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(54) MODULAR BUILDING CONSTRUCTION SYSTEM

(57) A modular building construction system for fabricating a facility 102 comprising a plurality of primary function modules 104, each primary function module configured to house equipment for a primary function; at least one transition module 106 configured to cooperate with at least two of the plurality of primary function modules 102 in order to allow people to move from at least one of the primary function modules 104 to at least one other of the primary function modules 104 via the transition module 106, and a support module 108 configured to house equipment for supporting the primary function modules 104 and the at least one transition modules 106.

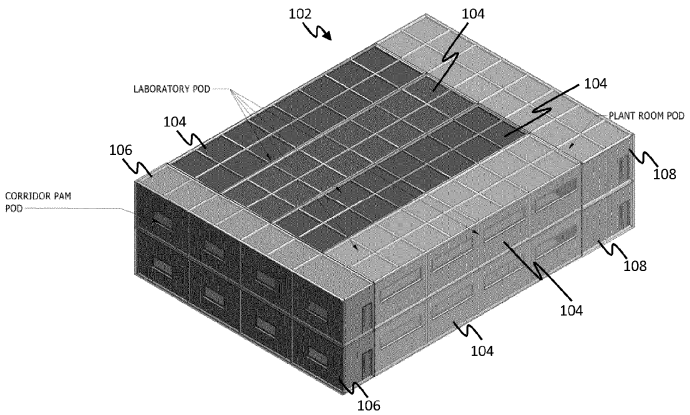

Fig 1

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Description

Technical Field

[0001] The present invention relates to a modular building construction system for fabricating a facility and particularly, but not exclusively, relates to a modular building construction system for fabricating a laboratory facility, a medicinal product manufacturing facility, a medical facility, a cleanroom facility or similar.

Background

[0002] The construction industry is known to have a chronically low level of productivity that has changed very little in the past seventy years. It is thought that the low level of productivity is a consequence of the generally accepted need for bespoke buildings to be developed for particular applications combined with 'tried-and-tested' construction methods.

[0003] Bespoke buildings typically take several years to design, construct and validate/qualify which is slow and by implication costly. Furthermore, building designs are also often subject to changes as a project progresses and, in some circumstances, buildings have to be further modified after completion in order to comply with a change in requirements, expansion or cost constraints.

[0004] The problem is particularly acute for research and medical facilities which often need to be constructed rapidly and which must be flexible to accommodate changes to their end use. For example, laboratory facilities such as vaccine development facilities, advanced therapy medicinal product facilities and cell and gene therapy facilities are often planned and then initiated very quickly, with a need for them to be constructed and commissioned in several months rather than several years and to be adaptable during and after construction.

[0005] In addition, once a building has been constructed, it is typically time consuming and costly to install service networks, such as ventilation systems, piping networks and electrical networks, in the building.

[0006] There is a need for a better way of constructing buildings which is rapid, low cost and flexible.

Summary of the Invention

[0007] According to a first aspect of the invention there is provided A modular building construction system for fabricating a facility comprising a plurality of primary function modules, each primary function module configured to house equipment for a primary function; at least one transition module configured to cooperate with at least two of the plurality of primary function modules in order to allow people to move from at least one of the primary function modules to at least one other of the primary function modules via the transition module, and a support module configured to house equipment for supporting the primary function modules and the at least one transition modules.

[0008] Equipment for supporting the primary function modules and the at least one transition module is service equipment such as a ventilation and air conditioning system, a fluid source, an electricity source and/or other source of a service which is supplied to one or more of the primary function modules and/or the transition modules to support its function, such as to facilitate habitation or operation, such as operation as a laboratory facility.

[0009] Each primary function module may comprise a framework having a plurality of openings and which is configured to provided structural rigidity for the primary function module.

[0010] Each primary function module may further comprise panels which attach to the framework and are configured to provide occlude the openings in the framework.

[0011] Each primary function module may be configured to receive at least one preassembled service module comprising at least one of ventilation ducting, an electrical cable tray, and piping for supply of at least one fluid to the primary function module.

[0012] Each primary function module may be configured such that the preassembled service module is mounted at the ceiling of the primary function module.

[0013] The framework may comprise lateral beams configured such that the preassembled service module is secured to the lateral beams such that it is suspended from the lateral beams.

[0014] The primary function module may be configured to be stacked one above the other.

[0015] Each primary function module may be a laboratory module.

[0016] The support module may be a plant room module configured to house plant machinery.

[0017] The plant machinery may comprises a heating, ventilation and air conditioning (HVAC) system.

[0018] The heating, ventilation and air conditioning (HVAC) system may be a once-through heating, ventilation and air conditioning (HVAC) system having heat recovery.

[0019] Each of the primary function modules, the transition module and the support module may be fabricated from uprights, beams and panels having standard dimensions.

[0020] The panels may comprise a material certified for a clean-room application.

[0021] Each module may have a length not greater than 20m, a width not greater than 5m and a height not greater than 4.2m.

[0022] According to a second aspect of the invention there is provided a facility comprising: a plurality of primary function modules, each primary function module is configured to house equipment for a primary function; at least one transition module connected with at least two of the plurality of primary function modules such that people are able to move from at least one of the primary function modules to at least one other of the primary function modules via the transition module, and a support

module configured to house equipment for supporting the primary function modules and the at least one transition modules.

[0023] The facility may comprise a first floor having at least one primary function module, at least one transition module and at least one support module which houses equipment arranged to support the at least one primary function module and the at least one transition module, and a second floor having at least one primary function module, at least one transition module and at least one support module which houses equipment arranged to support the at least one primary function module and the at least one transition module.

[0024] The facility may further comprise at least one preassembled service module comprising at least one of ventilation ducting, an electrical cable tray, and piping for supply of at least one fluid to the primary function module.

[0025] The at least one preassembled service module may be not greater than 6m in length.

[0026] According to a third aspect of the invention there is provided a method of assembling a facility comprising the steps: providing a plurality of primary function modules, each primary function module configured to house equipment for a primary function; connecting at least one transition module with at least two of the plurality of primary function modules in order to allow people to move from at least one of the primary function modules to at least one other of the primary function modules via the transition module, and connecting at least one support module configured to house equipment for supporting the primary function modules and the at least one transition modules to at least one of the primary function modules and/or the at least one transition module.

[0027] Each of the primary function modules, the at least one transition module and the at least one support module is fabricated remotely from a site at which the facility is assembled, and subsequently transported to the site for assembly with the other of said primary function, transition and support modules.

[0028] According to a fourth aspect of the invention there is provided a module for use in a modular building construction system comprising: a framework having a plurality of openings and which is configured to provided structural rigidity for the primary function module; panels which attach to the framework and are configured to provide occlude the openings in the framework, and at least one preassembled service module comprising at least one of ventilation ducting, an electrical cable tray, and piping for supply of at least one fluid to the primary function module, wherein the framework comprises lateral beams and the preassembled service module is secured to the lateral beams such that it is suspended from the beams.

[0029] According to a fifth aspect of the invention there is provided a method of constructing a facility at a predetermined site comprising the steps: providing a building structure at a predetermined site, the building structure having a plurality of primary function rooms and at least one transition room configured to allow people to move from at least one of the primary function rooms to at least one other of the primary function rooms via the at least one transition room; fabricating a support module remote from the predetermined site, wherein the support module is configured to house equipment for supporting the primary function rooms and the at least one transition room; transporting the support module to the predetermined site, and joining the support module to the building structure.

[0030] The method may further comprise the step of cladding the building structure and the support module with a cladding arrangement such that the building structure and the support module create an appearance of an integrated facility.

[0031] Equipment for supporting the primary function rooms and the at least one transition room is disposed within the support module. The equipment may be disposed in the support module during fabrication of the support module, after transporting of the support module to the predetermined site and before joining the support module to the building structure or after joining of the support module to the building structure.

[0032] The building structure may comprise at least one service network and the step of joining the support module with the building structure comprises connecting the equipment with at least one service network of the building structure.

[0033] The equipment may comprise a heating, ventilation and air conditioning (HVAC) system and the service network comprises a ventilation network.

[0034] The support module may be joined to the building structure such that it is disposed externally of the building structure.

[0035] Various further features and aspects of the invention are defined in the claims.

[0036] Certain aspects of the invention provide a modular construction system which allows for a bespoke facility to be designed in a way that significantly reduces design and construction time and costs, but which retains the individuality of design that traditional modular construction systems are unable to provide.

[0037] Certain aspects of the invention provide a modular construction system that allow for a significant proportion of construction work to be done offsite (i.e. away from the site at which a facility is located).

[0038] Certain aspects of the invention provide a modular construction system that is a hybrid of traditional onsite construction techniques to provide a building structure and offsite manufacturing to provide bespoke facilities in which time to completion and costs are lower than conventional onsite construction techniques.

[0039] Certain aspects of the invention provide a versatile modular construction system that allows for a facility to be reconfigured partially or wholly during design, build or subsequent operation rapidly, at low cost and with low impact.

[0040] Unless defined otherwise, all technical and sci-

entific terms used herein have the meaning commonly understood by a person skilled in the art to which this invention belongs.

Brief Description of the Drawings

[0041] Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings where like parts are provided with corresponding reference numerals and in which:

Figure 1 shows a first embodiment of a laboratory facility;

Figure 2 shows modules of the laboratory facility shown in Figure 1;

Figure 3 shows a laboratory module of Figure 1;

Figure 4 shows the laboratory facility showed in Figure 1;

Figure 5 shows a first embodiment of a services module;

Figure 6 shows a second embodiment of a services module;

Figure 7 shows a third embodiment of a services module;

Figure 8 shows a fourth embodiment of a services module;

Figure 9 shows a fifth embodiment of a services module;

Figure 10 shows a sixth embodiment of a services module;

Figure 11 shows a seventh embodiment of a services module;

Figure 12 shows a second embodiment of a laboratory facility;

Figure 13 shows a layout of a first floor the laboratory facility shown in Figure 12;

Figure 14 shows a layout of a second floor of the laboratory facility shown in Figure 12;

Figure 15 shows an embodiment of a facility; and

Figure 16 shows a layout of the facility shown in Figure 15.

Detailed Description

[0042] Figure 1 shows a first embodiment of a laboratory facility 102 fabricated using a modular building construction system. The laboratory facility 102 comprises a plurality of primary function modules in the form of laboratory pods 104, two transition modules in the form of corridor pods 106 and two support modules in the form of plant room pods 108.

[0043] The laboratory pods 104 are arranged in pairs, one above the other. Each pair is arranged adjacent another pair of laboratory pods 104. There are 8 laboratory pods 104 in total.

[0044] The two corridor pods 106 are arranged one above the other and are disposed at the ends of the laboratory pods 104 and are configured to allow people, such as laboratory staff, to move between the laboratory pods 104 via the corridor pods 106. Each corridor pod 106 defines a corridor or part of a corridor through which persons can move.

[0045] The plant room pods 108 are also arranged one above the other and are disposed at the ends of the laboratory pods 104 opposite the ends at which the corridor pods 106 are disposed. The plant room pods 108 are self-contained with easy access at the side of the laboratory facility 102, and can be configured to accommodate plant machinery that supplies selected other pods. This approach can be used to decentralise systems such as ventilation systems which, in turn, can reduce overall energy consumption. Each plant room pod 108 provides a room or multiple rooms in which services equipment such as plant machinery, for example a heating, ventilation and air conditioning (HVAC) system, may be located.

