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(71) Applicant(s)
The Boeing Company

(72) Inventor(s)
Senesac, Christopher J.

(74) Agent / Attorney
Spruson & Ferguson, L 35 St Martins Tower 31 Market St, Sydney, NSW, 2000

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ABSTRACT

A method and apparatus for identifying a condition of assembly (606). A model (216) for an aircraft (104) is identified. A state (600) from states (226) of assembly for the aircraft is identified. Parts (608) present in the aircraft (104) for the state (600) selected for the aircraft (104) are identified. Sections of the aircraft (104) with the parts (608) present in the aircraft (104) are displayed for the state (600) selected in a graphical user interface (208) on a display device.

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CONDITION OF ASSEMBLY VISUALIZATION SYSTEM

TECHNICAL FIELD

The present disclosure relates generally to manufacturing and, in particular, to manufacturing vehicles. Still more particularly, the present disclosure relates to a method and apparatus for assembling vehicles in a manufacturing environment.

BACKGROUND

The assembly of an aircraft is an extremely complex process. Hundreds of thousands of parts may be assembled for an aircraft.

The assembly of an aircraft may involve manufacturing different parts of aircraft in geographically diverse locations. These different parts may then be finally assembled in a single location. For example, different portions of a fuselage of the composite aircraft may be assembled in different locations and flown to a central location where the final assembly line is located. Additionally, other parts such as engines, auxiliary power units, seats, computer systems, line replaceable units, or other components in aircraft may be shipped to this final location for assembly to form the assembled aircraft.

The assembly of the different parts involves assigning tasks to different operators. The assignment of these tasks may take the form of shop order instances. Each shop order instance may include instructions and an identification of parts for a particular assembly in the aircraft.

Shop floor operators may have a need to identify locations of parts on the aircraft in order to follow

assembly instructions described in shop order instances. These locations are ones relative to the particular aircraft being assembled. Currently, operators assigned a task to assemble a part for the aircraft may look at paper copies of the parts of aircraft to determine where to perform tasks to install or assemble parts for the aircraft. These paper copies may provide some guidance to an operator, but often times they may be difficult to understand and may not include sufficient information.

In some cases, the operator may view a computer-aided design model of the aircraft using a computer-aided design software system. These types of systems, however, require training and experience to maneuver through the model of the aircraft.

For example, an operator of the computer-aided design software system often uses aircraft coordinates to identify locations in the aircraft. Aircraft coordinates have an origin relative to some location in the aircraft. Further, when traversing through the model, locations are identified using aircraft coordinates. These aircraft coordinates, however, are not helpful to an operator that is assigned a task in a shop order instance. The aircraft coordinates may need to be translated into action locations for the operator. Additionally, the model does not provide the operator an idea of what parts may or may not be already installed in the aircraft for performing a particular task.

As a result, operators may take more time than needed, may need additional training, or both to view locations in the aircraft where tasks in a shop order instance are to be performed. This additional time or training may increase the time or expense needed to assemble an aircraft.

Therefore, it would be desirable to have a method and apparatus that takes into account at least some of the issues discussed above, as well as other possible issues.

According to a first aspect, the present invention provides a computer implemented method of visualising a state of assembly of an aircraft, the method comprising: identifying a model for the aircraft; identifying a state of assembly from a plurality of states of assembly for the aircraft; identifying parts present in the aircraft for the state of assembly identified; displaying the parts identified in a graphical user interface on a display device; displaying a plurality of sections of the aircraft with the parts identified in the graphical user interface; detecting a selection of a section from the plurality of sections displayed; identifying a volume in the model corresponding to the selection selected; identifying parts present in the volume identified; displaying the section selected in the graphical user interface using the volume identified with the parts present in the volume identified; hiding a first group of parts in the volume identified that are absent from the section selected in the state of assembly identified; and displaying a second group of parts that are not hidden in the volume identified to display the section selected in the graphical user interface.

Also described is a computer implemented method of identifying a condition of assembly of an object, the method comprising: identifying a model for the object; identifying a state from states of assembly for the object, wherein the states of assembly for the object are based on a position of the object within a manufacturing facility; identifying a selection of the state for the object on a graphical user interface; identifying parts present in an aircraft for the state selected for the object; and identifying a condition of assembly of the object by displaying the parts present in the aircraft for the state selected in a graphical user interface on a display device.

According to a second aspect, the present invention provides an apparatus comprising: a processor; an object manager, running on the processor, configured to:

identify a model for an aircraft; identify a state of assembly from a plurality of states of assembly for the aircraft; identify parts present in the aircraft for the state of assembly identified; display, on a graphical user interface on a display device, a plurality of sections of the aircraft with the parts identified; detect a selection of a section

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from the plurality of sections displayed; identify a volume in the model corresponding to the selection selected; identify parts present in the volume identified; display the section selected in the graphical user interface using the volume identified with the parts present in the volume identified; hide a first group of parts in the volume identified that are absent from the section selected in the state of assembly identified; and display a second group of parts that are not hidden in the volume identified to display in the graphical user interface the section selected, wherein the object manager is further configured to generate information for operating manufacturing equipment to manufacture the aircraft.

According to a third aspect, the present invention provides an aircraft manufacturing system comprising: a processor; a control system configured to control operation of manufacturing equipment; and an object manager, running on the processor, in the control system, wherein the object manager is configured to: identify a model for the aircraft; identify a state of assembly from a plurality of states of assembly for the aircraft; identify parts present in the aircraft for the state of assembly; display, on a graphical user interface on a display device, a plurality of sections of the aircraft with the parts identified; detect a selection of a section from the plurality of sections displayed; identify a volume in the model corresponding to the selection selected; identify parts present in the volume identified; display the section selected in the graphical user interface using the volume identified with the parts present in the volume identified; hide a first group of parts in the volume identified that are absent from the section selected in the state of assembly identified; and display a second group of parts that are not hidden in the volume identified to display in the graphical user interface the section selected, wherein the object manager is further configured to generate information for operating the manufacturing equipment to manufacture the aircraft.

SUMMARY

In one illustrative embodiment, a method for identifying a condition of assembly is present. A model for an aircraft is identified. A state from states of assembly is identified for the aircraft. Parts present in the aircraft are identified for the state selected for the

aircraft. Sections of the aircraft with the parts present in the aircraft are displayed for the state selected in a graphical user interface on a display device.

In another illustrative embodiment, another method for identifying a condition of assembly is present. A model is identified for an object. A state from states of assembly for the object is identified. Parts present in an aircraft are identified for the state selected for the object. The parts present in the aircraft for the state selected in the graphical user interface are displayed on a display device.

In yet another illustrative embodiment, an apparatus comprises an object manager configured to identify a model for an aircraft. A state is identified from a plurality of states of assembly for the aircraft. Parts present in the aircraft are identified for the state selected for the aircraft. Sections of the aircraft are displayed with the parts present in the aircraft for the state selected. Information for operating manufacturing equipment to manufacture the aircraft is generated.

In yet another illustrative embodiment, an aircraft manufacturing system comprises a control system and an object manager in the control system. The control system is configured to control operation of manufacturing equipment. The object manager is configured to identify a model for the aircraft. The object manager is further configured

to identify a state from a plurality of states of assembly for the aircraft. The object manager is still further configured to identify parts present in the aircraft for the state selected for the aircraft. The object manager is further configured to display sections of the aircraft with the parts present in the aircraft for the state selected. The object manager is still further configured to generate information for operating the manufacturing equipment to manufacture the aircraft.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Figure 1 is an illustration of a block diagram of a manufacturing environment in accordance with an illustrative embodiment;

Figure 2 is an illustration of a block diagram of an object manager in accordance with an illustrative embodiment;

Figure 3 is an illustration of a block diagram of a sectional view in accordance with an illustrative embodiment;

Figure 4 is an illustration of a block diagram of a volume identifier in accordance with an illustrative embodiment;

Figure 5 is an illustration of a block diagram of a shop order instance in accordance with an illustrative embodiment;

Figure 6 is an illustration of a block diagram of a state for a section of an aircraft in accordance with an illustrative embodiment;

Figure 7 is an illustration of a graphical user interface for viewing statuses of shop order instances in accordance with an illustrative embodiment;

Figure 8 is an illustration of a graphical user interface of aircraft positions in a building in accordance with an illustrative embodiment;

Figure 9 is an illustration of a graphical user interface of aircraft sections in accordance with an illustrative embodiment;

Figure 10 is another illustration of a graphical user interface of aircraft sections in accordance with an illustrative embodiment;

Figure 11 is an illustration of a section of an aircraft in accordance with an illustrative embodiment;

Figure 12 is another illustration of a section of an aircraft in accordance with an illustrative embodiment;

Figure 13 is still another illustration of a section of an aircraft in accordance with an illustrative embodiment;

Figure 14 is an illustration of a flowchart of a process to identify a state of an object in accordance with an illustrative embodiment;

Figure 15 is an illustration of a more detailed flowchart of a process for identifying a state of an aircraft in accordance with an illustrative embodiment;

Figure 16 is an illustration of a flowchart for displaying a section in a graphical user interface in accordance with an illustrative embodiment;

Figure 17 is an illustration of a block diagram of a data processing system in accordance with an illustrative embodiment;

Figure 18 is an illustration of an aircraft manufacturing and service method in the form of a block diagram in accordance with an illustrative embodiment;

Figure 19 is an illustration of an aircraft in the form of a block diagram in which an illustrative embodiment may be implemented; and

Figure 20 is an illustration of a manufacturing system in the form of a block diagram in accordance with an illustrative embodiment.

DETAILED DESCRIPTION

The illustrative embodiments recognize and take into account one or more different considerations. For example, the illustrative embodiments recognize and take into account that in performing tasks in shop order instances, information such as what parts are currently present in the aircraft may be useful in planning or performing tasks to install parts.

The illustrative embodiments recognize and take into account that knowing what parts should be present for a particular state in the assembly of an aircraft may be desirable in performing tasks to assemble an aircraft. This knowledge may also be useful for planning or managing the performance of tasks. The performance of tasks includes planning operations to install parts, installing parts, inspecting installed parts, or some combination thereof.

Thus, the illustrative embodiments provide a method and apparatus for identifying a condition of assembly for an object such as an aircraft. A model of an aircraft is identified. A state from states of assembly for the aircraft is identified. The parts present in the aircraft are identified for the state selected for the aircraft. Sections of the aircraft with the parts present in the aircraft are displayed for the state selected in a graphical user interface on a display device.

With reference now to the figures, and in particular, with reference to **Figure 1**, an illustration of a block diagram of a manufacturing environment is depicted in accordance with an illustrative embodiment. Manufacturing environment **100** is an example of an environment in which object **102** may be assembled.

In this illustrative example, object **102** takes the form of aircraft **104**. Object **102** is completed by assembling parts **106**. A part is a group of components. As used herein, a "group of," when used with reference items, means one or more items. For example, a group of components is one or more components.

A part may be a single component or assembly of components in these depicted examples. For example, the part may be a seat, a row of seats, an in-flight entertainment system, a duct, a system of ducts, a global positioning system receiver, an engine, an engine housing, an inlet, or other suitable types of parts.

In this illustrative example, assembling parts **106** may take place in assembly location **107** in building **108** of buildings **110** at manufacturing facility **112**. The assembly of parts **106** in building **108** may occur in positions **114** in assembly location **107** for object **102**. Each position in

positions **114** is a location in building **108** in which a group of tasks **118** is performed to assemble object **102**.

In these illustrative examples, a task is a piece of work. A task may be comprised of one or more operations that are performed by a group of operators **122** assigned to work on the assembly of object **102**.

In the illustrative examples, object manager **124** may be used to manage the assembly of object **102**. When object **102** is aircraft **104**, object manager **124** may be part of an aircraft management system. Object manager **124** may be implemented in software, hardware, firmware or a combination of thereof. When software is used, the operations performed by object manager **124** may be implemented in program code configured to run on a processor unit. When firmware is used, the operations performed by object manager **124** may be implemented in program code and data and stored in persistent memory to run on a processor unit. When hardware is employed, the hardware may include circuits that operate to perform the operations in object manager **124**.

In the illustrative examples, the hardware may take the form of a circuit system, an integrated circuit, 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, a programmable array logic, a field programmable logic array, a field programmable gate array, or other suitable hardware devices. Additionally, the processes may be implemented in organic components

integrated with inorganic components and/or may be comprised entirely of organic components excluding a human being. For example, the processes may be implemented as circuits in organic semiconductors.

As depicted, object manager **124** may be implemented in computer system **126**. Computer system **126** is one or more computers. When more than one computer is present, the computers in computer system **126** may communicate with each other using a communications medium such as a network. Computer system **126** may be located all in the same location or in different geographic locations. For example, computer system **126** may be distributed through buildings **110** or located in building **108**. Portions of computer system **126** may even be located in another geographic location separate from manufacturing facility **112**.

In managing the assembly of object **102**, object manager **124** may manage tasks **118** and information **128** about object **102**.

In the illustrative example, the management of tasks **118** may include at least one of assigning tasks **118** to operators **122**, monitoring the status of tasks **118**, organizing tasks **118**, providing information about tasks **118**, or other suitable operations. Information **128** may include, for example, the models of objects, part inventories, or other suitable information relating to object **102**.

As used herein, the phrase "at least one of," when used with a list of items, means 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, 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. The item may be a particular object, thing, or a

category. In other words, at least one of means any combination of items and number of items may be used from the list but not all of the items in the list are required.

In these illustrative examples, object manager **124** may manage tasks **118** using assignments **130** in the form of shop order instances **132** based upon the aircraft program definitions. For example, object manager **124** may assign tasks through the use of shop order instances **132** to operators **122** for performance and assembling of object **102**. Additionally, the status of shop order instances **132** may be used to identify the state of assembly of object **102** by operators **122**.

Additionally, tasks **118** may have dependencies **133**. In other words, tasks **118** may be performed in a particular order. Dependencies **133** may dictate when tasks within tasks **118** should be performed relative to other tasks in tasks **118**. Dependencies **133** may also be for parts **106** in addition to or in place of tasks **118**. In this form, dependencies **133** may result in dependencies **133** for tasks **118**.

As a result, dependencies **133** may affect the manner in which assignments **130** are made as shop order instances **132**. In particular, dependencies **133** may be used to determine when shop order instances **132** should be performed.

In these illustrative examples, object manager **124** may provide different functions and capabilities for assembling object **102**. For example, object manager **124** may include at least one of object visualization system **134**, shop order status visualization system **135**, or other types of systems. The systems may be implemented using hardware, software, or some combination thereof.

