into an area of leakage for ammonia use only a single state of the ammonia in identifying flow rates and the amount of substance released into the area.

Thus, the different advantageous embodiments provide a method, data processing system, and computer program product for identifying gas leakage in a platform. A processor unit identifies a rate of the gas of the substance leaking from a container in a first compartment for a platform. The processor unit also identifies an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time. The processor unit also identifies an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments. The processor unit also determines whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas.

With reference now to FIG. **3**, an illustration of a containment environment depicted in accordance with an advantageous embodiment. Containment environment **300** may be implemented in a component such as spacecraft **200** in FIG. **2**, for example.

Containment environment **300** may be any type of environment where containment of a substance is performed, for example. Containment environment **300** includes computer system **302**, data storage unit **304**, and atmosphere **306**.

Computer system **302** is a number of computers. When more than one computer is present in computer system **302**, the computers may communicate with each other using a network, wireless communications links, and other type of communications mechanisms. In these examples, gas monitoring process **303** runs on computer system **302**.

Computer system **302** may be a number of processors, a multi-processor core, or some other type of processor, depending on the particular implementation. A number, as used herein with reference to an item, means one or more items.

Data storage unit **304** may be a hard drive, a flash memory, a rewritable optical disk, a rewritable magnetic tape, or some combination of the above. Data storage unit **304** may store different data used by computer system **302**.

Atmosphere **306** may be space, the Earth's atmosphere, a body of water, or a combination thereof. Atmosphere **306** includes platform **314**. Platform **314** may be a type of vehicle, spacecraft **316**, spacecraft, tank, water vehicle, type of building, or some other type of area.

Spacecraft **316** has number of compartments **322**. Spacecraft **316** has trajectory **318**. Spacecraft **316** may be a vehicle used to transport materials to a space station. Spacecraft **316** may also transport materials back from the space station. Spacecraft **316** may be used for other types of mission as well.

For example, trajectory **318** may be the route or flight path for spacecraft **316**. Trajectory **318** may be predetermined or calculated during flight. Trajectory **318** may be a route from a space station to a home base or landing site. Trajectory **318** includes position **320**. Position **320** is a certain point in trajectory **318** for spacecraft **316**. In different embodiments, position **320** is a range on trajectory **318**.

Number of compartments **322** may be different compartments and areas in spacecraft **316**. Each compartment of number of compartments **322**, such as first compartment **324**, may be a portion of spacecraft **316** that is partially closed off to other portions of spacecraft **316**. Partially closed off may mean that movement of gasses between number of compartments **322** is substantially restricted. In different advantageous embodiments, number of compartments **322** may be determined by some other manner. For example, first compartment **324** may be the inside of a wing, the payload bay of spacecraft **316**, or some other area.

First compartment **324** may include container **326**, pressure **328**, and desired amount **332**. Container **326** may be an object used to hold substance **334**. Container **326** may also be a tank used to deliver substance **334**. Container **326** may include a nozzle which releases substance **334** at rate **336**. Rate **336** may change depending on the condition of the nozzle.

Container **326** includes substance **334**, rate **336** of substance **334** exiting container **326**, amount **338** of substance **334** that has exited container **326**, and total time **340** that substance **334** has been exiting container **326**. Substance **334** may be any type of chemical, gas, or liquid. In an advantageous embodiment, substance **334** is ammonia **342**. In different advantageous embodiments, substance **334** may be another chemical, such as, for example, a chemical used to provide coolant to spacecraft **316**. In other advantageous embodiments, substance **334** may be a chemical which is flammable or corrosive. Gas monitoring process **303** performs a process to monitor the distribution of substance **334** among number of compartments **322**.

Ammonia **342** may be in state **343** of gas **344** or liquid **346**. State **343** is the form that different phases of matter take on. Container **326** may include ammonia **342** in both the form of gas **344** and liquid **346** or just one these forms. When both gas **344** and liquid **346** are present, container **326** has ratio **348** of gas **344** to liquid **346**. Ammonia **342** may exit container **326** at rate **336**. Amount **338** of ammonia **342** may be the quantity of ammonia **342** exited from container **326** at selected time **350**. Total time **340** is the amount **338** of time ammonia **342** has exited container **326**.

Based on pressure **328**, amount **338** of ammonia **342** is allowed into first compartment **324**. Amount **338** may be desired amount **332** or not. When amount **338** is not desired amount **332**, computer system **302** may generate alert **352**. Alert **352** may be a audible alert, visual alert, record made, printout, or some other type of alert. In different advantageous embodiments, computer system **302** may perform corrective action **354**. Corrective action **354** may be a change of direction, a cancellation of a mission, a design change or some other type of corrective action. Desired amount **332** may be threshold **356** or range **358**.