[0046] The facility 102 has a lower first floor (i.e. a ground floor) and an upper second floor, each floor having four laboratory pods 104 connected by a corresponding corridor pod 106, and a plant room pod 108.

[0047] Each floor (i.e. the upper and lower floors) is self-contained in the sense that services are supplied from a plant room pod 108 on the same floor. This allows for floors of the facility 102 to be repurposed and reconfigured with negligible impact on other floors.

[0048] Figure 2 shows a laboratory pod 104 adjacent a plant room pod 108 of Figure 1 in isolation. The laboratory pod 104 comprises four windows 110a, 110b, 110c, 110d and a door 112 at the end that is adjacent the corridor pod 106. The plant room pod 108 comprises a door 114.

[0049] With reference to Figure 3, each laboratory pod 104 is fabricated from a plurality of beams 116, 118, uprights 120 and panels 122, 124, 126 having standard dimensions. That is to say each beam 116, 118, upright 120 and panel 122, 124, 126 (only one example of each component has been indicated with a reference sign for clarity) has a dimensions, such as length, width and thicknesses, which are not specific to the laboratory pod 104 constructed. The panels 122, 124, 126 may be made of a material certified for a clean-room application and may

be resistant to vapourised hydrogen peroxide to allow them to be disinfected using vapourised hydrogen peroxide. Each laboratory pod 104 provides a laboratory room in which laboratory equipment may be disposed.

[0050] In the embodiment shown, the laboratory pod 104 has a length off 20 metres (m), a width of 5 metres (m) and a height of 4.2 metres (m), and so is configured to a standard size that can be transported using conventional road haulage.

[0051] The laboratory pod 104 is fabricated from twelve uprights 120 , five uprights 120 on one side, five uprights 120 on the other side, and one additional upright 120 at each end. Longitudinal beams 118 extend along each side, respectively, both top and bottom. Lateral beams 116 extend laterally from each side beam to a central longitudinal beam. The beams 116, 118 therefore form an open framework having openings between the beams for receiving the panels 122, 124, 126.

[0052] Ceiling panels 122 are provided between the lateral beams 116 and the longitudinal beams 118. End panels 124 are provided between the uprights 120 at the ends of the laboratory pod 104. The door 112 is provided in the panel 124 on the right hand side as viewed in Figure 3. Windowed panels 126 are provided between the uprights 120 along each side of the laboratory pod 104. Each windowed panel 126 has an elongate window 128 provided in it. Figure 4 shows the laboratory facility 102 shown in Figure 1 with the ceiling panels 122 of the laboratory pods 104, corridor pods 106, and plant room pods 108 absent. Each laboratory pod 104 is provided with a plurality of ceiling mounted service modules 130.

[0053] A service module 130 is a prefabricated module that may comprise any one or more ventilation ducts, electrical cable trays, lighting connectors, room utilities and piping for delivery of fluids, particularly gases. Each service module 130 has a preconfigured arrangement and is configured to occupy a space immediately below a ceiling panel 122 or to occupy a space immediately below a plurality of ceiling panels 122 which corresponds to an exact number of ceiling panels 122.

[0054] Figure 5 shows a first embodiment of a service module 130a. The service module 130a comprises a support framework 132a having support uprights 134a and upper and lower support beams 136a, 137a. The support beams 136a, 137a extend laterally and are connected to the support uprights 134a to provide structural rigidity. The support uprights 134a and upper and lower support beams 136a, 137a may comprise met-strut 41x41 or 82x41 configurations which are assembled by welding the met-struts together. Support uprights 134a and upper and lower support beams 136a, 137a may, however, be fabricated for specific loading requirements based on standard British steel sizes which may then be welded or bolted together.

[0055] The upper support beams 136a are configured to be secured to the lateral beams 116 of the laboratory pod 104 such that the service module 130a is suspended below the lateral beams 116. The service module 130a has a size and shape which corresponds to the size and shape of ceiling panel 122 and so fits directly under a ceiling panel 122 without protruding laterally from beneath it. This allows service modules 130 to be placed in close proximity to each other under adjacent ceiling panels 122 which, in turn, allows for conveying components such as ventilation ducting, cable trays and piping of adjacent service modules to be connected directly to each other.

[0056] A first air supply ventilation duct 138a is suspended below the upper support beams 136a. The first air supplied ventilation duct 138a has a downwardly facing outlet 140a.

[0057] A second air supply ventilation duct 142a is suspended below the upper support beams 136a adjacent the first air supply ventilation duct 138a.

[0058] An air extract ventilation duct 144a is also suspended below the upper support beams 136a adjacent the second air supply ventilation duct 142a.

[0059] The ventilation ducts 138a , 142a, 144a are arranged such that they can be connected to ducts of an adjacent service module with which they align. In the present embodiment, each ventilation duct 138a , 142a, 144a comprises a connector at each open end in the form of a flange arrangement that is configured to be directly connected to a corresponding duct of an adjacent service module having a corresponding flange arrangement. For instance, when the services modules are installed, the respective flange arrangements are brought into pressing engagement with each other. The flange arrangements are then held together by clamping means, such as a G-clamp, to provide an air-tight connection. An example of a suitable connector arrangement is a slide-on and crimp flange connector system.

[0060] Each ventilation duct 138a , 142a, 144a may comprise one or more of the following features: straight ducting, bend ducting, such as an elbow for changing the direction in which a duct extends, a reducer, manual and/or automatic dampers (which may be electrically, hydraulically or pneumatically actuated), attenuators, heater batteries, temperature transmitters and gas-tight dampers. The ducts may be any suitable configuration including ducts having a rectangular cross-section, circular cross-section, a spiral configuration, or a combination of these depending on requirements. Ducting may also be provided for exhausting specific gases arising from processes.

[0061] Fluid supply pipes comprising an oxygen supply pipe 146a, a nitrogen supply pipe 148a, a compressed air supply pipe 150a, and a carbon dioxide supply pipe 152a are connected to lower support beams 136a such that they extend horizontally. The fluid supply pipes 146a, 148a, 150a, 152a are arranged such that they can be directly connected at each of their ends to fluid supply pipes of an adjacent service module with which they align. The fluid supply pipes 146a, 148a, 150a, 152a turn through right angles in a horizontal plane as they extend through the service module 130a.

[0062] There may also be provided supply and return pipes for various services and/or pneumatic systems including low-temperature hot water, reverse osmosis, process cooling water, chilled water, boosted cold water, hot water, water for injection, such as high pressure water and/or natural gas. Each pipe is provided with a connector arranged to connect to a connector of a corresponding pipe in an adjacent services module. Such a connector may comprise a flange connector, threaded connector, welded connection, coupling connector, ferule and triclover™ connector or a press-fit connection depending on requirements and suitability.

[0063] The pipes may also comprise bend sections, such as elbows, for changing the direction in which a pipe extends, reducers, valves and/or inline instrumentation. Pipes may be fabricated from suitable materials including stainless steel, such as 304 and 316L, ASME BPE, schedule carbon steel and copper.

[0064] Cable trays 154a, 156a, 158a, 160a, 162a are connected to auxiliary support beams 164a that are situated above the lower support beams 137a and so provide an intermediate level for supporting the cable trays 154a, 156a, 158a, 160a, 162a. The cable trays 154a, 156a, 158a, 160a, 162a are arranged to allow electrical cables to be laid along them and can be aligned with cable trays of an adjacent service module having similarly configured cable trays. The cable trays 154a, 156a, 158a, 160a, 162a may comprise light, medium and/or heavy-duty cable trays. There may also be provided other cable containment and associated component(s) including ladder rack(s), cable basket(s) and/or cable trunking.

[0065] In an alternative embodiment, one or more busbars may be provided to distribute electrical services as an alternative or addition to cables. Such services include, low-voltage and high-voltage distribution, data distribution and retrieval, including communication networks, lighting power distribution, Environmental Monitoring System (EMS) distribution and Building Management System (BMS) distribution. The busbars are arranged such that they are aligned with at least one respective busbar of an adjacent service module such that the busbars of adjacent service modules can be connected directly to each other by a suitable connector such as a busbar end feed connector.

[0066] Other electrical components that may be supported by the service module include bends/elbows, tee pieces, reducers, joining plates, junction boxes, end feed units, tap off units, junction blocks, distribution boards, remote ethernet IO modules, control panels.

[0067] Figure 6 shows a second embodiment of a service module 130b. The service module 130b is similar to the first embodiment in that it comprises a support framework 132b having support uprights 134b and upper and lower support beams 136b, 137b. The support beams 136b, 137b extend laterally and are connected to the support uprights 134b to provide structural rigidity.

[0068] The upper support beams 136b are configured to be secured to the lateral beams 116 of the laboratory pod 104 such that the service module 130b is suspended underneath the lateral beams 116. The support beams 136b, 137b are approximately double the length of the support beams of the first embodiment of service module 130a shown in Figure 5. The service module 130b therefore has a size and shape which corresponds to the size and shape of two adjacent ceiling panels 122 and so fits directly under two adjacent ceiling panels 122 without protruding laterally from beneath them.

[0069] A first air supply ventilation duct 138b is suspended below the upper support beams 136b. The first air supplied ventilation duct 138a has downwardly facing outlets 140b.

[0070] A second air supply ventilation duct 142b is suspended below the upper support beams 136b adjacent the first air supply ventilation duct 138b.

[0071] An air extract ventilation duct 144b is also suspended below the upper support beams 136a adjacent the second air supply ventilation duct 142b.

[0072] The first air supply ventilation duct 138b extends longitudinally within the service module 130b. The second air supply ventilation duct 142b and the air extract ventilation duct 144b are configured to bend within the service module 130b such that the ends of the ducts 142b, 144b are at different height within the service module 130b. The ducts 138b, 142b, 144b are arranged such that they can be connected to ducts of an adjacent service module with which they align.

[0073] Fluid supply pipes comprising an oxygen supply pipe 146b, a nitrogen supply pipe 148b, a compressed air supply pipe 150b, and a carbon dioxide supply pipe 152b are connected to lower support beams 136b such that they extend horizontally. The fluid supply pipes 146b, 148b, 150b, 152b are arranged such that they can be connected at each of their ends to air supply pipes of an adjacent service module with which they align. The fluid supply pipes 146b, 148b, 150b, 152b extend longitudinally within the service module 130b.

[0074] Cable trays 154b, 156b, 158b, 160b, 162b are connected to auxiliary support beams 164b that are situated above the lower support beams 137b. The cable trays 154b, 156b, 158b, 160b, 162b are arranged to allow electrical cables along them and can be aligned with cable trays of an adjacent service module having similarly configured cable trays.

[0075] It will be appreciated that a service module 130 may be configured to a desired specification. The service modules may have predefined standard unit widths, lengths and heights. The widths and lengths may vary between service modules, but do so in predefined increments that correspond to a unit width. For example, the first embodiment of a service module 130a (shown in Figure 5) which occupies the space under a single ceiling panel 122 may be considered to have a single unit width and a single unit length. The second embodiment of a service module 130b (shown in Figure 6) which occupies the space under two ceiling panels 122 may be considered to have a single unit width and a double unit length.

