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Pongiluppi et al.

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(54) **MOBILE CLEAN ROOM**

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E04B 1/348	(2006.01)
F24F 11/52	(2018.01)
G07C 9/00	(2020.01)

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CPC ***F24F 3/167*** (2021.01); ***E04B 1/34869*** (2013.01); ***F24F 11/52*** (2018.01); ***G07C 9/00896*** (2013.01); *G07C 9/00309* (2013.01)

(58) **Field of Classification Search**

CPC F24F 3/167; F24F 11/52; E04B 1/34869; G07C 9/00896; G07C 9/00309; G07C 2209/63

See application file for complete search history.

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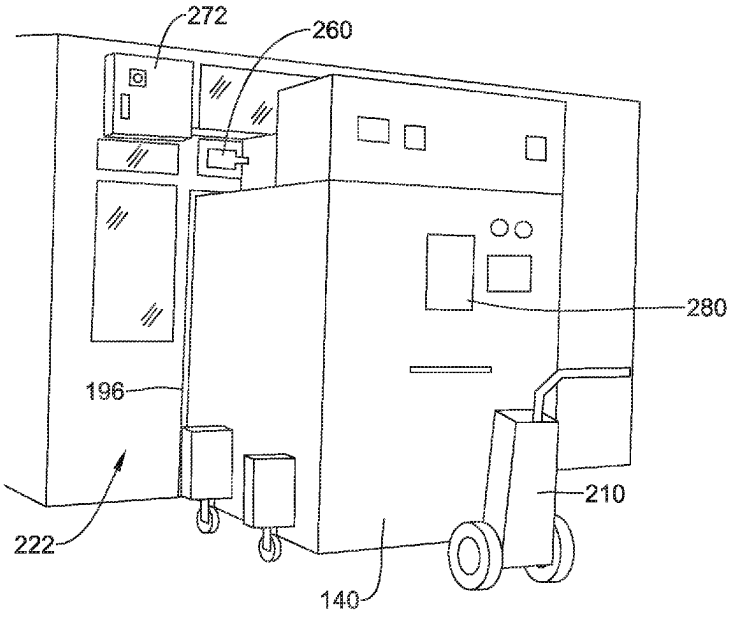
(57) **ABSTRACT**

A mobile clean room is configured to provide a clean room environment while moving components between a first stationary clean room and a second stationary clean room. The mobile clean room includes an interior volume and an air quality system configured to maintain a clean room environment within the interior volume. The mobile clean room includes an on-board power supply, an electric tractor coupled to the mobile clean room and configured to move the mobile clean room, and a controller that is operably coupled with the filtration system and the on-board power supply. The controller is configured to monitor and control performance of the air quality system, monitor performance of the on-board power supply, and communicate with a stationary controller controlling operation of the first stationary clean room and/or the second stationary clean room.

20 Claims, 17 Drawing Sheets



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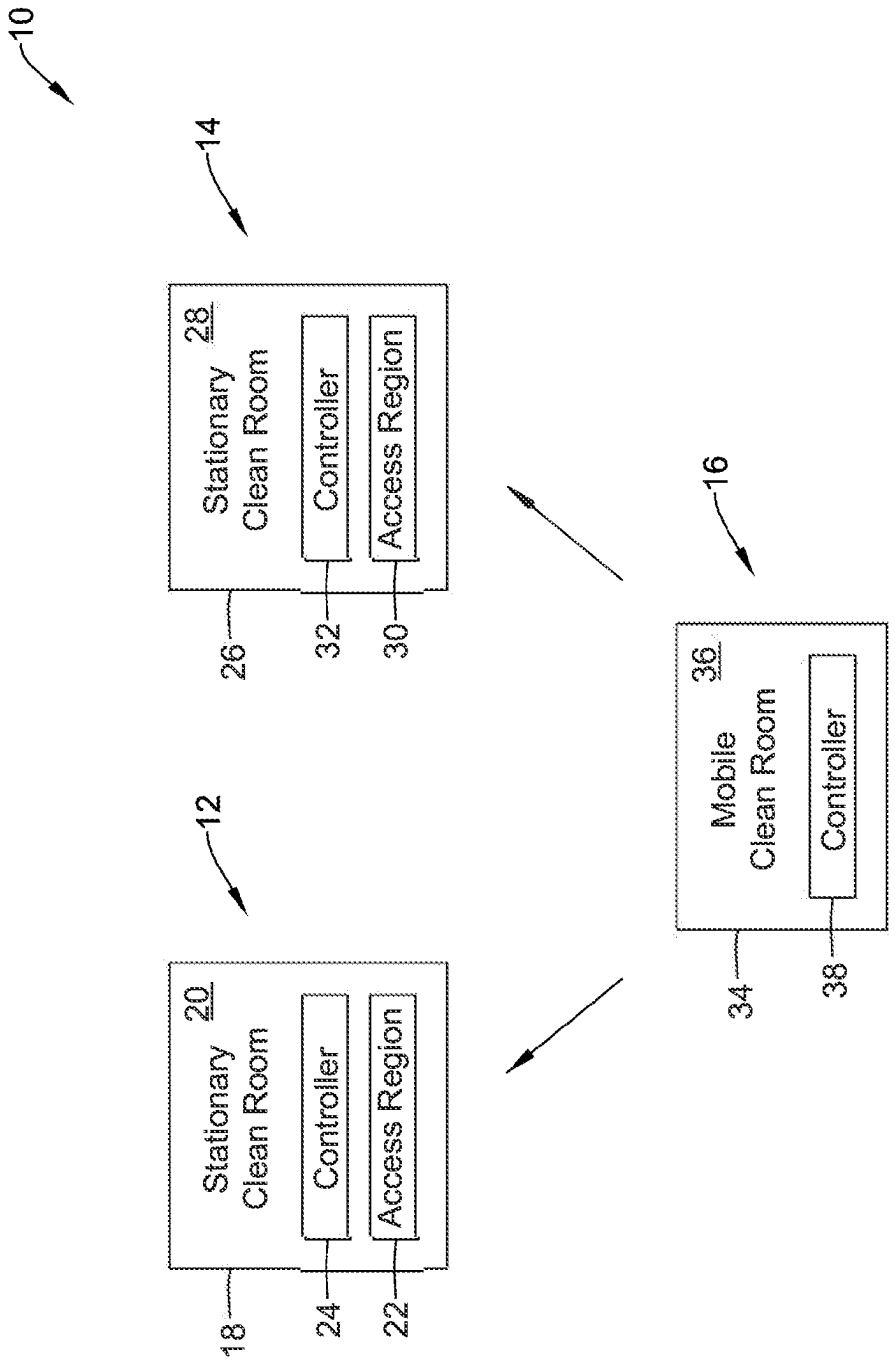

10
14
Stationary Clean Room
28
Controller
Access Region
26
32
30
16
Mobile Clean Room
36
Controller
34
38
12
Stationary Clean Room
20
Controller
Access Region
18
24
22

FIG. 1

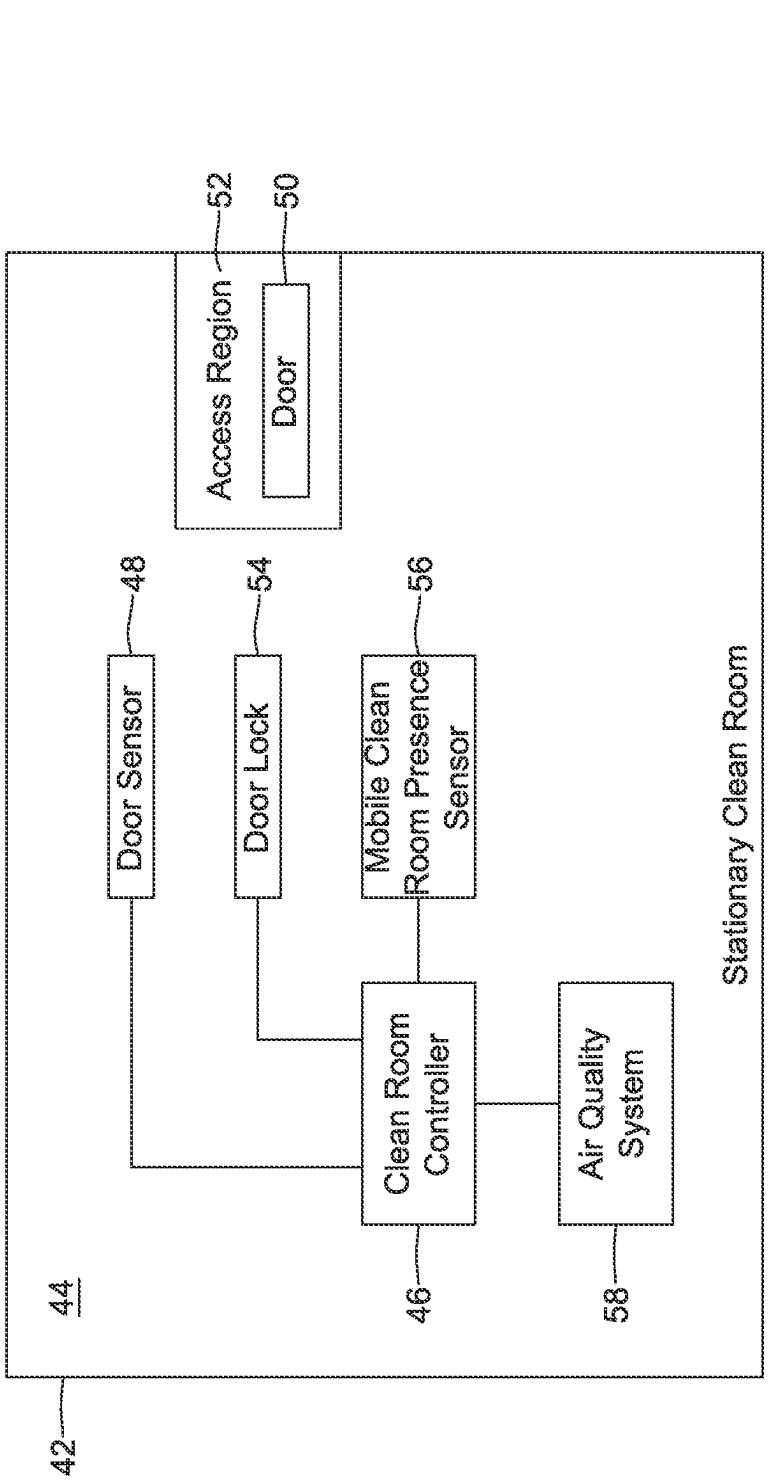

40
42
44
Stationary Clean Room
Access Region
52
Door
50
Door Sensor
48
Door Lock
54
Mobile Clean Room Presence Sensor
56
Clean Room Controller
46
Air Quality System
58

FIG. 2

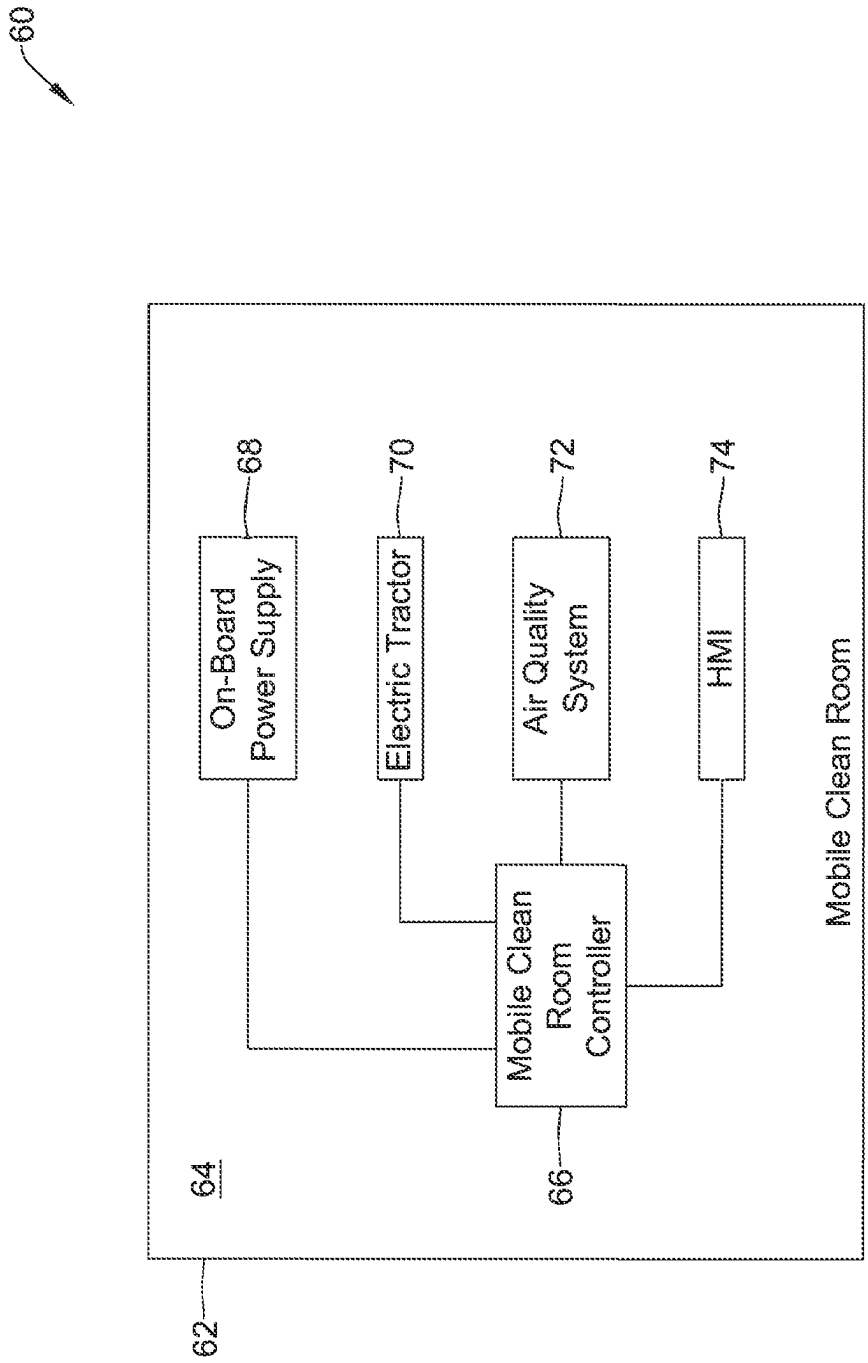

60
62
64
66
68
On-Board Power Supply
70
Electric Tractor
72
Air Quality System
74
HMI
Mobile Clean Room Controller
Mobile Clean Room

