

REMOVABLE PANEL ROOF FOR MODULAR, SELF-CONTAINED, MOBILE CLEAN ROOM

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CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/887,303, filed Aug. 15, 2019, which is hereby incorporated by reference in its entirety for all purposes.

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BACKGROUND

[0002] 1. Field of the Invention

[0003] The present application generally relates to chemical or physical laboratory apparatuses for general use including dust-free rooms or enclosures, specifically to mobile building cleanrooms with a walkable, removable panel roof under which utilities are routed from a mechanical room to over the ceiling of the cleanroom and underneath the panels.

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[0004] 2. Description of the Related Art

[0005] In some traditional cleanroom-within-a-warehouse architectures, plumbing and other utilities are routed into a set of components well above a cleanroom. The set of components includes HVAC (heating, ventilation, and air conditioning) air handling units, plumbing utilities, and circuit breaker panels. Ducts, piping, and electrical conduit extend from the components down to just above the ceiling of the cleanroom. At this point, they may meet with dampers, valves, and junction boxes.

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[0006] These dampers, valves, and junction boxes sometimes need servicing by maintenance personnel. Because this “mezzanine” area on the ceiling is open, access is not normally a problem.

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[0007] Modern cleanrooms are built like modular buildings, complete with their own mechanical rooms that house the HVAC air handling units, plumbing utilities, and circuit breaker panels. These modular buildings can be pre-fabricated in a factory and then shipped by rail, aircraft, or truck to a final location. So that they fit inside the envelope of the

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modular building frame, the mechanical rooms are located on the same floor as the cleanroom, often sharing a wall with it. Ducts, piping, and electrical conduit run from the mechanical room through the walls to the cleanroom or over its ceiling to where they need to go.

- 5 **[0008]** Just like for traditional cleanrooms, there must be dampers, valves, and junction boxes into which the ducts, piping, and conduit run. And they need to be serviced. However, because everything is enclosed in a modular building structure built for transport, access to them is difficult. Further, just inspecting them may be difficult because space is at a premium and components are close together.
- 10 **[0009]** There is a need in the art for modern, transportable cleanrooms that are serviceable and maintainable.

BRIEF SUMMARY

- 15 **[0010]** Generally, an interstitial area above a modular building cleanroom's ceiling is covered with walkable floor panels, such as bar grating, that is removable so that dampers, valves, and junction boxes on the ceiling may be serviced by removing sections of the floor panels. The floor panels are suspended above the ceiling on joists that run the full width of the modular building so that ductwork, piping, and electrical conduit may be routed from a mechanical room at one end of the modular building's frame to where they need to go in the
- 20 cleanroom.

[0011] If the walkable floor panels are bar grating, then the utility service components connected with the ductwork, piping, and electrical conduit can be more easily inspected by a maintenance technician inspector walking the roof because he or she can see through the grating to components below without having to remove the panels.

- 25 **[0012]** A folding stand can be incorporated to hold electrical panelboards. The electrical panelboard may be pre-connected at a factory through a flexible conduit to electrical and other connections to the cleanroom. Once delivered to a warehouse gray space in which the modular building is installed, the stand can be unfolded or otherwise deployed so that the panelboard is upright, accessible, and meets electrical codes.

- 30 **[0013]** Some embodiments of the invention are related to a modular building apparatus for pharmaceutical cleanroom manufacturing including a controlled air, sealable cleanroom

having a ceiling, a mechanical room, a unitary frame for a modular building, the frame surrounding the cleanroom and the mechanical room and projecting above the cleanroom ceiling, joists suspended by the frame above the ceiling of the sealable cleanroom and forming an interstitial volume above the ceiling and below the joists, a utility service component mounted within the interstitial volume, a duct, a pipe, or an electrical conduit running from the mechanical room, through the interstitial volume, and to the utility service component, and walkable floor panels supported by the joists and over the utility service component, at least some of the floor panels being removable in order to provide personnel access to the utility service component.

- 10 **[0014]** The walkable floor panels can be grating sections, each grating section being independently removable from the joists. The grating sections can include a smooth bar grating or a serrated bar grating. A hinge can support an end of each grating section. The grating can be made of aluminum, steel, fiberglass, or other materials.