[0076] Figures 7, 8, 9, 10 and 11 show third, fourth, fifth, sixth and seventh embodiments of a service module 130c, 130d, 130e, 130f, 130g.

[0077] The third embodiment 130c has a unit width and a double unit length. The fourth and fifth embodiments 130d, 130e have a single unit width and a unit length. The fifth and embodiments 130f, 130g have a single unit width and a quadruple unit length.

[0078] Each embodiment 130c, 130d, 130e, 130f, 130g has components that correspond to at least some of the components of the first and second embodiments 130a, 130b. The components take the same reference numbers with the relevant letter for each embodiment. The embodiments illustrate how the various components may be arranged in accordance with a specification. For example, cable trays may be arranged two extend perpendicularly with respect to each other or to have bends in them.

[0079] The system provides a means by which ducting, cable, pipes and connectors can be preassembled in modules in accordance with a desired layout whereupon the service modules when connected to a laboratory pod 102 follow a desired layout. Multiple service networks can therefore be installed in a predetermined layout by installing the preassembled service modules. This allows for a substantially proportion of the network to be assembled remotely from the building in which it is to be installed and provides a significant reduction in installation time on-site.

[0080] By providing ceiling mounted service modules 130, ready access is provided to services from above through the ceiling of the laboratory pod 102, such as cables, piping and ducting, which greatly reduces the time taken for installation of services (e.g. traditional first and second 'fix' services) and commissioning.

[0081] Figure 12 shows a second embodiment of a laboratory facility 202 fabricated using a modular building construction system. The facility 202 is a hybrid arrangement fabricated using a combination of conventional building techniques and a modular building construction system.

[0082] Figure 13 shows a layout of a first floor (the ground floor) of the laboratory facility 202 shown in Figure 12. The first floor of the laboratory facility 202 comprises three support modules in the form of first, second and third plant room pods 204, 206, 208 which are positioned adjacent a conventional building structure 203.

[0083] The conventional building structure 203 includes an office room 210, which provides office space, a reception space and also a dedicated space preparing food and beverages, each of which may be sub-divisions of the office room 210; a break out room 212, which provides an informal meeting space annexed to the office room 210; a male change room 214, which provides a space for male personnel to change attire; a female change room 216, which provides a space for female personnel to change attire; a water closet room 218, which is subdivided to provide individual toilet cubicles; a computer hardware room 220, which provides a space for accommodating computer hardware; first, second and third meeting room 222, 224 226, which provide private meeting spaces; a conferencing room 228, which provides a conferencing space; a consumables room 230, which provides a storage facility for consumables used in the laboratories such as bottles, carboys, centrifuge tubes, vials slides and petri dishes and which may be transferred to the laboratories as required; a sample delivery room 232, which is where specimens are delivered, catalogued and stored awaiting testing in the laboratories; and an autoclave and waste out room 234, in which waste from laboratories is sorted and stored, and in which re-useable utensils are processed and sterilised using an autoclave washer before being catalogued to the consumables room 230.

[0084] The conventional building structure 203 also includes an entrance room 236, a first stairwell 238 and a second stairwell 240.

[0085] Figure 14 shows a layout of a second floor (an upper floor) of the laboratory facility 202 shown in Figure 12. The second floor of the laboratory facility 202 comprises three support modules in the form of fourth, fifth and sixth plant room pods 242, 244, 246 which are positioned adjacent the building structure 203 and above the first, second and third plant rooms 204, 206, 208.

[0086] The second floor of the conventional building structure 203 includes first, second, third, fourth and fifth laboratory rooms 248, 250, 252, 254, 256. Each laboratory room 248, 250, 252, 254, 256 is subdivided into a gowning space and a laboratory space.

[0087] The conventional building structure 203 also comprises a first corridor 258 which extends around the laboratory rooms 248, 250, 252, 254, 256 and also has a portion which extends between the first, second, third and fourth laboratory rooms 248, 250, 252, 254, which are positioned in a line adjacent one another, and the fifth laboratory room 256. The corridor 258 is subdivided by three doors 259a, 259b, 259c to form an 'entrance' corridor 258a and an 'exit' corridor 258b.

[0088] The conventional building structure 203 also comprises a third stairwell 260, which is disposed directly above and adjoins the first stairwell 238 to form a single stairwell between the first and second floors, and a second stairwell 262 which is disposed directly above and adjoins the second stairwell 240 to form a single stairwell between the first and second floors.

[0089] Each plant room pod is fabricated using uprights, longitudinal and lateral beams, and panels having standard configurations such as those used in the fabrication of the laboratory pod 104 described with reference to Figure 3, and is equipped with service modules, as required.

[0090] The plant room pods 204, 206, 208, 242, 244, 246 may be assembled off-site away from the conventional building structure 203 before being transported to the building location and loated in position adacent the conventional building structure 203, as shownin Figures

13 and 14. Once in position the plant room pods 204, 206, 208, 242, 244, 246 are joined with the conventional building structure and clad with a suitable cladding system that is the same as the cladding system used for the conventional building structure 203 so as to create the appearance of an integrated facility 202.

[0091] Figures 15 and 16 show a facility having a single primary function module in the form of a dry room pod 304; two transition modules in the form of an air lock module 306 and a lobby module 308; and a support module in the form of a plant room pod 310. Each pod is fabricated using uprights, longitudinal and lateral beams, and panels having standard configurations such as those used in the fabrication of the laboratory pod 104 described with reference to Figure 3, and is equipped with service modules, as required.

[0092] The modular building construction system may be used for a range of applications including the fabrication of medical, research and manufacturing facilities. For example, the modular building construction system may be used to construct vaccine development facilities, cell gene therapy facilities and advanced therapy medicinal product facilities.

[0093] Buildings may use heat recovery, heat pumps and integrated solar panels to reduce or eliminate carbon dioxide emissions. The modular building construction system may reduce the amount of space (area) required for a plant room by 50% or more.

[0094] *All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive. Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features. The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.*

[0095] *With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.*

[0096] *It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims are generally intended as "open" terms (e.g., the term "including" or "comprising" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations).*

[0097] *It will be appreciated that various embodiments of the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope of the present disclosure. Accordingly, the various embodiments disclosed herein are not intended to be limiting, with the true scope being indicated by the following claims.*

Claims

1. A modular building construction system for fabricating a facility comprising:

   a plurality of primary function modules, each primary function module configured to house equipment for a primary function;
   at least one transition module configured to cooperate with at least two of the plurality of primary function modules in order to allow people to move from at least one of the primary function modules to at least one other of the primary function modules via the transition module, and
   a support module configured to house equipment for supporting the primary function modules and the at least one transition modules.

2. The modular building construction system of claim 1, wherein each primary function module comprises a framework having a plurality of openings and which

is configured to provided structural rigidity for the primary function module.

3. The modular building construction system of claim 2, wherein each primary function module further comprises panels which attach to the framework and are configured to provide occlude the openings in the framework.

4. The modular building construction system of claim 2 or 3, wherein each primary function module is configured to receive at least one preassembled service module comprising at least one of ventilation ducting, an electrical cable tray, and piping for supply of at least one fluid to the primary function module, and wherein each primary function module is optionally configured such that the preassembled service module is mounted at the ceiling of the primary function module, and wherein the framework optionally comprises lateral beams configured such that the preassembled service module is secured to the lateral beams such that it is suspended from the lateral beams.

5. The modular building construction system of any one of the preceding claims, wherein the primary function modules are configured to be stacked one above the other, and/or wherein each primary function module is optionally a laboratory module, and/or wherein the support module is optionally plant room module configured to house plant machinery, and wherein the plant machinery optionally comprises a heating, ventilation and air conditioning (HVAC) system, and wherein the heating, ventilation and air conditioning (HVAC) system is optionally a once-through heating, ventilation and air conditioning (HVAC) system having heat recovery.

6. The modular building construction system of any one of the preceding claims, wherein each of the primary function modules, the transition module and the support module is fabricated from uprights, beams and panels having standard dimensions, and wherein the panels optionally comprise a material certified for a clean-room application.

7. The modular building construction system of any one of the preceding claims, wherein each module has a length not greater than 20m, a width not greater than 5m and a height not greater than 4.2m.

8. A facility comprising:

a plurality of primary function modules, each primary function module is configured to house equipment for a primary function;
at least one transition module connected with at least two of the plurality of primary function modules such that people are able to move from at least one of the primary function modules to at least one other of the primary function modules via the transition module, and
a support module configured to house equipment for supporting the primary function modules and the at least one transition modules.

9. The facility of claim 8, wherein the facility comprises:

a first floor having at least one primary function module, at least one transition module and at least one support module which houses equipment arranged to support the at least one primary function module and the at least one transition module, and
a second floor having at least one primary function module, at least one transition module and at least one support module which houses equipment arranged to support the at least one primary function module and the at least one transition module.

10. The facility of claim 8 or 9, further comprising at least one preassembled service module comprising at least one of ventilation ducting, an electrical cable tray, and piping for supply of at least one fluid to the primary function module, and wherein the at least one preassembled service module is optionally not greater than 6m in length.

11. A method of assembling a facility comprising the steps:

providing a plurality of primary function modules, each primary function module configured to house equipment for a primary function;
connecting at least one transition module with at least two of the plurality of primary function modules in order to allow people to move from at least one of the primary function modules to at least one other of the primary function modules via the transition module, and
connecting at least one support module configured to house equipment for supporting the primary function modules and the at least one transition modules to at least one of the primary function modules and/or the at least one transition module.

12. The method of claim 11, wherein each of the primary function modules, the at least one transition module and the at least one support module is fabricated remotely from a site at which the facility is assembled, and subsequently transported to the site for assembly with the other of said primary function, transition and support modules.

13. A module for use in a modular building construction system comprising:

a framework having a plurality of openings and which is configured to provided structural rigidity for the primary function module;
panels which attach to the framework and are configured to provide occlude the openings in the framework, and
at least one preassembled service module comprising at least one of ventilation ducting, an electrical cable tray, and piping for supply of at least one fluid to the primary function module, wherein the framework comprises lateral beams and the preassembled service module is secured to the lateral beams such that it is suspended from the beams.

14. A method of constructing a facility at a predetermined site comprising the steps:

providing a building structure at a predetermined site, the building structure having a plurality of primary function rooms and at least one transition room configured to allow people to move from at least one of the primary function rooms to at least one other of the primary function rooms via the at least one transition room;
fabricating a support module remote from the predetermined site, wherein the support module is configured to house equipment for supporting the primary function rooms and the at least one transition room;
transporting the support module to the predetermined site, and
joining the support module to the building structure.

15. The method of claim 14, further comprising the step of cladding the building structure and the support module with a cladding arrangement such that the building structure and the support module create an appearance of an integrated facility, and/or wherein equipment for supporting the primary function rooms and the at least one transition room is optionally disposed within the support module, and wherein the building structure optionally comprises at least one service network and the step of joining the support module with the building structure optionally comprises connecting the equipment with at least one service network of the building structure, and/or wherein the equipment optionally comprises a heating, ventilation and air conditioning (HVAC) system and the service network optionally comprises a ventilation network, and/or wherein the support module is optionally joined to the building structure such that it is disposed externally of the building structure.