FIG. 3

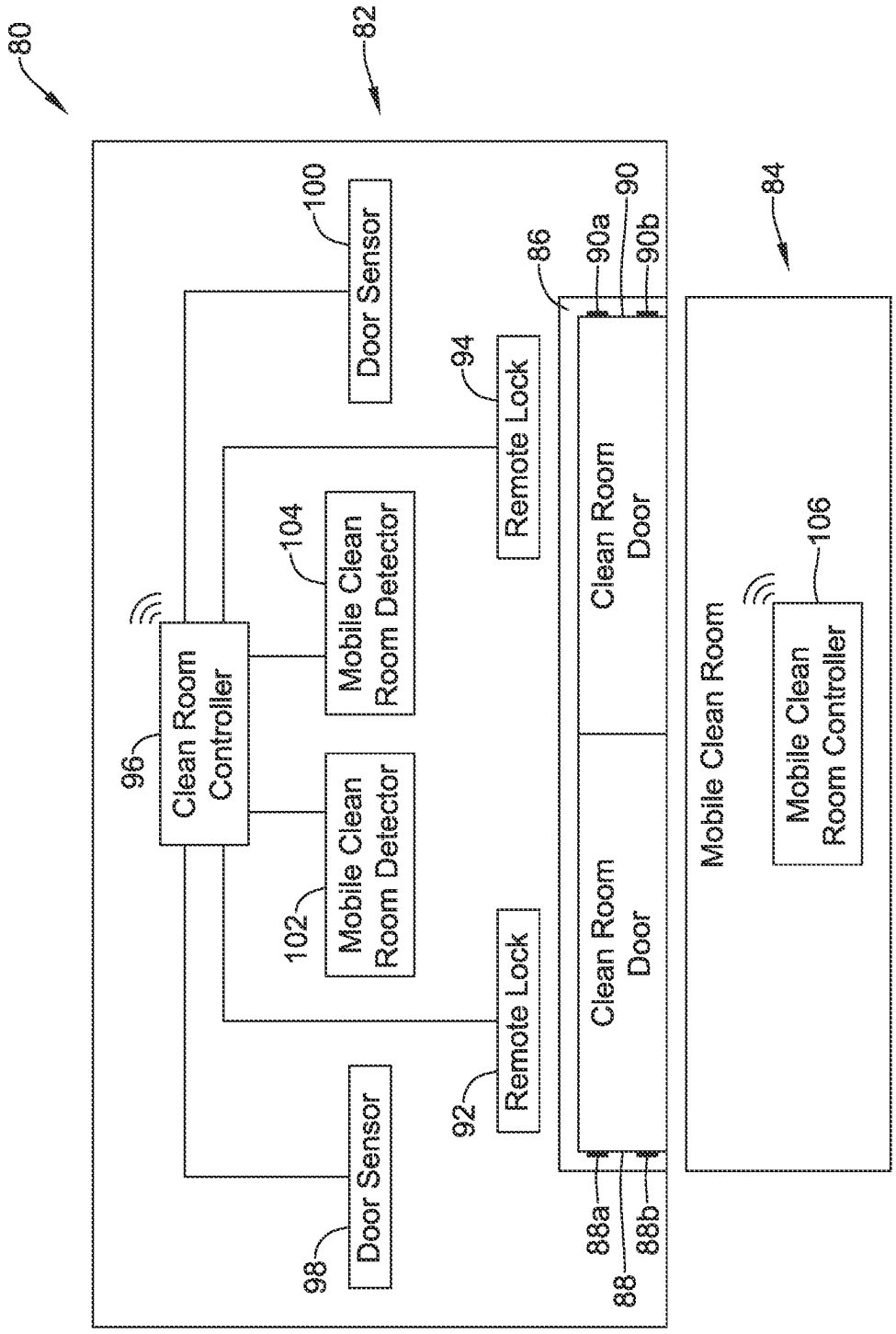

80
82
84
Door Sensor
100
Clean Room Controller
96
Mobile Clean Room Detector
104
Mobile Clean Room Detector
102
Door Sensor
98
Remote Lock
94
Remote Lock
92
86
90
90a
90b
Clean Room Door
Clean Room Door
88
88a
88b
Mobile Clean Room
Mobile Clean Room Controller
106

FIG. 4

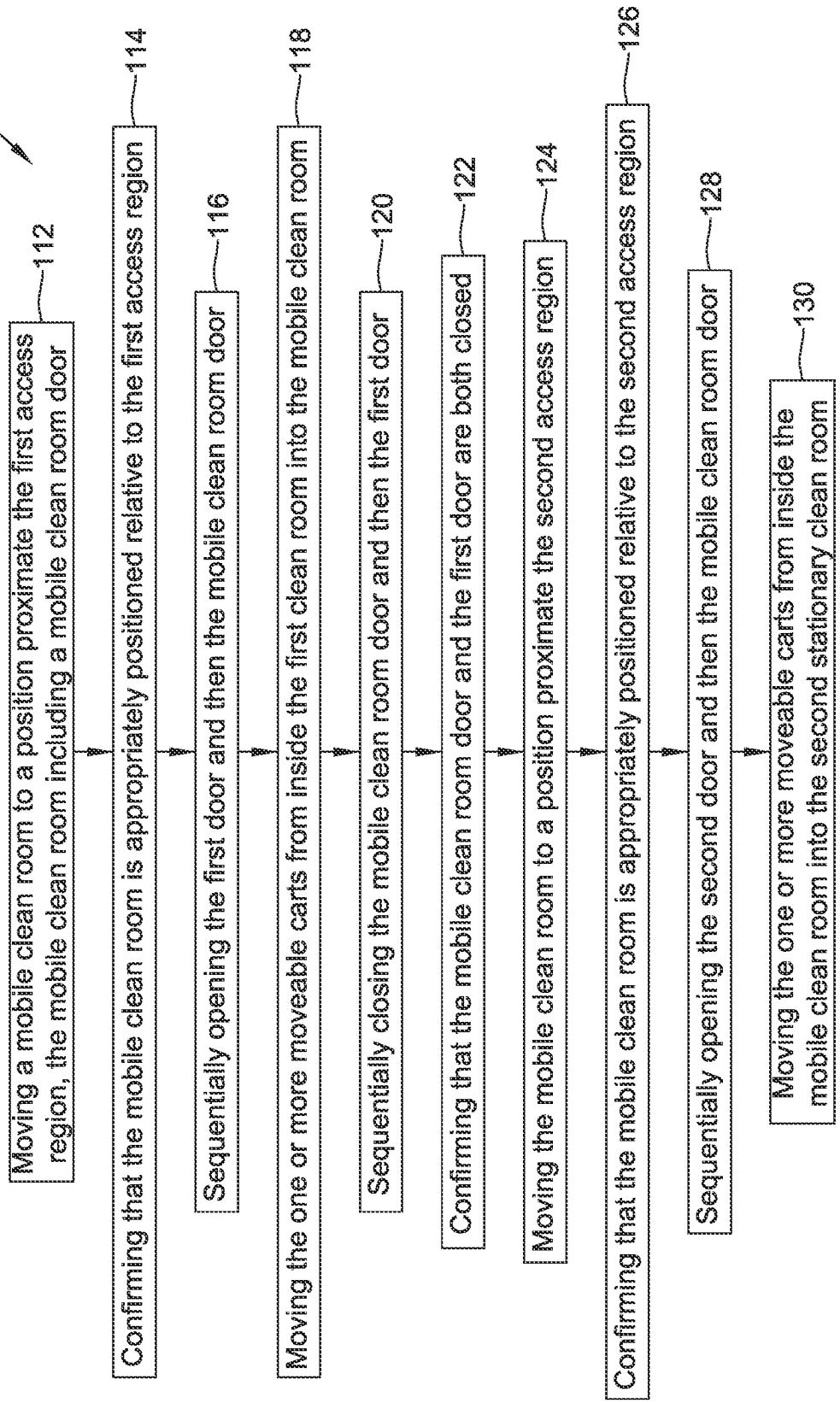

110
Moving a mobile clean room to a position proximate the first access region, the mobile clean room including a mobile clean room door
112
Confirming that the mobile clean room is appropriately positioned relative to the first access region
114
Sequentially opening the first door and then the mobile clean room door
116
Moving the one or more moveable carts from inside the first clean room into the mobile clean room
118
Sequentially closing the mobile clean room door and then the first door
120
Confirming that the mobile clean room door and the first door are both closed
122
Moving the mobile clean room to a position proximate the second access region
124
Confirming that the mobile clean room is appropriately positioned relative to the second access region
126
Sequentially opening the second door and then the mobile clean room door
128
Moving the one or more moveable carts from inside the mobile clean room into the second stationary clean room
130