- 15 **[0015]** Each joist can include a lateral support ledge, and the floor panels can be configured to rest between the joists. Each internal joist of the joists can include lateral support ledges on opposite sides of said internal joist, and multiple floor panels can be supported on either side of said internal joist. Each joist can include a lateral support ledge at a depth equal to a height of the floor panels, and the floor panels can be configured to rest between the joists and have a top that is flush with a top of the joists. Each joist can include extruded metal and
20 be welded to a metal wall plate, each extruded metal joist including a 5 cm (2 inch) depth between a bottom of a lateral support ledge and a bottom of the joist, the depth being suitable for a 5 cm thick solid panel.

- [0016]** The floor panels can extend an entire width and length of the cleanroom below. The floor panels can extend an entire length of the unitary frame. The mechanical room can be
25 above the ceiling of the cleanroom. The mechanical room can have a personnel entry point separate from an entry point of the cleanroom. A height of the mechanical room can extend to a height of the floor panels.

[0017] The utility service component can include a damper, a valve, a junction box, or other utility access point.

- 30 **[0018]** Some embodiments are related to a modular building apparatus for pharmaceutical cleanroom manufacturing including a controlled air, sealable cleanroom having a ceiling, a unitary frame for a modular building, the frame surrounding the cleanroom and projecting

above the cleanroom ceiling, joists suspended by the frame above the ceiling of the sealable cleanroom and forming an interstitial volume above the ceiling and below the joists, walkable floor panels supported by the joists, each floor panel being removable in order to provide personnel access to the interstitial volume, and a deployable stand connected with at least one of the joists, the deployable stand supporting an electrical panelboard connected with conduit running to the cleanroom, the deployable stand being repositionable from i) a horizontal configuration laying down over the joists and ii) an upright configuration.

[0019] There can exist a clear working space over the floor panels in front of the electrical panelboard at least 750 millimeters (mm) wide and at least 900 mm deep when the deployable stand is in the upright configuration. This area is per National Electric Code § 110.26(A).

[0020] At least some of the conduit connected with the electrical panelboard can be flexible conduit that does not require withdrawing internal wires when the deployable stand is repositioned between the horizontal and upright configurations. The deployable stand can be connected through a pivot to at least one of the joists, and the deployable stand can be configured to rotate around the pivot from the horizontal configuration to the upright configuration.

[0021] The floor panels can be set between the joists, and tops of the floor panels can be flush with tops of the joists. The floor panels can be solid or see-through bar grating.

[0022] Some embodiments are related to a method of assembling a modular cleanroom apparatus for pharmaceutical cleanroom manufacturing, the method including providing a controlled air, sealable cleanroom having a ceiling, installing a unitary frame for a modular building, the frame surrounding the cleanroom and projecting above the cleanroom ceiling, fastening joists to the frame above the ceiling of the sealable cleanroom to form an interstitial volume above the ceiling and below the joists, attaching a deployable stand to at least one of the joists, the deployable stand being repositionable from i) a horizontal configuration laying down over the joists and ii) an upright configuration, wiring an electrical panelboard mounted on the deployable stand to the cleanroom through flexible conduit, positioning the deployable stand to the horizontal configuration after the wiring, transporting, to a destination, the cleanroom with the unitary frame and horizontally configured deployable stand, and deploying, at the destination, the deployable stand with the electrical panelboard to the upright configuration.

[0023] A portion of the deployable stand can rest between at least two of the joists when in the horizontal configuration. The deployable stand can be connected through a pivot to at least one of the joists, the positioning including rotating the deployable stand around the pivot from the horizontal configuration to the upright configuration.

- 5 **[0024]** The method can further include inserting walkable floor panels between the joists, each floor panel being removable in order to provide personnel access to the interstitial volume.

BRIEF DESCRIPTION OF THE DRAWINGS

- 10 **[0025]** FIG. 1 is a perspective, elevation view of a modular cleanroom building in accordance with an embodiment.

[0026] FIG. 2A is an inside perspective view of two modular building sections being put together in accordance with an embodiment.

- 15 **[0027]** FIG. 2B is an inside perspective view of the two modular building of FIG. 2A closer together.

[0028] FIG. 3 is a top, side isometric view of interstitial space of an assembled modular building in accordance with an embodiment.

[0029] FIG. 4 is an isometric view of walkable bar grating on top of a modular building in accordance with an embodiment.

- 20 **[0030]** FIG. 5A is an isometric view of bar grating between joists in accordance with an embodiment.

[0031] FIG. 5B is a cross section view of the bar grating of FIG. 5A.

[0032] FIG. 6 is a perspective view of a section of bar grating removed from its joists in accordance with an embodiment.

- 25 **[0033]** FIG. 7A is a perspective view of an electrical panelboard laying down in accordance with an embodiment.