In one illustrative example, object visualization system **134** may provide a visualization of object **102** to operators **122**. In particular, operators **122** may perform

queries using object visualization system **134** to view a number of sections **136** in object **102**. In particular, sections **136** may be sections that correspond to sections at manufacturing facility **112** for assembly of object **102**, such as aircraft **104**.

Additionally, object visualization system **134** may provide a visualization of parts **106** in aircraft **104** during different times or positions in positions **114**. In other words, parts **106** may be present at different times or positions in positions **114**. Object visualization system **134** provides operators **122** an ability to visualize these different conditions of assembly for aircraft **104** as well as other types of objects. In other words, object visualization system **134** may operate as a condition of assembly visualization system. In these illustrative examples, the manufacturing may include at least one of fabricating components for parts, assembling components to form parts, assembling parts for object **102**, or some other suitable manufacturing operation performed to assemble object **102**. For example, object manager **124** may provide visual information about all of object **102** or one or more specific sections of object **102**. This type of visualization may be especially useful when object **102** takes the form of aircraft **104**. Information **128** may be used when operators **122** perform tasks **118** with respect to parts **106** to assemble aircraft **104**.

In another illustrative example, shop order status visualization system **135** may provide a visualization of status **137** of shop order instances **132**. This information may be provided visually to operators **122**. In particular, object manager **124** may function as shop order status visualization system **135** as well as provide other suitable functions in managing the assembly of object **102**.

Turning now to **Figure 2**, an illustration of a block diagram of an object manager is depicted in accordance with an illustrative embodiment. Examples of components that may be implemented in object manager **124** in **Figure 1** are shown in this figure.

As depicted, object manager **124** includes a number of different components. For example, object manager **124** includes assignment manager **202**, object visualizer **204**, inventory identifier **206**, status identifier **207**, and graphical user interface **208**. These different components along with object manager **124** may be implemented using hardware, software, or some combination thereof.

Graphical user interface **208** is configured to provide an interface for operators **122** in **Figure 1** to interact with object manager **124**. In these illustrative examples, graphical user interface **208** may be displayed on display system **209** in interface system **210**. Display system **209** is hardware and may include one or more display devices selected from at least one of a liquid crystal display(LCD), a light emitting display (LED), an organic light emitting display (OLED), or other suitable types of display devices.

Input may be received from operators **122** through input system **211** in interface system **210**. Input system **211** is a hardware system. Input system **211** may include one or more devices. These devices may include at least one of a keyboard, a mouse, a joystick, a touchscreen panel, or other suitable types of devices.

In this illustrative example, assignment manager **202** is configured to manage assignments **130** in the form of shop order instances **132** in shop order database **212**. For example, assignment manager **202** may be used to assign tasks **118** in **Figure 1** to operators **122** using shop order instances **132**. Additionally, assignment manager **202** also may be

configured to receive information about the performance of tasks **118** assigned through shop order instances **132**. This information may be used by assignment manager **202** to generate and update status **213** for shop order instances **132**.

Object visualizer **204** is configured to generate graphical representations **214** for parts **106** in **Figure 1**. Graphical representations **214** may be displayed on graphical user interface **208** in display system **209**. As depicted, object visualizer **204** is configured to access model database **215**. Object visualizer **204** may identify model **216** from models **217** in model database **215** for object **102** in **Figure 1** and, in particular, for aircraft **104** in **Figure 1**. Model **216** is used to generate graphical representations **214** in the illustrative example.

In these illustrative examples, graphical representations **214** may be generated for sections **136** of object **102** in **Figure 1**, which may take the form of aircraft **104**. In this illustrative example, model **216** may be identified for object **102** from models **217** in model database **215**. Models **217** may take various forms. For example, without limitation, models **217** may include computer-aided design (CAD) files.

Each model in models **217** may be for a particular object. The objects may be of the same type but for different shop order instances. For example, if models **217** are for a particular type of aircraft, each model may be for a particular aircraft that is being assembled for a customer. The different models may be for the same aircraft model but may have variations for different options selected by a customer. In other illustrative examples, models **217** may include models for different types of aircraft **104**.

The generation of graphical representations **214** may be based on all of model **216** or a group of volumes **218** in model

216. These items may have different shapes. For example, volume 219 in volumes 218 may be a cube, a cuboid, a cylinder, a sphere, or some other suitable shape.

In these illustrative examples, volume 219 is for at least a portion of a part in parts 106 of object 102. Volume 219 may be large enough to encompass the part. Volume 219 may also be larger than the part. In these illustrative examples, volume 219 may comprise an amount of space around the part for viewing the part in a graphical user interface. For example, the amount of space around the part may be for viewing the part in the graphical user interface from one or more angles. In this example, the one or more angles may be one or more angles from the point of view of an operator. In this example, the point of view of the operator may be of an operator performing a task associated with the part.

As depicted, volumes 218 may be identified in model 216 using volume database 220. Volume database 220 is a collection of information that may be used to identify which volumes in volumes 218 may be displayed as graphical representations 214. In particular, the collection of information may include volume identifiers 221. For example, volume identifier 222 in volume identifiers 221 may define volume 219 in volumes 218.

In these illustrative examples, an identification of volume 219 may be made using sectional view 223 in sectional views 224 in sectional view database 225. Sectional views 224 may include sectional views of the different objects. For example, sectional view 223 may correspond to model 216. An operator may select volumes 218 using sectional view 223 displayed on graphical user interface 208 in this particular example.

As depicted, sectional views **224** in sectional view database **225** may provide views of sections **136** for object **102**. In the illustrative examples, sections **136** correspond to sections manufactured for assembly of object **102**. In particular, sections **136** may correspond to sections manufactured for assembly of aircraft **104**.

Further, sectional views **224** may include different levels of detail. For example, sectional views **224** may include a hierarchy of levels in which the lower levels have more detail about aircraft **104** than higher levels in the hierarchy. In some illustrative examples, a selection of a sectional view in sectional views **224** may result in another sectional view being displayed. In other illustrative examples, a selection made in a sectional view may result in graphical representations **214** being generated from model **216** and displayed on graphical user interface **208**. In this manner, an operator may visually query aircraft **104** through the different sectional views in sectional views **224**.

As a result, operator interaction generating user input with sectional view **223** displayed in graphical user interface **208** may be used to identify volumes **218** in model **216**. The user input may be used to identify volume identifier **222** from volume identifiers **221**. Volume identifier **222** may point to volume **219** in model **216**.

In these illustrative examples, object visualizer **204** may generate queries using volume identifiers **221** to obtain information from model **216** in model database **215**. In particular, the information may be data about volume **219** in model **216** for aircraft **104**.

As depicted, object visualizer **204** also may be configured to generate graphical representations **214** for states **226** of object **102**. In these illustrative examples, states **226** may be used for object **102** in the form of

aircraft **104**. In other words, aircraft **104** may have different parts in parts **106** that are installed at different states within states **226**. For example, states **226** may include, at least one of a state of fabrication of components, a state of assembly of parts, or other suitable states. In the illustrative example, states **226** may take the form of conditions of assembly **227** for object **102**. Conditions of assembly **227** may be different states in which different parts are assembled to form object **102**.

In the illustrative example, states **226** may be based on positions **114** of aircraft **104** within assembly location **107** in building **108** in **Figure 1**. In these illustrative examples, states **226** may be selected from at least one of planned states **228** or actual states **229**.

Aircraft **104** may have different planned states in planned states **228** in different positions in positions **114**. In this illustrative example, a planned state in planned states **228** includes the parts that are expected to be installed at a particular position in positions **114**. In other words, these parts may or may not have been installed at that position.

In these illustrative examples, the planned state may be based on the past position, current position, or the future position of aircraft **104** in positions **114**. In other words, graphical representations **214** may be generated for any position that has occurred, is currently present, or planned for aircraft **104**.

As depicted, an actual state in actual states **229** includes parts **106** that have actually been installed in aircraft **104**. In other words, a particular state may have a selected number of parts that are installed at that state. The actual state in actual states **229** may be based on at least one of a past position, or the current position of

aircraft **104**. In other words, graphical representations **214** may be generated for parts **106** actually installed at a prior point in time. This prior point in time may be selected by an operator. In this manner, an operator may view tasks **118** performed to install parts **106** at some prior point in time.

Additionally, the actual state may be the current state of aircraft **104**. In other words, graphical representations **214** may be generated for parts **106** that have been installed at the current point in time. In this manner, graphical representations **214** may be used to visualize parts **106** that are currently present in aircraft **104**.

In these illustrative examples, the identification of parts that have already been installed or parts installed in prior points in time may be identified using shop order instances **132** in shop order database **212**. In particular, shop order instances **132** may indicate what parts in parts **106** have been installed.

Model database **215** is a database of models for objects. In these illustrative examples, these models may be, for example, computer-aided design models (CAD). Of course, any type of model that may provide information about the three-dimensional geometries of objects may be used. Additionally, these models may also include other information about materials, instruction assemblies, or other suitable types of information.

As depicted, inventory identifier **206** is configured to access inventory database **230**. Inventory database **230** contains information about parts. Inventory database **230** may include information about whether parts are in stock, when parts will be delivered, the number of parts available, or other suitable types of information.

As depicted, status identifier **207** is configured to provide a visualization of the status for one or more of

shop order instances **132**. In this illustrative example, status identifier **207** is configured to provide an operator a graphical front end through graphical user interface **208** to identify the status of a shop order instance in a specific location of object **102**, such as aircraft **104**. This information may be identified without the operator knowing the coordinates of the particular location.

In these illustrative examples, object visualizer **204** is configured to identify a model of object **102**, such as aircraft **104**. For example, object visualizer **204** may identify the model in model database **215** for object **102**.

Status identifier **207** is also configured to identify shop order instances **132** for object **102**. The identification may be made through interaction with assignment manager **202**.

In the illustrative example, status identifier **207** is also configured to identify status **213** of shop order instances **132**. This identification also may be made through assignment manager **202**.

Object visualizer **204** is configured to display graphical representations **214** of parts **106** in **Figure 1** for a group of shop order instances **132** in graphical user interface **208** on a display device in display system **209**. The generation of graphical representations **214** may be based on the identification of a group of shop order instances **132**. In other words, object visualizer **204** is configured to receive an identification of parts in the group of shop order instances **132**. The identification of these parts may be used to generate graphical representations **214**.

Further, status identifier **207** is also configured to display a set of graphical indicators **231** in association with graphical representations **214** of parts **106** displayed on graphical user interface **208** by object visualizer **204**. As used herein, a "set of," when used with reference items,

means one or more items. For example, a set of graphical indicators **231** is one or more of graphical indicators **231**.

In these illustrative examples, a graphical indicator in graphical indicators **231** is considered to be displayed in association with a graphical representation in graphical representations **214** when the attention of an operator viewing graphical indicators **231** is drawn to the parts. Thus, the graphical indicator may be displayed as part of the graphical representation, on the graphical representation, in some proximity of the graphical representation, or in some other suitable manner that draws attention to the graphical representation.

The set of graphical indicators **231** displayed in association with graphical representations **214** of parts **106** may take different forms. For example, the set of graphical indicators **231** may be selected from at least one of a color, cross hatching, an icon, high lighting, animation, or other suitable types of graphical indicators.

Further, the group of shop order instances **132** may be identified in a number of different ways. For example, the group of shop order instances **132** may be identified by a user input to graphical user interface **208** from an operator. For example, the user input received may be a selection of the group of shop order instances **132**.

In another illustrative example, the identification of the group of shop order instances **132** may be identified from a user input selecting a group of parts **106** in object **102** in **Figure 1**. The selection of the group of parts **106** may be one of a selection of the group of parts **106** from a list of parts **106** and a selection of the group of parts **106** from a display of graphical representations **214** of parts **106** in graphical user interface **208**.

Additionally, status identifier **207** may display information about a shop order instance for a part selected from graphical representations **214** of parts **106** displayed in graphical user interface **208**.

With this information in graphical user interface **208**, real-world operations may be performed. For example, the assembly of object **102** in **Figure 1** may be managed based on graphical representations **214** of parts **106** for shop order instances **132** and the set of graphical indicators **231** displayed on graphical user interface **208**. For example, identifications of operations that should be performed may be made using this visualization. These operations may include when particular parts should be assembled, when inspections of parts assembled in object **102** should be made, or other suitable types of operations.

In **Figure 2**, different components are illustrated as being located in object manager **124**. These different components may be used as part of different systems. The systems may include at least one of object visualization system **134** in **Figure 1**, shop order status visualization system **135** in **Figure 1**, and other suitable systems. A component in object manager **124** may be used in more than one system. For example, object visualizer **204** may be in both object visualization system **134** and shop order status visualization system **135**. In other words, the different components illustrated in object manager **124** may be used at the same time by different systems in object manager **124**.

Turning now to **Figure 3**, an illustration of a block diagram of a sectional view is depicted in accordance with an illustrative embodiment. An example of one implementation for sectional view **223** in **Figure 2** is shown.

As depicted, sectional view **223** includes a number of different pieces of information. For example, sectional view **223** includes sections **300** and hotspots **302**.

Sections **300** are graphical representations corresponding to sections **136** for object **102** and, in particular, aircraft **104** in **Figure 1**. In these illustrative examples, sections **300** may be located in a single image, multiple images, or some other suitable form. Further, sections **300** are graphical representations corresponding to sections **136** manufactured for assembly of aircraft **104**.

In these illustrative examples, sections **300** may be selectable. A selection of section **304** in sections **300** having hotspot **306** in hotspots **302** results in a volume corresponding to section **304** in model **216** being displayed in this illustrative example. Hotspot **306** may be a pointer to volume identifier **222** associated with volume **219**. For example, hotspot **306** may include a universal resource locator, or some other addressing convention to identify volume identifier **222** from volume identifiers **221** in volume database **220**.

Turning now to **Figure 4**, an illustration of a block diagram of a volume identifier is depicted in accordance with an illustrative embodiment. In this illustrative example, one implementation for volume identifier **222** in **Figure 2** is shown.

Volume identifier **222** includes a number of components. As depicted, volume identifier **222** includes identifier **400** and volume descriptor **402**.

Identifier **400** distinguishes volume identifier **222** from others of volume identifiers **221** that may be present in volume database **220**. Identifier **400** may take various forms. For example, identifier **400** may be a word, a phrase, a number, an alphanumeric string, or some other suitable form.

Volume descriptor **402** describes the volume in model **216**. For example, volume descriptor **402** may take the form of coordinates **406**. Coordinates **406** are in the coordinate system used by model **216** in this example. For example, coordinates **406** may be three coordinates that may be used to define a polygon, a cube, or a cuboid. Of course, other information may be present in volume descriptor **402** other than coordinates **406**. For example, volume descriptor **402** may include a single coordinate and a radius used to define volume **219** in a form of a sphere. In still other illustrative examples, a single coordinate may be present with pre-selected offsets that define volume **219** as a cube or some other shape.