The advantageous embodiments provide that with gas monitoring process **303** running on computer system **302**, identification of undesired amounts of ammonia **342** in a number of compartments is possible.

The illustration of containment environment **300** in FIG. **3** is not meant to imply physical or architectural limitations to the manner in which different advantageous embodiments may be implemented. Other components in addition 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, spacecraft **316** may be separate from platform **314**. In different advantageous embodiments, there may be multiple platforms and/or spacecrafts.

Turning now to FIG. **4**, an illustration of a data processing system is depicted in accordance with an advantageous embodiment. In this illustrative example, data processing system **400** includes communications fabric **402**, which provides communications between processor unit **404**, memory **406**, persistent storage **408**, communications unit **410**, input/output (I/O) unit **412**, and display **414**.

Processor unit **404** serves to execute instructions for software that may be loaded into memory **406**. Processor unit **404** may be a number of processors, a multi-processor core, or some other type of processor, depending on the particular implementation. A number, as used herein with reference to an item, means one or more items. Further, processor unit **404** may be implemented using a number of heterogeneous processor systems in which a main processor is present with secondary processors on a single chip. As another illustrative example, processor unit **404** may be a symmetric multi-processor system containing multiple processors of the same type.

Memory **406** and persistent storage **408** are examples of storage devices **416**. 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 on a permanent basis. Storage devices **416** may also be referred to as computer readable storage devices in these examples. Memory **406**, in these examples, may be, for example, a random access memory or any other suitable

volatile or non-volatile storage device. Persistent storage **408** may take various forms, depending on the particular implementation.

For example, persistent storage **408** may contain one or more components or devices. For example, persistent storage **408** 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 **408** also may be removable. For example, a removable hard drive may be used for persistent storage **408**.

Communications unit **410**, in these examples, provides for communications with other data processing systems or devices. In these examples, communications unit **410** is a network interface card. Communications unit **410** may provide communications through the use of either or both physical and wireless communications links.

Input/output unit **412** allows for input and output of data with other devices that may be connected to data processing system **400**. For example, input/output unit **412** may provide a connection for user input through a keyboard, a mouse, and/or some other suitable input device. Further, input/output unit **412** may send output to a printer. Display **414** provides a mechanism to display information to a user.

Instructions for the operating system, applications, and/or programs may be located in storage devices **416**, which are in communication with processor unit **404** through communications fabric **402**. In these illustrative examples, the instructions are in a functional form on persistent storage **408**. These instructions may be loaded into memory **406** for execution by processor unit **404**. The processes of the different embodiments may be performed by processor unit **404** using computer implemented instructions, which may be located in a memory, such as memory **406**.

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 **404**. The program code in the different embodiments may be embodied on different physical or computer readable storage media, such as memory **406** or persistent storage **408**.

Program code **418** is located in a functional form on computer readable media **420** that is selectively removable and may be loaded onto or transferred to data processing system **400** for execution by processor unit **404**. Program code **418** and computer readable media **420** form computer program product **422** in these examples. In one example, computer readable media **420** may be computer readable storage media **424** or computer readable signal media **426**. Computer readable storage media **424** 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 **408** for transfer onto a storage device, such as a hard drive, that is part of persistent storage **408**. Computer readable storage media **424** also may take the form of a persistent storage, such as a hard drive, a thumb drive, or a flash memory, that is connected to data processing system **400**. In some instances, computer readable storage media **424** may not be removable from data processing system **400**. In these illustrative examples, computer readable storage media **424** is a non-transitory computer readable storage medium.

Alternatively, program code **418** may be transferred to data processing system **400** using computer readable signal media **426**. Computer readable signal media **426** may be, for example, a propagated data signal containing program code **418**. For example, computer readable signal media **426** 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, optical fiber cable, 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 advantageous embodiments, program code **418** may be downloaded over a network to persistent storage **408** from another device or data processing system through computer readable signal media **426** for use within data processing system **400**. For instance, program code stored in a computer readable storage medium in a server data processing system may be downloaded over a network from the server to data processing system **400**. The data processing system providing program code **418** may be a server computer, a client computer, or some other device capable of storing and transmitting program code **418**.

The different components illustrated for data processing system **400** are not meant to provide architectural limitations to the manner in which different embodiments may be implemented. The different advantageous embodiments may be implemented in a data processing system including components in addition to or in place of those illustrated for data processing system **400**. Other components shown in FIG. **4** can be varied from the illustrative examples shown. The different embodiments may be implemented using any hardware device or system capable of running program code. As one example, the data processing system 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.