[0034] FIG. 7B is a perspective view of the electrical panelboard of FIG. 7A deployed upright.

[0035] FIG. 8 is a flowchart illustrating an embodiment in accordance with the present invention.

DETAILED DESCRIPTION

- 5 [0036] A transportable, modular building cleanroom is described with an adjoining mechanical room that routes air, fluids, electrical power, and communications from a floor area of the mechanical room into an interstitial space over the ceiling of the cleanroom to dampers, valves, junction boxes, etc. in the interstitial space. The roof of the module building comprises a set of walkable, removable floor panels that rest between extruded metal joists.
- 10 The floor panels can be bar grating through which personnel can see in order to locate and inspect the dampers, etc.. Whether bar grating or solid, the floor panels can be lifted off by personnel so that they can service the equipment below.

[0037] An “internal joist” is a joist that is not a rim joist or at the end of a row of joists and exposed externally, or as otherwise known in the art.

- 15 [0038] An “interstitial volume” or “interstitial space” is an area above a ceiling of a cleanroom and below a roof of a modular building structure surrounding the cleanroom, or as otherwise known in the art.

- [0039] FIG. 1 is a perspective, elevation view of a cleanroom modular building. Modular building assembly 100 includes modular building structure 102 that is designed to be
- 20 transported from one location to another. This can mean that has a welded or bolted unitary frame 104, is rigid enough to be transported by aircraft, ship, or tractor trailer, is sized to fit on or in such vehicles, or as otherwise known in the art.

- [0040] Unitary frame 104 surrounds controlled air, sealable cleanroom 114. Cleanroom 114 is defined by several walls, ceiling 110, and floor 112. Personnel can ingress or egress
- 25 the cleanroom through doorway 108 and see into or out of the cleanroom through window 106.

[0041] In some configurations, the entrance and exit may be separated into distinct doorways and have airlock-type areas through which personnel may don or doff gowns or other protective equipment.

- 30 [0042] Mechanical room 116 is adjacent cleanroom 114. Its height 118 in the exemplary embodiment is the same height has cleanroom 114. Mechanical room 116 houses heating,

ventilation, and air conditioning (HVAC) blower and conditioning units, electrical power and computer subsystems, pipe valves, and other utility systems.

5 **[0043]** In some embodiments, the height of the mechanical room can extend all the way to the roof instead of being at the same height as the cleanroom. Removing a walkable floor panel can then allow one to see all the way to the floor of the mechanical room.

10 **[0044]** Truss 124 of unitary frame 104 projects above cleanroom 114 and mechanical room 116, forming an attic-like interstitial volume 120. The interstitial space is a meter or so high, too short for personnel to stand up in. It is above cleanroom ceiling 110 and below walkable panel roof supported by joists 125. Through interstitial space 120 runs ducts 122, which run to vents 127 within cleanroom 114. Pipes and electrical wires also run through interstitial space 120 to outlets 128 and 129, respectively.

15 **[0045]** Within the cleanroom, personnel can perform research & development activities or manufacturing that requires a clean, dustless environment. The uses for such spaces are innumerable. The fact that the cleanroom is manufactured in a factory as a modular building and then connected together to others in a warehouse or other gray space with a flat floor typically means that its walls are straighter and tolerances tighter than if an equivalent room were built in place. Further, its electrical systems and other utilities can be factory checked with centralized test equipment before transport. This generally results in better quality checks and fewer leaks in the final product.

20 **[0046]** FIGS. 2A-2B are inside perspective views of two modular building sections being put together. Two frames 204 with interstitial spaces 220 and metal structural supports 205 are moved horizontally together on a smooth, flat floor such that they join. They are then bolted and fastened together such that their floors converge and their ceilings 210 connect to form a common floor and ceiling. The common floor and ceiling define a large room inside.
25 The common ceiling and the frame structure above it define one or more interstitial spaces through which utilities are routed.

30 **[0047]** There can be several vents, outlets for chilled or hot water, lights and detectors within the cleanroom. Associated with these fixtures are dampers, valves, and junction boxes in the ceiling. During maintenance, accessing the dampers, valves, and junction boxes from inside the cleanroom would create a problem with potential contamination of the cleanroom because they are, at least in relation to the cleanroom, dirty. Thus, it is desirable to access them from outside the cleanroom.

[0048] FIG. 3 is a top, side isometric view of interstitial space of modular buildings in accordance with an embodiment. Within modular building 302 are interstitial spaces 320 above cleanroom 314 and mechanical room 316, shown here without their ceilings.