In some illustrative examples, volume identifier **222** may also include point of view **408**. Point of view **408** may define the view of the volume displayed to an operator when graphical representations **214** are displayed on graphical user interface. For example point of view **408** may include coordinates **410** of the point of view using the coordinate system for the volume.

With reference now to **Figure 5**, an illustration of a block diagram of a shop order instance is depicted in accordance with an illustrative embodiment. As depicted, shop order instance **500** is an example of a shop order instance from shop order instances **132** in **Figure 1**.

As depicted, shop order instance **500** may include a number of different parts. Shop order instance **500** includes identifier **502**, classification **503**, description **504**, task **505**, assigned operators **506**, part identifier **508**, location **510**, instructions **512**, and status **518**.

As depicted, identifier **502** may be used to uniquely identify a task in tasks **118** in **Figure 1**. Identifier **502**

may be an alphanumeric identifier, a number, or some other suitable type of identifier.

In the illustrative example, classification **503** is used to classify the shop order instance. This classification may be based on the type of task to be performed. For example, the classifications may include seat installation, wiring, line replaceable unit installation, or other suitable types of classifications. The classification may be descriptive or may take the form of an identifier or other type of code.

Description **504** provides a description of task **505**. This description may be a short description to provide the operator information about task **505**. The description may be several words or a single sentence in some illustrative examples.

Task **505** identifies the work to be performed. For example, task **505** may be to install a part, assemble parts, perform an inspection, or some other suitable piece of work.

Assigned operators **506** identifies a group of operators that may be assigned to perform task **505**. In some cases, an operator may not yet be assigned to perform task **505** for shop order instance **500**.

In this illustrative example, part identifier **508** identifies a part assembled in object **102** using shop order instance **500**. In this illustrative example, part identifier **508** is a part number for the part. For example, part identifier **508** may be a serial number, a combination of a serial number and vendor identifier, or some other suitable type of identification that uniquely identifies a particular part from other parts even if those parts are the same type.

In the illustrative examples, part identifier **508** may be used to generate the graphical representation of the parts identified. For example, part identifier **508** may be

used to locate the information in a model needed to generate the graphical representation of the part for display.

Location **510** identifies the location where task **505** is to be performed. This location may be in coordinates for object **102** or some other coordinate system.

Instructions **512** are a group of instructions for performing task **505**. In particular, the group of instructions may be for assembling a group of parts. These instructions may be step-by-step instructions, guidance, or other suitable types of instructions. These instructions may provide guidance for assembling parts, inspecting parts, or other suitable operations that may be performed for task **505**. Instructions **512** also may include plans for the location in which task **505** is to be performed.

As depicted, status **518** provides information about the performance of task **505** for shop order instance **500**. In this illustrative example, the status may indicate that work is to be performed, has been completed, is in progress, is unassigned, has been planned, is on hold, has been canceled, or some other suitable status for shop order instance **500**. The status may be indicated using text, codes, symbols, or other suitable mechanisms. Additionally, if status **518** indicates that the work to be performed has been completed, status **518** also may include a date and time of when work for performing task **505** occurred.

Turning next to **Figure 6**, an illustration of a block diagram of a state for a section of an aircraft is depicted in accordance with an illustrative embodiment. In this depicted example, state **600** is an example of the state in states **226**.

In this illustrative example, state **600** is a data structure that stores information about parts that may be present for state **600**. This data structure may be, for

example, a flat file, a linked list, a record in a database, or some other suitable type of data structure.

State **600** may take the form of planned state **602**, actual state **604**, or both. In these illustrative examples, state **600** may be condition of assembly **606** for a particular position of aircraft **104** in positions **114**. In particular, condition of assembly **606** may be a condition of assembly in conditions of assembly **227** in **Figure 2**.

In this illustrative example, state **600** includes parts **608**. Parts **608** are parts present in aircraft **104** for state **600** selected for aircraft **104**. As depicted, parts **608** may be identified using part identifiers **610**. Part identifiers **610** may take various forms. For example, part identifier **612** in part identifiers **610** may be a part number for part **614** in parts **608**. For example, part identifier **612** may be a serial number, a combination of a serial number and vendor identifier, or some other suitable type of identification. In the illustrative examples, part identifier **612** may be any identifier that uniquely identifies a particular part from other parts even if those parts are the same type.

In this illustrative example, state **600** may be used by object visualizer **204** in object manager **124** to generate graphical representations **214** for parts **608** that may be present for state **600**. In these illustrative examples, state **600** represents a particular position of aircraft **104** in positions **114**. As a result, only parts **608** present for aircraft **104** are displayed in graphical representations **214** on graphical user interface **208**.

The illustration of the different components that may be used in manufacturing environment **100** in **Figures 1-6** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of

the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some functional components. One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment. For example, although the illustrative examples are described with respect to an aircraft, an illustrative embodiment may be applied to other objects other than aircraft, such as, for example, without limitation, a vehicle, a submarine, a personnel carrier, a tank, a train, an automobile, a bus, a spacecraft, a surface ship, a spacecraft, a satellite, a rocket, an engine, a computer, harvesters, construction cranes, bulldozers, mining equipment, or other suitable types of objects.

In another illustrative example, a selection of section **304** with hotspot **306** may result in an inquiry being generated directly without using volume database **220**. For example, hotspot **306** may include a query for the volume corresponding to section **304**.

With reference now to **Figures 7-13**, the illustrations of the display of graphical user interfaces for viewing an aircraft in different states are depicted in accordance with an illustrative embodiment. These figures illustrate one manner in which graphical user interface **208** in **Figure 2** may be implemented. The different graphical user interfaces may be displayed on a display system, such as display system **209** in **Figure 2**, and an operator may interact with the graphical user interfaces using an input system, such as input system **211** in **Figure 2**.

With reference to **Figure 7**, an illustration of a graphical user interface for identifying a model of an aircraft for viewing is depicted in accordance with an illustrative embodiment. In this illustrative example,

graphical user interface **700** displays buildings **702** including building **704**, building **706**, and building **708**.

In this particular example, each building in buildings **702** in graphical user interface **700** represents a location where manufacturing of aircraft occurs. Each building may correspond to a database of aircraft that are manufactured within the building.

Turning now to **Figure 8**, an illustration of a graphical user interface of aircraft positions in a building is depicted in accordance with an illustrative embodiment. In this illustrative example, aircraft positions **800** are displayed in graphical user interface **802**. These positions correspond to tasks that may be performed at different stages of the assembly of an aircraft.

In this particular example, aircraft positions **800** include position **804**, position **806**, position **808**, position **810**, and position **812**. In these illustrative examples, certain tasks are performed in different positions in aircraft positions **800**. In other words, the aircraft assembly progresses from position to position with different parts being added to the aircraft at the different positions in aircraft positions **800**.

A selection of one of these positions results in identifying graphical representations for parts that would be installed at a particular position as well as any parts that may have been installed from a prior position. As a result, parts that are not to be installed into a subsequent position are not present. For example, an aircraft in position **812** is a fully configured aircraft. An aircraft in position **810** may not have seats and carpet. An aircraft in position **808** may not include stove ends, lavatories, galleys, and other parts. These different positions in

aircraft positions **800** may have different conditions of assembly for the aircraft in these illustrative examples.

Additionally, in these illustrative examples, shop order instances in a shop order database may be identified for each of the positions. In other words, each position may have a shop order database containing shop order instances that may be generated for those particular positions. As a result, positions with fewer parts have less shop order instances to monitor or manage. In this manner, faster query of a shop order database for a particular position may be made when that database is for a position with fewer parts. After the selection of the position, an operator may select a section of aircraft for review.

Turning now to **Figure 9**, an illustration of a graphical user interface of aircraft sections is depicted in accordance with an illustrative embodiment. In this illustrative example, graphical user interface **900** displays sections **902** for an aircraft in area **904** of graphical user interface **900**.

As depicted, sectional view **905** is displayed in area **904** of graphical user interface **900**. Sectional view **905** is an example of one implementation for sectional view **223** shown in block form in **Figure 2** and **Figure 3**. In this particular example, sectional view **905** may be for an aircraft in position **812** in **Figure 8**.

An operator may select a section from sections **902**. As depicted, sections **902** are examples of sections **300** in **Figure 3** as displayed in graphical user interface **900**. Sections **902** are selectable in this particular example. In other words, sections **902** may include hotspots. These hotspots are not seen in this illustrative example. Hotspots are areas in graphical user interface **900** that may

be selected to cause an action. In these illustrative examples, these hotspots correspond to sections **902**. The hotspots may encompass sections **902** or may be around sections **902** or some combination thereof.

As another example, section **906** is an example of a section in sections **902** that may be selected. A selection of this section results in a more detailed illustration of section **906** being displayed. In this example, section **906** is an upper barrel portion of an aircraft.

Additionally, an identification of the parts present in the section is also made in response to the user selection of a particular section. This identification may include any parts that are present for the particular position of the aircraft in that section. In other words, the same section of an aircraft in different positions may have different parts that are present based on tasks for installing parts. This identification may be made through the use of states **226** in **Figure 2**.

In the illustrative example, an operator may select to view the entire aircraft by selecting entire aircraft area **908** in graphical user interface **900**. In other words, the volume for display may be the entire aircraft. Further, an operator may select groups of sections **902**. As depicted, the selection may be made by selecting one of area **910**, area **912**, area **914**, area **916**, area **918**, and area **920** in graphical user interface **900**. In these illustrative examples, these areas have hotspots. In this manner, an operator may view different portions of an aircraft in a manner that suits the particular query that is the operator desires.

Turning now to **Figure 10**, another illustration of a graphical user interface of aircraft sections is depicted in accordance with an illustrative embodiment. In this illustrative example, graphical user interface **1000** displays

sections **1002** for an aircraft in area **1004** of graphical user interface **1000**.

As depicted, sectional view **1005** is displayed in area **1004** of graphical user interface **1000**. Sectional view **1005** is an example of one implementation for sectional view **223** shown in block form in **Figure 2** and **Figure 3**. In this particular example, sectional view **1005** may be for an aircraft in position **804** in **Figure 8**.

In this illustrative example, only a portion of an aircraft is illustrated in the view of sections **1002** in sectional view **1005**. As depicted, only sections **1002** that are present in a particular position are shown in this particular example.

Further, sections **1002** also may be selectable. The selectable ability of sections **1002** may be enabled through the use of hotspots associated with sections **1002**. As a result, the selection of a particular section in sections **1002** may result in the display of the volume from a model of aircraft containing the selected section.

As depicted, area **1008**, area **1010**, and **1012** are also selectable. These areas may also have hotspots associated with them. The selection of one of these areas results in a volume containing the different sections within an area being displayed.

The illustration of graphical user interface **700** with buildings **702** in **Figure 7**, graphical user interface **802** with aircraft positions **800** in **Figure 8**, and graphical user interface **900** with sections **902** in **Figure 9**, and graphical user interface **1000** with sections **1002** in **Figure 10** are examples of multilevel querying that may be performed in accordance with an illustrative embodiment. As depicted, the selection of a building from buildings **702** may select a particular model for an aircraft. The particular model may

be displayed with positions using graphical user interface **802**. The selection of a position may result in another view being displayed with sections **902** in graphical user interface **900** or sections **1002** in graphical user interface **1000**. In this manner, an operator may more easily traverse models of different aircraft, depending on the position selected.

As depicted, **Figures 11-13** are illustrations of a section of an aircraft in different positions in a factory, such as manufacturing facility **112** in **Figure 1**. These figures show the same section with different parts to reflect the state of aircraft in different assembly positions. In particular, each figure shows the same section of aircraft in a different condition of assembly.

With reference now to **Figure 11**, an illustration of a section of an aircraft is depicted in accordance with an illustrative embodiment. In this illustrative example, section **906** of aircraft is displayed in graphical user interface **1100**.

In this illustrative example, parts **1102** displayed within section **906** in graphical user interface **1100** are parts present in position **812** in **Figure 8**. In other words, section **906** shows parts **1102** in a completed aircraft.

With reference now to **Figure 12**, another illustration of a section of an aircraft is depicted in accordance with an illustrative embodiment. In this illustrative example, section **906** of aircraft is displayed in graphical user interface **1200**. In this display of section **906**, parts **1202** are parts that are present within section **906** in position **810** of the aircraft in **Figure 8**. As seen, fewer parts are present in this view of section **906** as compared to view of section **906** to in **Figure 11**.

With reference now to **Figure 13**, still another illustration of a section of an aircraft is depicted in accordance with an illustrative embodiment. In this illustrative example, section **906** of aircraft is displayed in graphical user interface **1300**. In this display of section **906**, parts **1302** are parts that are present within section **906** in position **808** of the aircraft in **Figure 8**. As can be seen, even fewer parts are present in this view of section **906** as compared to the view of section **906** in **Figure 12**.

Figures 11-13 are only intended as some illustrative examples of parts that may be displayed in a section that reflect a state of an aircraft and, in particular, a condition of assembly of an aircraft. The different states illustrated in **Figures 11-13** may be for planned states or actual states.

The illustrations of the different graphical user interfaces in **Figures 7-13** are provided only as examples of some implementations for graphical user interface **208** in **Figure 2**. These examples are not meant to limit the manner in which an illustrative embodiment may be implemented. For example, although the different examples are displayed with reference to aircraft, similar displays may be used for other types of vehicles or objects. For example, the graphical user interfaces may be configured for sections of objects such as an automobile, a ship, a satellite, an engine, or some other suitable type of object.

As another illustrative example, the display of the different graphical user interfaces may be performed using other graphical user interfaces in addition to or in place of the ones depicted. Further, the order of the graphical user interfaces may vary from the order described above.

As depicted above, the display of a condition of assembly for an aircraft has been shown in a section in the aircraft in **Figures 11-13**. In other illustrative examples, the condition of assembly may be shown for the entire aircraft or some other type of partitioning other than the ones illustrated herein.

With reference next to **Figure 14**, an illustration of a flowchart of a process to identify a state of an object is depicted in accordance with an illustrative embodiment. In this illustrative example, the method may be used to visually query an object such as an aircraft. The process may be implemented using object manager **124** in **Figure 1**. In particular, one or more of the different components for object manager **124** illustrated in **Figure 2** may be used to visually query an aircraft.

In these illustrative examples, this process may be used to identify a state of an object, such as an aircraft. The state may be a condition of assembly.

The process begins by identifying a model for the object (operation **1400**). In the illustrative examples, a model for the object may be identified in a number of ways as described above. For example, a model may be identified by selecting the model from a list of models. In other illustrative examples, the model may be identified visually using a graphical user interface such as graphical user interface **700** in **Figure 7**.