In another illustrative example, processor unit **404** may take the form of a hardware unit that has circuits that are manufactured or configured for a particular use. This type of hardware may perform operations without needing program code to be loaded into a memory from a storage device to be configured to perform the operations.

For example, when processor unit **404** takes the form of a hardware unit, processor unit **404** may be a circuit system, an application specific integrated circuit (ASIC), a programmable logic device, or some other suitable type of hardware configured to perform a number of operations. With a programmable logic device, the device is configured to perform the number of operations. The device may be reconfigured at a later time or may be permanently configured to perform the number of operations. Examples of programmable logic devices include, for example, a programmable logic array, programmable array logic, a field programmable logic array, a field programmable gate array, and other suitable hardware devices. With this type of implementation, program code **418** may be omitted because the processes for the different embodiments are implemented in a hardware unit.

In still another illustrative example, processor unit **404** may be implemented using a combination of processors found in computers and hardware units. Processor unit **404** may have a number of hardware units and a number of processors that are configured to run program code **418**. With this depicted example, some of the processes may be implemented in the number of hardware units, while other processes may be implemented in the number of processors.

As another example, a storage device in data processing system **400** is any hardware apparatus that may store data. Memory **406**, persistent storage **408**, and computer readable media **420** are examples of storage devices in a tangible form.

In another example, a bus system may be used to implement communications fabric **402** 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 **406**, or a cache, such as found in an interface and memory controller hub that may be present in communications fabric **402**.

With reference now to FIG. **5**, an illustration of a flowchart illustrating a process for identifying a concentration of a substance within a number of compartments is depicted in accordance with an advantageous embodiment. The process in FIG. **5** may be implemented by a component such as computer system **302** in FIG. **3**, for example.

The process begins by identifying a rate of the gas of the substance leaking from a container in a first compartment for a platform (operation **502**). Operation **502** may comprise identifying a ratio of a liquid of the substance to the gas of the substance in the container. Operation **502** may also comprise identifying the rate of the gas leaking from the container based on the ratio.

The process then identifies an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time (operation **504**). The process then retrieves a pressure for each compartment in the number of compartments from a data storage unit (operation **506**). The number of compartments is configured to allow air to flow between the number of compartments.

The process also identifies an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and the pressure for each compartment in the number of compartments (operation **508**). The number of compartments may be within a spacecraft. Operation **508** may comprise identifying a position in a trajectory of the spacecraft in an atmosphere.

The process then determines whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas (operation **510**). The desired amount for each compartment may be the range in which a concentration of ammonia is flammable. The desired amount for the gas may be a threshold or a range. The process generates an alert in response to the amount of gas in at least one of the first compartment and the number of compartments is outside of the desired amount for the gas (operation **512**). Alternatively, in different advantageous embodiments, the process performs a corrective action in response to the amount of gas in at least one of the first compartment and the number of compartments is outside of the desired amount for the gas. Thereafter, the process terminates.

With reference now to FIG. **6**, an illustration of a flowchart illustrating a process for identifying a concentration of a substance within a number of compartments is depicted in accordance with an advantageous embodiment. The process in FIG. **6** may be implemented by a component such as computer system **302** in FIG. **3**, for example.

The process begins by creating a new simulation (operation **602**). The simulation includes the arrangement of how variables that will be input in the simulation will interact with one another. The simulation uses processes and equations used to calculate rate of flow for fluids and substances. In different advantageous embodiments, the simulation may be a programming language working directory, such as a UNIX® working directory.

The process then retrieves container venting models, flight models, and programs for use by the simulation (operation **604**). Container venting models include the data for initial venting of the container with a substance. Flight models include the data for flight trajectories and venting for different compartments in the spacecraft.

The process then retrieves trajectory data for a flight path of the spacecraft comprising the container and a number of compartments (operation **606**). The trajectory data includes the predicted and/or actual trajectory of the spacecraft. The trajectory data also includes initial pressures for each compartment of the number of compartments during every position of the trajectory.

The process then selects a range of the trajectory data to form the start and end of the simulation (operation **608**). The start and the end of the simulation may a desired range of the trajectory where pressures in the different compartments are desired. The start and end of the simulation may also indicate a range of the trajectory that includes points of the trajectory where different compartments have shown selected amounts of a substance. The substance may be any type of chemical or substance. For example, the substance may be ammonia. The substance may be in gas, liquid, or a combination of both.