FIG. 5

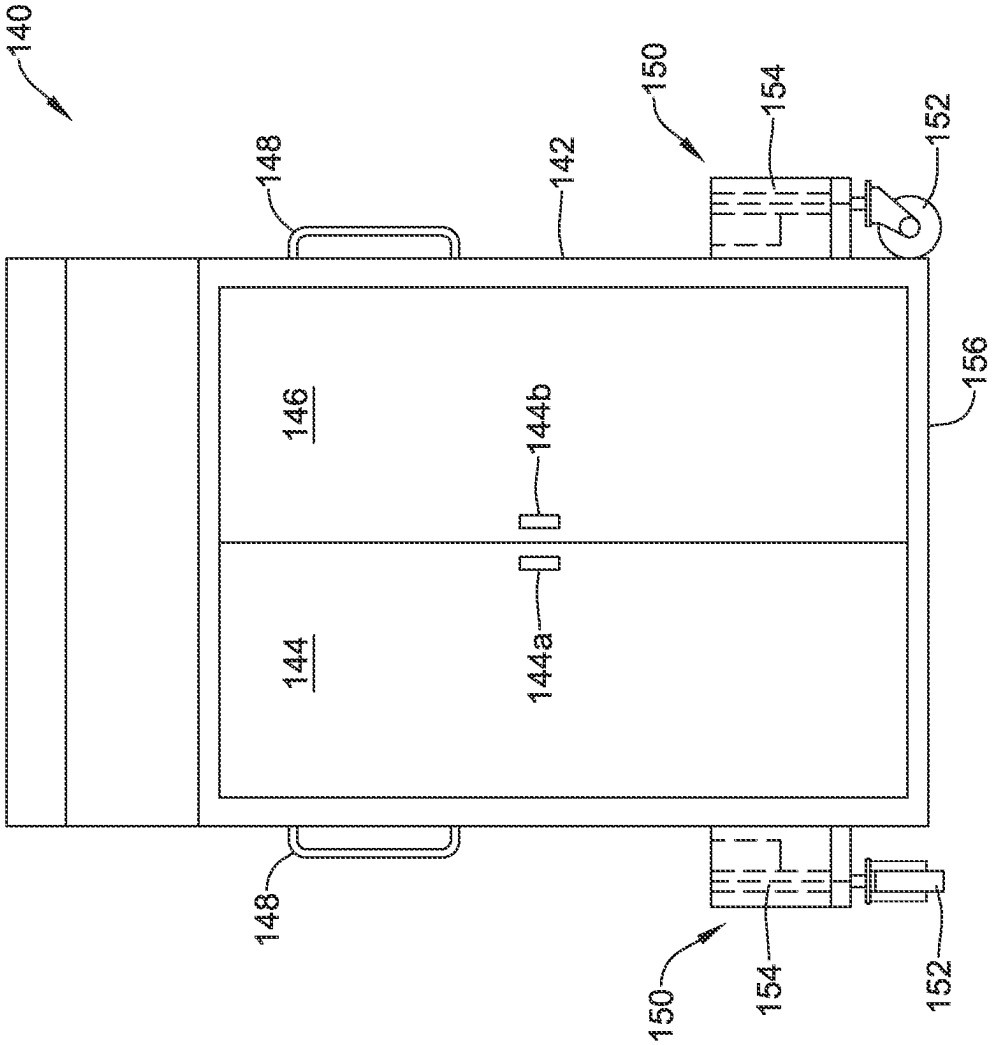


FIG. 6

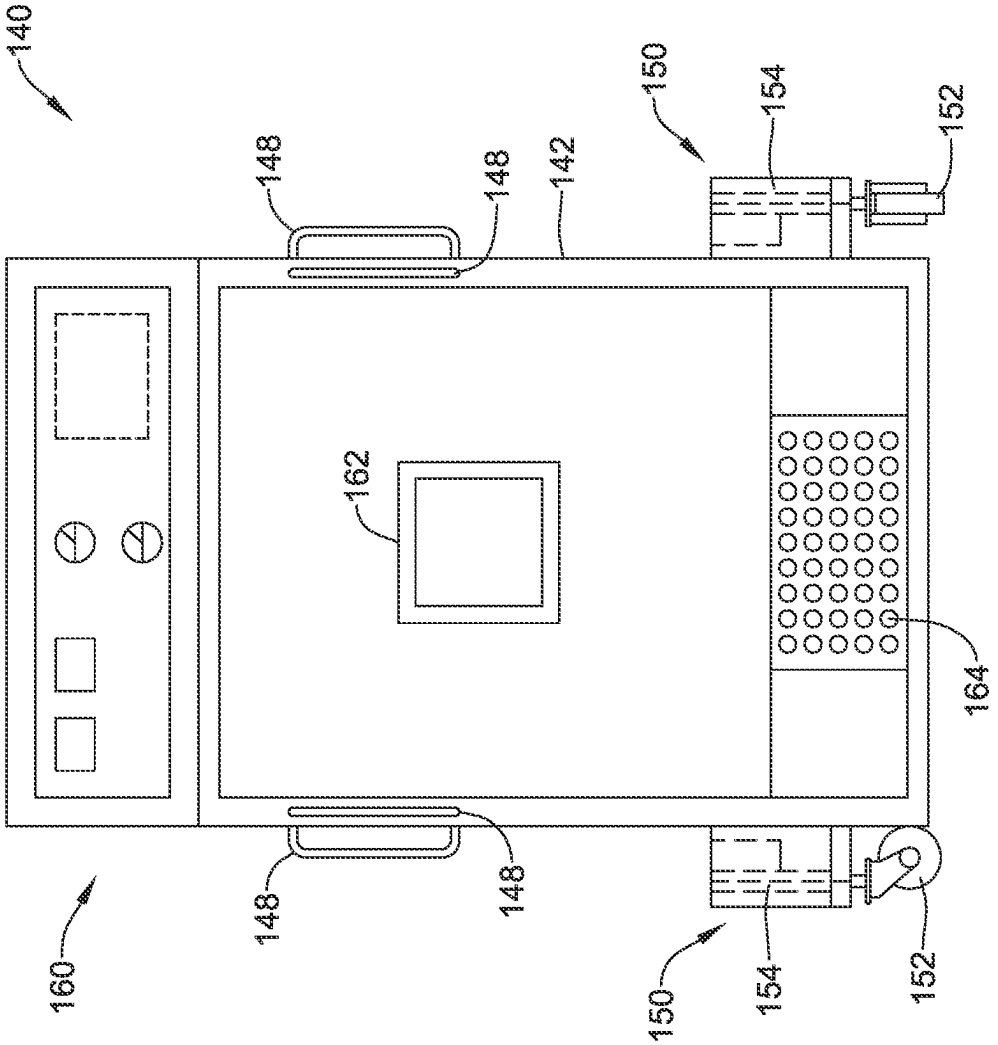


FIG. 7

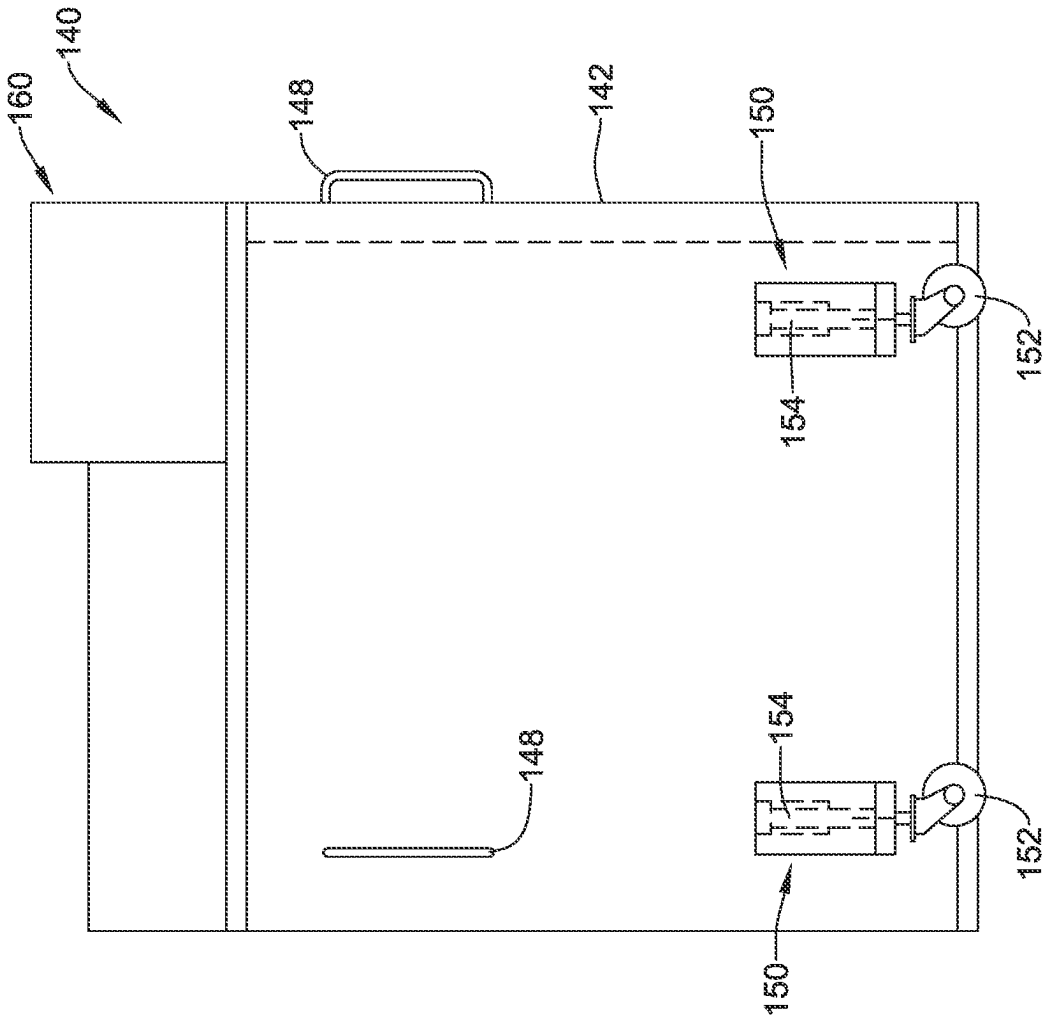


FIG. 8

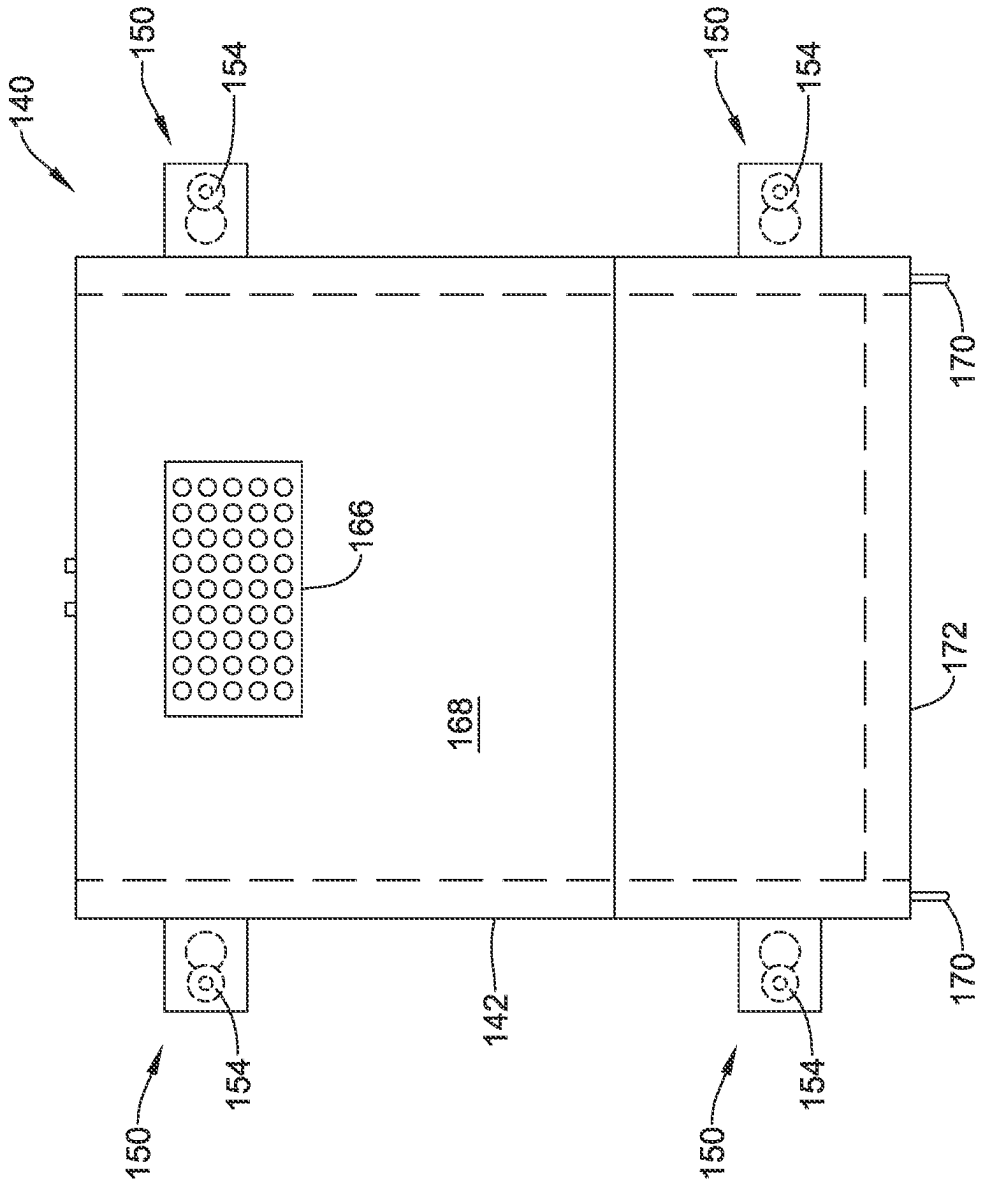


FIG. 9

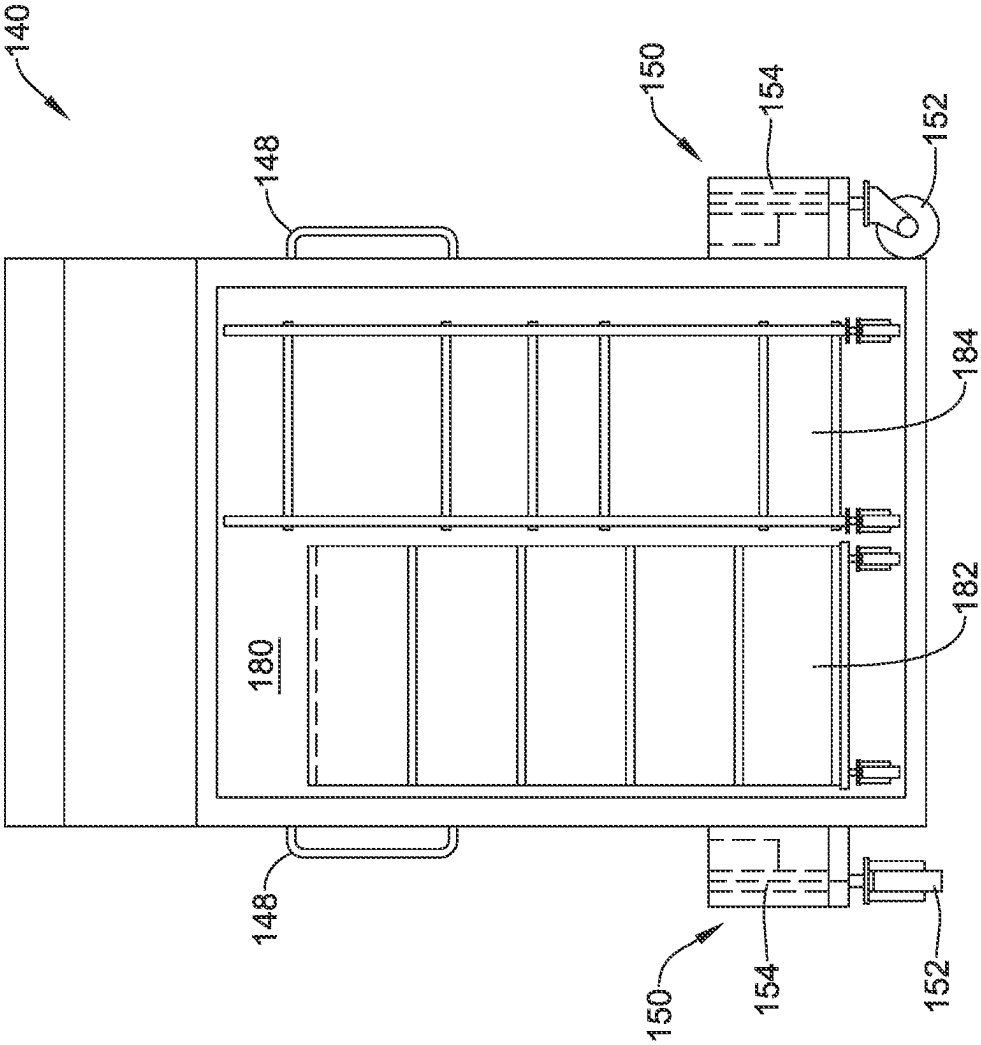
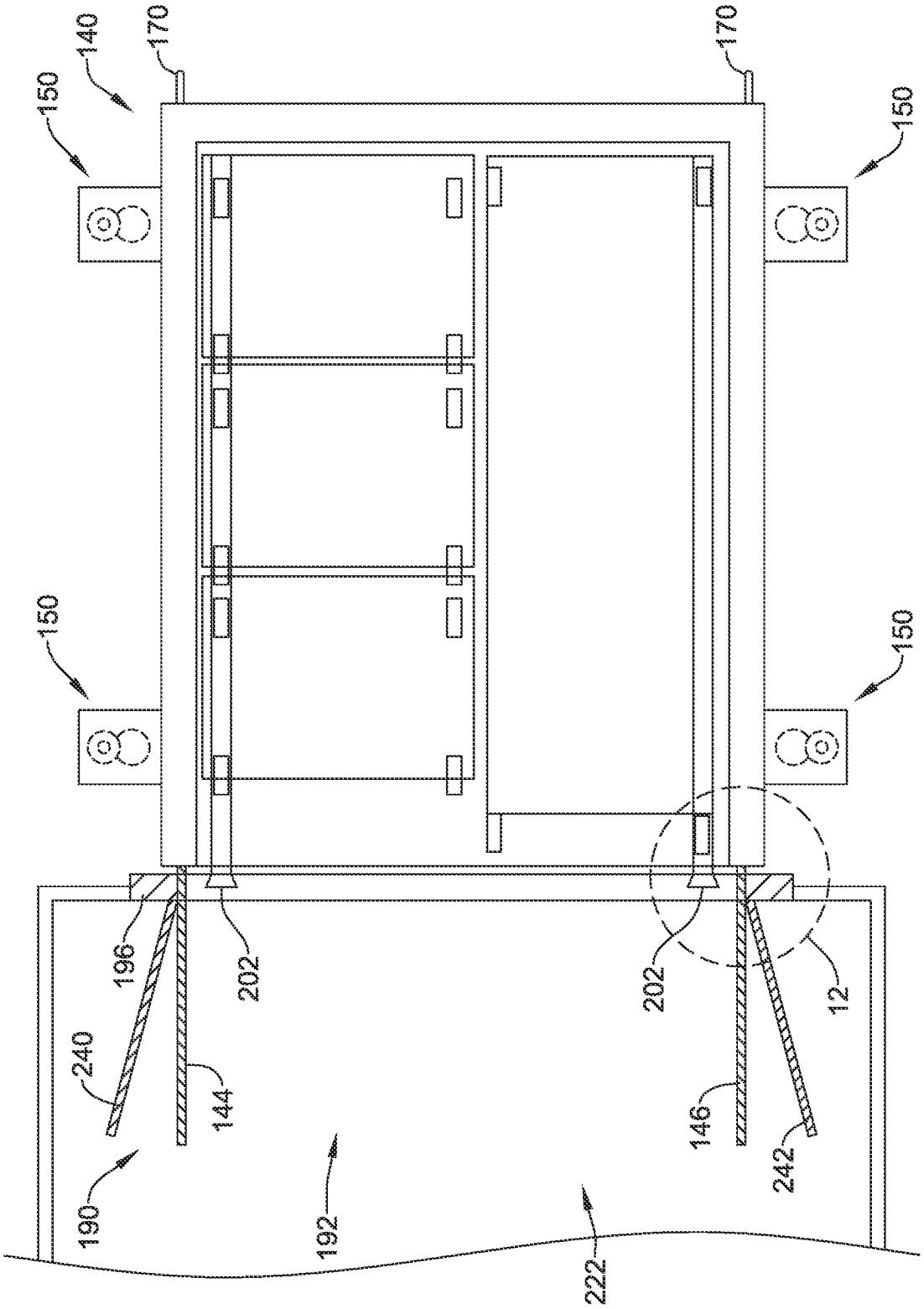