Next, the process identifies a state from states of assembly for the object (operation **1402**). In these illustrative examples, the state may be based on a position of the object within a manufacturing facility. In other illustrative examples, the state may be based on other criteria. For example, the criteria may be based on time in addition to or in place of the location of the aircraft. In

these illustrative examples, the state may be a condition of assembly for the object.

The process then identifies parts present in the object for the state selected for the object (operation **1404**). The visualized parts are the parts that have been assembled for the aircraft in the particular state. As a result, depending on the state selected, the object may have different parts for the state.

The process then displays the parts present in the aircraft for the state selected for the object in a graphical user interface on a display device (operation **1406**), with the process terminating thereafter. In some illustrative examples, sections of aircraft are displayed with the parts present in the aircraft for the state selected in the graphical user interface. In other words, the display similar to graphical user interface **900** may be used to display sections **902**. The sections correspond to sections manufactured for assembly of aircraft.

In other words, the sections displayed for the aircraft may vary depending on the state. For example, the state of the aircraft in graphical user interface **900** in **Figure 9** is different from the state of the aircraft in graphical user interface **1000** in **Figure 10**. The different sections may be present for different states. Additionally, within the same section, different parts may be present based on the parts that have been assembled so far.

Further, the sections also are selectable in the illustrative examples. The ability to initially select which section to begin the object visualization may be provided through various mechanisms. In the illustrative example, the selectability may be provided through hot spots associated with the sections that are displayed in the

graphical user interface. Further, the sections are displayed in an exploded view in operation **1406**.

Turning now to **Figure 15**, an illustration of a more detailed flowchart of a process for identifying a state of an aircraft is depicted in accordance with an illustrative embodiment. This process is one illustrative example of identifying states and, in particular, conditions of assembly for an aircraft. The process illustrated in this figure may be implemented in object manager **124**. In particular, this process may be part of object visualization system **134**. One or more operations illustrated may be implemented using object visualizer **204** in **Figure 2**.

The process begins by displaying a graphical user interface with a group of buildings in a manufacturing facility (operation **1500**). The graphical user interface includes hotspots for the buildings that can be selected. A hotspot is a portion of the graphical user interface that may be selected to cause an action. In these illustrative examples, the buildings are hotspots that may be selected by an operator.

The process then receives user input selecting a building (operation **1502**). In the illustrative example, each building may be used to assemble a particular aircraft. The particular aircraft may be a particular type of aircraft such as the model. In some cases, more than one building may be used to assemble the same type of aircraft, but the particular aircraft may be a specific build for a customer with specific options. In other words, different aircraft of the same type may be assembled in different buildings that have different options although they are of the same type.

Next, a model of the aircraft is identified from a selection of the building in the group of buildings in the

manufacturing facility (operation **1503**). Positions in the building are identified (operation **1504**). Each building may have different positions for the aircraft that are being assembled. Further, even if a building has the same positions, the status of an aircraft at a particular building at particular positions may be different from other buildings. Further, even with the same positions, different aircraft may be assembled in the positions in different buildings.

The positions are displayed in a graphical user interface (operation **1506**). In these illustrative examples, the different positions are hotspots that may be selected through user input entered by an operator. The process then receives user input for selecting a position.

The process then identifies a sectional view for the aircraft based on a selection of the position (operation **1508**). In the illustrative example, each position may have a different sectional view that may be displayed. The sections of aircraft in a position are the sections manufactured at the position selected in these illustrative examples. The sectional view includes sections for that particular position.

As depicted, the sectional view may be, for example, sectional view **223** in sectional views **224**. Different sectional views are present for different positions in the illustrative example. Sectional view **905** in **Figure 9** and sectional view **1005** in **Figure 10** are examples of sectional views that may be selected depending on the position selected for the aircraft in operation **1508**.

In these illustrative examples, the sectional views were selected for parts that are present in the aircraft for the position. These are parts that may already be present

from assembly of the aircraft in a prior position or may be parts that are to be assembled in the position selected.

The process then displays sections of the aircraft (operation **1510**). In operation **1510**, the sections are displayed in the sectional view of the aircraft. Further, the different sections are displayed in association with hotspots that may be selected by user input entered by an operator. The process then detects a selection of a section from the sections displayed in the graphical user interface (operation **1512**). In operation **1512**, the section has hotspots associated with the volume identifier. The selection of a section of an aircraft involves selecting the hot spot associated with the aircraft. The hot spot points to a volume identifier, such as volume identifier **222** in **Figure 2**. In some cases, the hotspot may be a link pointing to the volume identifier. For example, the hotspot may be an index used to identify a volume identifier.

The process then identifies a volume in the model corresponding to the section selected from the sections displayed in the graphical user interface (operation **1514**). In these illustrative examples, each section of an aircraft is associated with the volume for the aircraft. This volume is identified from volume identifiers associated with sections in the sectional view using the volume identifier pointed to by the hotspot selected for the section. The volume identifier may include information defining the volume. For example, volume identifier **222** may include volume descriptor **402** as depicted in **Figure 4**. In particular, the volume identifier may include a group of coordinates defining the volume in the model.

Next, the process identifies a state from states of assembly for the aircraft (operation **1516**). In these illustrative examples, the state of assembly may be a

condition of assembly based on the position of the aircraft within a manufacturing facility. The process then identifies parts that are present for the state in the volume in the model corresponding to the section selected (operation **1518**). These parts that are present are ones that are present for a particular state for the aircraft.

Next, sections of the aircraft with the parts present in aircraft for the state selected are displayed in a graphical user interface on a display device (operation **1520**). The process then displays the section in the graphical user interface using the volume identified in the model with the parts present in the section selected with the state identified (operation **1522**).

Next, a determination is made as to whether a new section of the aircraft has been selected for the position of the aircraft (operation **1524**). If any section has been selected, the process then returns to operation **1510** as described above.

If a new section has not been selected, a determination is made as to whether a new position has been selected for the aircraft (operation **1526**). If a new position has been selected, the process then returns to operation **1508** as described above. If a new position has not been selected, the process determines whether a new building has been selected (operation **1528**). If a new building has been selected, the process returns to operation **1504**. Otherwise, the process performs the operation selected by the operator (operation **1530**), with the process then returning to operation **1522**. In operation **1530**, the operator may rotate the parts displayed in the volume, magnify the display, remove parts, annotate parts, or perform other operations with respect to the parts displayed in the volume.

Turning now to **Figure 16**, an illustration of a flowchart for displaying a section in a graphical user interface is depicted in accordance with an illustrative embodiment. The different operations illustrated in **Figure 16** are examples of an implementation for operation **1522** in **Figure 15**.

The process identifies the parts present in the aircraft in a completed state (operation **1600**). Thereafter, the process identifies the parts present in the aircraft in the state selected to form a second group of parts (operation **1602**). The second group of parts is subtracted from the parts present in the aircraft in a completed state to identify a first group of parts (operation **1604**).

The process hides the first group of parts in the volume that is absent from the section of aircraft in the state selected (operation **1606**). The second group of parts that is not hidden in the volume are displayed to display the section selected in the graphical user interface (operation **1608**), with the process terminating thereafter.

The flowcharts and block diagrams in the different depicted embodiments illustrate the architecture, functionality, and operation of some possible implementations of apparatuses and methods in an illustrative embodiment. In this regard, each block in the flowcharts or block diagrams may represent a module, a segment, a function, and/or a portion of an operation or step. For example, one or more of the blocks may be implemented as program code, in hardware, or a combination of the program code and hardware. When implemented in hardware, the hardware may, for example, take the form of integrated circuits that are manufactured or configured to perform one or more operations in the flowcharts or block diagrams. When implemented as a combination of program code

and hardware, the implementation may take the form of firmware.

In some alternative implementations of an illustrative embodiment, the function or functions noted in the blocks 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 performed in the reverse order, depending upon the functionality involved. Also, other blocks may be added in addition to the illustrated blocks in a flowchart or block diagram.

In one illustrative example, sections may not be displayed in an exploded view in operation **1406**. Instead, the sections may be displayed as a whole aircraft in which different sections may be selected through hotspots. The different sections may be indicated using lines or other graphical indicators in this type of implementation.

Turning now to **Figure 17**, an illustration of a block diagram of a data processing system is depicted in accordance with an illustrative embodiment. Data processing system **1700** may be used to implement computer system **126** in **Figure 1**. In this illustrative example, data processing system **1700** includes communications framework **1702**, which provides communications between processor unit **1704**, memory **1706**, persistent storage **1708**, communications unit **1710**, input/output unit **1712**, and display **1714**. In this example, communications framework may take the form of a bus system.

Processor unit **1704** serves to execute instructions for software that may be loaded into memory **1706**. Processor unit **1704** may be a number of processors, a multi-processor core, or some other type of processor, depending on the particular implementation.

Memory **1706** and persistent storage **1708** are examples of storage devices **1716**. 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. Storage devices **1716** may also be referred to as computer readable storage devices in these illustrative examples. Memory **1706**, in these examples, may be, for example, a random access memory or any other suitable volatile or non-volatile storage device. Persistent storage **1708** may take various forms, depending on the particular implementation.

For example, persistent storage **1708** may contain one or more components or devices. For example, persistent storage **1708** 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 **1708** also may be removable. For example, a removable hard drive may be used for persistent storage **1708**.

Communications unit **1710**, in these illustrative examples, provides for communications with other data processing systems or devices. In these illustrative examples, communications unit **1710** is a network interface card.

Input/output unit **1712** allows for input and output of data with other devices that may be connected to data processing system **1700**. For example, input/output unit **1712** may provide a connection for user input through a keyboard, a mouse, and/or some other suitable input device. Further, input/output unit **1712** may send output to a printer. Display **1714** provides a mechanism to display information to a user.

Instructions for the operating system, applications, and/or programs may be located in storage devices **1716**, which are in communication with processor unit **1704** through communications framework **1702**. The processes of the different embodiments may be performed by processor unit **1704** using computer-implemented instructions, which may be located in a memory, such as memory **1706**.

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 **1704**. The program code in the different embodiments may be embodied on different physical or computer readable storage media, such as memory **1706** or persistent storage **1708**.

Program code **1718** is located in a functional form on computer readable media **1720** that is selectively removable and may be loaded onto or transferred to data processing system **1700** for execution by processor unit **1704**. Program code **1718** and computer readable media **1720** form computer program product **1722** in these illustrative examples.

In one example, computer readable media **1720** may be computer readable storage media **1724** or computer readable signal media **1726**. In these illustrative examples, computer readable storage media **1724** is a physical or tangible storage device used to store program code **1718** rather than a medium that propagates or transmits program code **1718**.

Alternatively, program code **1718** may be transferred to data processing system **1700** using computer readable signal media **1726**. Computer readable signal media **1726** may be, for example, a propagated data signal containing program code **1718**. For example, computer readable signal media **1726** 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.

The different components illustrated for data processing system **1700** 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 and/or in place of those illustrated for data processing system **1700**. Other components shown in **Figure 17** 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 **1718**.

Illustrative embodiments of the disclosure may be described in the context of aircraft manufacturing and service method **1800** as shown in **Figure 18** and aircraft **1900** as shown in **Figure 19**. Turning first to **Figure 18**, an illustration of an aircraft manufacturing and service method is depicted in the form of a block diagram in accordance with an illustrative embodiment. During pre-production, aircraft manufacturing and service method **1800** may include specification and design **1802** of aircraft **1900** in **Figure 19** and material procurement **1804**.

During production, component and subassembly manufacturing **1806** and system integration **1808** of aircraft **1900** in **Figure 19** takes place. Thereafter, aircraft **1900** in **Figure 19** may go through certification and delivery **1810** in order to be placed in service **1812**. While in service **1812** by a customer, aircraft **1900** in **Figure 19** is scheduled for routine maintenance and service **1814**, which may include modification, reconfiguration, refurbishment, and other maintenance or service.

Each of the processes of aircraft manufacturing and service method **1800** 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 aircraft manufacturers and major-system subcontractors; a third party may include, without limitation, any number of vendors, subcontractors, and suppliers; and an operator may be an airline, a leasing company, a military entity, a service organization, and so on.

With reference now to **Figure 19**, an illustration of an aircraft is depicted in the form of a block diagram in which an illustrative embodiment may be implemented. In this example, aircraft **1900** is produced by aircraft manufacturing and service method **1800** in **Figure 18** and may include airframe **1902** with systems **1904** and interior **1906**. Examples of systems **1904** include one or more of propulsion system **1908**, electrical system **1910**, hydraulic system **1912**, and environmental system **1914**. Any number of other systems may be included. Although an aerospace example is shown, different illustrative embodiments may be applied to other industries, such as the automotive industry.

Apparatuses and methods embodied herein may be employed during at least one of the stages of aircraft manufacturing and service method **1800** in **Figure 18**. For example, one or more illustrative embodiments may be implemented during system integration **1808**. The different illustrative examples may be implemented to identify information to perform tasks to assemble parts on aircraft **1900**.

In particular, the visual query of aircraft may be used to identify locations where tasks for shop order instances are to be performed or where tasks have been performed.

Additionally, an illustrative embodiment also may be implemented during maintenance and service **1814**. For example, information about the aircraft may be visually queried and viewed by an operator to perform tasks to assemble parts for maintenance, upgrades, refurbishment, and other operations during maintenance and service **1814** may be identified using an illustrative embodiment.

Turning now to **Figure 20**, an illustration of a block diagram of a manufacturing system is depicted in the form of a block diagram in accordance with an illustrative embodiment. Manufacturing system **2000** is a physical hardware system and is configured to manufacture products, such as aircraft **1900** in **Figure 19**.

As depicted, manufacturing system **2000** includes manufacturing equipment **2002**. Manufacturing equipment **2002** includes at least one of fabrication equipment **2004** or assembly equipment **2006**.

Fabrication equipment **2004** is equipment that may be used to fabricate components for parts used to form aircraft **1900**. For example, fabrication equipment **2004** may include machines and tools. These machines and tools may be at least one of a drill, a hydraulic press, a furnace, a mold, a composite tape laying machine, a vacuum system, a lathe, or other suitable types of equipment. Fabrication equipment **2004** may be used to fabricate metal parts, composite parts, semiconductors, circuits, fasteners, ribs, skin panels, spars, antennas, pharynx, and other suitable types of parts.

Assembly equipment **2006** is equipment used to assemble parts to form aircraft **1900**. In particular, assembly equipment **2006** may be used to assemble components and parts to form aircraft **1900**. Assembly equipment **2006** also may include machines and tools. These machines and tools may be at least one of a robotic arm, a crawler, a faster

installation system, a rail-based drilling system, or a robot. Assembly equipment **2006** may be used to assemble parts such as seats, horizontal stabilizers, wings, engines, engine housings, landing gear systems, and other parts for aircraft **1900**.