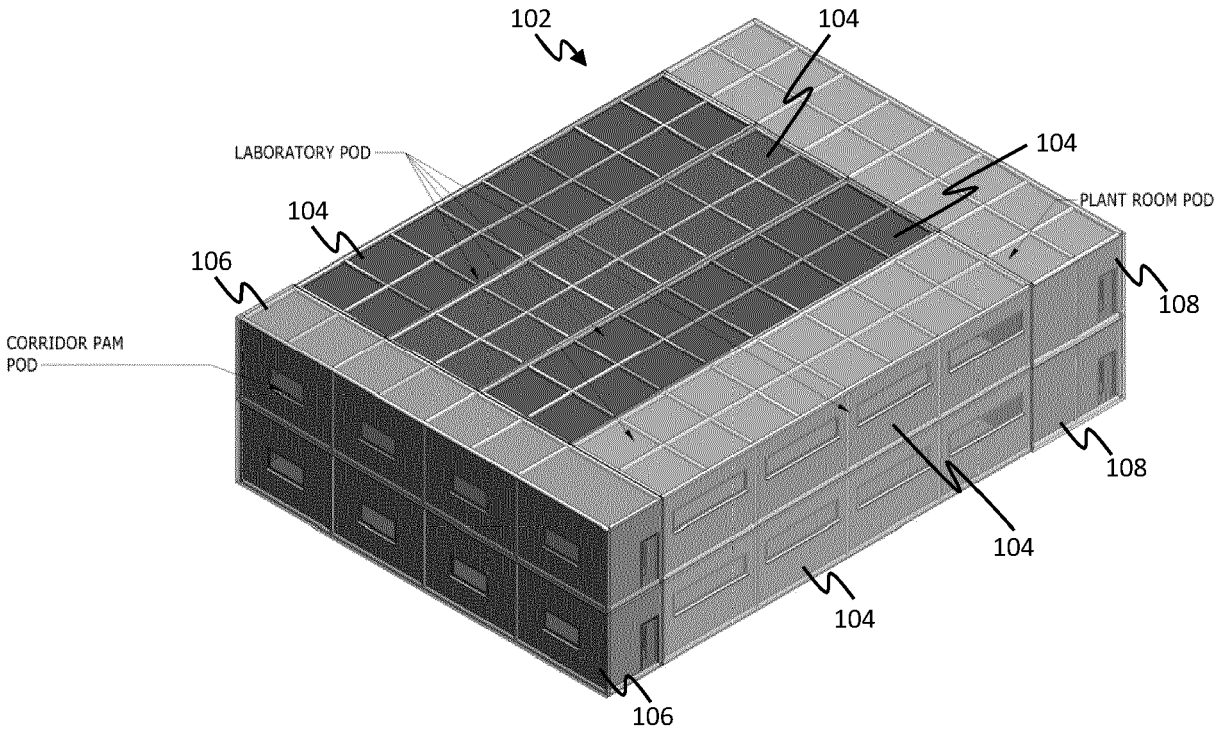

102
104
104
LABORATORY POD
104
PLANT ROOM POD
106
108
CORRIDOR PAM POD
108
104
104
106

Fig 1

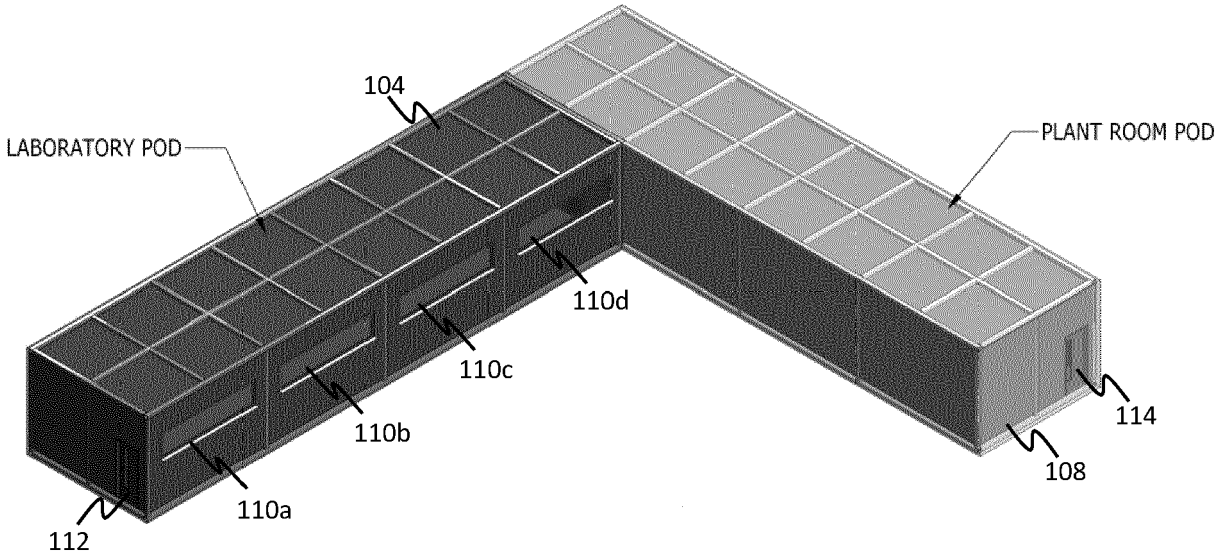
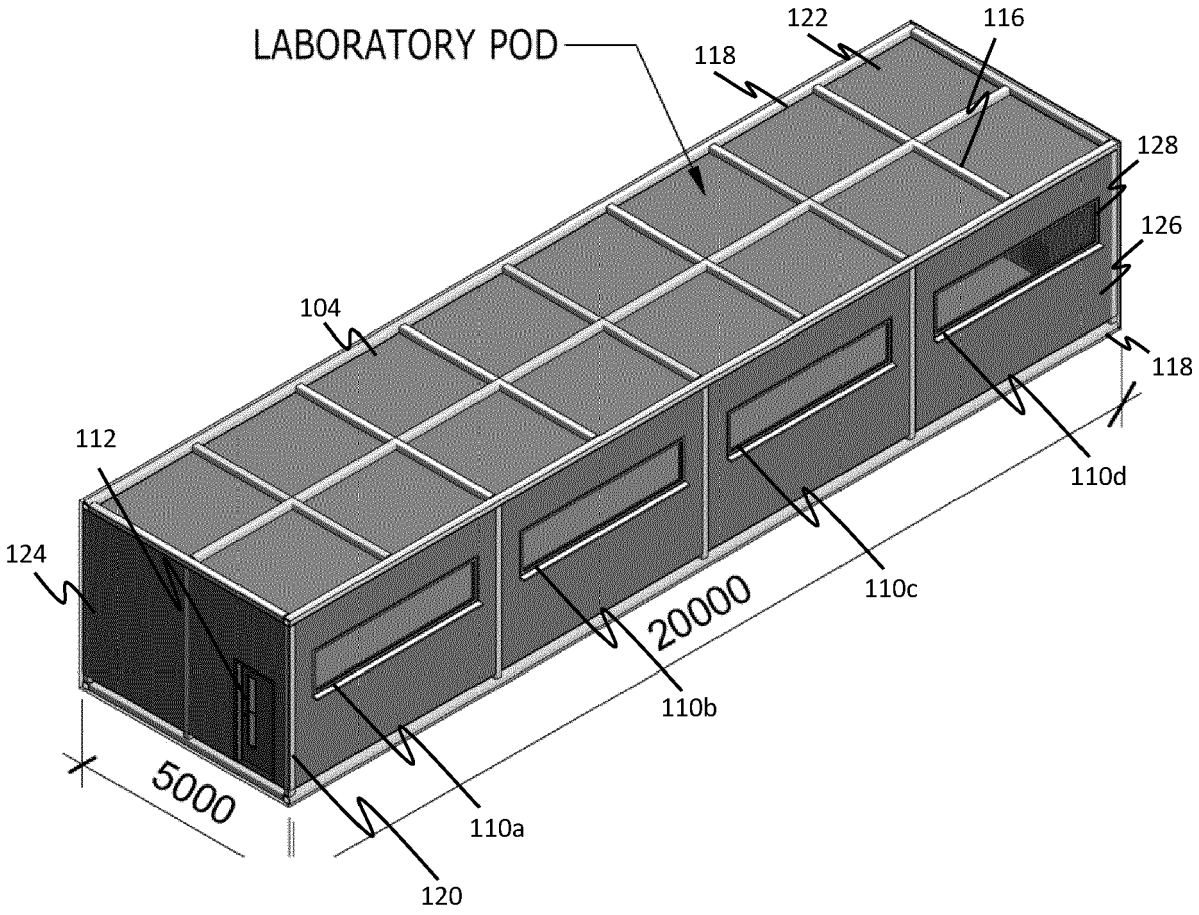

LABORATORY POD
104
PLANT ROOM POD
110d
110c
110b
110a
112
114
108

Fig 2


LABORATORY POD
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116
118
128
126
104
118
112
110d
124
110c
20000
110b
5000
110a
120

Fig 3

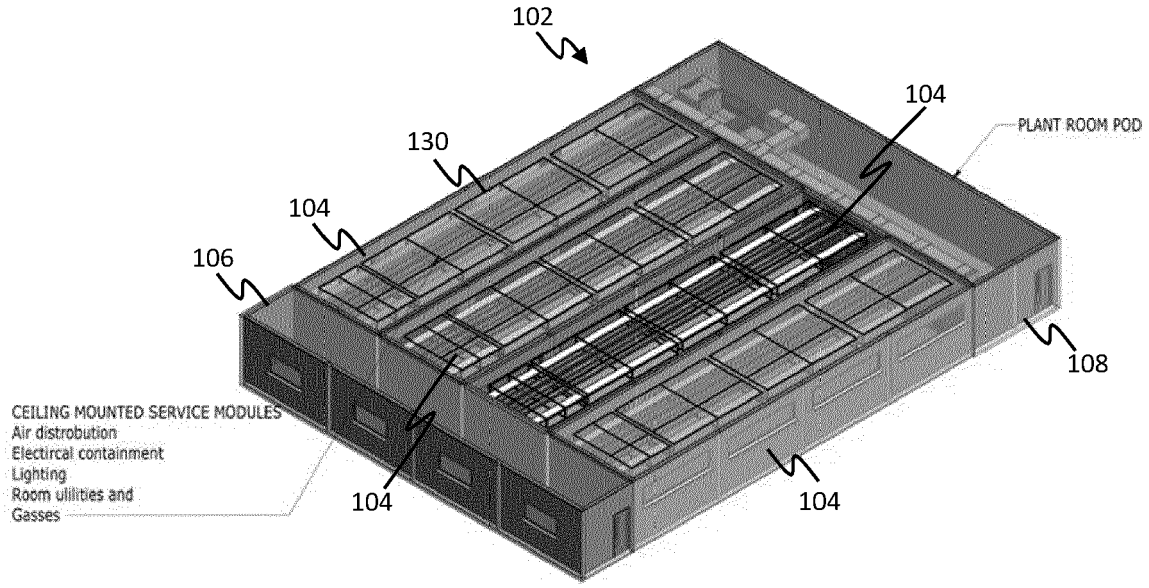
102
104
PLANT ROOM POD
130
104
106
108
CEILING MOUNTED SERVICE MODULES
Air distrobution
Electircal containment
Lighting
Room ulilities and
Gasses
104
104