FIG. 10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202
12
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192
222

FIG. 11

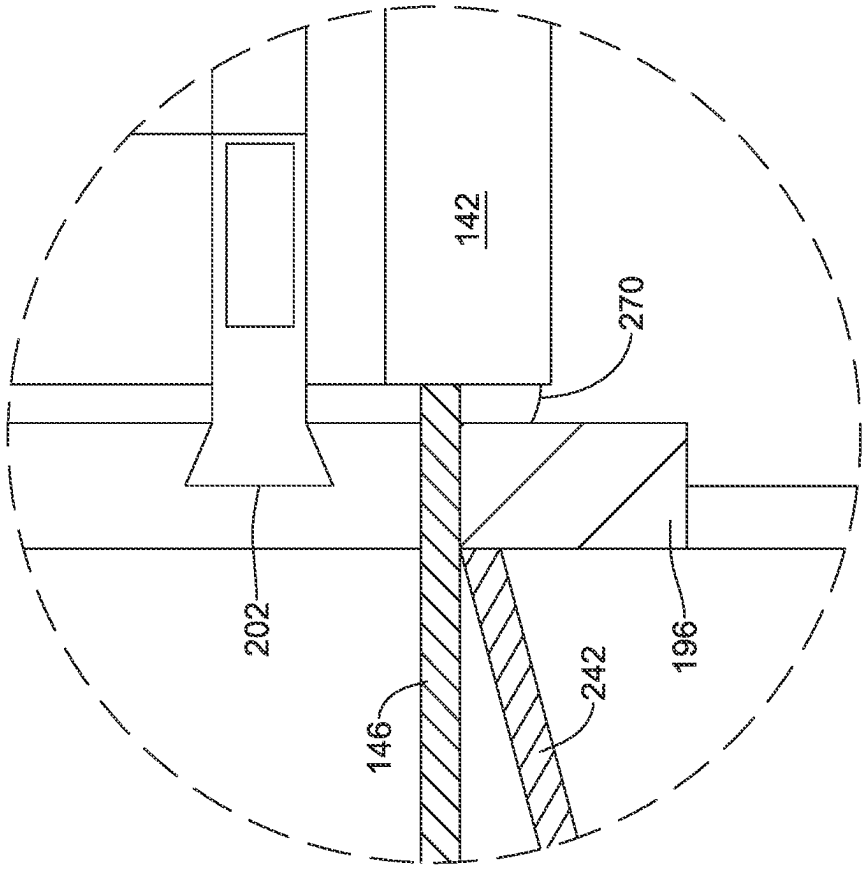

FIG. 12

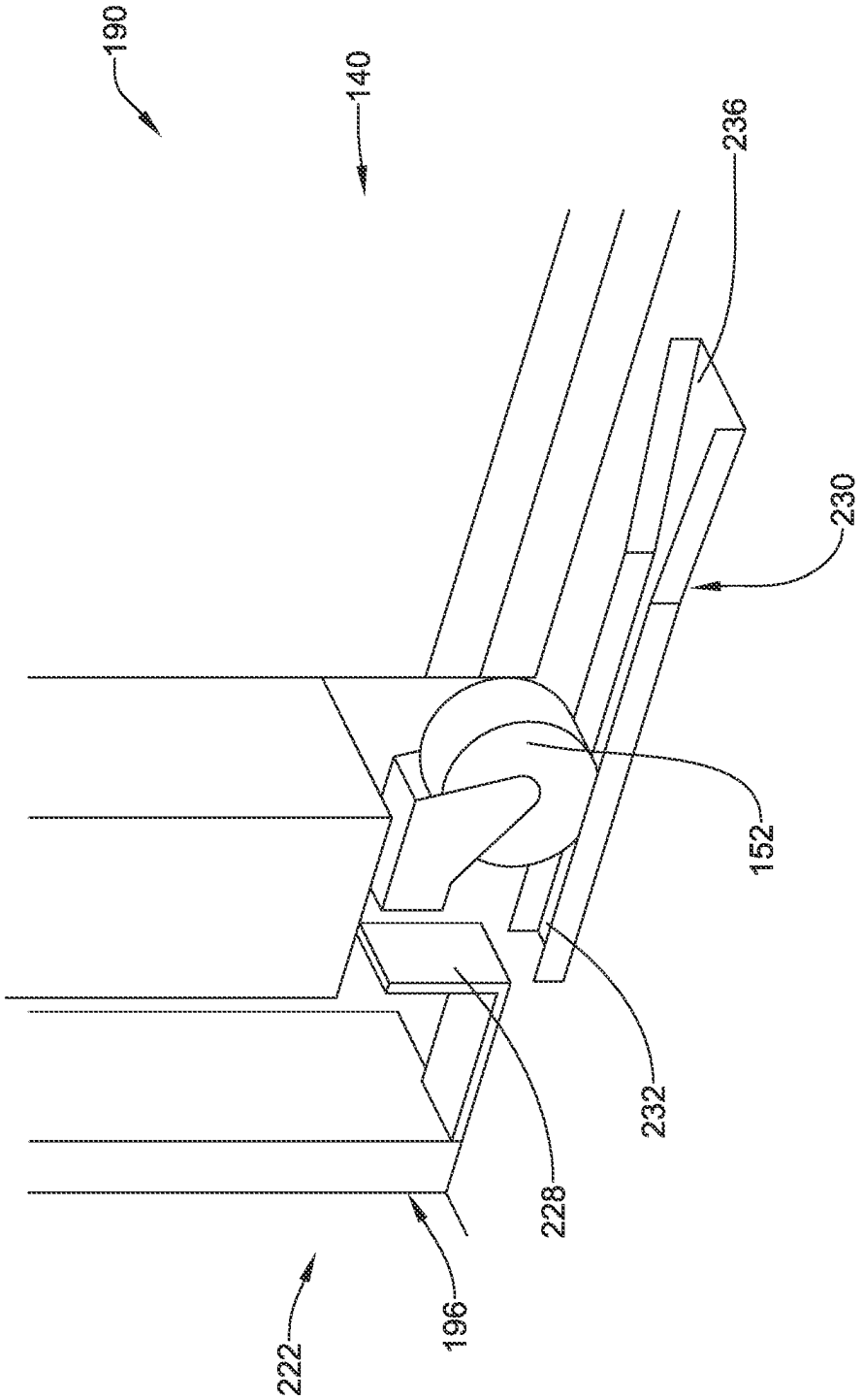

FIG. 13

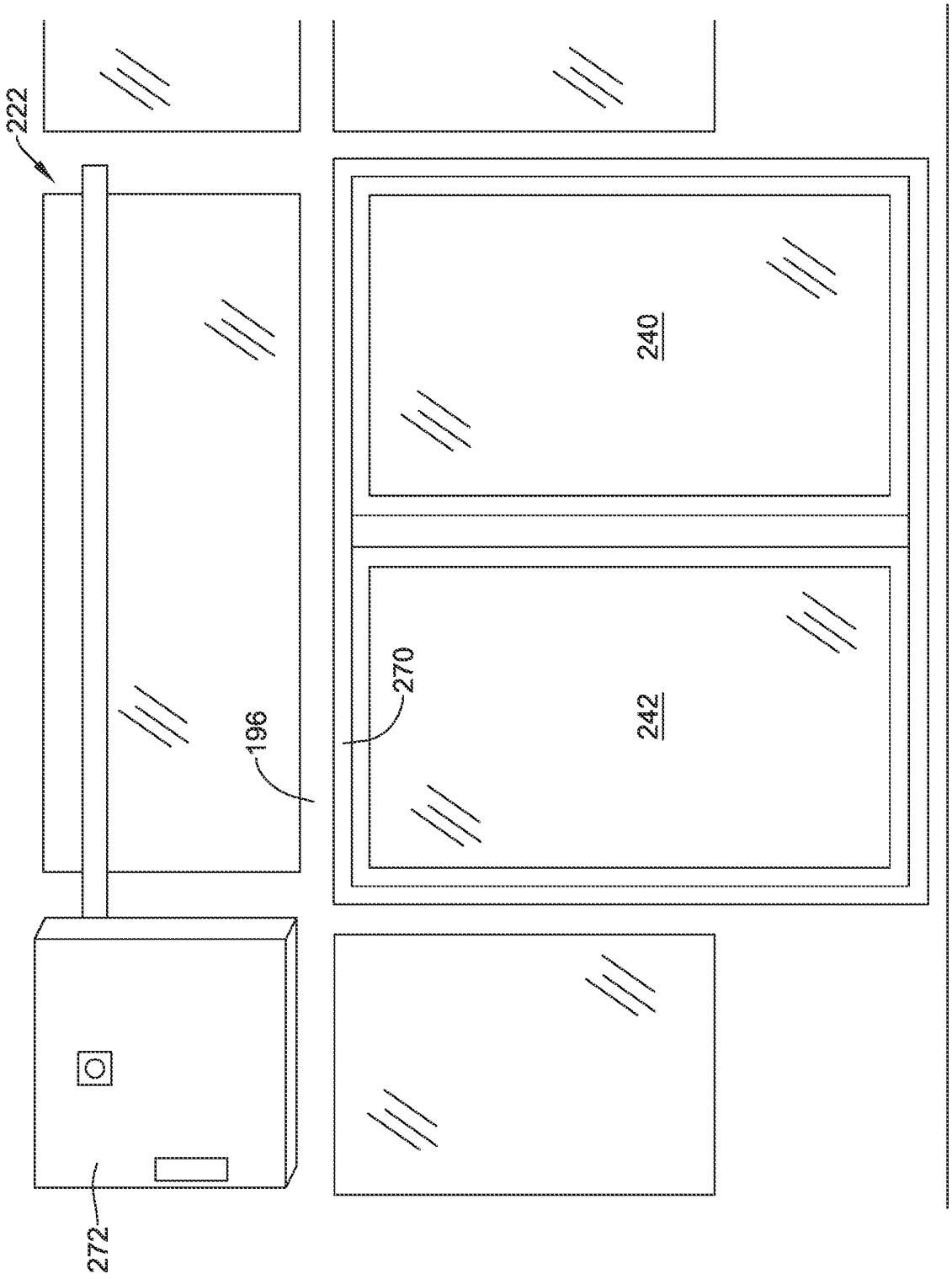

FIG. 14

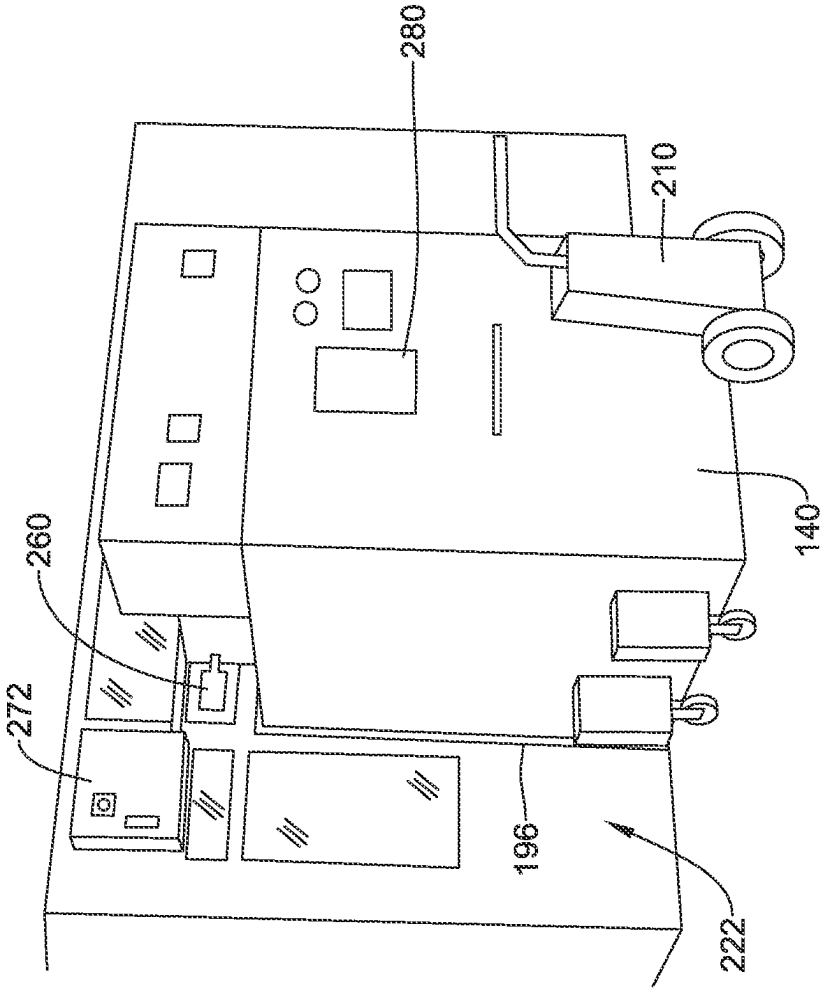

FIG. 15

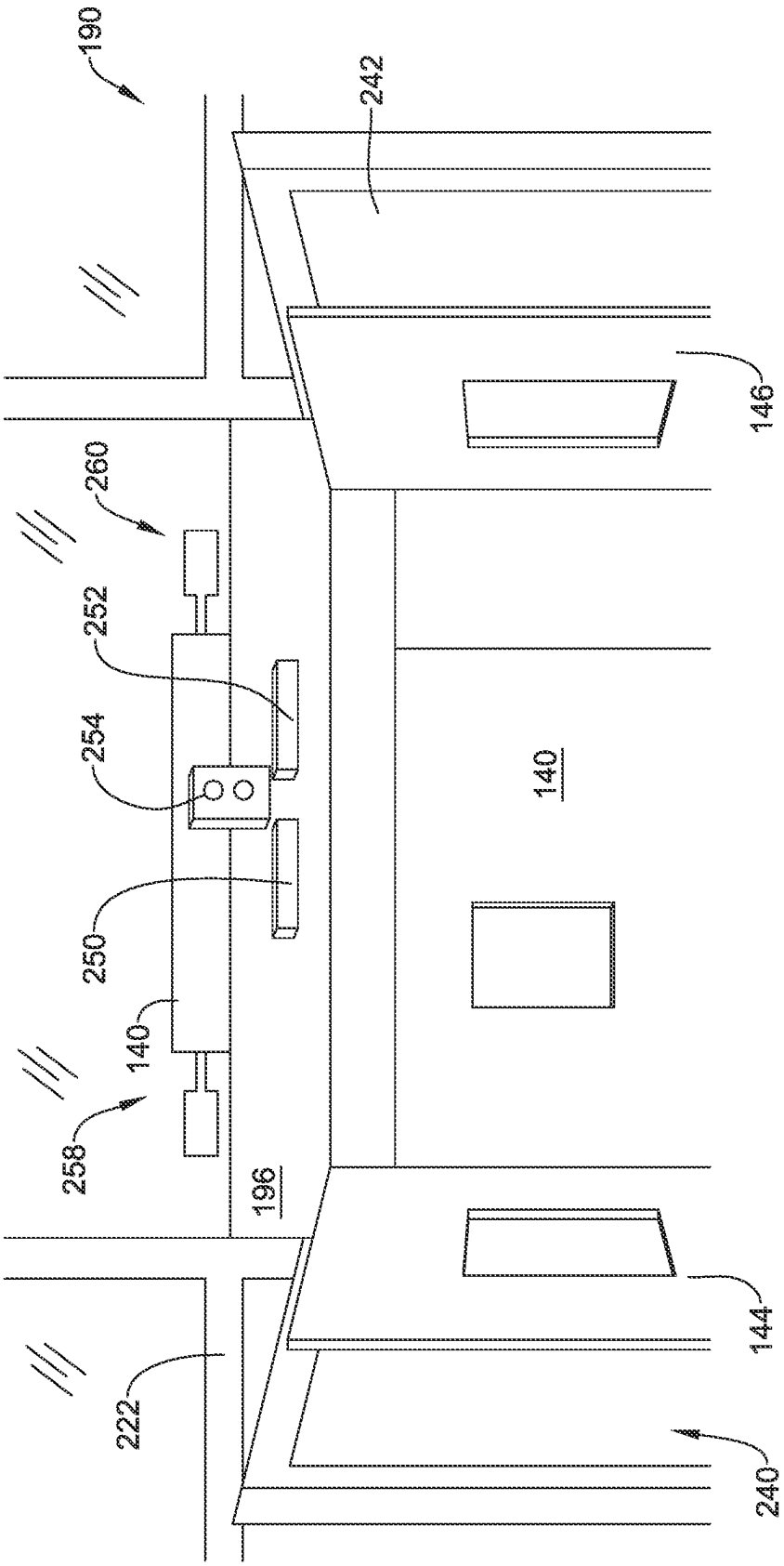

FIG. 16


280
286
286a
286b
286c
286d
286e
Open
Close
Raise
Stop
Lower
Operator
284d
Battery OK
Ventilation Closed
Door Closed
UPS with Main Power Supply 230V
UPS with Battery Power Supply
Clean Room Door Closed
Filter OK
State OK
SX Interface Docked
Trolley Correctly Positioned
Automatic Trolley
288
282
284
Home
Setup
Alarm
284a
284b
284c

FIG. 17

MOBILE CLEAN ROOM

TECHNICAL FIELD

The present disclosure pertains to clean rooms. More particularly, the present disclosure pertains to mobile clean rooms for isolation of its contents from environmental contamination.

BACKGROUND

A wide variety of devices including medical devices are manufactured and/or stored within clean rooms. In some cases, a particular medical device may be manufactured within two or more different clean rooms, such as when particular steps within the manufacturing process for that particular medical device occur in a first clean room, and one or more subsequent steps within the manufacturing process occur in a second clean room. In some cases, medical device components may be manufactured in a first clean room, and the medical device components may subsequently be assembled together into an assembly in a second clean room.

It will be appreciated that moving the partially constructed medical device from the first clean room to the second clean room can require substantial packaging materials (at some expense) and labor in order to essentially maintain the partially constructed medical device within a clean environment within the packaging. There may be delays between when a number of medical device components are manufactured and when they are subsequently assembled together, necessitating clean storage.

Accordingly, there is an ongoing need to provide an improved way to safely move materials, including medical devices, between clean room environments.

SUMMARY

This disclosure provides alternative clean room systems including a mobile clean room and methods for using a mobile clean room. An example includes a manufacturing system that includes a mobile clean room and a first clean room. The mobile clean room includes a mobile clean room interior volume, wheels that are moveable between an extended position and a retracted position, and an electric tractor that is releasably securable to the mobile clean room and configured to move the mobile clean room when the electric tractor is secured to the mobile clean room and the wheels are in the extended position. The first clean room includes a first clean room interior, a first access region that is configured to provide access to the first clean room interior volume, the mobile clean room configured to dock with first access region, and one or more first doors that are disposed within the first access region, the one or more first doors configured to move between a closed position preventing access to the first clean room interior volume through the one or more first doors and an open position permitting access to the first clean room interior volume through the one or more first doors, each of the one or more first doors including a first door lock. The first clean room includes a first mobile clean room detection sensor that is configured to provide a signal indicating whether the mobile clean room is in position relative to the first access region. The first clean room includes a first clean room controller that is configured to receive the signal from the first mobile clean room detection sensor, send a signal to unlock the first door locks when the signal from the first mobile clean room detection sensor indicates that the mobile clean room is in position relative to the first access region, and not send a signal to unlock the first door locks when the signal from the first mobile clean room detection sensor indicates that the mobile clean room is not in position relative to the first access region.

Alternatively or additionally, the mobile clean room may further include a mobile clean room controller that may be configured to communicate with the first clean room controller.

Alternatively or additionally, the manufacturing system may further include a first door sensor dedicated to each of the one or more first doors, each first door sensor outputting a signal indicating whether a corresponding first door is in an open position or a closed position.

Alternatively or additionally, the mobile clean room controller may be configured to receive a signal from each first door sensor indicating whether each of the one or more first doors is in the open position or the closed position. When the signal from each first door sensor indicates that at least one of the one or more first doors is in the open position, the mobile clean room controller may be configured to output a tractor command preventing the electric tractor from moving the mobile clean room away from the first access region. When the signal from each first door sensor indicates that each of the one or more first doors are in the closed position, the mobile clean room controller may be configured to output a tractor command permitting the electric tractor to move the mobile clean room away from the first access region.

Alternatively or additionally, when the signal from each first door sensor indicates that at least one of the one or more first doors is still open, the mobile clean room controller may be configured to output a wheels command preventing the wheels from being moved into the extended position. When the signal from each first door sensor indicates that each of the one or more first doors are closed, the mobile clean room controller may be configured to output a wheels command enabling the wheels being moved into the extended position.

Alternatively or additionally, the mobile clean room controller may be further configured to send a signal informing the first clean room controller that the electric tractor is permitted to move the mobile clean room away from the first access region, and the first clean room controller may be configured to send a signal to lock the first door locks in response to the signal informing the first clean room controller that the electric tractor is permitted to move the mobile clean room away from the first access region.

Alternatively or additionally, the first mobile clean room detection sensor may include a pair of first mobile clean room detection sensors, and the first clean room controller may be configured to only send a signal to unlock the first door locks when the signals from both first mobile clean room detection sensors indicate that the mobile clean room is in position relative to the first access region.

Alternatively or additionally, the mobile clean room controller may be configured to receive the signals from each first door sensor directly from the first door sensor.

Alternatively or additionally, the first clean room may include a filtration system controlled by the first clean room controller in order to maintain a clean room environmental standard within the first clean room interior volume.

Alternatively or additionally, the manufacturing system may further include a second clean room. The second clean room may include a second clean room interior volume, a second access region providing access to the second clean room interior volume, the mobile clean room configured to dock with the second access region, and one or more second

doors that are disposed within the second access region, the one or more second doors configured to move between a closed position preventing access to the second clean room interior volume through the one or more second doors and an open position permitting access to the second clean room interior volume through the one or more second doors, each of the one or more second doors including a second door lock. The second clean room may include a second mobile clean room detection sensor that is configured to provide a signal indicating whether the mobile clean room is in position relative to the second access region. The second clean room may include a second clean room controller that is configured to receive the signal from the second mobile clean room detection sensor, send a signal to unlock the second door locks when the signal from the second mobile clean room detection sensor indicates that the mobile clean room is in position relative to the second access region, and not send a signal to unlock the second door locks when the signal from the second mobile clean room detection sensor indicates that the mobile clean room is not in position relative to the second access region.

Alternatively or additionally, the electric tractor may be configured to move the mobile clean room between the first access region and second access region.