[0049] HVAC duct 330 feeds vent 336, while electrical conduit 332 feeds electrical outlets.

5 Pipes 334 feed air and water outlets in the cleanroom. Ducts 330, electrical conduit 332, and pipes 334 travel through interstitial volume 320 from mechanical room 316 to their respective ends in cleanroom 320.

[0050] FIG. 4 is an isometric view of walkable bar grating on top of a modular building 402. On the roof of modular building assembly 400, walkable floor panels 440 are supported
10 between joists 425. Each floor panel 440 is independently removable from its surrounding joists to provide for access by personnel.

[0051] In the exemplary embodiment, the swath of floor panels 440 extend an entire width and length of the unitary frame of modular building 402.

[0052] Each commercially available bar grating section is 147 cm (4 ft. 10 inches) x 91 cm
15 (3 ft.) long, but other sizes are available. Modular buildings are about 366 cm (12 ft.) wide by 1524 cm (50 ft.) long. Therefore, four of the grating sections placed side-by-side can go across the roof to cover the 366 cm (12 ft.) width. Twelve sets of the grating sections placed end to end between the joists cover the 1524 cm (50 ft.) length.

[0053] In some embodiments, the mechanical room is mounted on a skid above the ceiling
20 of the cleanroom. This allows more floor space to be devoted to the cleanroom operations and may reduce the length of pipes and conduit needed to reach all parts of the cleanroom.

[0054] In some embodiments, the mechanical room has a doorway or other personnel entry point that is separate from an entry point of the cleanroom. This allows maintenance people to service utilities without dirtying the cleanroom or interrupting operations there.

25 [0055] FIGS. 5A-5B illustrate bar grating 540 that is set between extruded inner joist 525 and end joist 542. End joist 542 and inner joist 525 are welded to metal wall plate 544.

[0056] Grating 540 rests upon lateral support ledge 546 (see FIG. 5B) of internal joist 525 and lateral support ledge 548 of end joist 542. Inner joist 525 includes lateral support ledges 546 on opposite sides such that it supports multiple gratings. Its cross section is plus '+'

shaped. Meanwhile, end joist 542 includes a single lateral support ledge 548 to form a tee 'T' shape.

5 [0057] The depth of each lateral support ledge 546 and 548 is equal to the height of the grating. Thus, the top of each floor panel grating 540 is flush with the top of joist 525 and 548.

[0058] The joists are fabricated from aluminum so that they are strong, corrosion resistant, and light weight.

10 [0059] Each extruded end joist 542 and internal joist 525 include a common depth between a bottom of their lateral support ledges 546 and 548 and their respective bottoms. This depth is different from the common depth between a top of their lateral support ledges 546 and 548 and their respective tops. This is so that the extruded joists can be flipped upside down so that their alternate common depth is facing up. This alternate depth can accommodate a different depth of floor panels. For example, the alternate common depth can be 5 centimeters (2 inches) to accommodate opaque floor panels instead of a thinner see-through bar grating.

15 [0060] FIG. 6 is a perspective view of a section of walkable floor panel bar grating removed from joists 625. Utility service component 660, as well as junction box 629, is mounted within the interstitial space. The utility service component can include a damper, valve, or other components. Data cables 632 in cable trays and pipe 634 are also mounted within the interstitial space. Removing the grating section allows personnel to access the components in the interstitial space without having to enter the cleanroom.

[0061] FIGS. 7A-7B are perspective views of the roof 700 of a modular building with a reconfigurable electrical panelboard mounting system. Walkable gratings 740 are set between joists 725.

25 [0062] Deployable stand 750 supports electrical conduit 754, which runs from the cleanroom and mechanical room to electrical panelboards 752 that are mounted on the stand. Electrical and other connections are made and tested at the factory in preparation for the modular building to be transported to its operating location. When the stand is deployed, the flexible conduit section does not require withdrawing internal wires or otherwise re-wiring the panelboard connections.

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5 [0063] Connected to joists 725 through mechanical pivot 758, deployable stand is reconfigurable from a laying down, horizontal position, shown in FIG. 7A, to a deployed, upright configuration, shown in FIG. 7B. It simply rotates around pivot 758. In its upright configuration, it is secured with a diagonal brace. In the horizontal position, the deployable stand may require one or more of the removable gratings to be removed so that its components may fit between the joists for travel.

10 [0064] When the deployable stand is upright, there is a clear, flat area in front of the panelboard(s) of the stand at least 750 millimeters (mm) wide and at least 900 mm deep. This meets typical requirements for access to such panelboards in electric codes, such as National Electric Code § 110.26(A).