The process then retrieves an initial history of pressure and temperature data of the container and craft compartments based on the flight path of the craft for the selected range of trajectory data (operation **610**). In operation **610**, a history of pressure and temperature data is used. The history is from past flights by similar spacecraft. The pressure and temperature data is the pressure and temperature of the container and each compartment for different points along the flight path for the spacecraft. Operation **610** may be all or part of operation **506** in FIG. **5**.

The process then selects a start time and a size, in diameter, for an initial venting of the container (operation **612**). Initial venting may be the venting of the ammonia from the container under initial pressures and conditions. Initial pressures and conditions may be pressures and conditions in which the container operates. The container may operate by providing thermal cooling to compartments of the spacecraft.

The process then generates an initial venting model for the initial venting of the container in the number of compartments using initial simulated pressure and temperature data of the container and number of compartments (operation **614**). The initial venting model is for container contents comprising ammonia in states of liquid and/or gas. Gas may also be referred to as vapor. Operation **614** may be all or part of operations **502** and **504** in FIG. **5**.

The process then selects an initial configuration for the container and container contents using an initial mass or mass ratio of gas to total mass of the contents of the container, a volume of the container, and either an initial pressure or temperature of the contents of the container (operation **616**). Either the mass or the mass ratio is given and the other is calculated thereafter. The process then processes the initial configuration for the container and container contents to determine the initial mass or mass ratio of gas to total mass of the contents of the container necessary to simulate the selected amount of mass in the container (operation **618**).

The process then generates a first simulated dual state pressure and temperature of the container and craft compartments using the initial configuration of the container and container contents and the initial venting model (operation **620**). Dual state means the gas and liquid components are both generated. Pressure and temperature data is for the container and each compartment in the craft. Operation **620** may be all or part of operation **508** in FIG. **5**.

The process then generates a first single state simulated pressure and temperature of the container simulating a

selected condition of the container using as input the first simulated dual state pressure and temperature of the container and number of compartments, (operation **622**). The simulation program may only support estimating the pressure and temperature using a single state of ammonia and not both the liquid and vapor states of ammonia. In these illustrative embodiments, the vapor state may be used. In different illustrative embodiments, the liquid state may be used. Pressure and temperature data is for the container and each compartment in the craft.

The process then generates a second venting model for the selected condition simulation venting of the container in the number of compartments using the first single state simulated pressure and temperature of the container and number of compartments (operation **624**). The venting model is for container contents comprising a substance such as ammonia in liquid and vapor states. The venting model is second because it is a new venting model after the initial venting model. Operation **624** may be all or part of operations **502** and **504** in FIG. **5**.

The process then generates a second dual state simulated pressure and temperature of the container and number of compartments using the initial configuration of the container and container contents and the second venting model (operation **626**). Operation **626** may be all or part of operation **508** in FIG. **5**. The process then generates a second single state simulated pressure and temperature of the container simulating a selected condition of the container using as input the second dual state simulated pressure and temperature of the container and craft compartments (**628**).

The process then compares the first and second single state simulated histories (operation **630**). The process then determines whether the histories match within a selected level of tolerance (operation **632**). The selected level of tolerance may be chosen by a user, the processor unit, a policy of rules, or some other method. Operations **630** and **632** may be all or part of operation **510** in FIG. **5**. If the histories do match within a selected level of tolerance, the process reports the results (operation **634**). Thereafter, the process terminates. The results may be reported in any manner such as, for example, on a computer display screen, a printed report, using alerts, corrective actions, and/or another type of report. Operation **634** may be one example of one implementation of operation **512** in FIG. **5**.

If the histories do not match within the selected level of tolerance, the process sets the second single state simulated history as the initial single state simulated history and goes back to operation **624** (operation **636**). The repeated operations of **624-628** may further generate a more accurate set of results.

The flowcharts and block diagrams in the different depicted embodiments illustrate the architecture, functionality, and operation of some possible implementations of apparatus, methods and computer program products. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of computer usable or readable program code, which comprises one or more executable instructions for implementing the specified function or functions. In some alternative implementations, the function or functions noted in the block may occur out of the order noted in the figures. For example, in some cases, two blocks shown in succession may be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved.

The different advantageous embodiments provide for identifying gas leakage in a platform. A processor unit identifies a rate of the gas of the substance leaking from a container in a first compartment for a platform. The processor unit also identifies an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time. The processor unit identifies an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments. The processor unit determines whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas.

The different advantageous embodiments provide for identifying different concentrations of ammonia in different compartments of a spacecraft. The different compartments may be flammable for different concentrations.