Fig 4

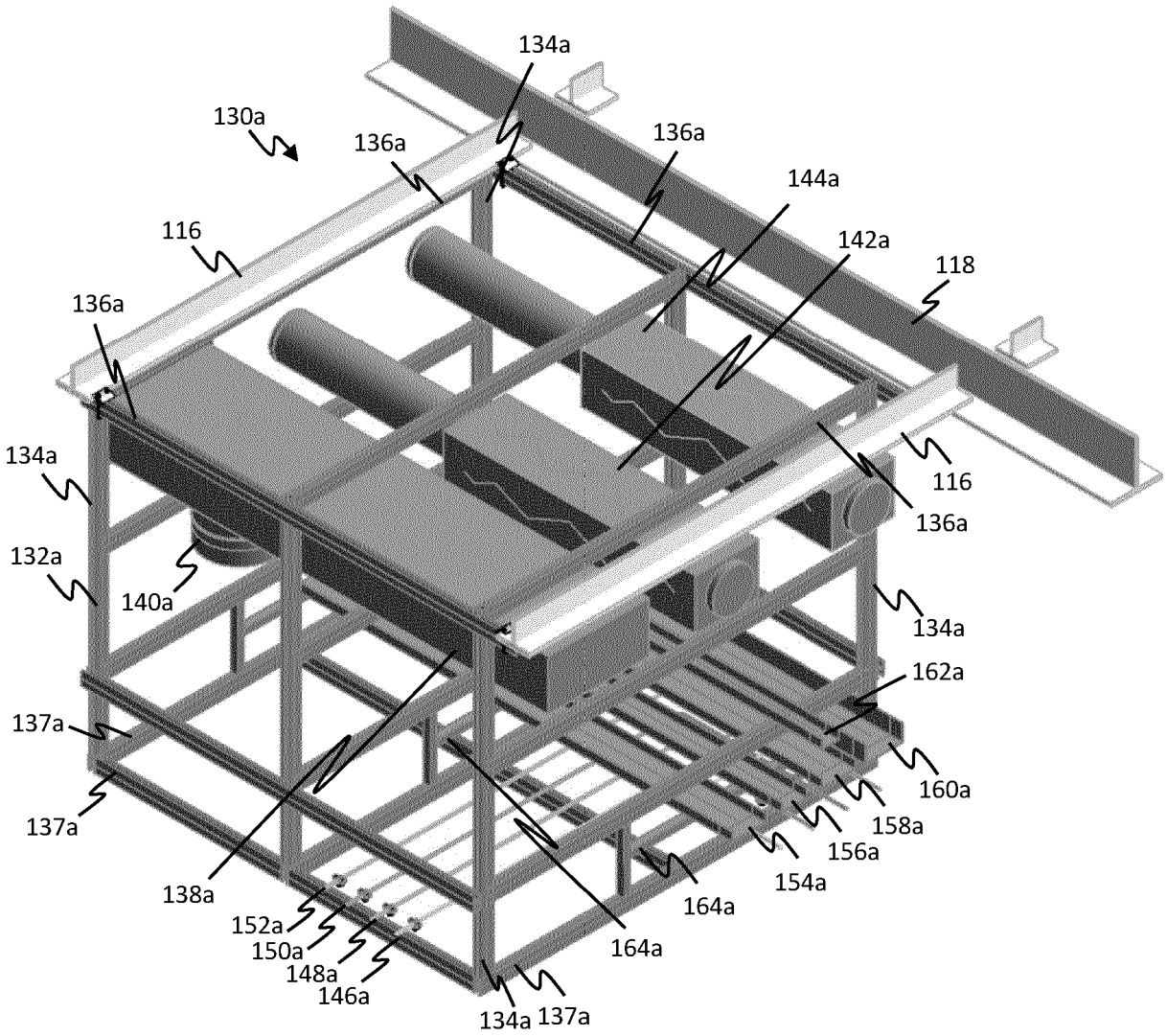
134a
130a
136a
136a
144a
116
142a
118
136a
134a
116
136a
132a
140a
134a
162a
137a
160a
158a
137a
156a
154a
138a
164a
152a
150a
164a
148a
146a
134a
137a

Fig 5

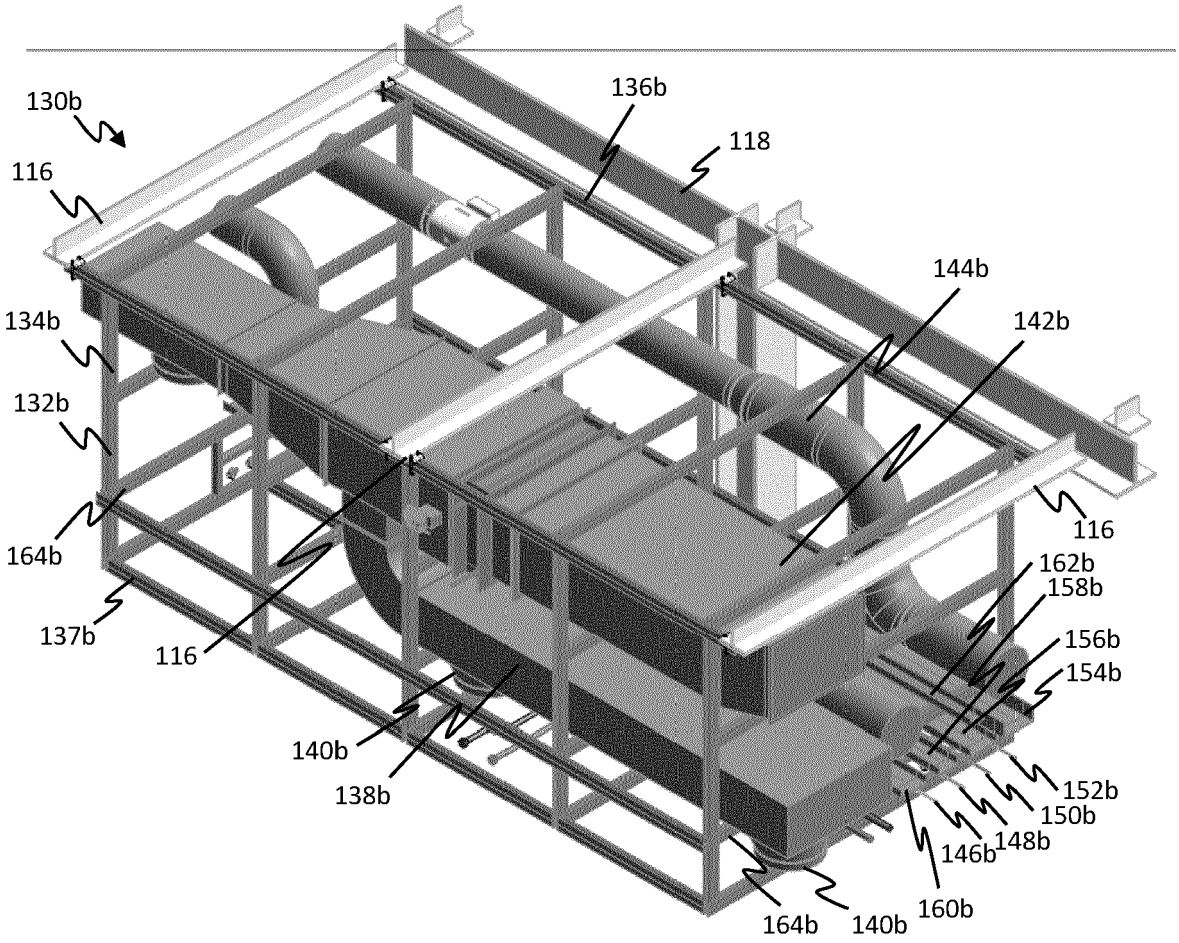
130b
136b
118
116
144b
142b
134b
132b
164b
116
162b
158b
156b
154b
137b
116
140b
138b
152b
150b
148b
146b
160b
164b
140b

Fig 6

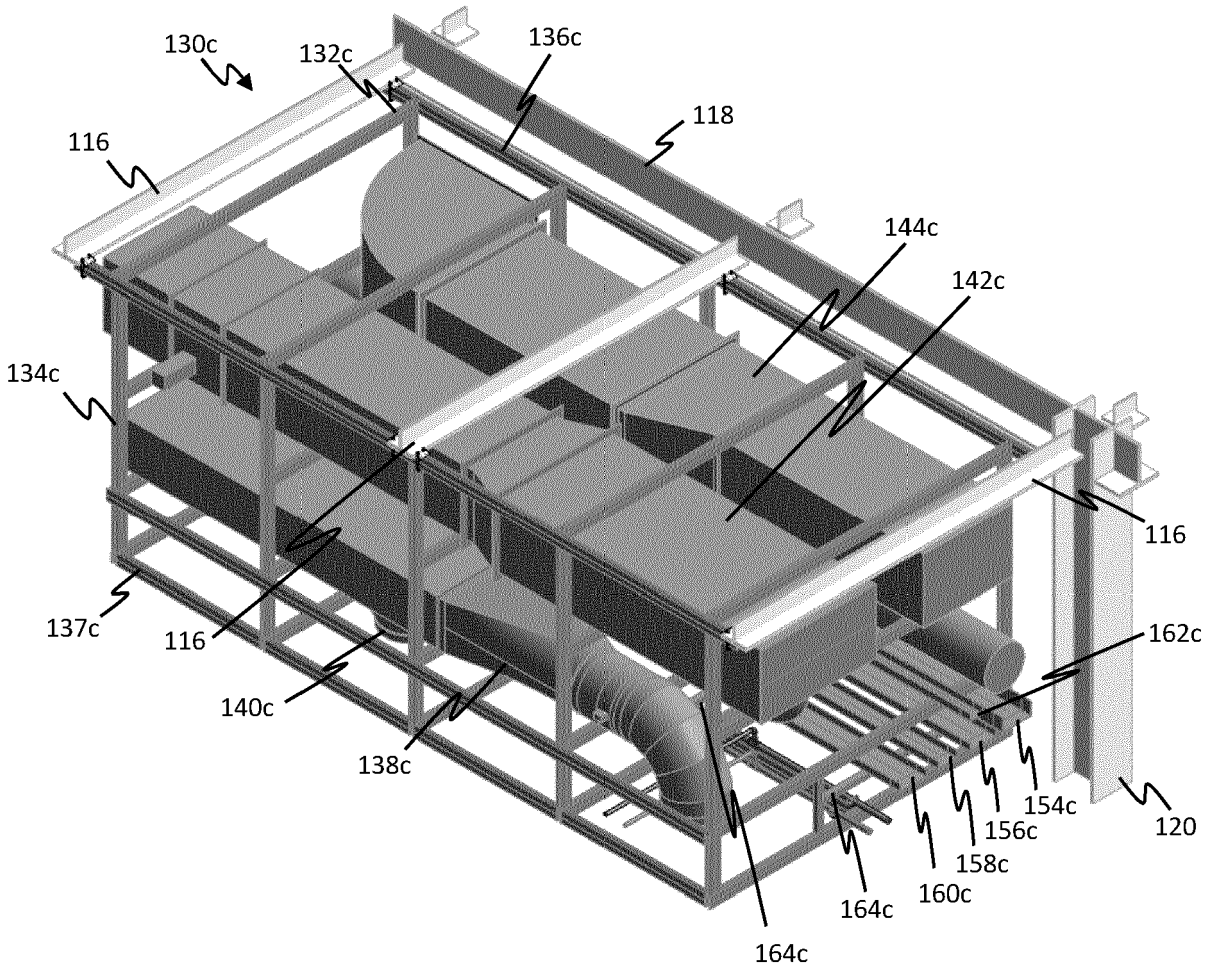
130c
132c
136c
118
116
144c
142c
134c
116
137c
116
162c
140c
138c
154c
120
156c
158c
160c
164c
164c