Manufacturing system **2000** also includes control system **2008**. Control system **2008** is a hardware system and may also include software or other types of components. Control system **2008** is configured to control the operation of manufacturing equipment **2002**. Control system **2008** may be implemented using hardware. The hardware may include computers, circuits, networks, and other types of equipment. Control system **2008** may take the form of direct control of manufacturing equipment **2002**. For example, robots, computer-controlled machines, and other equipment may be controlled by control system **2008**. In other illustrative examples, control system **2008** may manage operations performed by human operators **2010** in manufacturing aircraft **1900**.

In these illustrative examples, object manager **124** in **Figure 1** may be implemented in control system **2000** to manage the manufacturing of aircraft **1900** in **Figure 19**. As depicted, object manager **124** may generate information for operating manufacturing equipment to manufacture the aircraft.

For example, displaying a condition of assembly for an aircraft may be useful in managing the manufacture of aircraft **1900**. In particular, the manufacture of aircraft **1900** may be managed using sections of aircraft displayed with the parts present in the aircraft for the state selected in a graphical user interface on a display device. In the different illustrative examples, the state may be a condition of assembly. This condition assembly may be used

by different operators in human operators **2010** to manufacture aircraft **1900**. For example, human operators **2010** may identify locations where assembly of parts should occur. Also, human operators **2010** also may identify whether the particular parts have been installed when the condition of assembly is an actual condition of assembly for aircraft **1900**.

In the different illustrative examples, human operators **2010** may operate or interact with at least one of manufacturing equipment **2002** or control system **2008**. This interaction may be performed to manufacture aircraft **1900**.

Of course, manufacturing system **2000** may be configured to manufacture other products. Although manufacturing system **2000** has been described with respect to manufacturing in the aerospace industry, manufacturing system **2000** may be configured to manufacture products for other industries. For example, manufacturing system **2000** may be configured to manufacture products for the automotive industry as well as any other suitable industries.

In this manner, operators may visualize information about an aircraft using a graphical user interface. This visualization may be performed on the shop floor by operators who may not have experience and training with computer-aided design software. This visual query allows an operator to visually look at an aircraft or other object.

The visualization may be performed without operators having to know coordinates for locations in the aircraft. In these illustrative examples, the graphical user interface displays graphical representations of the aircraft that allows the operators to view different portions of the aircraft without using coordinates to traverse the views of the aircraft.

Further, with an ability to visualize different conditions of assembly for aircraft **1900**, the management of operations performed by manufacturing system **2000** may occur in a manner that reduces the time to manufacture aircraft **1900**, increases the efficiency in manufacturing aircraft **1900**, increases efficiency in assigning shop order instances for manufacturing aircraft **1900**, and other suitable goals.

The description of the different illustrative 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 illustrative embodiments may provide different features as compared to other illustrative 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.

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CLAIMS:

1. A computer implemented method of visualising a state of assembly of an aircraft, the method comprising:

identifying a model for the aircraft;

identifying a state of assembly from a plurality of states of assembly for the aircraft;

identifying parts present in the aircraft for the state of assembly identified;

displaying the parts identified in a graphical user interface on a display device;

displaying a plurality of sections of the aircraft with the parts identified in the graphical user interface;

detecting a selection of a section from the plurality of sections displayed;

identifying a volume in the model corresponding to the selection selected;

identifying parts present in the volume identified;

displaying the section selected in the graphical user interface using the volume identified with the parts present in the volume identified;

hiding a first group of parts in the volume identified that are absent from the section selected in the state of assembly identified; and

displaying a second group of parts that are not hidden in the volume identified to display the section selected in the graphical user interface.

2. The method of claim 1, wherein the plurality of sections correspond to sections manufactured for assembly of the aircraft and wherein the plurality of sections are selectable.

3. The method of claim 1 further comprising:

identifying the parts present in the aircraft in a completed state of assembly;

identifying the parts present in the aircraft in the state of assembly selected to form the second group of parts; and

subtracting the second group of parts from the parts present in the aircraft in the completed state of assembly to identify the first group of parts.

4. The method of claim 1 further comprising:

managing manufacturing of the aircraft using the plurality of sections of the aircraft displayed with the parts identified in the graphical user interface.

5. The method of claim 1, wherein the state of assembly is identified from a position of the aircraft from a plurality of positions for the aircraft.

6. The method of claim 1, wherein the states of assembly for the aircraft are based on a position of the aircraft within a manufacturing facility

7. An apparatus comprising:

a processor;

an object manager, running on the processor, configured to:

identify a model for an aircraft;

identify a state of assembly from a plurality of states of assembly for the aircraft;

identify parts present in the aircraft for the state of assembly identified;

display, on a graphical user interface on a display device, a plurality of sections of the aircraft with the parts identified;

detect a selection of a section from the plurality of sections displayed;

identify a volume in the model corresponding to the selection selected;

identify parts present in the volume identified;

display the section selected in the graphical user interface using the volume identified with the parts present in the volume identified;

hide a first group of parts in the volume identified that are absent from the section selected in the state of assembly identified; and

display a second group of parts that are not hidden in the volume identified to display in the graphical user interface the section selected, wherein the object manager is further configured to generate information for operating manufacturing equipment to manufacture the aircraft.

8. The apparatus of claim 7, wherein the plurality of sections correspond to sections as manufactured for assembly of the aircraft and wherein the plurality of sections are selectable.

9. The apparatus of claim 7, wherein the object manager is further configured to:

identify the parts present in the aircraft in a completed state of assembly;

identify the parts present in the aircraft in the state of assembly selected to form the second group of parts; and

subtract the second group of parts from the parts present in the aircraft in the completed state of assembly to identify the first group of parts.

10. The apparatus of claim 7, wherein the state of assembly is identified from a position of the aircraft from a plurality of positions for the aircraft.

11. An aircraft manufacturing system comprising:

a processor;

a control system configured to control operation of manufacturing equipment; and

an object manager, running on the processor, in the control system, wherein the object manager is configured to:

identify a model for the aircraft;

identify a state of assembly from a plurality of states of assembly for the aircraft;

identify parts present in the aircraft for the state of assembly;

display, on a graphical user interface on a display device, a plurality of sections of the aircraft with the parts identified;

detect a selection of a section from the plurality of sections displayed;

identify a volume in the model corresponding to the selection selected;

identify parts present in the volume identified;

display the section selected in the graphical user interface using the volume identified with the parts present in the volume identified;

hide a first group of parts in the volume identified that are absent from the section selected in the state of assembly identified; and

display a second group of parts that are not hidden in the volume identified to display in the graphical user interface the section selected, wherein the object manager is further configured to generate information for operating the manufacturing equipment to manufacture the aircraft.

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12. The aircraft manufacturing system of claim 11, wherein the plurality of sections correspond to sections manufactured for assembly of the aircraft and wherein the plurality of sections are selectable.

THE BOEING COMPANY
Patent Attorneys for the Applicant/Nominated Person
SPRUSON & FERGUSON

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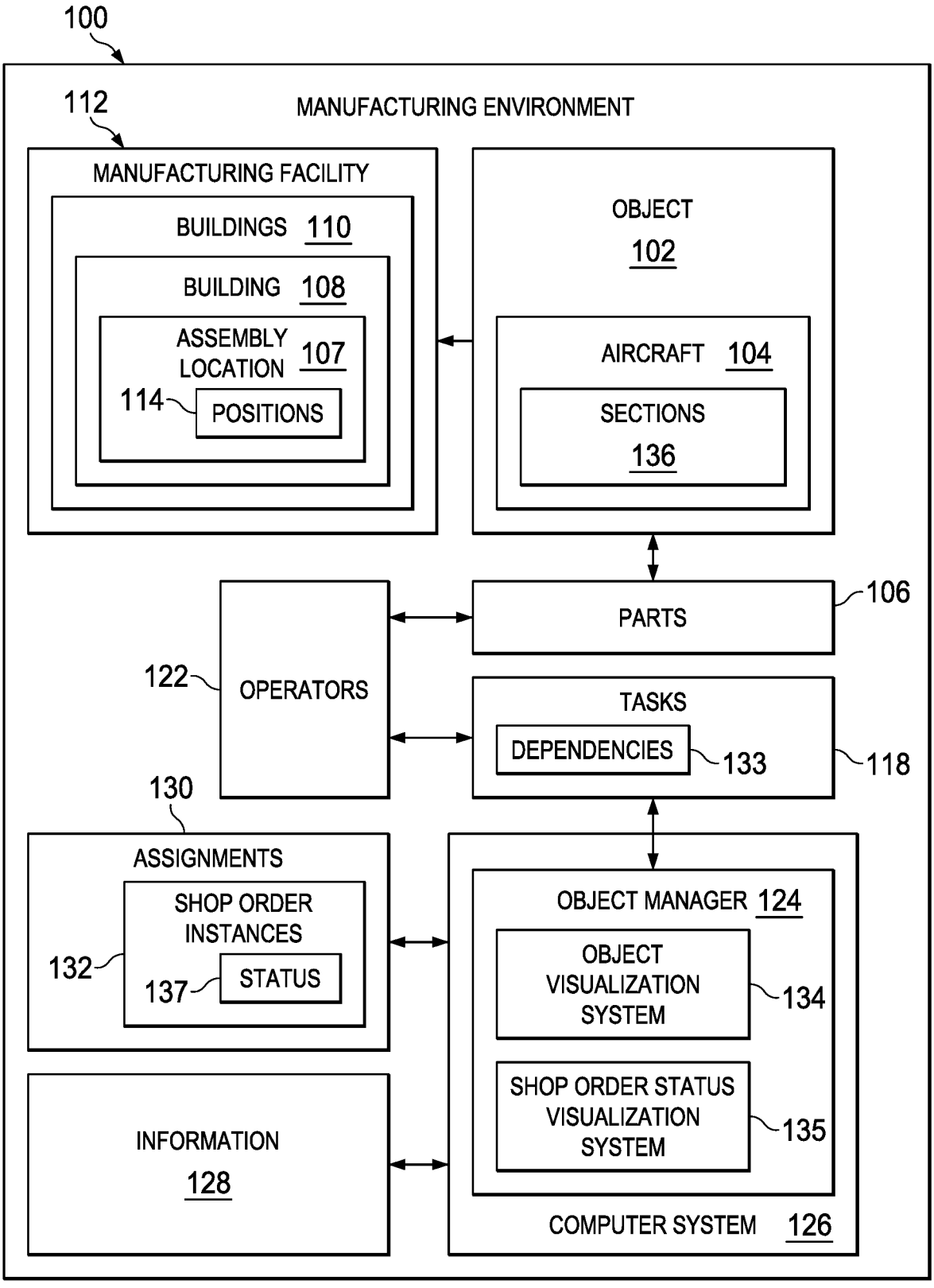
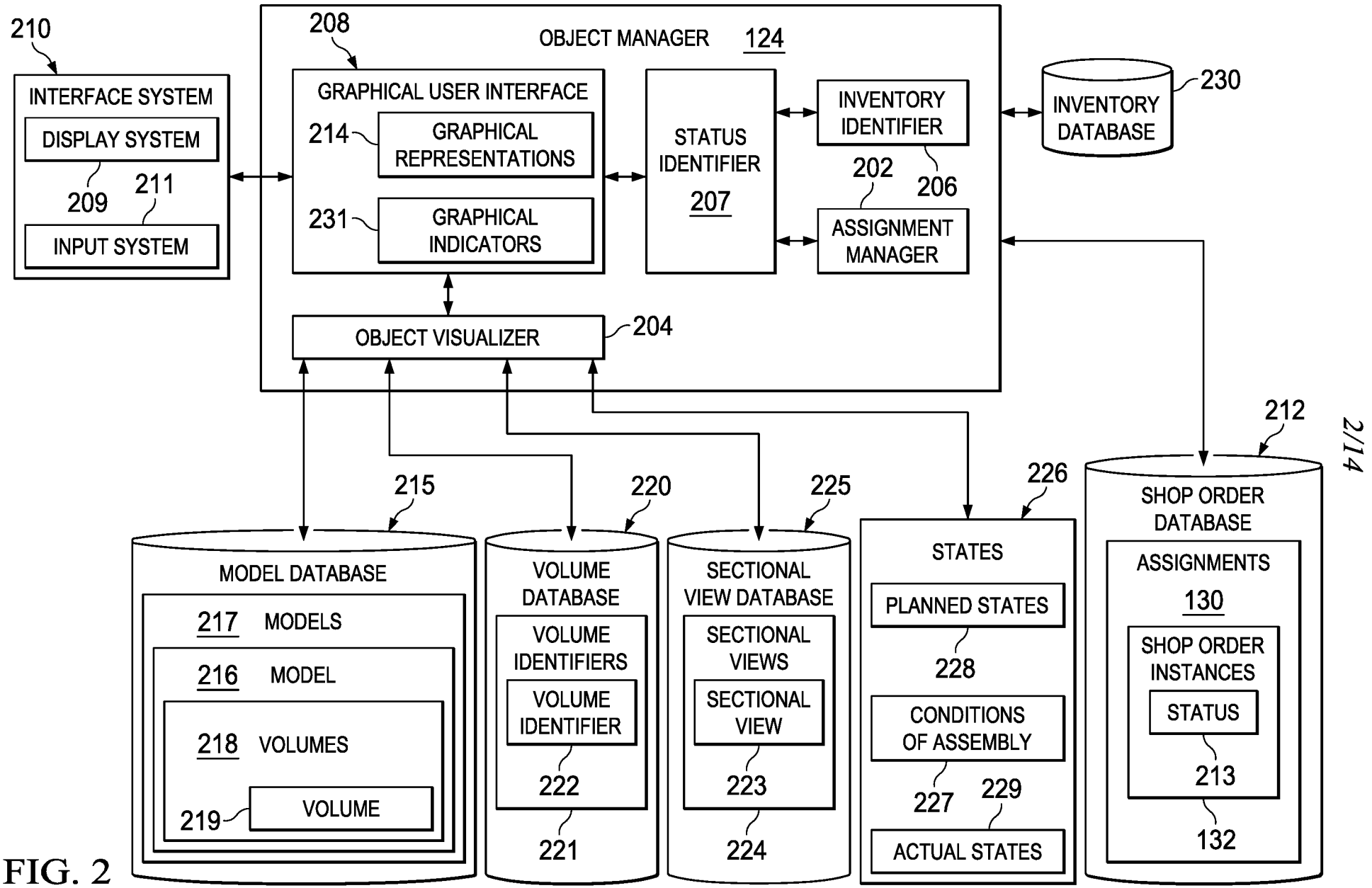