The different advantageous embodiments further provide for a more accurate determination of ammonia in the different compartments that current systems. The advantageous embodiments provide for using a dual state input to determine the flow rate of the container. Using a dual state input allows for more accurate outputs.

The description of the different advantageous embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. Further, different advantageous embodiments may provide different advantages as compared to other advantageous embodiments. The embodiment or embodiments selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. A method for identifying gas leakage in a platform, the method comprising:

identifying, by a processor unit, a rate of the gas of the substance leaking from a container in a first compartment for the platform;

identifying an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time;

identifying a position in a trajectory of the platform in an atmosphere;

identifying an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments, the pressure determined using data associated with the position in the trajectory; and

determining whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas of the substance.

2. The method of claim **1**, further comprising:

generating an alert responsive to the amount of gas in at least one of the first compartment and the number of compartments being outside of the desired amount for the gas.

3. The method of claim **1**, further comprising:

performing a corrective action responsive to the amount of gas in at least one of the first compartment and the number of compartments being outside of the desired amount for the gas.

4. The method of claim 1, wherein the desired amount is a threshold.

5. The method of claim 1, wherein the desired amount is a range.

6. The method of claim 1, wherein the substance is ammonia.

7. The method of claim 1, wherein the step of identifying, by the processor unit, the rate of the gas of the substance leaking from the container in the first compartment for the platform comprises:

identifying a ratio of a liquid of the substance to the gas of the substance in the container; and

identifying the rate of the gas leaking from the container based on the ratio.

8. The method of claim 1, wherein the step of identifying a position in a trajectory of the platform in an atmosphere includes selecting a range of the trajectory and retrieving a history of temperature and pressure data based on the range of the trajectory, and further comprising:

indicating when a concentration of the gas in each compartment of the number of compartments is within a selected range for each compartment of the number of compartments.

9. The method of claim 1, wherein the desired amount for each compartment is the range in which a concentration of ammonia is flammable.

10. The method of claim 1, wherein the number of compartments are configured to allow air to flow between the number of compartments.

11. The method of claim 1, wherein the platform is a spacecraft.

12. The method of claim 11, wherein the number of compartments is within the spacecraft, and wherein the step of identifying the pressure for each compartment in the number of compartments includes:

identifying a position in a trajectory of the spacecraft in an atmosphere.

13. The method of claim 1, further comprising:

retrieving the pressure for each compartment in the number of compartments from a data storage unit.

14. A data processing system for identifying gas leakage in a platform, the data processing system comprising:

a bus system;

a storage device connected to the bus system, wherein the storage device includes a set of instructions; and

a processing unit connected to the bus system in communication with the storage device, wherein the processing unit executes the set of instructions to

identify a rate of the gas of the substance leaking from a container in a first compartment for the platform;

identify an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time;

identifying a position in a trajectory of the platform in an atmosphere;

identify an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments, the pressure determined using data associated with the position in the trajectory; and

determine whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas of the substance.

15. The data processing system of claim 14, further comprising:

the processing unit executes the set of instructions to generate an alert in response to the amount of gas in at least one of the first compartment and the number of compartments is outside of the desired amount for the gas.

16. The data processing system of claim 14, further comprising:

the processing unit executes the set of instructions to perform a corrective action in response to the amount of gas in at least one of the first compartment and the number of compartments is outside of the desired amount for the gas.

17. The data processing system of claim 14, wherein the desired amount for each compartment is the range in which a concentration of ammonia is flammable.

18. The data processing system of claim 14, wherein the number of compartments are configured to allow air to flow between the number of compartments.

19. The data processing system of claim 14, further comprising:

the processing unit executes the set of instructions to retrieve the pressure for each compartment in the number of compartments from a data storage unit.

20. A computer program product for identifying gas leakage in a platform, the computer program product comprising:

a non-transitory computer recordable storage medium;

program code, stored on the computer recordable storage medium, for identifying a rate of the gas of the substance leaking from a container in a first compartment for the platform;

program code, stored on the computer recordable storage medium, for identifying an amount of gas that has leaked from the container at a selected time based on the rate of the gas of the substance leaking from the container and a total time;

program code, stored on the computer readable storage medium, for identifying a position in a trajectory of the platform in an atmosphere;

program code, stored on the computer recordable storage medium, for identifying an amount of the gas of the substance present in a number of compartments associated with the first compartment using the amount of gas leaked from the container in the first compartment and a pressure for each compartment in the number of compartments, the pressure determined using data associated with the position in the trajectory;

program code, stored on the computer recordable storage medium, for determining whether the amount of gas in at least one of the first compartment and the number of compartments is outside of a desired amount for the gas.

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