Fig 7

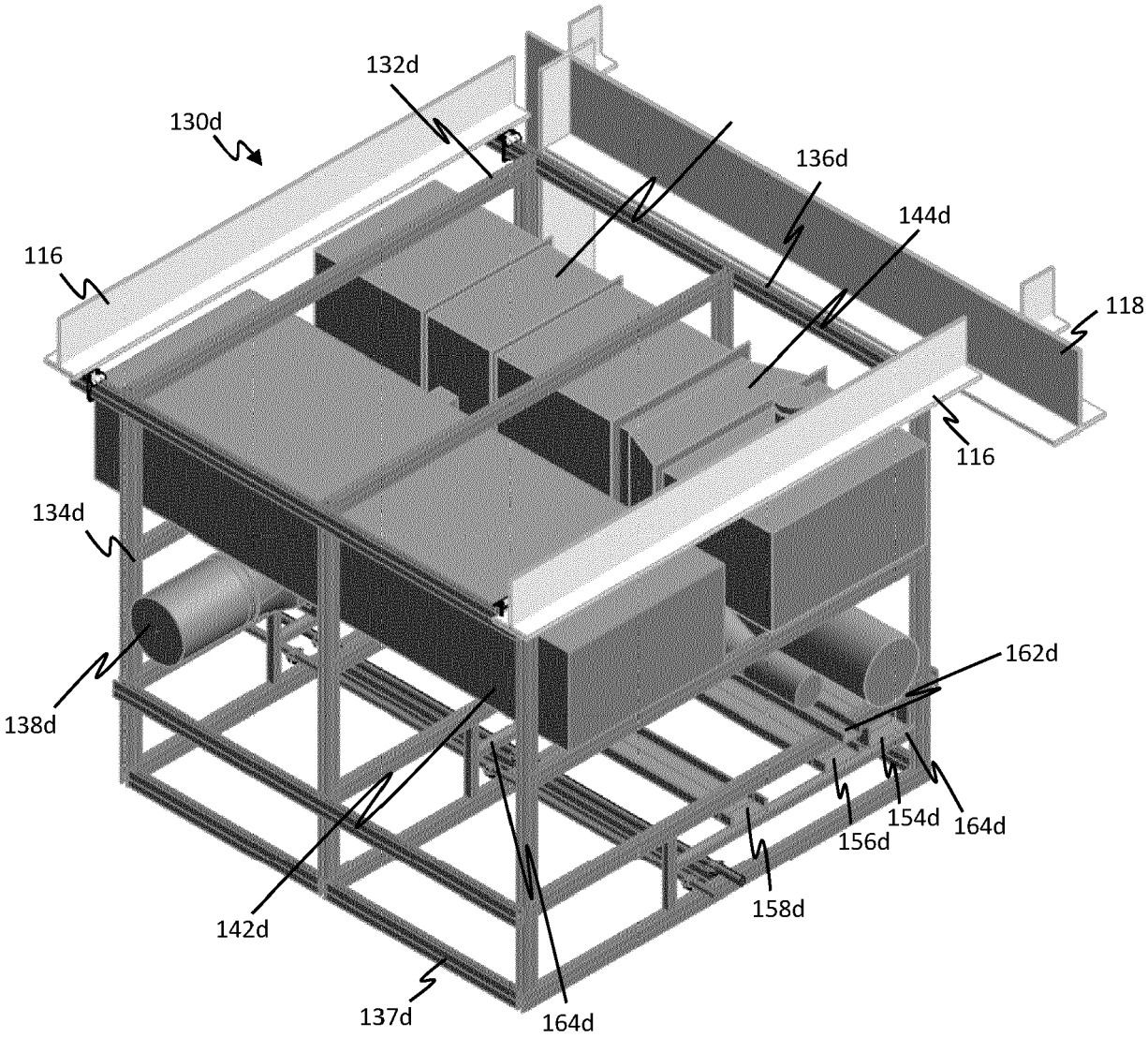
132d
130d
136d
144d
116
118
116
134d
162d
138d
154d
164d
156d
158d
142d
137d
164d

Fig 8

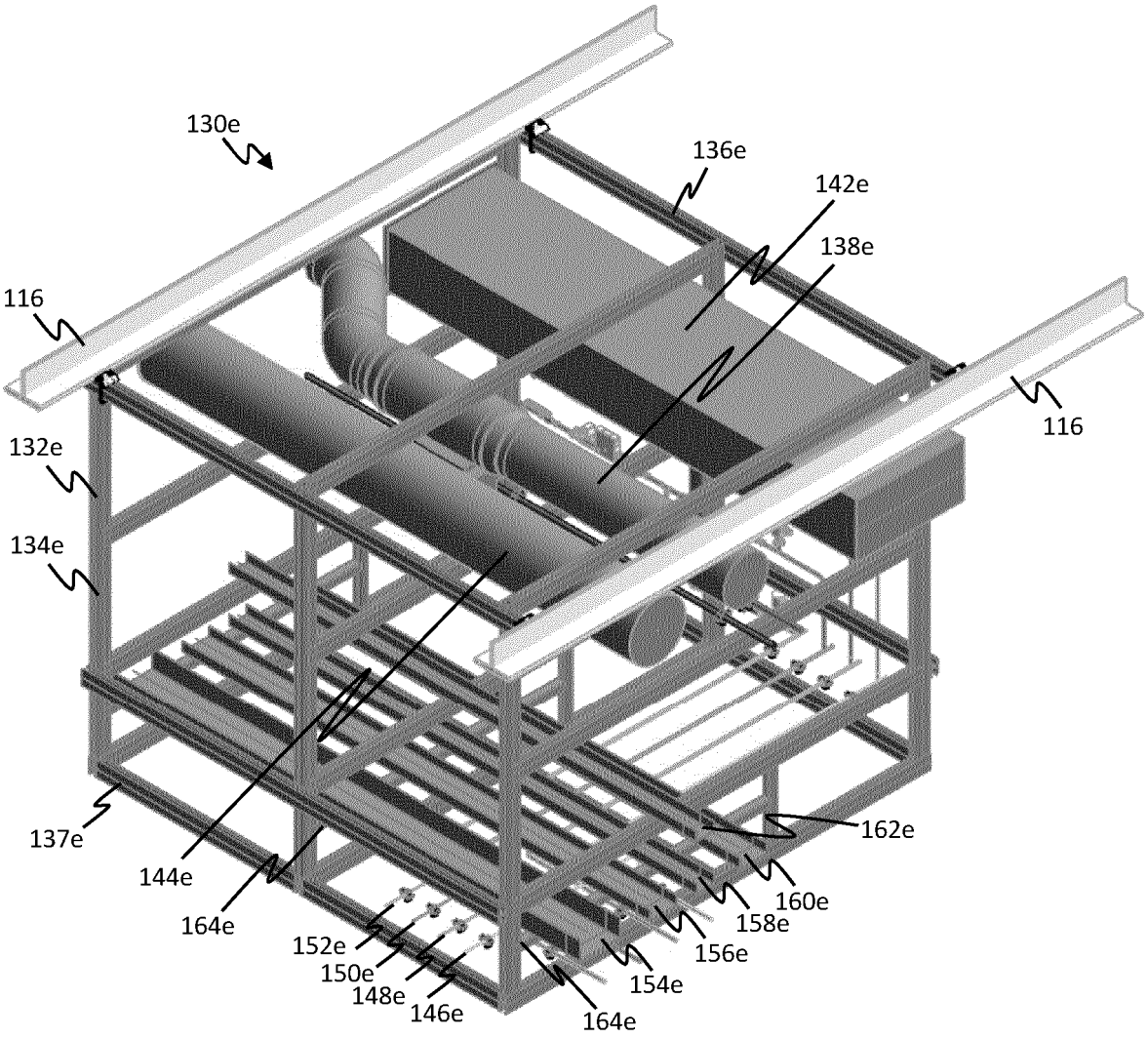
130e
136e
142e
138e
116
116
132e
134e
137e
144e
164e
152e
150e
148e
146e
164e
154e
156e
158e
160e
162e

Fig 9

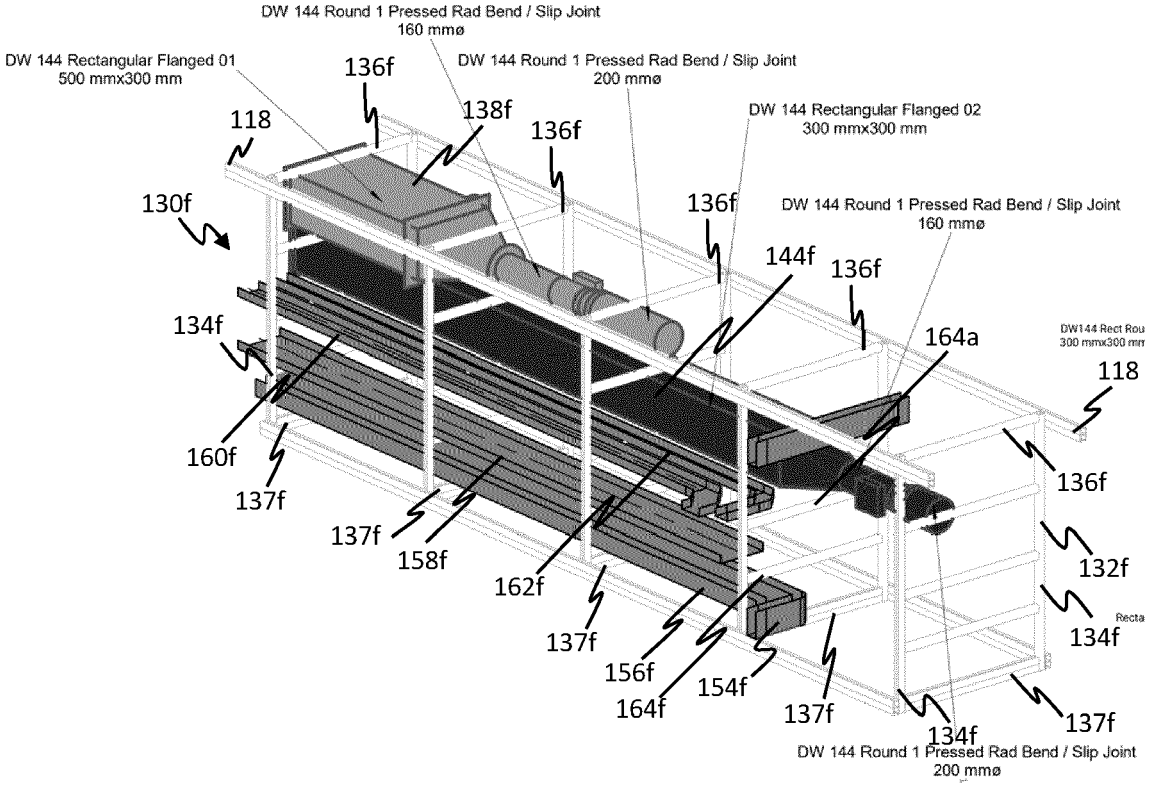
DW 144 Round 1 Pressed Rad Bend / Slip Joint
160 mmø
DW 144 Rectangular Flanged 01
500 mmx300 mm
136f
DW 144 Round 1 Pressed Rad Bend / Slip Joint
200 mmø
DW 144 Rectangular Flanged 02
300 mmx300 mm
118
138f
136f
130f
136f
DW 144 Round 1 Pressed Rad Bend / Slip Joint
160 mmø
144f
136f
134f
164a
DW144 Rect Rou
300 mmx300 mm
118
160f
136f
137f
137f
158f
132f
162f
134f
137f
156f
154f
164f
137f
134f
137f
DW 144 Round 1 Pressed Rad Bend / Slip Joint
200 mmø