FIG. 1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INTERFACE SYSTEM
DISPLAY SYSTEM
209
211
INPUT SYSTEM
208
OBJECT MANAGER 124
GRAPHICAL USER INTERFACE
214
GRAPHICAL REPRESENTATIONS
231
GRAPHICAL INDICATORS
OBJECT VISUALIZER
204
STATUS IDENTIFIER 207
INVENTORY IDENTIFIER
202
206
ASSIGNMENT MANAGER
INVENTORY DATABASE
230
212
215
220
225
226
MODEL DATABASE
217 MODELS
216 MODEL
218 VOLUMES
219
VOLUME
VOLUME DATABASE
VOLUME IDENTIFIERS
VOLUME IDENTIFIER
222
221
SECTIONAL VIEW DATABASE
SECTIONAL VIEWS
SECTIONAL VIEW
223
224
STATES
PLANNED STATES
228
CONDITIONS OF ASSEMBLY
227
229
ACTUAL STATES
SHOP ORDER DATABASE
ASSIGNMENTS
130
SHOP ORDER INSTANCES
STATUS
213
132

FIG. 2

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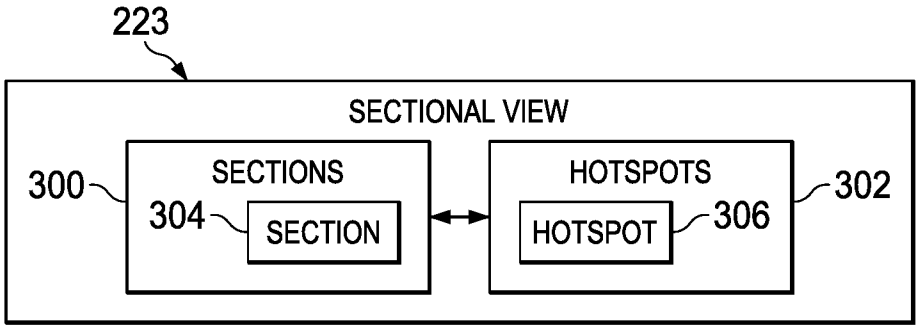

FIG. 3

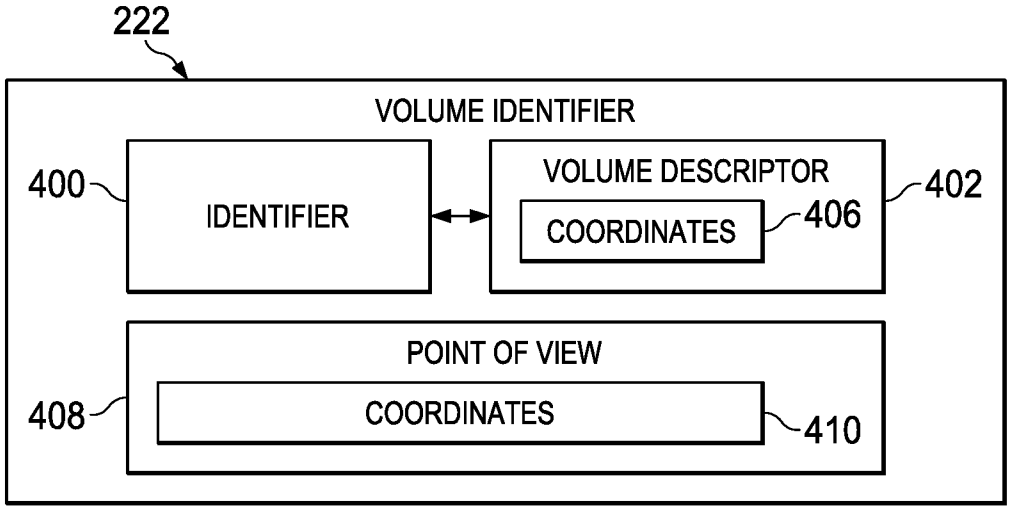

FIG. 4

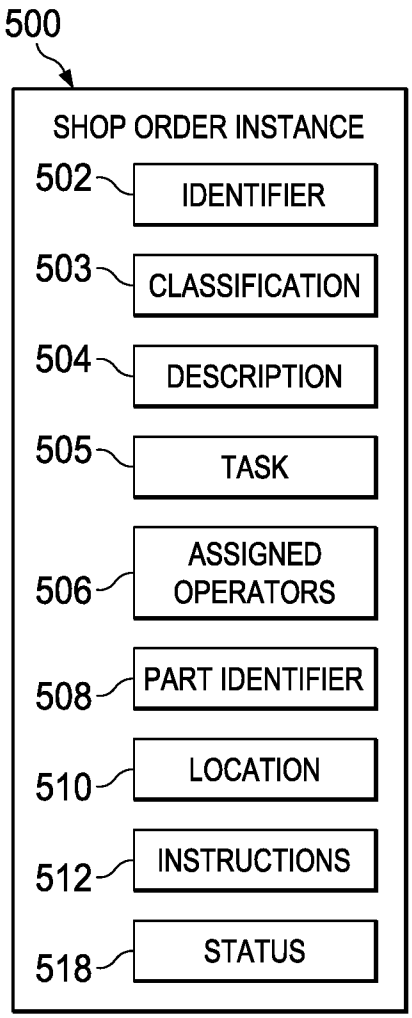
500
SHOP ORDER INSTANCE
502
IDENTIFIER
503
CLASSIFICATION
504
DESCRIPTION
505
TASK
506
ASSIGNED OPERATORS
508
PART IDENTIFIER
510
LOCATION
512
INSTRUCTIONS
518
STATUS

FIG. 5

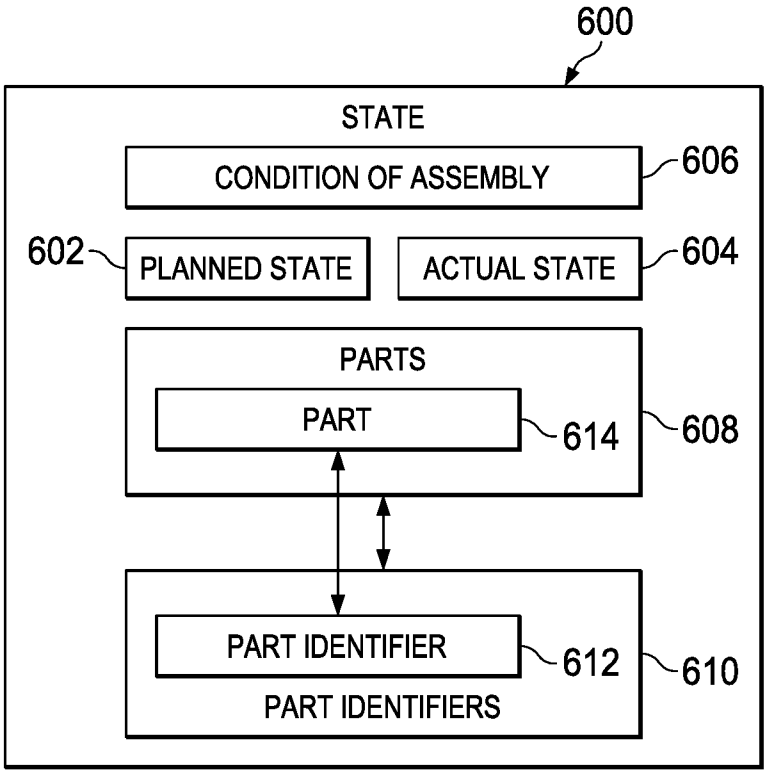
600
STATE
CONDITION OF ASSEMBLY
606
602
PLANNED STATE
ACTUAL STATE
604
PARTS
PART
614
608
PART IDENTIFIER
612
610
PART IDENTIFIERS

FIG. 6

FIG. 7

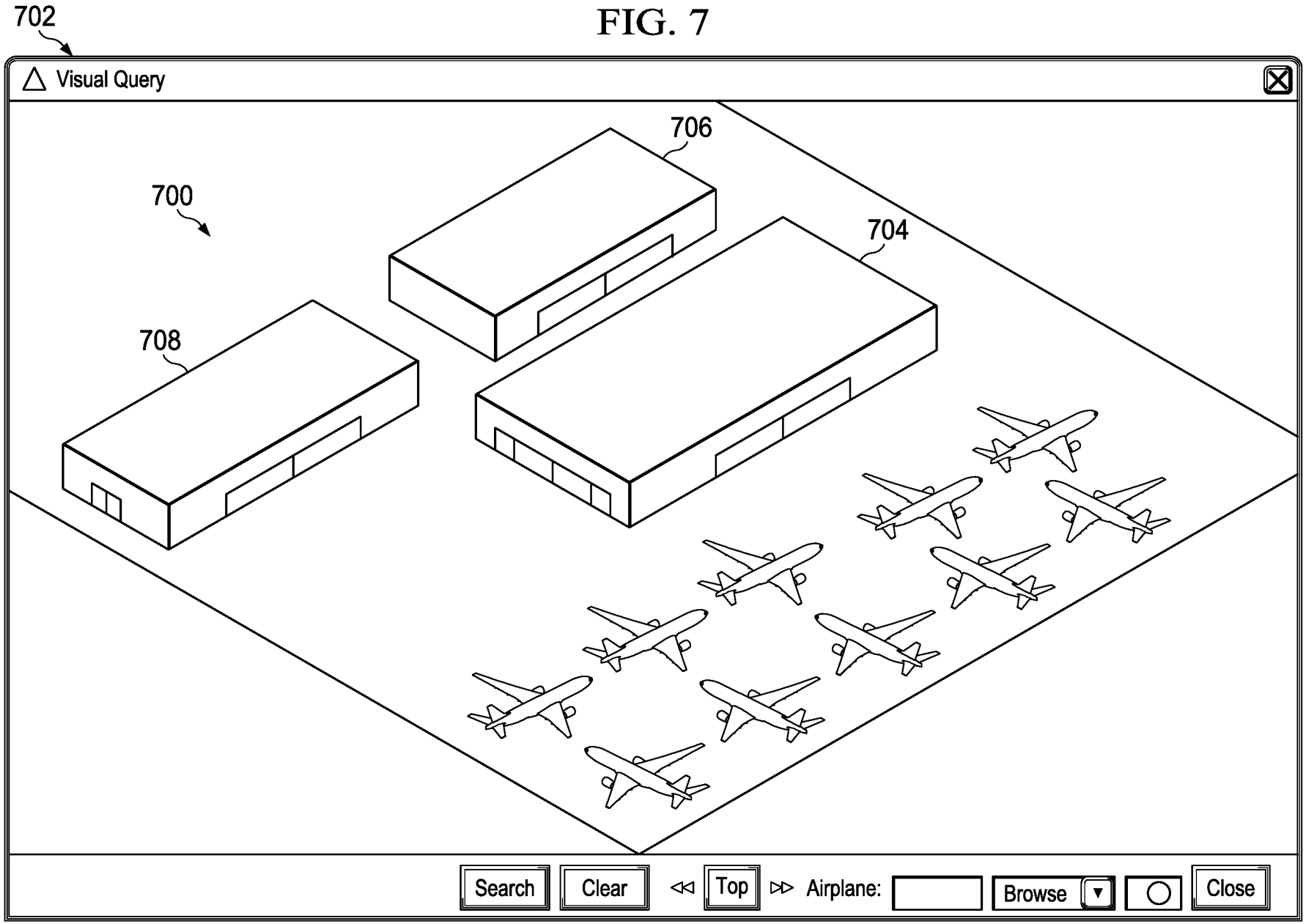
702
Visual Query
706
700
704
708
Search
Clear
Top
Airplane:
Browse
Close