Another example includes a mobile clean room that is configured to provide a clean room environment while moving components between a first stationary clean room and a second stationary clean room. The mobile clean room includes an interior volume, an on-board power supply, an electric tractor that is coupled to the mobile clean room and is configured to move the mobile clean room, an air quality system that is configured to maintain a clean room environment within the interior volume and a controller that is operably coupled with the filtration system and the on-board power supply. The controller is configured to monitor and control performance of the air quality system, monitor performance of the on-board power supply, and communicate with a stationary controller controlling operation of the first stationary clean room and/or the second stationary clean room.

Alternatively or additionally, the stationary controller may include a first stationary controller controlling operation of the first stationary clean room and a second stationary controller controlling operation of the second stationary clean room.

Alternatively or additionally, the mobile clean room may further include a human machine interface (HMI) that is operably coupled with the controller and is configured to display information determined by the controller or received from the stationary controller.

Alternatively or additionally, the mobile clean room may further include extendable wheels that are moveable between an extended position and a retracted position in response to a command from the controller.

Alternatively or additionally, the controller may be configured to provide a command to prevent the extendable wheels from being moved into the extended position or to enable the extendable wheels to be moved into the extended position in response a signal to do so from the stationary controller, wherein when the signals from each first door sensor indicate that at least one of the one or more first doors is in the open position, the mobile clean room controller outputs a wheels command preventing the extendable wheels from being moved into the extended position, and wherein when the signals from each first door sensor indicate that each of the one or more first doors are in the closed position, the mobile clean room controller outputs a wheels command enabling the extendable wheels being moved into the extended position.

Alternatively or additionally, the HMI may be configured to display one or more of a status of on-board power supply, a status of the air quality system including filtration status and/or ventilation status, an open/closed door status of a door providing access to the interior volume of the mobile clean room, whether the mobile clean room is positioned correctly or not, whether either the first stationary clean room or the second stationary clean room is prepared to accept the mobile clean room or to allow the mobile clean room to depart, and whether there are any current alarms.

Alternatively or additionally, the HMI may be configured to allow a user to enter information for the controller.

Another example includes a method of moving components from a first clean room having a first access region with a first door to a second clean room having a second access region with a second door, the components arranged on one or more moveable carts disposed within the first clean room. The method includes moving a mobile clean room to a position proximate the first access region, the mobile clean room including a mobile clean room door and confirming that the mobile clean room is appropriately positioned relative to the first access region. The first door and then the mobile clean room door are sequentially opened. The one or more moveable carts are moved from inside the first clean room into the mobile clean room. The mobile clean room door and then the first door are sequentially closed, and the closure of the mobile clean room door and the first door are confirmed. The mobile clean room is moved to a position proximate the second access region and appropriate positioning of the mobile clean room relative to the second access region is confirmed. The second door and then the mobile clean room door are sequentially opened. The one or more moveable carts are moved from inside the mobile clean room into the second stationary clean room.

Alternatively or additionally, the mobile clean room may include extendable wheels moveable between an extended position for moving the mobile clean room and a retracted position, and moving the mobile clean room into a position proximate either the first access region or the second access region includes moving the extendable wheels into the extended position before moving the mobile clean room into the position proximate either the first access region or the second access region, and moving the extendable wheels into the retracted position after moving the mobile clean room into the position proximate either the first access region or the second access region.

Alternatively or additionally, confirming that the mobile clean room door and the first door are both closed may include receiving confirmation from a stationary clean room door sensor configured to indicate whether the first door is open or closed.

The above summary of some embodiments is not intended to describe each disclosed embodiment or every implementation of the present disclosure. The Figures, and Detailed Description, which follow, more particularly exemplify these embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosure may be more completely understood in consideration of the following detailed description in connection with the accompanying drawings, in which:

FIG. **1** is a schematic block diagram of an illustrative manufacturing system including a first stationary clean

room, a second stationary clean room and a mobile clean room that may be used to move materials between the first stationary clean room and the second stationary clean room;

FIG. **2** is a schematic block diagram of an illustrative stationary clean room that may be used as either the first stationary clean room or the second stationary clean room shown in FIG. **1**;

FIG. **3** is a schematic block diagram of an illustrative mobile clean room that may be used as part of the manufacturing system shown in FIG. **1**;

FIG. **4** is a schematic block diagram of an illustrative manufacturing system;

FIG. **5** is a flow diagram showing an illustrative method of using a mobile clean room to move components from a first clean room to a second clean room;

FIG. **6** is a front view of an illustrative mobile clean room;

FIG. **7** is a back view of the illustrative mobile clean room shown in FIG. **6**;

FIG. **8** is a side view of the illustrative mobile clean room shown in FIG. **6**;

FIG. **9** is a top view of the illustrative mobile clean room shown in FIG. **6**;

FIG. **10** is a front view of the illustrative mobile clean room shown in FIG. **6**, shown with the doors open to illustrate an interior space of the illustrative mobile clean room;

FIG. **11** is a top view showing an illustrative interface between a stationary clean room and the mobile clean room shown in FIG. **6**;

FIG. **12** is an enlarged view of a portion of the illustrative interface shown in FIG. **11**;

FIG. **13** is a perspective view of a portion of an illustrative manufacturing system including a stationary clean room and a mobile clean room;

FIG. **14** is a perspective view of a portion of an illustrative manufacturing system including a stationary clean room and a mobile clean room;

FIG. **15** is a perspective view of a portion of an illustrative manufacturing system including a stationary clean room and a mobile clean room;

FIG. **16** is a perspective view of a portion of an illustrative manufacturing system including a stationary clean room and a mobile clean room; and

FIG. **17** is a view of an illustrative human machine interface (HMI) forming a part of an illustrative mobile clean room.

While the disclosure is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail. It should be understood, however, that the intention is not to limit the disclosure to the particular embodiments described. On the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure.

DETAILED DESCRIPTION

For the following defined terms, these definitions shall be applied, unless a different definition is given in the claims or elsewhere in this specification.

All numeric values are herein assumed to be modified by the term "about", whether or not explicitly indicated. The term "about" generally refers to a range of numbers that one of skill in the art would consider equivalent to the recited value (e.g., having the same function or result). In many instances, the terms "about" may include numbers that are rounded to the nearest significant figure.

The recitation of numerical ranges by endpoints includes all numbers within that range (e.g. 1 to 5 includes 1, 1.5, 2, 2.75, 3, 3.80, 4, and 5).

As used in this specification and the appended claims, the singular forms "a", "an", and "the" include plural referents unless the content clearly dictates otherwise. As used in this specification and the appended claims, the term "or" is generally employed in its sense including "or" unless the content clearly dictates otherwise.