15 [0065] FIG. 8 is a flowchart of a process 800 in accordance with an embodiment. In operation 801, a controlled air, sealable cleanroom having a ceiling is provided. In operation 802, a unitary frame for a modular building is installed surrounding the cleanroom and projecting above the cleanroom ceiling. In operation 803, joists are fastened to the frame above the ceiling of the sealable cleanroom to form an interstitial volume above the ceiling and below the joists. In operation 804, a deployable stand is attached to at least one of the joists, the deployable standing being repositionable from i) a horizontal configuration laying down over the joists and ii) an upright configuration. In operation 805, an electrical panelboard mounted on the deployable stand is wired to the cleanroom through flexible conduit. In operation 806, the deployable stand is positioned to the horizontal configuration after the wiring. In operation 807, the cleanroom with the unitary frame and horizontally configured deployable stand is transported to a destination. In operation 808, the deployable stand with the electrical panelboard is deployed to the upright configuration.

25 [0066] It is contemplated that any embodiment discussed in this specification can be implemented with respect to any method, kit, reagent, or composition of the invention, and vice versa. Furthermore, compositions of the invention can be used to achieve methods of the invention.

30 [0067] It will be understood that particular embodiments described herein are shown by way of illustration and not as limitations of the invention. The principal features of this invention can be employed in various embodiments without departing from the scope of the invention. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, numerous equivalents to the specific procedures described herein.

Such equivalents are considered to be within the scope of this invention and are covered by the claims.

[0068] All publications and patent applications mentioned in the specification are indicative of the level of skill of those skilled in the art to which this invention pertains. All
5 publications and patent applications are herein incorporated by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

[0069] The use of the word “a” or “an” when used in conjunction with the term “comprising” in the claims and/or the specification may mean “one,” but it is also consistent
10 with the meaning of “one or more,” “at least one,” and “one or more than one.” The use of the term “or” in the claims is used to mean “and/or” unless explicitly indicated to refer to alternatives only or the alternatives are mutually exclusive, although the disclosure supports a definition that refers to only alternatives and “and/or.” Throughout this application, the term “about” is used to indicate that a value includes the inherent variation of error for the device,
15 the method being employed to determine the value, or the variation that exists among the study subjects.

[0070] As used in this specification and claim(s), the words “comprising” (and any form of comprising, such as “comprise” and “comprises”), “having” (and any form of having, such as “have” and “has”), “including” (and any form of including, such as “includes” and “include”) or “containing” (and any form of containing, such as “contains” and “contain”) are inclusive
20 or open-ended and do not exclude additional, unrecited elements or method steps.

[0071] The term “or combinations thereof” as used herein refers to all permutations and combinations of the listed items preceding the term. For example, “A, B, C, or combinations thereof” is intended to include at least one of: A, B, C, AB, AC, BC, or ABC, and if order is
25 important in a particular context, also BA, CA, CB, CBA, BCA, ACB, BAC, or CAB. Continuing with this example, expressly included are combinations that contain repeats of one or more item or term, such as BB, AAA, MB, BBC, AAABCCCC, CBBAAA, CABABB, and so forth. The skilled artisan will understand that typically there is no limit on the number of items or terms in any combination, unless otherwise apparent from the context.

[0072] As used herein, words of approximation such as, without limitation, “about”, “substantial” or “substantially” refers to a condition that when so modified is understood to not necessarily be absolute or perfect but would be considered close enough to those of

ordinary skill in the art to warrant designating the condition as being present. The extent to which the description may vary will depend on how great a change can be instituted and still have one of ordinary skilled in the art recognize the modified feature as still having the required characteristics and capabilities of the unmodified feature. In general, but subject to
5 the preceding discussion, a numerical value herein that is modified by a word of approximation such as “about” may vary from the stated value by at least ± 1 , 2, 3, 4, 5, 6, 7, 10, 12 or 15%.

[0073] All of the compositions and/or methods disclosed and claimed herein can be made and executed without undue experimentation in light of the present disclosure. While the
10 compositions and methods of this invention have been described in terms of preferred embodiments, it will be apparent to those of skill in the art that variations may be applied to the compositions and/or methods and in the steps or in the sequence of steps of the method described herein without departing from the concept, spirit and scope of the invention. All such similar substitutes and modifications apparent to those skilled in the art are deemed to
15 be within the spirit, scope and concept of the invention as defined by the appended claims.