Fig 10

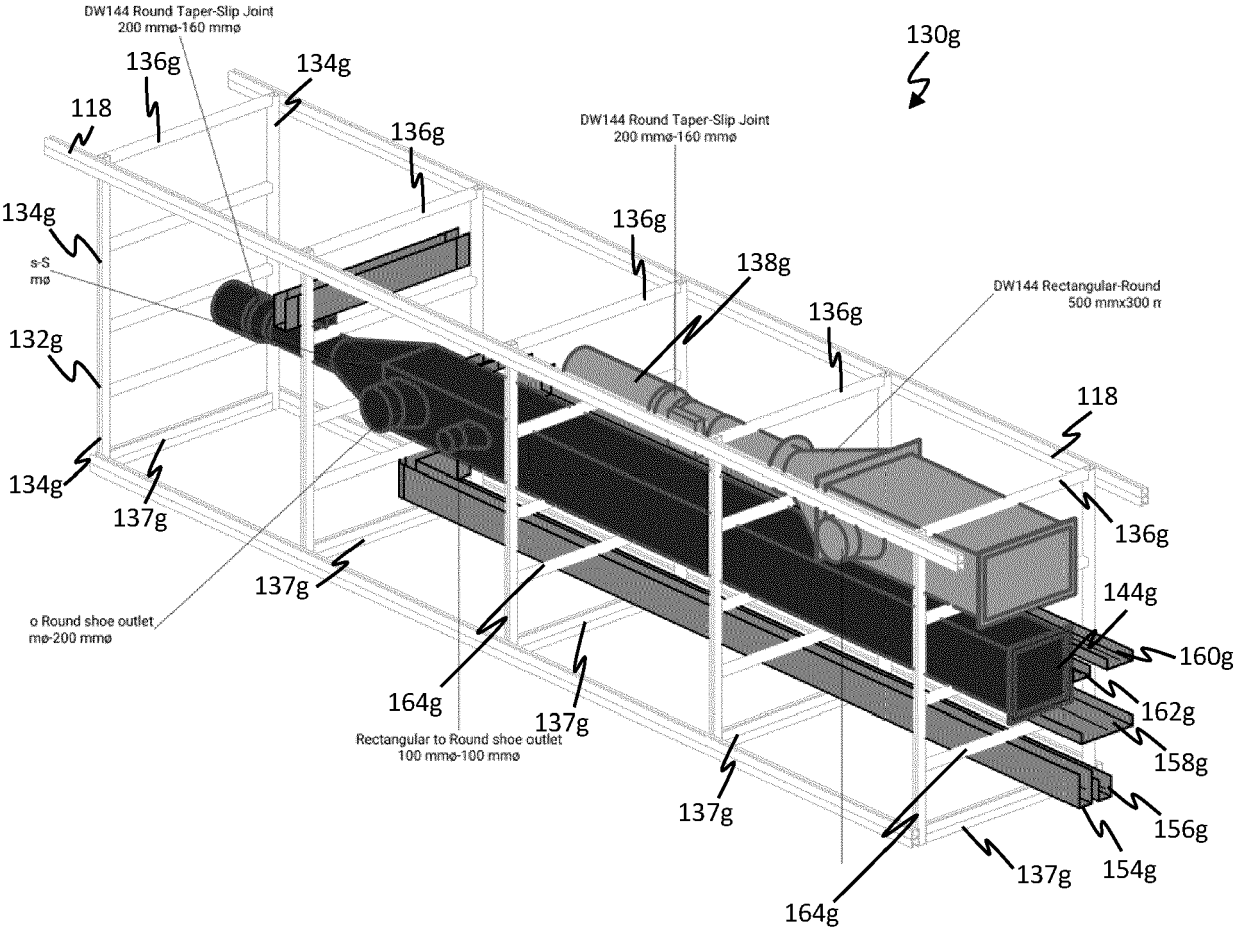
DW144 Round Taper-Slip Joint
200 mmø-160 mmø
136g
134g
118
136g
130g
DW144 Round Taper-Slip Joint
200 mmø-160 mmø
134g
136g
s-S
mø
138g
DW144 Rectangular-Round
500 mmx300 m
132g
136g
118
134g
137g
136g
137g
o Round shoe outlet
mø-200 mmø
144g
160g
164g
137g
162g
158g
Rectangular to Round shoe outlet
100 mmø-100 mmø
137g
156g
137g
154g
164g