It is noted that references in the specification to "an embodiment", "some embodiments", "other embodiments", etc., indicate that the embodiment described may include one or more particular features, structures, or characteristics. However, such recitations do not necessarily mean that all embodiments include the particular features, structures, or characteristics. Additionally, when particular features, structures, or characteristics are described in connection with one embodiment, it should be understood that such features, structures, or characteristics may also be used connection with other embodiments whether or not explicitly described unless clearly stated to the contrary.

The following detailed description should be read with reference to the drawings in which similar elements in different drawings are numbered the same. The drawings, which are not necessarily to scale, depict illustrative embodiments and are not intended to limit the scope of the present disclosure.

Clean rooms are relied upon when manufacturing a variety of different products that can be negatively impacted if the products are manufactured in a dirty environment. For example, clean rooms may be used in medical device manufacturing, life sciences, pharmaceuticals and biotech. Clean rooms may be used in critical process manufacturing in fields such as aerospace, DOE (department of energy), military, and optics, for example. Clean rooms can also be relied upon in scientific research.

A clean room is an environment having a controlled level of allowed contamination. In some cases, the contamination level is measured in terms of a number of particles per cubic meter at a particular particle size. Clean rooms can employ air quality systems, such as but not limited to air filtration systems and ventilation systems to ensure that the air quality inside the clean room meets one or more of a variety of different air quality standards. In some cases, HEPA (high efficiency particulate air) filters or ULPA (ultra-low particular air) filters may be used to limit contaminate concentrations within the clean room.

Individuals working within a clean room may enter and exit the clean room through air locks (an inner door and an outer door separated by a space) or an air shower. In some cases, individuals may enter and exit through a gowning room that may essentially form the space between the inner door and the outer door, for example.

Individuals working within a clean room may utilize a range of protective clothing, ranging from the relatively simple, such as a lab coat and a hair net, to complex, such as a multiple layer suit with self-contained breathing apparatus, in order to reduce or eliminate chances of substances being released into the environment within the clean room. It will be appreciated that there is a wide range of protective clothing options, depending at least in part upon the particular air quality standards being employed for a particular clean room.

For example, air quality standards for the interior of a clean room may be determined in accordance with ISO 14644. The ISO 14644 standard defines a number of classes, ranging from ISO 1 to ISO 9. ISO 1 defines particularly

stringent limitations on particle counts per cubic meter for each of a variety of different particle sizes while ISO 9 is approximately equal to outside air.

In some cases, various products, or perhaps components of those products, may be manufactured within a single clean room. In some instances, various products, or perhaps components of those products, may be manufactured within two or more clean rooms that may be physically separated. One or more, or several components for a particular product may be manufactured in a first clean room and may be assembled into the actual product in a second clean room. A first clean room may be in a west wing of a building, for example, while a second clean room may be in an east wing of the same building. In some cases, a first clean room may be in a first building within a complex and a second clean room may be in a second building within the complex.

FIG. **1** is a schematic block diagram of an illustrative manufacturing system **10** that includes a stationary clean room **12** and a stationary clean room **14**. While a total of two stationary clean rooms **12**, **14** are shown, this is merely illustrative, as the manufacturing system **10** may employ two, three, four, five or more clean rooms, for example. The manufacturing system **10** includes a mobile clean room **16** that may be used to move products or components of products from the stationary clean room **12** to the stationary clean room **14**, or to move products or components of products from the stationary clean room **14** to the stationary clean room **12**. In this, "stationary" is used to refer to the clean rooms **12** and **14** in order to distinguish between the stationary clean rooms **12** and **14** and the mobile clean room **16**.

The stationary clean room **12** and/or the stationary clean room **14** may be clean rooms that are permanently built into a building, or into separate buildings within a complex. The stationary clean room **12** and/or the stationary clean room **14** may be clean rooms that are built in a modular fashion, and may be intended for either permanent use or only temporary use. However, a distinguishing feature of the stationary clean room **12** and the stationary clean room **14** is that they do not move relative to each other in order to transfer materials therebetween. Rather, the mobile clean room **16** is relied upon to transfer materials between the stationary clean room **12** and the stationary clean room **14**.

The stationary clean room **12** includes a periphery **18** that defines an interior volume **20** within the periphery **18**. The periphery **18** may include walls that are built within the building, for example. Not pictured are any sort of air lock or other features for workers within the stationary clean room **12** to enter the stationary clean room **12**. The stationary clean room **12** includes an access region **22** that as will be discussed, may be configured to allow the mobile clean room **16** to dock with the access region **22**. The access region **22** may include one or more doors that may be selectively opened in order to provide access between the stationary clean room **12** and the mobile clean room **16** while effectively preventing outside air (air not within the stationary clean room **12** or the mobile clean room **16**) from entering the stationary clean room **12** or the mobile clean room **16**.

A controller **24** controls operation of the stationary clean room **12**, such as but not limited to operation of the particular air quality control systems employed within the stationary clean room **12**. As will be discussed, the controller **24** also monitors signals from sensors (not shown) that provide information regarding the status of the access region **22** and the mobile clean room **16**.

The stationary clean room **14** includes a periphery **26** that defines an interior volume **28** within the periphery **26**. The periphery **26** may include walls that are built within the building, for example. Not pictured are any sort of air lock or other features for workers within the stationary clean room **14** to enter the stationary clean room **14**. The stationary clean room **14** includes an access region **30** that as will be discussed, may be configured to allow the mobile clean room **16** to dock with the access region **30**. The access region **30** may include one or more doors that may be selectively opened in order to provide access between the stationary clean room **14** and the mobile clean room **16** while effectively preventing outside air (air not within the stationary clean room **14** or the mobile clean room **16**) from entering the stationary clean room **14** or the mobile clean room **16**.

A controller **32** controls operation of the stationary clean room **14**, such as but not limited to operation of the particular air quality control systems employed within the stationary clean room **14**. As will be discussed, the controller **32** also monitors signals from sensors (not shown) that provide information regarding the status of the access region **30** and the mobile clean room **16**.

The controller **24** and the controller **32** are shown as being separate controllers. In some cases, the controller **24** and the controller **32** may be separate. In some instances, the controller **24** and the controller **32** may be manifested within a single controller, which may be a dedicated-purpose machine, a personal computer that has been programmed to control operation of the stationary clean room **12** and/or the stationary clean room **14**, or even a cloud-based server. In some cases, the controller **24** and the controller **32** are able to communicate with each other, through a wired or wireless LAN (local area network) within the building or building complex housing the stationary clean room **12** and the stationary clean room **14**.

The mobile clean room **16** includes a periphery **34** that defines an interior volume **36** within the periphery **34**. The mobile clean room **16** includes a controller **38** that controls operation of the mobile clean room **16**, such as but not limited to operation of the particular air quality control systems employed within the mobile clean room **16**. As will be discussed, the controller **38** may communicate with the controllers **24** and **32** in order to share information regarding the status of each of the stationary clean room **12**, the stationary clean room **14**, and the mobile clean room **16**.

The periphery **34** may define a large box that has dimensions sufficient to accommodate the materials to be transferred within the mobile clean room **16** while not too large to be able to easily move the mobile clean room **16** within the building or even between buildings, as desired. Accordingly, the periphery **34** of the mobile clean room **16** may have overall dimensions providing the mobile clean room **16** with an overall width of about two to eight feet, an overall length of about four to about ten feet, and an overall height of about four to ten feet. In some cases, the mobile clean room **16** may have an overall width of about four to six feet, an overall length of about five to seven feet, and an overall height of about seven to eight feet.

FIG. **2** is a schematic block diagram of an illustrative stationary clean room **40**. The illustrative stationary clean room **40** may be considered as being an example of the stationary clean room **12** and/or the stationary clean room **14**, for example. Features ascribed to the stationary clean room **12** or the stationary clean room **14** may be considered as being applicable to the stationary clean room **40**. Simi-

larly, features ascribed to the stationary clean room **40** may be applicable to the stationary clean room **12** or the stationary clean room **14**.

The stationary clean room **40** includes a periphery **42** defining an interior volume **44** within the periphery **42**. The stationary clean room **40** includes a clean room controller **46** that may be located within the interior volume **44**. In some instances, the clean room controller **46** may instead be located outside of the stationary clean room **40**. The clean room controller **46** may be configured to monitor signals from one or more sensors, for example, as well as to provide appropriate commands for systems within the stationary clean room **40**.

The stationary clean room **40** includes a door sensor **48** that may be configured to output a signal indicating whether a door **50**, which is located within an access region **52** is open or closed, or locked or unlocked. In some instances, the door sensor **48** may be a proximity sensor or a contact sensor, for example. The signal from the door sensor **48** may be provided to the clean room controller **46**, for example. In some cases, the signal from the door sensor **48** may be communicated directly to a mobile clean room controller **66** (seen in FIG. **3**). For instance, the door sensor **48** may send a signal to the clean room controller **46** indicative of whether the door is unlocked and/or open, or indicative of whether the door is locked and/or closed. The door sensor **48**, which may be a single sensor if the access region **52** only includes a single door **50** such as a single hinged door or a roll-up door, or which may represent two or more door sensors if the access region **52** includes two or more doors. In some cases, the access region **52** may include a pair of oppositely hinged swinging doors that can close together to close the access region **52** or can open together to form a large opening within the access region **52** to accommodate the mobile clean room **16**.

The stationary clean room **40** includes a door lock **54**. The door lock **54** may be an electromechanical lock, for example, and can be locked or unlocked via an appropriate electrical signal from the clean room controller **46**. A mobile clean room presence sensor **56** is configured to provide a signal to the clean room controller **46** indicating whether a mobile clean room (such as the mobile clean room **16**) is properly in position proximate the access region **52**. In some cases, if the mobile clean room presence sensor **56** indicates that the mobile clean room is properly in position proximate the access region **52**, the clean room controller **46** may send a command to the door lock(s) **54**, instructing the door lock(s) **54** to unlock. If the mobile clean room presence sensor **56** does not provide such an indication, the door lock(s) **54** may be kept locked, or may be commanded to lock if not already locked.

The stationary clean room **40** includes an air quality system **58** that is configured to regulate air quality within the stationary clean room **40**. The air quality system **58** may be monitored and controlled by the clean room controller **46**, for example. The air quality system **58** may include a filtration system and/or a ventilation system, for example. The air quality system **58** may include one or more sensors (not shown) that provide feedback to the clean room controller **46** in order to help the clean room controller **46** properly manage operation of the air quality system **58**.

FIG. **3** is a schematic block diagram of an illustrative mobile clean room **60** that may be considered as being an example of the mobile clean room **16**. Features ascribed to the mobile clean room **16** may be considered as being applicable to the mobile clean room **60**. Similarly, features ascribed to the mobile clean room **60** may be applicable to the mobile clean room **16**

The mobile clean room **60** includes a periphery **62** that defines an interior volume **64**. The periphery **62** of the mobile clean room **60** may have overall dimensions providing the mobile clean room **60** with an overall width of about two to eight feet, an overall length of about four to about ten feet, and an overall height of about four to ten feet. In some cases, the mobile clean room **60** may have an overall width of about four to six feet, an overall length of about five to seven feet, and an overall height of about seven to eight feet.

The mobile clean room **60** includes a mobile clean room controller **66** that controls operation of the mobile clean room **16**, such as but not limited to operation of the particular air quality control systems employed within the mobile clean room **60**. As will be discussed, the mobile clean room controller **66** may communicate with the clean room controller **46** in order to share information regarding the status of the stationary clean room **40** and the mobile clean room **60**.

The mobile clean room **60** includes an on-board (e.g., portable) power supply **68** that allows the mobile clean room **60** to have power to function without requiring that the mobile clean room **60** be connected to a source of building power. In some cases, the on-board power supply **68** may include the circuitry (not shown) that allows the mobile clean room **60** to be plugged into building power, such as 120 volts or 240 volts when the mobile clean room **60** is positioned within reach of building power, and to use some of that power to recharge the on-board power supply **68**. The on-board power supply **68** may include one or more batteries, such as rechargeable batteries, for example. The mobile clean room controller **66** may monitor a remaining charge within the on-board power supply **68**, for example, and may inform a user that recharging is required when the power supply drops down or below a particular power level threshold. The on-board power supply **68** provides power for operation of the mobile clean room **60**, particularly when not plugged in or when there is a loss of building power.

The mobile clean room **60** includes an electric tractor **70** that may be used to move the mobile clean room **60** when appropriate. In some instances, the electric tractor **70** is built into the mobile clean room **60**. In some instances, the electric tractor **70** is separate from the mobile clean room **60**, but can be operably coupled to the mobile clean room **60** when it is desired to use the electric tractor **70** to move the mobile clean room **60**. This may allow a single electric tractor **70** to be used to move two or more different mobile clean rooms **60**, rather than requiring that each mobile clean room **60** has its own electric tractor **70**. In some cases, the electric tractor **70** may essentially take the form of a pallet jack or a pallet truck, which can have its own power supply or can operably couple to the mobile clean room **60** in order to utilize power provided by the on-board power supply **68**.

The mobile clean room **60** includes an air quality system **72** that is configured to regulate air quality within the mobile clean room **60**. The air quality system **72** may be monitored and controlled by the mobile clean room controller **66**, for example. The air quality system **72** may include a filtration system and/or a ventilation system, for example. The air quality system **72** may include one or more sensors (not shown) that provide feedback to the mobile clean room controller **66** in order to help the mobile room controller **66** properly manage operation of the air quality system **72**.

In some cases, the mobile clean room **60** may include an HMI (human machine interface) **74** that is operably coupled

with the mobile clean room controller **66**. The HMI **74** allows the mobile clean room controller **66** to display various information such as sensor outputs for a human to see and understand. The HMI **74** may allow the mobile clean room controller **66** to solicit information from the user, such as but not limited to settings, threshold values and the like. In some cases, the HMI **74** may include a display that can display information as well as a keyboard or other data entry device that can be used by the user to enter information. The HMI **74** may be a touch screen display, for example, which effectively combines both display and data entry functionality.

In some cases, the HMI **74** may be configured to display one or more of a status of an on-board power supply, a status of the air quality system including filtration status and/or ventilation status, an open/closed door status of a door providing access to the interior volume of the mobile clean room, whether the mobile clean room is positioned correctly or not, whether either the first stationary clean room or the second stationary clean room is prepared to accept the mobile clean room or to allow the mobile clean room to depart, and whether there are any current alarms. In some instances, the HMI **74** may be configured to allow a user to enter information for the mobile clean room controller **66**.