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FIG. 8

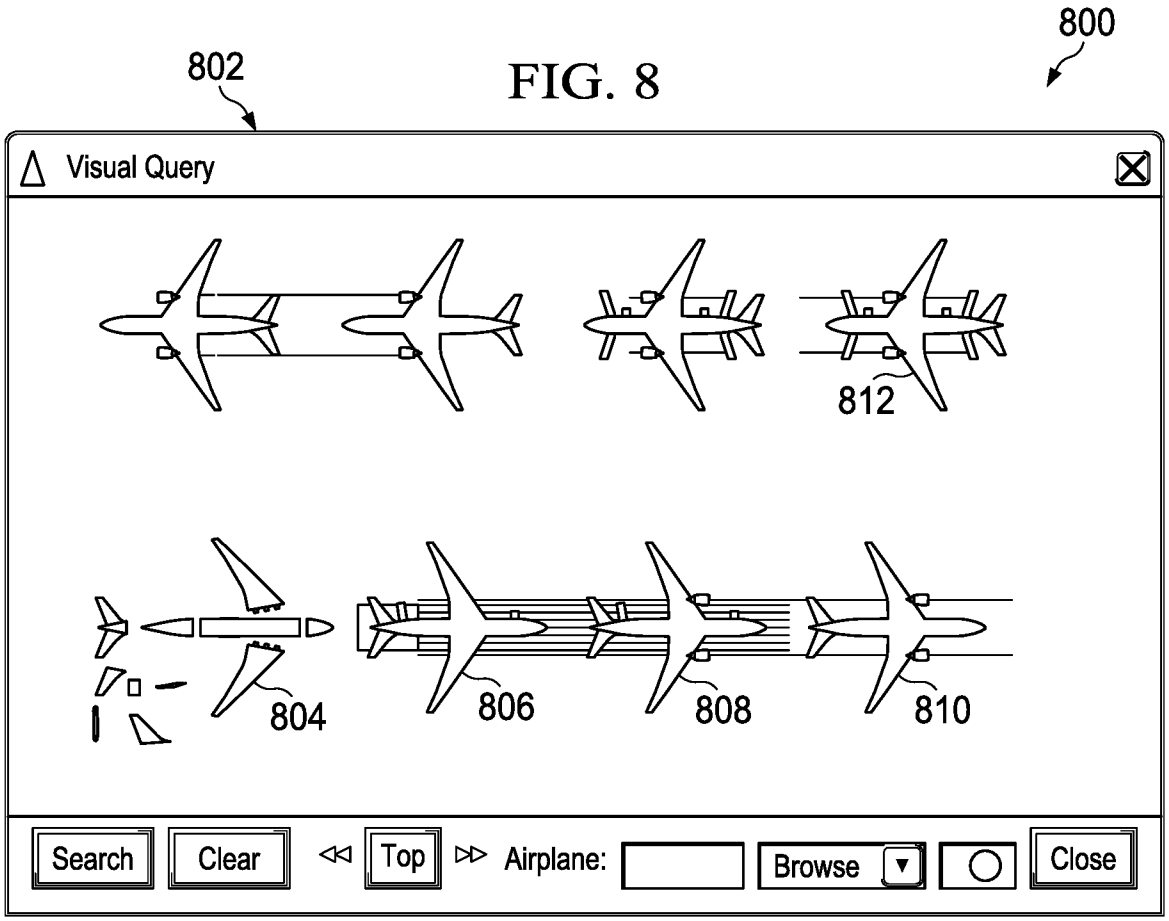

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FIG. 9

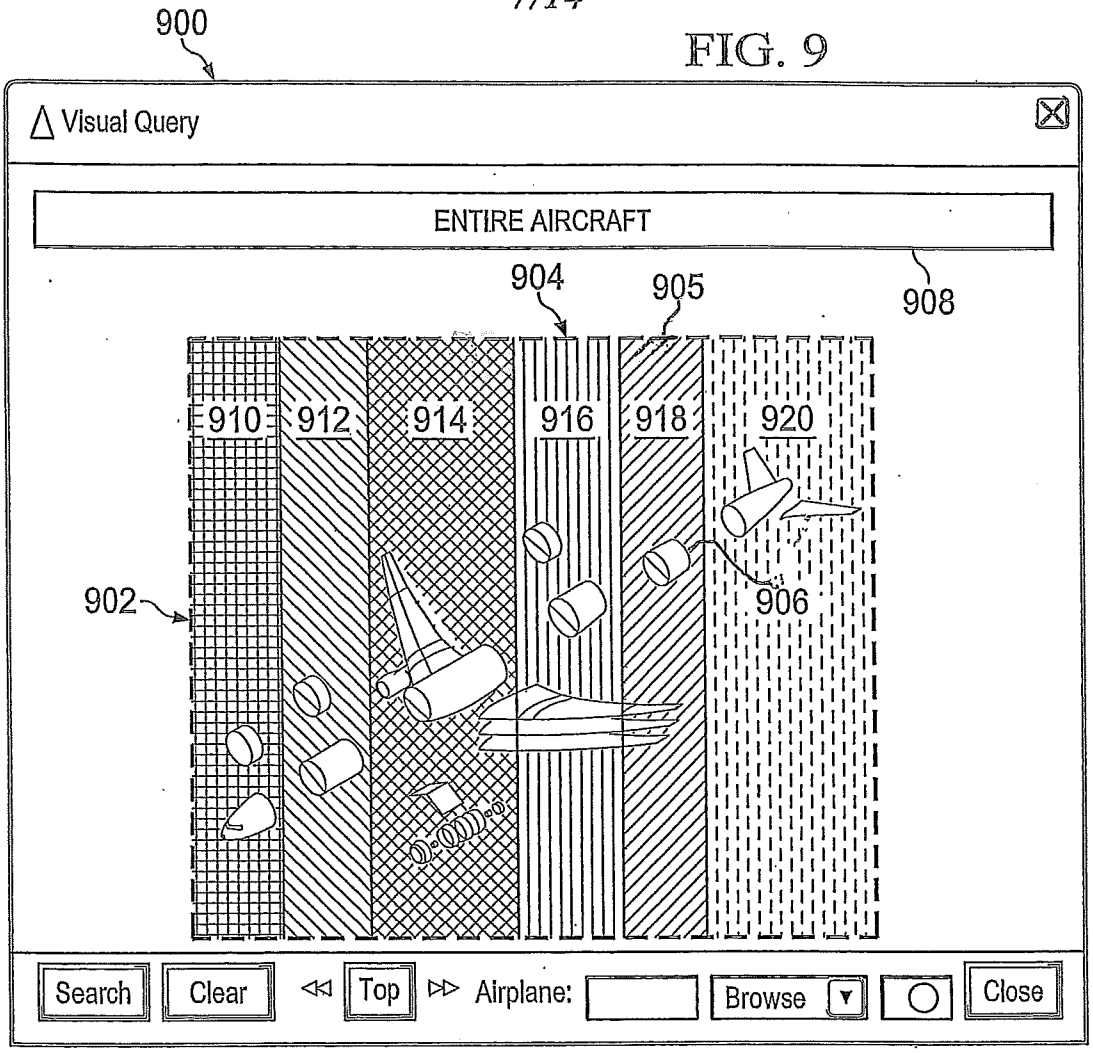
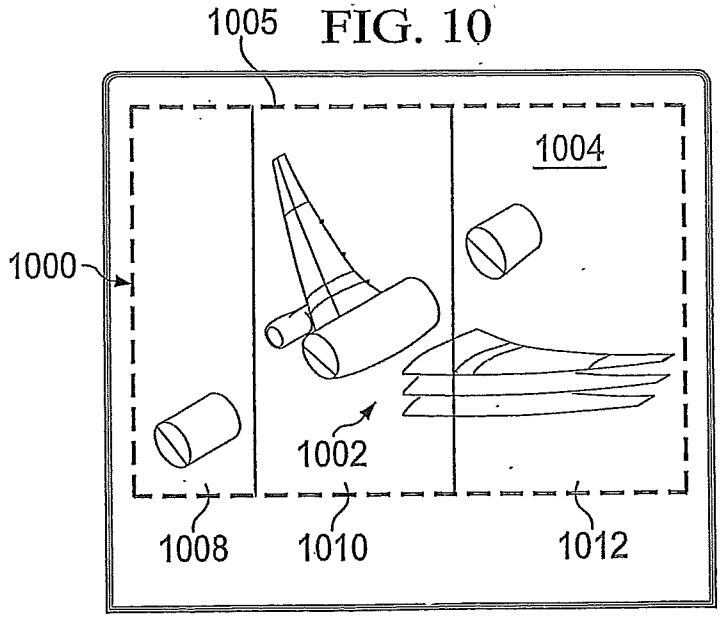


FIG. 10



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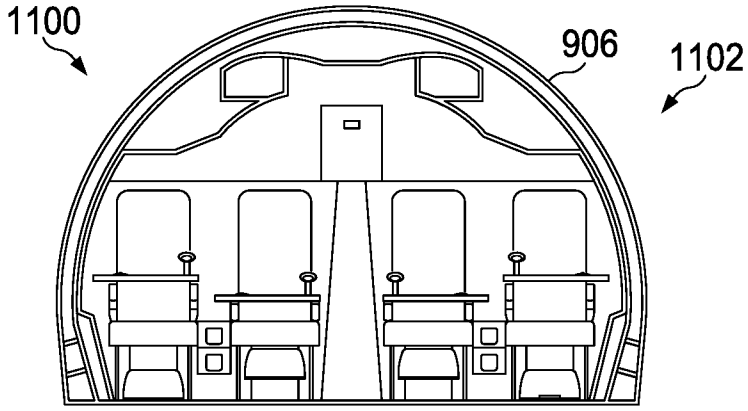

FIG. 11

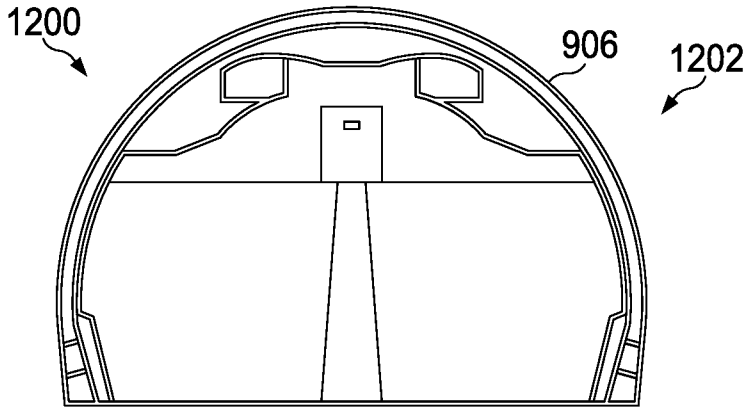

FIG. 12

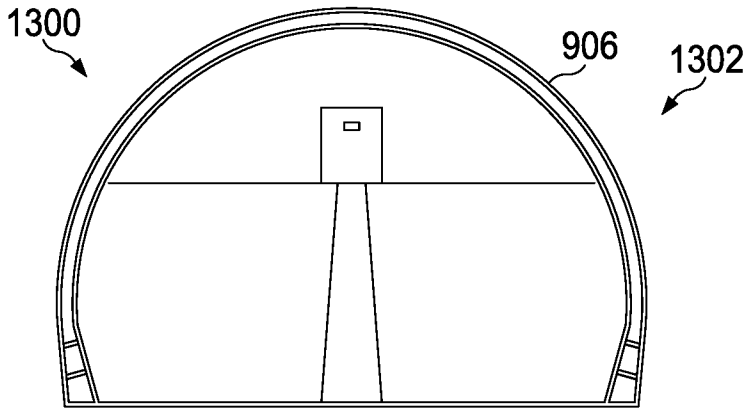

FIG. 13

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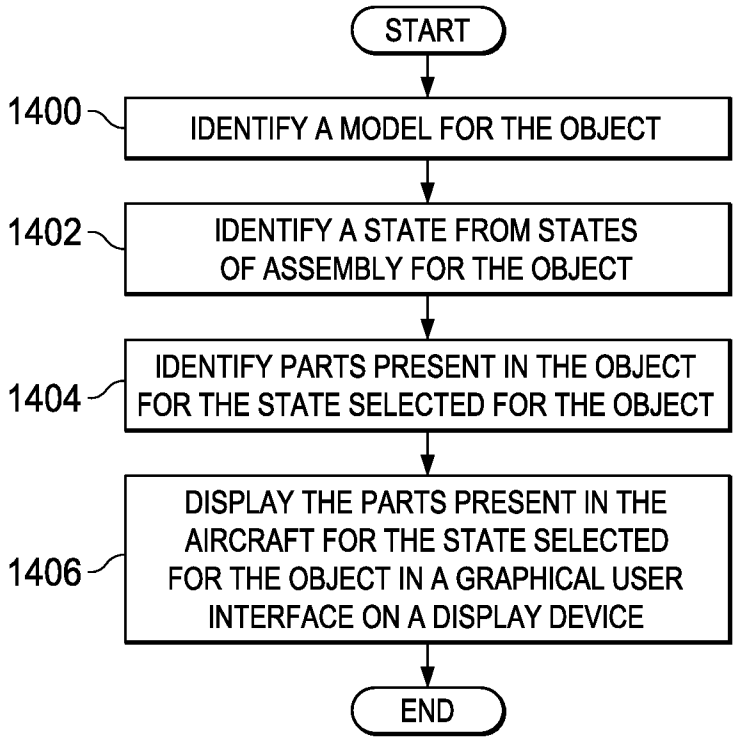
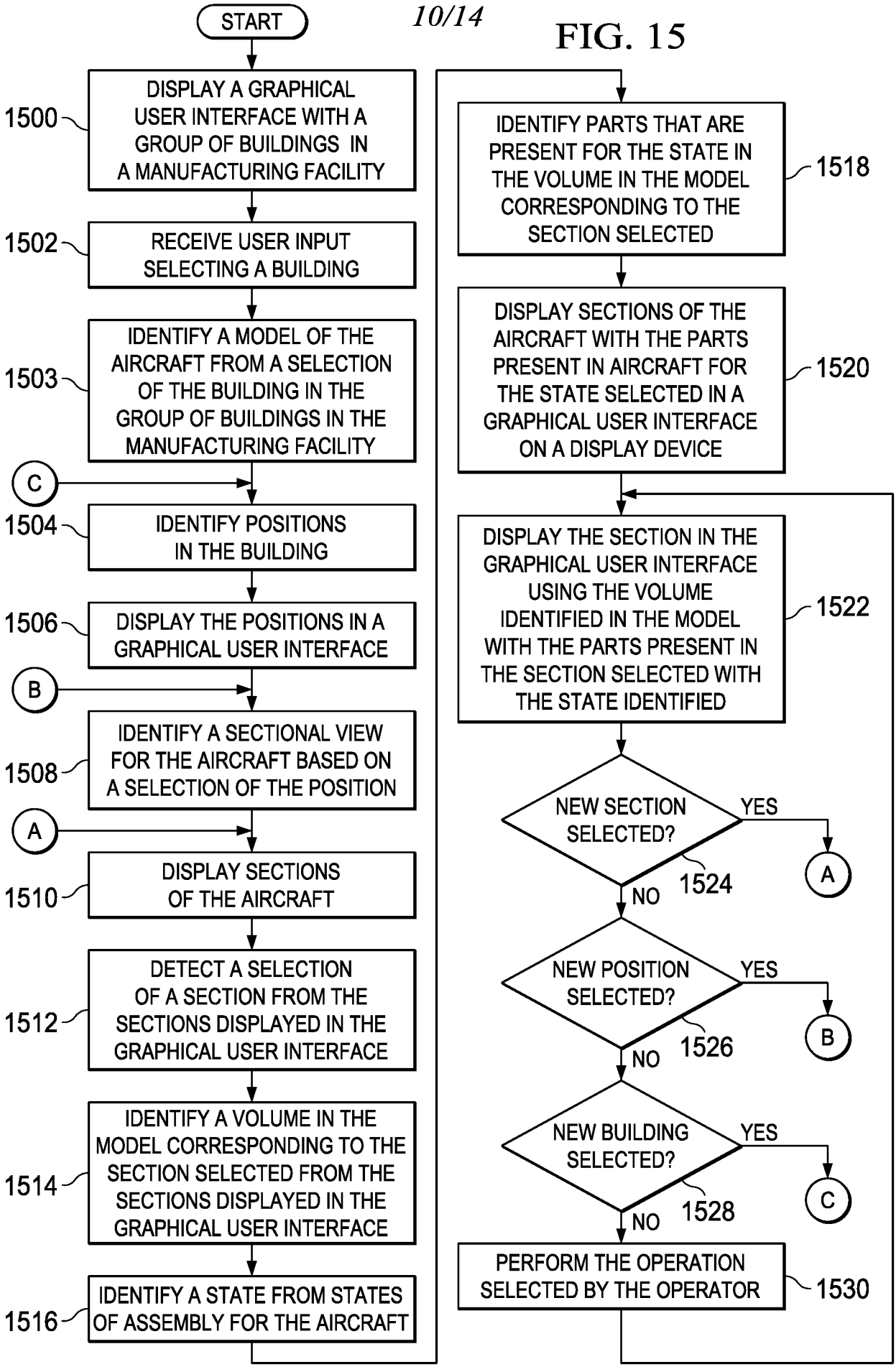


FIG. 14

FIG. 15


START
1500
DISPLAY A GRAPHICAL USER INTERFACE WITH A GROUP OF BUILDINGS IN A MANUFACTURING FACILITY
1502
RECEIVE USER INPUT SELECTING A BUILDING
1503
IDENTIFY A MODEL OF THE AIRCRAFT FROM A SELECTION OF THE BUILDING IN THE GROUP OF BUILDINGS IN THE MANUFACTURING FACILITY
C
1504
IDENTIFY POSITIONS IN THE BUILDING
1506
DISPLAY THE POSITIONS IN A GRAPHICAL USER INTERFACE
B
1508
IDENTIFY A SECTIONAL VIEW FOR THE AIRCRAFT BASED ON A SELECTION OF THE POSITION
A
1510
DISPLAY SECTIONS OF THE AIRCRAFT
1512
DETECT A SELECTION OF A SECTION FROM THE SECTIONS DISPLAYED IN THE GRAPHICAL USER INTERFACE
1514
IDENTIFY A VOLUME IN THE MODEL CORRESPONDING TO THE SECTION SELECTED FROM THE SECTIONS DISPLAYED IN THE GRAPHICAL USER INTERFACE
1516
IDENTIFY A STATE FROM STATES OF ASSEMBLY FOR THE AIRCRAFT
1518
IDENTIFY PARTS THAT ARE PRESENT FOR THE STATE IN THE VOLUME IN THE MODEL CORRESPONDING TO THE SECTION SELECTED
1520
DISPLAY SECTIONS OF THE AIRCRAFT WITH THE PARTS PRESENT IN AIRCRAFT FOR THE STATE SELECTED IN A GRAPHICAL USER INTERFACE ON A DISPLAY DEVICE
1522
DISPLAY THE SECTION IN THE GRAPHICAL USER INTERFACE USING THE VOLUME IDENTIFIED IN THE MODEL WITH THE PARTS PRESENT IN THE SECTION SELECTED WITH THE STATE IDENTIFIED
NEW SECTION SELECTED?
1524
YES
A
NO
NEW POSITION SELECTED?
1526
YES
B
NO
NEW BUILDING SELECTED?
1528
YES
C
NO
PERFORM THE OPERATION SELECTED BY THE OPERATOR
1530

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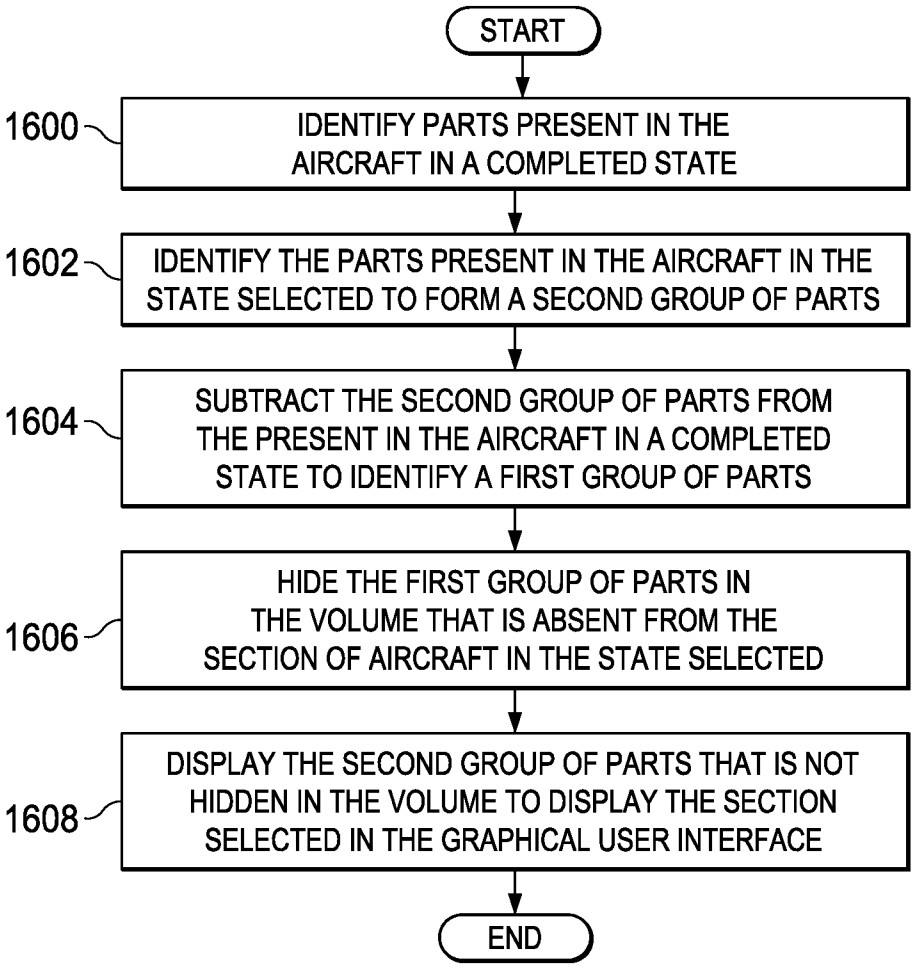

FIG. 16

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FIG. 17

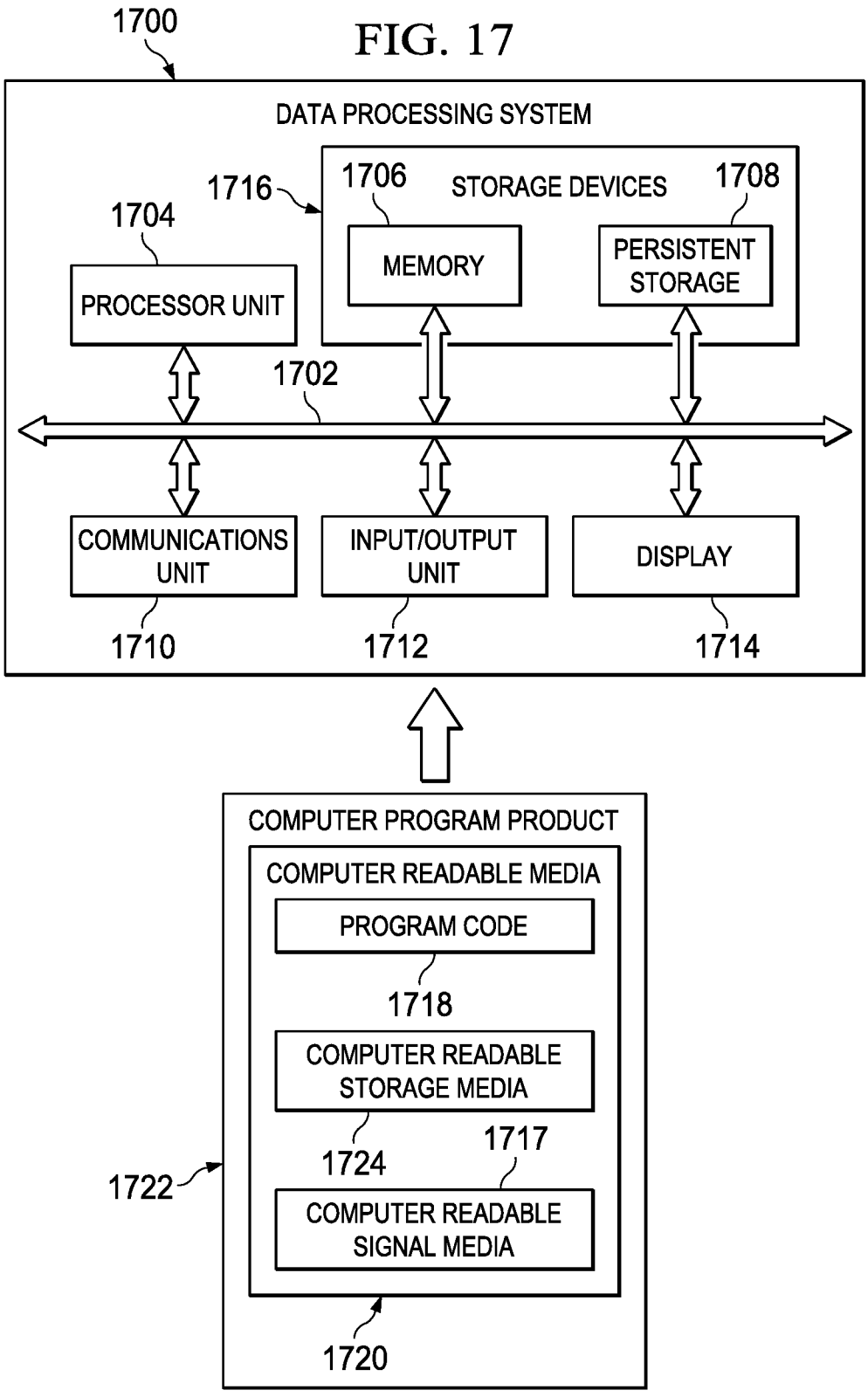

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FIG. 18

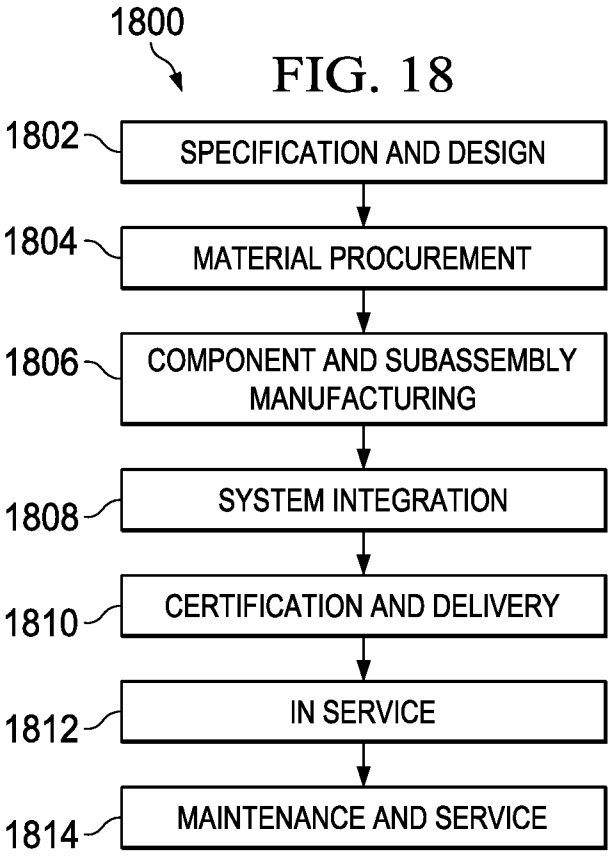
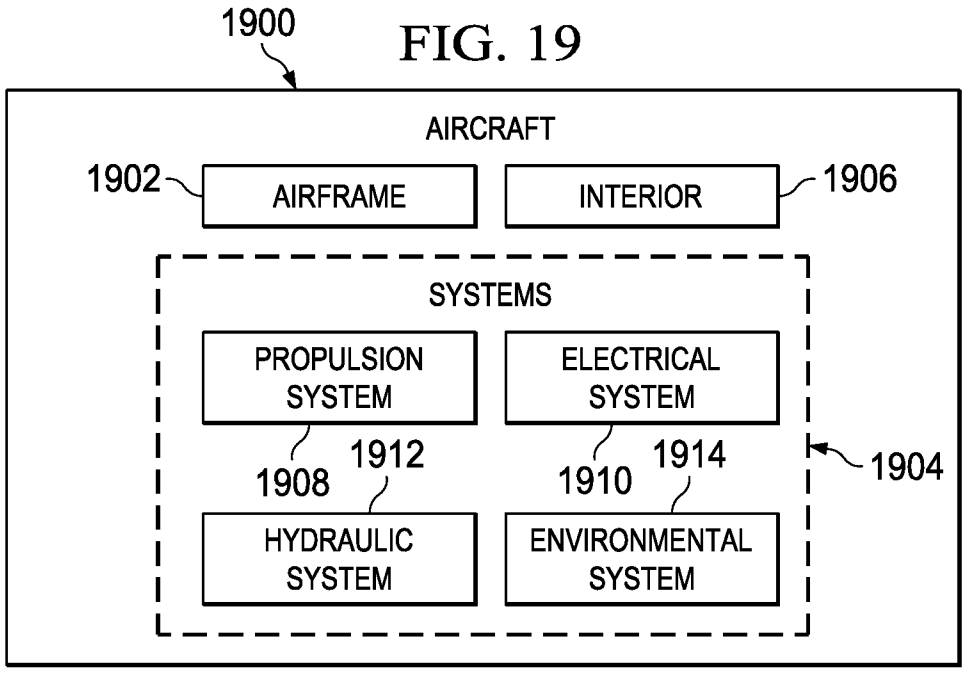


FIG. 19



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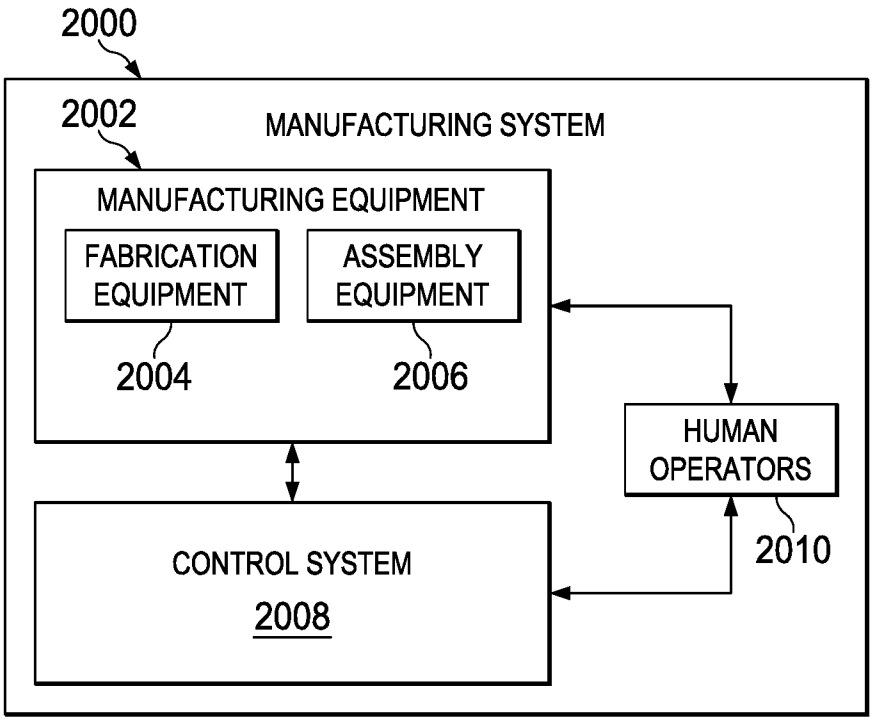

FIG. 20