FIG. **4** is a schematic block diagram of an illustrative manufacturing system **80**. The illustrative manufacturing system **80** may be considered as being an example of the manufacturing system **10**. Features ascribed to the manufacturing system **10** may be considered as being applicable to the manufacturing system **80**. Similarly, features ascribed to the manufacturing system **80** may be applicable to the manufacturing system **10**.

The manufacturing system **80** includes a stationary clean room **82** and a mobile clean room **84**. The stationary clean room **82** may be considered as being an example of the stationary clean room **12**, the stationary clean room **14** or the stationary clean room **40**. Features ascribed to the stationary clean room **82** may be applicable to any of the stationary clean room **12**, the stationary clean room **14** and the stationary clean room **40**, and vice versa. Features ascribed to the mobile clean room **84** may be applicable to the mobile clean room **16** or the mobile clean room **60**, and vice versa.

The stationary clean room **82** includes an access region **86**. Within the access region **86** is a clean room door **88** and a clean room door **90**. The clean room door **88** may include hinges **88***a* and **88***b* and the clean room door **90** may include hinges **90***a* and **90***b*. It will be appreciated that the clean room door **88** and the clean room door **90** together may swing together to close access through the access region **86** and may swing apart in order to provide access through the access region **86**.

The stationary clean room **82** includes a door lock **92** and a door lock **94**, each of which are operably coupled with a clean room controller **96**. The door lock **92** may be positioned to reversibly lock or unlock the clean room door **88** and the door lock **94** may be positioned to reversibly lock or unlock the clean room door **90**. In some cases, the door lock **92** may be commanded to lock or unlock the clean room door **88** in response to a command to do so from the clean room controller **96**. The door lock **94** may be commanded to lock or unlock the clean room door **90** in response to a command to do so from the clean room controller **96**.

The stationary clean room **82** includes a door sensor **98** and a door sensor **100**. The door sensor **98** and the door sensor **100** are each operably coupled with the clean room controller **96**. The door sensor **98** may be positioned and configured to provide a signal to the clean room controller **96** indicating whether the clean room door **88** is open or closed. The door sensor **100** may be positioned and configured to provide a signal to the clean room controller **96** indicating whether the clean room door **90** is open or closed.

The stationary clean room **82** includes a mobile clean room detection sensor **102** and a mobile clean room detection sensor **104**. In some cases, the mobile clean room detection sensor **102** and the mobile clean room detection sensor **104** are both positioned and configured to detect the presence or absence of the mobile clean room **84** and to provide signals indicating the presence or absence of the mobile clean room **84** to the clean room controller **96**. The mobile clean room detection sensor **102** and the mobile clean room detection sensor **104** may both be optical or laser sensors, for example. In other instances, the mobile clean room detection sensor **102** may emit an optical or laser beam while the mobile clean room detection sensor **104** may detect the optical or laser beam. The proper position of the mobile clean room **84** may interrupt an optical or laser beam extending between the mobile clean room detection sensor **102** and the mobile clean room detection sensor **104**. In some cases, detection of the interruption of the optical or laser beam provides a verification that the mobile clean room **84** is in fact positioned proximate the access region **86**, as evidenced by both the mobile clean room detection sensor **102** and the mobile clean room detection sensor **104** before the clean room controller **96** commands the door locks **92** and **94** to unlock the clean room doors **88** and **90**, respectively.

The mobile clean room **84** includes a mobile clean room controller **106**. The mobile clean room controller **106** manages operation of the mobile clean room **84**. In some instances, the clean room controller **106** may be configured to communicate wirelessly with the clean room controller **96** in order to share status information between the mobile clean room controller **106** and the clean room controller **96**. In some cases, the clean room controller **96** may be configured to communicate wirelessly with the mobile clean room controller **106** when the mobile clean room **84** is not yet in position proximate the access region **96** and to communicate in a wired fashion once the mobile clean room **84** is properly positioned proximate the access region **96**. A wired connection such as but not limited to an Ethernet cable may be connected between the mobile clean room **84** and the stationary clean room **82** when the mobile clean room **84** is positioned proximate the access region **96**. A wired connection may include multiple connections, and may accommodate unidirectional or even bidirectional flow of information between the clean room controller **96** and the mobile clean room controller **106**, but also a flow of power from the stationary clean room **82** to the mobile clean room **84**.

The mobile clean room controller **106** may be configured to receive a signal from each door sensor **98** and **100** indicating whether each of the clean room doors **88** and **90** is open or closed. When the signal from the door sensors **98** and **100** indicates that at least one of the clean room doors **88** and **90** is still open, the mobile clean room controller may be configured to output a tractor command preventing the electric tractor from moving the mobile clean room **82** away from the access region **86**. When the signal from the door sensors **98** and **100** indicate that each of the clean room doors **88** and **90** is closed, the mobile clean room controller **106** may be configured to output a tractor command permitting the electric tractor to move the mobile clean room **106** away from the access region **86**.

In some cases, the mobile clean room **84** may include extendable wheels moveable between an extended position

for moving the mobile clean room and a retracted position. When the signal from the door sensors **98** and **100** indicate that at least one of the clean room doors **88** and **90** are still open, the mobile clean room controller **106** may be configured to output a wheels command preventing the extendable wheels from being moved into the extended position. When the signal from the door sensors **98** and **100** indicate that each of the clean room doors **88** and **90** is closed, the mobile clean room controller **106** may be configured to output a wheels command enabling the extendable wheels being moved into the extended position. In some cases, before the electric tractor is commanded to move the mobile clean room **84** away from the access region **106**, the mobile clean room controller **106** may be configured to send a signal informing the clean room controller **96** of this, and in response the clean room controller **96** may be configured to send a signal to lock the door locks **92** and **94**.

FIG. **5** is a flow diagram showing an illustrative method **110** of moving components, such as medical device components, from a first clean room (such as the stationary clean room **12**) having a first access region (such as the access region **22**) with a first door to a second clean room (such as the stationary clean room **14**) having a second access region (such as the access region **30**) with a second door, the components arranged on one or more moveable carts disposed within the first clean room. The method **110** includes moving a mobile clean room (such as the mobile clean room **16** or the mobile clean room **60**) to a position proximate the first access region, the mobile clean room including a mobile clean room door, as indicated at block **112**. Confirmation is made that the mobile clean room is appropriately positioned relative to the first access region, as indicated at block **114**. For example, confirmation may be made that the mobile clean room has been moved into sealing engagement with a door frame around the first door of the first access region. As a result, the first door and then the mobile clean room door are sequentially opened, as indicated at block **116**.

The one or more moveable carts are moved from inside the first clean room into the mobile clean room, as indicated at block **118**. The mobile clean room door and then the first door are sequentially closed, as indicated at block **120**. Confirmation is made that the mobile clean room door and the first door are both closed, as indicated at block **122**. The mobile clean room is moved to a position proximate the second access region, as indicated at block **124**. Confirmation is made that the mobile clean room is appropriately positioned relative to the second access region, as indicated at block **126**. For example, confirmation may be made that the mobile clean room has been moved into sealing engagement with a door frame around the second door of the second access region. The second door and then the mobile clean room door are sequentially opened, as indicated at block **128**. The one or more moveable carts are moved from inside the mobile clean room into the second stationary clean room, as indicated at block **130**.

In some cases, the mobile clean room includes extendable wheels moveable between an extended position for moving the mobile clean room and a retracted position, and moving the mobile clean room into a position proximate either the first access region or the second access region includes moving the extendable wheels into the extended position before moving the mobile clean room into the position proximate either the first access region or the second access region, and moving the extendable wheels into the retracted position after moving the mobile clean room into the position proximate either the first access region or the second access region.

FIGS. **6** through **16** illustrate aspects of a mobile clean room **140** and a stationary clean room **222** of a manufacturing system **190**. It is understood that aspects described above may be incorporated into the mobile clean room **140** and/or the stationary clean room **222**. Thus, the features and functionality of the mobile clean room **16**, the mobile clean room **60**, and/or the mobile clean room **84** may be included in the mobile clean room **140**, as desired. Furthermore, the features and functionality of the stationary clean room **12**, the stationary clean room **14**, the stationary clean room **40**, and/or the stationary clean room **82** may be included in the stationary clean room **222**, as desired.

FIG. **6** is a front view of an illustrative mobile clean room **140**. The illustrative mobile clean room **140** may be considered as being an example of the mobile clean room **16**, the mobile clean room **60** or the mobile clean room **84**. Features ascribed to the mobile clean room **140** may be applicable to any of the mobile clean room **16**, the mobile clean room **60** or the mobile clean room **84**. Features ascribed to any of the mobile clean room **16**, the mobile clean room **60** or the mobile clean room **84** may be applicable to the mobile clean room **140**.

The mobile clean room **140** includes an enclosure **142**. The enclosure **142** may be formed of any suitable material. In some cases, the enclosure **142** is metallic, such as but not limited to aluminum or steel, for example. The enclosure **142** may have dimensions sufficient to accommodate the materials to be transferred within the mobile clean room **140** while not too large to be able to easily move the mobile clean room **140** within the building or even between buildings, as desired. Accordingly, the enclosure **142** may have overall dimensions providing the mobile clean room **140** with an overall width of about two to eight feet, an overall length of about four to about ten feet, and an overall height of about four to ten feet. In some cases, the mobile clean room **140** may have an overall width of about four to six feet, an overall length of about five to seven feet, and an overall height of about seven to eight feet.

The mobile clean room **140** includes a pair of doors **144** and **146** having handles **144***a* and **144***b*, respectively. In some cases, the doors **144** and **146** may be configured to be able to open into an access region of a stationary clean room once the doors of the stationary clean room have been opened. Accordingly, the doors **144** and **146** may be opened from an interior of a stationary clean room, assuming that the doors **144** and **146** have been permitted to be unlocked, and the doors within the access region of the stationary clean room have first been unlocked and opened.

The mobile clean room **140** includes several handles **148** that may be used in moving the mobile clean room **140** without an electric tractor. In some cases, the handles **148** may be used to fine tune the position of the mobile clean room relative to an access region of a stationary clean room. The handles **148** may be formed of steel, for example, and may be welded, soldered or bolted onto the side of the enclosure **142**.

The mobile clean room **140** includes a total of four wheel assemblies **150**, one near each corner of the enclosure **142**, although only two wheel assemblies **150** are visible in FIG. **6**. Each wheel assembly **150** includes a wheel **152** and a wheel support mechanism **154**. In some cases, each wheel **152** is free to pivot. Each wheel support mechanism **154** may be configured to move between an extended position, as shown, in which the wheels **152** extend downward beyond a bottom edge **156** of the enclosure **142** and lift the enclosure **142** off the ground a short distance so as to be able to move the enclosure **142**, and a retracted position (not shown) in

which the wheels **152** are lifted above the bottom edge **156** of the enclosure **142**. The wheel support mechanisms **154** may be electromechanical mechanisms that can be operated by the mobile clean room controller, for example. In some instances, the wheel support mechanisms **154** may be manually operated to move them between their extended and retracted positions.

FIG. **7** is a back view of the mobile clean room **140**. In this view, four handles **148** are visible, but it will be appreciated that the mobile clean room **140** may include more or less than four handles **148**. The mobile clean room **140** includes an overhead region **160** that as shown includes various instruments that pertain to operation of the mobile clean room **140**, and in particular pertain to maintaining a desired environment within the mobile clean room **140** in order to meet desired ISO standards. In some cases, the mobile clean room **140** may satisfy ISO 7 standards. In some cases, the mobile clean room **140** may satisfy ISO 6 standards, which are more rigorous than ISO 7 standards. In some cases, the mobile clean room **140** controller (not illustrated) may also be located within the overhead region **160**.

The mobile clean room **140** includes an HMI **162**, which in some cases may be a touch screen display that is configured to display information as well as to solicit and accept inputs from a user via the touch screen display. In some cases, the HMI **162** may display a variety of status information. The HMI display **162** may display alarm statuses. In some instances, the HMI **162** may be configured to provide audible indications that an alarm status has been reached, for any of a variety of different reasons. An audible indication could include a bell or siren, for example. An audible indication could include a previously recorded error message, or an error message spoken by the mobile clean room controller.

Because the mobile clean room **140** includes an air quality system such as a filtration system and/or a ventilation system, the mobile clean room **140** includes an air outlet **164** that is located at or near the bottom of the enclosure **142**. In some cases, a corresponding air inlet may be located within a top surface of the enclosure **142**, as will be seen in FIG. **9**.

FIG. **8** is a side view of the mobile clean room **140** and FIG. **9** is a top view of the mobile clean room **140**. An air inlet **166** can be seen disposed within a top surface **168** of the enclosure **142**. A pair of extensions **170** extend forward from a front face **172** of the enclosure **142** and define the handles **148** that may be used by one or more operators when manually positioning the mobile clean room **84**.

FIG. **10** is a front view of the mobile clean room **140**, with the doors **144** and **146** removed to reveal an interior **180** of the mobile clean room **140**. As shown, the interior **180** provides sufficient space to accommodate a first rolling cart **182** and a second rolling cart **184**. In some cases, the interior **180** may accommodate only one relatively larger cart. In some cases, the interior **180** may accommodate three or more relatively smaller carts. It will be appreciated that these rolling carts **182** and **184** may be easily moved from a stationary clean room into the mobile clean room **140**, and into another stationary clean room.

FIG. **11** is an overhead view of an illustrative manufacturing system **190** including a portion of a stationary clean room **222** and the mobile clean room **140** positioned proximate the stationary clean room **222**. The stationary clean room **222** includes an access region **196**, and a pair of clean room doors **240** and **242** that are hingedly secured within the access region **196**. As shown, the clean room doors **240** and **242** have been fully opened into the interior **192** of the stationary clean room **222**.

The mobile clean room **140** includes a pair of rails **202** that extend partially into the access region **196**. The rails **202** may be used to help guide carts, shelves, etc. into and out of the mobile clean room **140**. FIG. **12** is an enlarged view of a portion of the manufacturing system **190**. As can be seen, there is a resilient gasket **270** disposed between the access region **196** (i.e., doorway of the stationary clean room **222**) and the enclosure **142** of the mobile clean room **140**. In some cases, the resilient gasket **270** is secured to the access region **196**. In some cases, the resilient gasket **270** may be secured to the mobile clean room **140**. The resilient gasket **270** insures an air tight seal between the access region **196** of the stationary clean room **222** and the enclosure **142** of the mobile clean room **140** such that environmental contamination cannot enter into the sealed off interiors of the stationary clean room **222** and the mobile clean room **140**. The resilient gasket **270** may extend around an entire perimeter of the opening between the stationary clean room **222** and the mobile clean room **140**.

FIG. **13** is a perspective view of a portion of the illustrative manufacturing system **190** showing several features. The illustrative manufacturing system **190** includes a portion of the stationary clean room **222** and the mobile clean room **140** positioned proximate the stationary clean room **222**. In some cases, as shown, the access region **196** of the stationary clean room **222** includes a physical stop **228** that is secured near the floor. The physical stop **228** is intended to stop the forward progress of the mobile clean room **224** from damaging the stationary clean room **222** by moving too far towards the stationary clean room **222**. In some instances, contact with the physical stop **228** may indicate correct positioning of the mobile clean room **224** relative to the stationary clean room **222** to ensure an air-tight seal is attained therebetween.

In some cases, as shown, there may be a guide **230** that is secured relative to the floor near the stationary clean room **222**. The guide **230**, which may be a U-shaped track or rail, for example, helps to direct the mobile clean room **140** into alignment with the stationary clean room **222**, and more particularly, with the access region **196** thereof. The guide **230**, which may be formed of steel or aluminum and bolted to the floor, for example, may have an enlarged opening **236** that allows the guide **230** to capture a wheel **152** of the mobile clean room **140**, and then narrows to better guide the wheel **152** into position.

FIG. **14** is a view of an exterior of the stationary clean room **222**, looking into the stationary clean room **222** from a position outside of the stationary clean room **222**, essentially where the mobile clean room **140** would be if positioned proximate the stationary clean room **222**. The stationary clean room **222** includes an access region **196** having an opening or doorway including a door **240** and a door **242** for accessing the interior of the stationary clean room **222**. The doors **240**/**242** are shown in a closed position in FIG. **14**. The stationary clean room **222** includes a resilient gasket **270** that extends around the access region **196** (e.g., extends around the doorway or opening into the stationary clean room **222**). The resilient gasket **270** is configured to form a seal around the doorway or access region **196** when the mobile clean room **140** is docked with the stationary clean room **222**, as described further herein. FIG. **14** also shows an enclosure **272** that in some instances may include the stationary clean room controller in communication with one or more sensors as described herein.

FIG. **15** is a view of the exterior of the stationary clean room **222** with the mobile clean room **140** docked up to the access region **196**. As shown in FIG. **15**, the doors of the

mobile clean room **140** may be aligned with the doors **240**/**242** of the stationary clean room **222** such that the interior of the mobile clean room **140** is accessible from the interior of the stationary clean room **222**. As shown in FIG. **15**, an electric tractor **210**, which may essentially take the form of a pallet jack or a pallet truck, may be used to move the mobile clean room **140** into position to be docked with the access region **196** of the stationary clean room **22** and/or move the mobile clean room **140** away from the access region **196** of the stationary clean room **222**.

FIG. **16** is another view of the illustrative manufacturing system **190**, looking into the mobile clean room **140** from the stationary clean room **222** with the mobile clean room **140** docked with the stationary clean room **222** and both doors **240**/**242** of the mobile clean room **140** have been opened. The mobile clean room **140** includes a door **144** and a door **146**, both of which have also been opened. Both the doors **240**/**242** of the stationary clean room **222**, as well as both the doors **144**/**146** of the mobile clean room **140** open into the interior of the stationary clean room **222**.

As seen in FIG. **16**, the stationary clean room **222** also includes a first mobile clean room detection sensor **258** and a second mobile clean room detection sensor **260**. The first mobile clean room detection sensor **258** and the second mobile clean room detection sensor **260**, which may be optical or laser sensors, are actually located on an exterior wall of the stationary clean room **222**, and are visible in FIG. **16** through a glass panel forming a portion of that exterior wall. Each of the first mobile clean room detection sensor **258** and the second mobile clean room detection sensor **260** are configured to ascertain whether the mobile clean room **140** is properly positioned proximate the access region **196**. Both sensors **258** and **260** are configured to detect the presence (or lack thereof) of the mobile clean room **140**. The sensors **258** and **260** may be optical or laser sensors, with an optical or laser beam extending therebetween. In other instances, the sensor **258** may emit an optical or laser beam while the sensor **260** may detect the optical or laser beam, or vice versa. When the mobile clean room **140** is lowered to the ground, the light beam is interrupted and thus the sensors **258** and **260** are able to confirm the proper positioning of the mobile clean room **140**. The sensors **258** and **260** include a visual alarm, which can illuminate either a red light or a green light, depending on the relative position of the mobile clean room **140**. The sensors **258**/**260** may be communicatively coupled to components within the enclosure **272** and/or the mobile clean room controller, which may be provided with the mobile clean room **140**, that controls operation of the mobile clean room **140**, for example.

Above the access region **196** in which the doors **240** and **242** are located, a pair of door sensors **250** and **252** are positioned to determine whether the doors **240** and **242** are open or closed (or unlocked or locked). The door sensor **250** is configured to output a signal indicating whether the door **240** is open or closed (or unlocked or locked), and the door sensor **252** is configured to output a signal indicating whether the door **242** is open or closed (or unlocked or locked). The door sensors **250** and **252** are connected to a visual alarm **254**, which can illuminate either a red light or a green light, depending on the door status, for example. The sensors **250**/**252** may be communicatively coupled to components within the enclosure **272** and/or the mobile clean room controller, which may be provided with the mobile clean room **140**, that controls operation of the mobile clean room **140**, for example.

FIG. **17** is a view of an illustrative display **280** that may be displayed by an HMI forming part of the mobile clean room **140**, shown in FIG. **15**. The display **280** includes an information section **282** that includes information regarding battery status, filter status, UPS (uninterruptible power supply) status and others. The information section **282** includes green lights for those statuses that are within range and are viewed as good. Some are not illuminated, meaning that perhaps they are not relevant. It will be appreciated that if there is an alarm, one or more of the green lights within the information section **282** may glow in a different colored light, such as for example red, in order to draw the attention of a user to the alarm status.

The display **280** includes a series of buttons **284** across the bottom of the display **280**, including a HOME button **284***a*, a SETUP button **284***b*, an ALARMS button **286***c* and an Operator button **286***d*. The HOME button **284***a* may be selected to reach a home screen, for example. The SETUP button **284***b* may be selected to reach one or more setup menus. The ALARMS button **286***c* may be selected in order to view any alarms, for example, or to reach a screen at which the user can cancel or silence an alarm. The Operator button **286***d* may, if pressed, allow a user to reach a place where they can update their username, change their password, and the like.

The display **280** includes a series of buttons **286** across the right side of the display **280**, including an OPEN button **286***a*, a CLOSE button **286***b* (which seems to be currently selected), a RAISE button **286***c*, a STOP button **286***d* and a LOWER button **286***e*. The RAISE button **286***c* and the LOWER button **286***e* may be used, as appropriate, to raise or lower a value of a particular set point or threshold. The display **280** also includes a general status notice **288** that is displayed within a center portion of the display **280**.

It should be understood that this disclosure is, in many respects, only illustrative. Changes may be made in details, particularly in matters of shape, size, and arrangement of steps without exceeding the scope of the disclosure. This may include, to the extent that it is appropriate, the use of any of the features of one example embodiment being used in other embodiments. The scope of the present disclosure is, of course, defined in the language in which the appended claims are expressed.

What is claimed is:

1. A manufacturing system, comprising:

a mobile clean room including:

a mobile clean room interior volume;

wheels moveable between an extended position and a retracted position; and

an electric tractor releasably securable to the mobile clean room, the electric tractor configured to move the mobile clean room when the electric tractor is secured to the mobile clean room and the wheels are in the extended position;

a first clean room including:

a first clean room interior volume;

a first access region providing access to the first clean room interior volume, the mobile clean room configured to dock with the first access region;

one or more first doors disposed within the first access region, the one or more first doors configured to move between a closed position preventing access to the first clean room interior volume through the one or more first doors and an open position permitting access to the first clean room interior volume through the one or more first doors, each of the one or more first doors including a first door lock;

a first mobile clean room detection sensor configured to provide a signal indicating whether the mobile clean room is in position relative to the first access region; and

a first clean room controller that is configured to:

receive the signal from the first mobile clean room detection sensor;

send a signal to unlock the first door locks when the signal from the first mobile clean room detection sensor indicates that the mobile clean room is in position relative to the first access region; and

not send a signal to unlock the first door locks when the signal from the first mobile clean room detection sensor indicates that the mobile clean room is not in position relative to the first access region.

2. The manufacturing system of claim **1**, wherein the first mobile clean room detection sensor comprises a pair of first mobile clean room detection sensors, and the first clean room controller only sends a signal to unlock the first door locks when the signals from both first mobile clean room detection sensors indicate that the mobile clean room is in position relative to the first access region.

3. The manufacturing system of claim **1**, further comprising a second clean room, the second clean room including:

a second clean room interior volume;

a second access region providing access to the second clean room interior volume, the mobile clean room configured to dock with the second access region;

one or more second doors disposed within the second access region, the one or more second doors configured to move between a closed position preventing access to the second clean room interior volume through the one or more second doors and an open position permitting access to the second clean room interior volume through the one or more second doors, each of the one or more second doors including a second door lock;

a second mobile clean room detection sensor configured to provide a signal indicating whether the mobile clean room is in position relative to the second access region; and

a second clean room controller that is configured to:

receive the signal from the second mobile clean room detection sensor;

send a signal to unlock the second door locks when the signal from the second mobile clean room detection sensor indicates that the mobile clean room is in position relative to the second access region; and

not send a signal to unlock the second door locks when the signal from the second mobile clean room detection sensor indicates that the mobile clean room is not in position relative to the second access region.

4. The manufacturing system of claim **3**, wherein the electric tractor is configured to move the mobile clean room between the first access region and second access region.

5. The manufacturing system of claim **1**, wherein the mobile clean room further comprises a mobile clean room controller that is configured to communicate with the first clean room controller.

6. The manufacturing system of claim **5**, further comprising a first door sensor dedicated to each of the one or more first doors, each first door sensor outputting a signal indicating whether a corresponding first door is in an open position or a closed position.

7. The manufacturing system of claim **6**, wherein the mobile clean room controller is configured to:

receive a signal from each first door sensor indicating whether each of the one or more first doors is in the open position or in the closed position;

when the signal from each first door sensor indicates that at least one of the one or more first doors is in the open position, the mobile clean room controller outputs a tractor command preventing the electric tractor from moving the mobile clean room away from the first access region; and

when the signal from each first door sensor indicates that each of the one or more first doors are in the closed position, the mobile clean room controller outputs a tractor command permitting the electric tractor to move the mobile clean room away from the first access region.

8. The manufacturing system of claim **7**, wherein the mobile clean room controller is further configured to send a signal informing the first clean room controller that the electric tractor is permitted to move the mobile clean room away from the first access region, and the first clean room controller is configured to send sends a signal to lock the first door locks in response to the signal informing the first clean room controller that the electric tractor is permitted to move the mobile clean room away from the first access region.

9. The manufacturing system of claim **7**, wherein:

when the signal from each first door sensor indicates that at least one of the one or more first doors is in the open position, the mobile clean room controller outputs a wheels command preventing the wheels from being moved into the extended position; and

when the signal from each first door sensor indicates that each of the one or more first doors are in the closed position, the mobile clean room controller outputs a wheels command enabling the wheels being moved into the extended position.

10. The manufacturing system of claim **9**, wherein the mobile clean room controller is configured to receive the signals from each first door sensor directly from the first door sensor.

11. A mobile clean room configured to provide a clean room environment while moving components between a first stationary clean room and a second stationary clean room, the mobile clean room comprising:

an interior volume;

an on-board power supply;

an electric tractor coupled to the mobile clean room,

the electric tractor configured to move the mobile clean room;

an air quality system configured to maintain a clean room environment within the interior volume; and

a controller operably coupled with a filtration system and the on-board power supply, the controller configured to:

monitor and control performance of the air quality system;

monitor performance of the on-board power supply; and

communicate with a stationary controller controlling operation of the first stationary clean room and/or the second stationary clean room.

12. The mobile clean room of claim **11**, wherein the stationary controller comprises a first stationary controller controlling operation of the first stationary clean room and a second stationary controller controlling operation of the second stationary clean room.

13. The mobile clean room of claim **11**, further comprising extendable wheels that are moveable between an

extended position and a retracted position in response to a command from the controller.

14. The mobile clean room of claim **13**, wherein the controller is configured to provide a command to prevent the extendable wheels from being moved into the extended position or to enable the extendable wheels to be moved into the extended position in response to a signal to do so from the stationary controller;

wherein when the signals from each first door sensor indicate that at least one of the one or more first doors is in the open position, the mobile clean room controller outputs a wheels command preventing the extendable wheels from being moved into the extended position; and

wherein when the signals from each first door sensors indicate that each of the one or more first doors are in the closed position, the mobile clean room controller outputs a wheels command enabling the extendable wheels being moved into the extended position.

15. The mobile clean room of claim **11**, further comprising a human machine interface (HMI) that is operably coupled with the controller, wherein the HMI is configured to display information determined by the controller or received from the stationary controller.

16. The mobile clean room of claim **15**, wherein the HMI is configured to display one or more of:

a status of on-board power supply;

a status of the air quality system including filtration status and/or ventilation status;

an open/closed door status of a door providing access to the interior volume of the mobile clean room;

whether the mobile clean room is positioned correctly or not;

whether either the first stationary clean room or the second stationary clean room is prepared to accept the mobile clean room or to allow the mobile clean room to depart; and

whether there are any current alarms.

17. The mobile clean room of claim **13**, wherein the HMI is configured to allow a user to enter information for the controller.

18. A method of moving components from a first clean room having a first access region with a first door to a second clean room having a second access region with a second door, the components arranged on one or more moveable carts disposed within the first clean room, the method comprising:

moving a mobile clean room to a position proximate the first access region, the mobile clean room including a mobile clean room door;

confirming that the mobile clean room is appropriately positioned relative to the first access region;

sequentially opening the first door and then the mobile clean room door;

moving the one or more moveable carts from inside the first clean room into the mobile clean room;

sequentially closing the mobile clean room door and then the first door;

confirming that the mobile clean room door and the first door are both closed;

moving the mobile clean room to a position proximate the second access region;

confirming that the mobile clean room is appropriately positioned relative to the second access region;

sequentially opening the second door and then the mobile clean room door; and

moving the one or more moveable carts from inside the mobile clean room into the second stationary clean room.

19. The method of claim **18**, wherein the mobile clean room comprises extendable wheels moveable between an extended position for moving the mobile clean room and a retracted position, and moving the mobile clean room into a position proximate either the first access region or the second access region comprises:

moving the extendable wheels into the extended position before moving the mobile clean room into the position proximate either the first access region or the second access region; and

moving the extendable wheels into the retracted position after moving the mobile clean room into the position proximate either the first access region or the second access region.

20. The method of claim **18**, wherein confirming that the mobile clean room door and the first door are both closed comprises receiving confirmation from a stationary clean room door sensor configured to indicate whether the first door is open or closed.

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