Fig 11

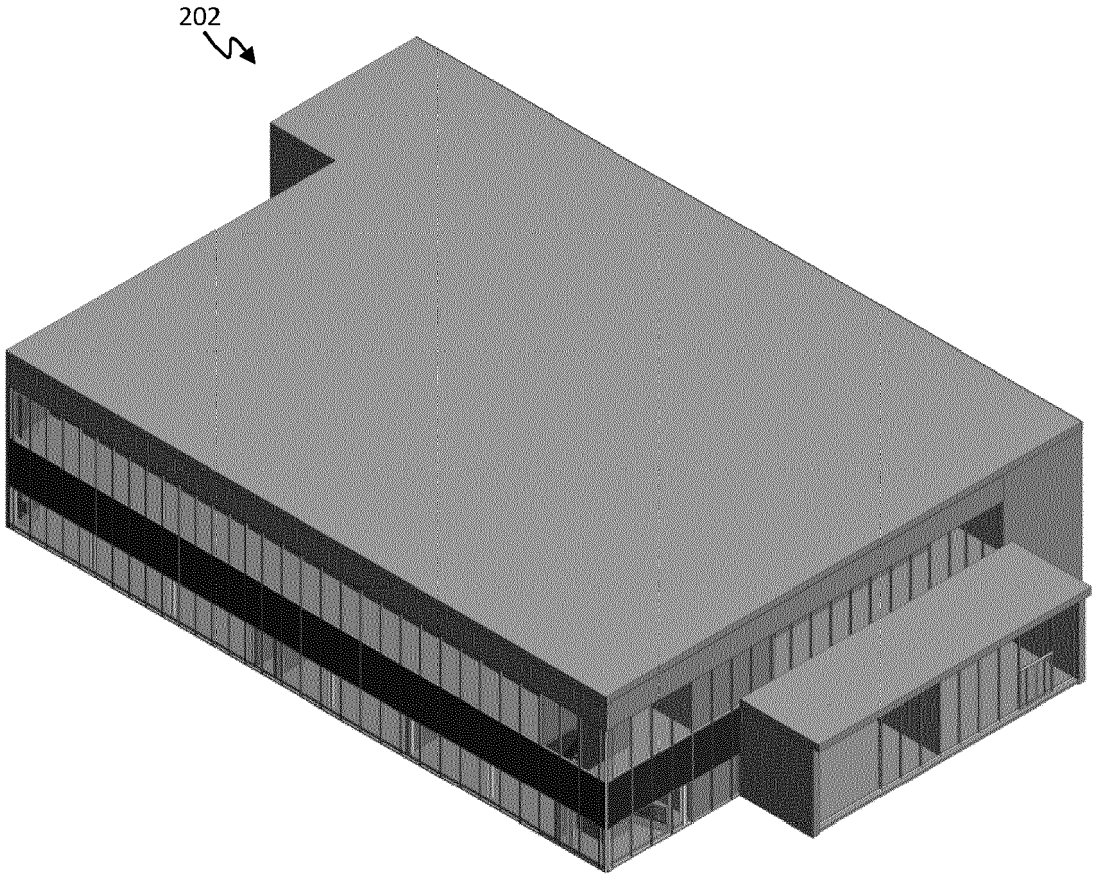

Fig 12

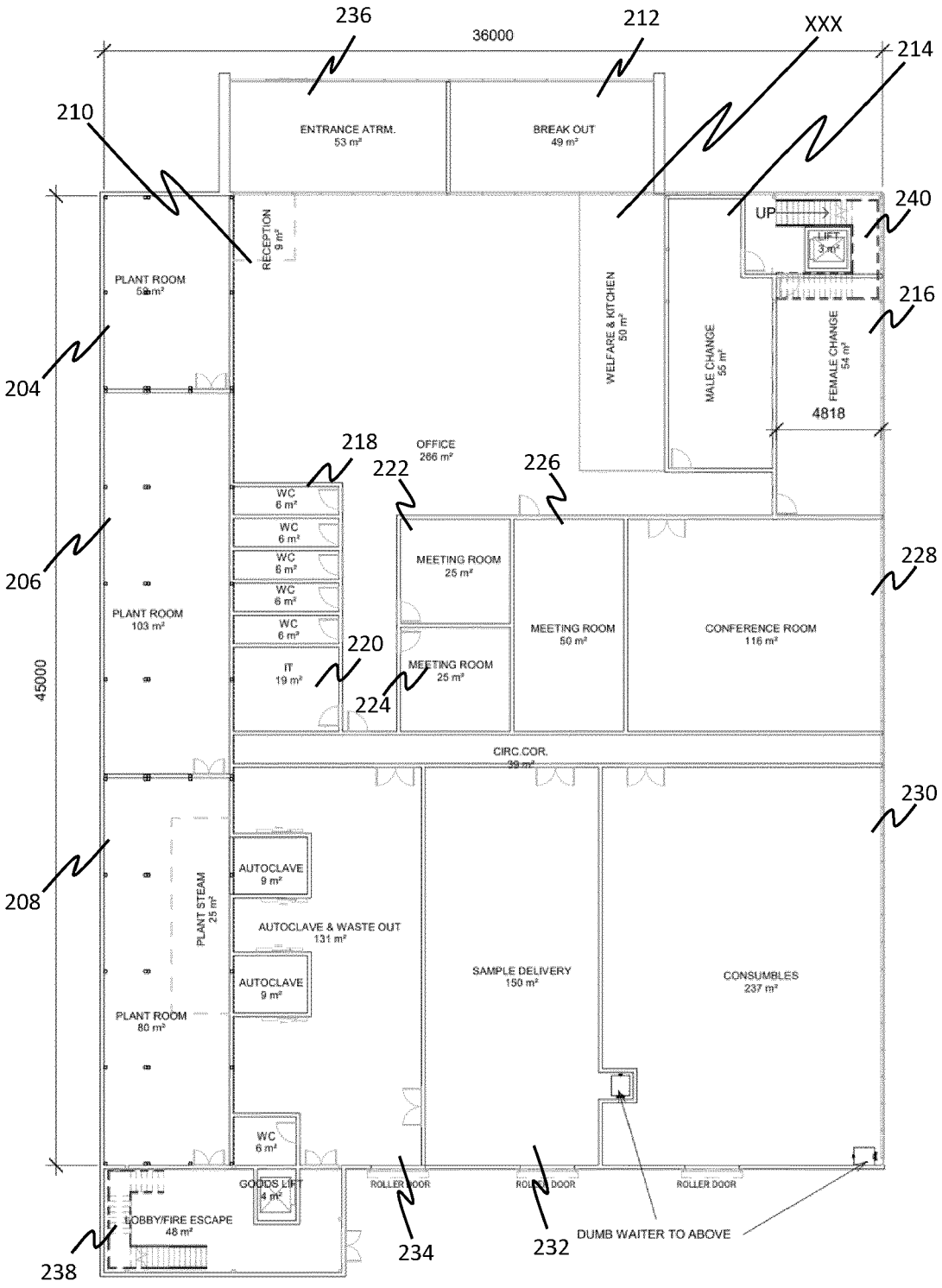
236
212
XXX
214
210
36000
ENTRANCE ATRM.
53 m²
BREAK OUT
49 m²
RECEPTION
9 m²
UP
240
LIFT
3 m²
PLANT ROOM
58 m²
WELFARE & KITCHEN
50 m²
MALE CHANGE
55 m²
FEMALE CHANGE
54 m²
216
204
4818
218
OFFICE
266 m²
222
226
WC
6 m²
WC
6 m²
WC
6 m²
WC
6 m²
WC
6 m²
IT
19 m²
MEETING ROOM
25 m²
MEETING ROOM
50 m²
CONFERENCE ROOM
116 m²
228
206
PLANT ROOM
103 m²
220
MEETING ROOM
25 m²
224
45000
CIRC.COR.
230
208
AUTOCLAVE
9 m²
PLANT STEAM
25 m²
AUTOCLAVE & WASTE OUT
131 m²
AUTOCLAVE
9 m²
SAMPLE DELIVERY
150 m²
CONSUMBLES
237 m²
PLANT ROOM
80 m²
WC
6 m²
GOODS LIFT
4 m²
ROLLER DOOR
ROLLER DOOR
ROLLER DOOR
LOBBY/FIRE ESCAPE
48 m²
DUMB WAITER TO ABOVE
238
234
232

Fig 13

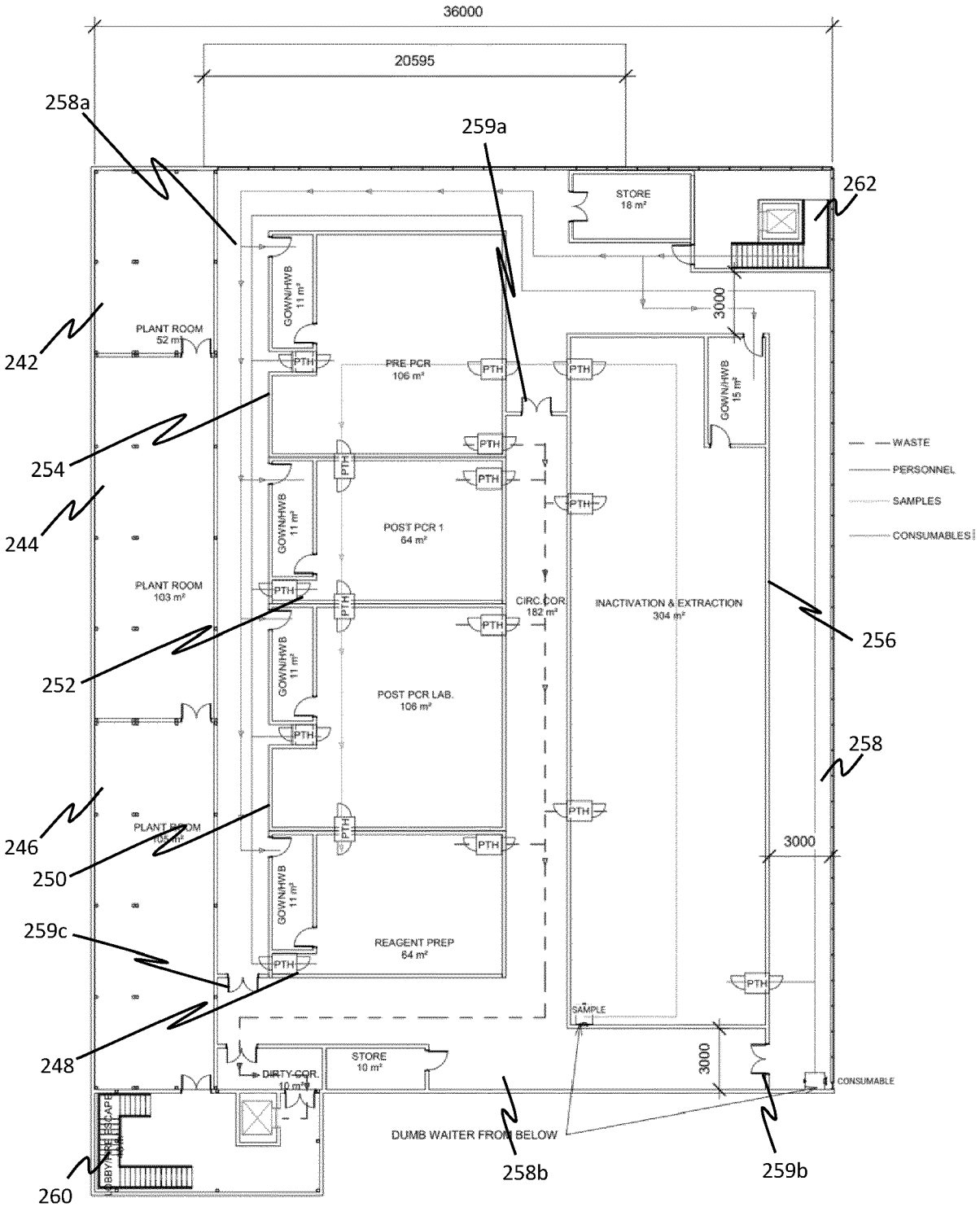
36000
20595
258a
259a
262
242
254
244
252
256
258
246
250
259c
248
260
258b
259b
PLANT ROOM
52 m²
PLANT ROOM
103 m²
PLANT ROOM
105 m²
GOWN/HWB
11 m²
PRE-PCR
106 m²
POST PCR 1
64 m²
POST PCR LAB.
106 m²
REAGENT PREP
64 m²
CIRC. COR.
182 m²
INACTIVATION & EXTRACTION
304 m²
GOWN/HWB
15 m²
STORE
18 m²
STORE
10 m²
DIRTY COR.
10 m²
SAMPLE
CONSUMABLE
DUMB WAITER FROM BELOW
PTH
3000
WASTE
PERSONNEL
SAMPLES
CONSUMABLES

Fig 14

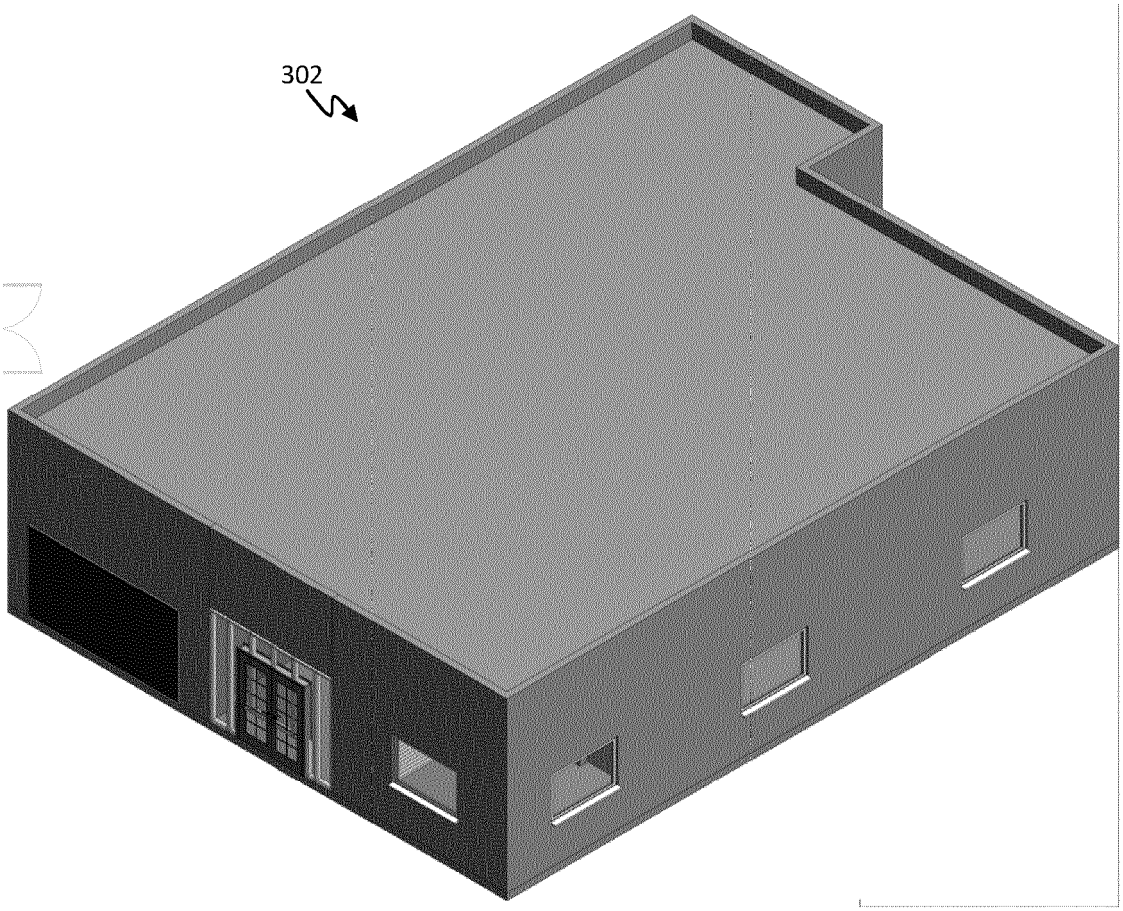

Fig 15

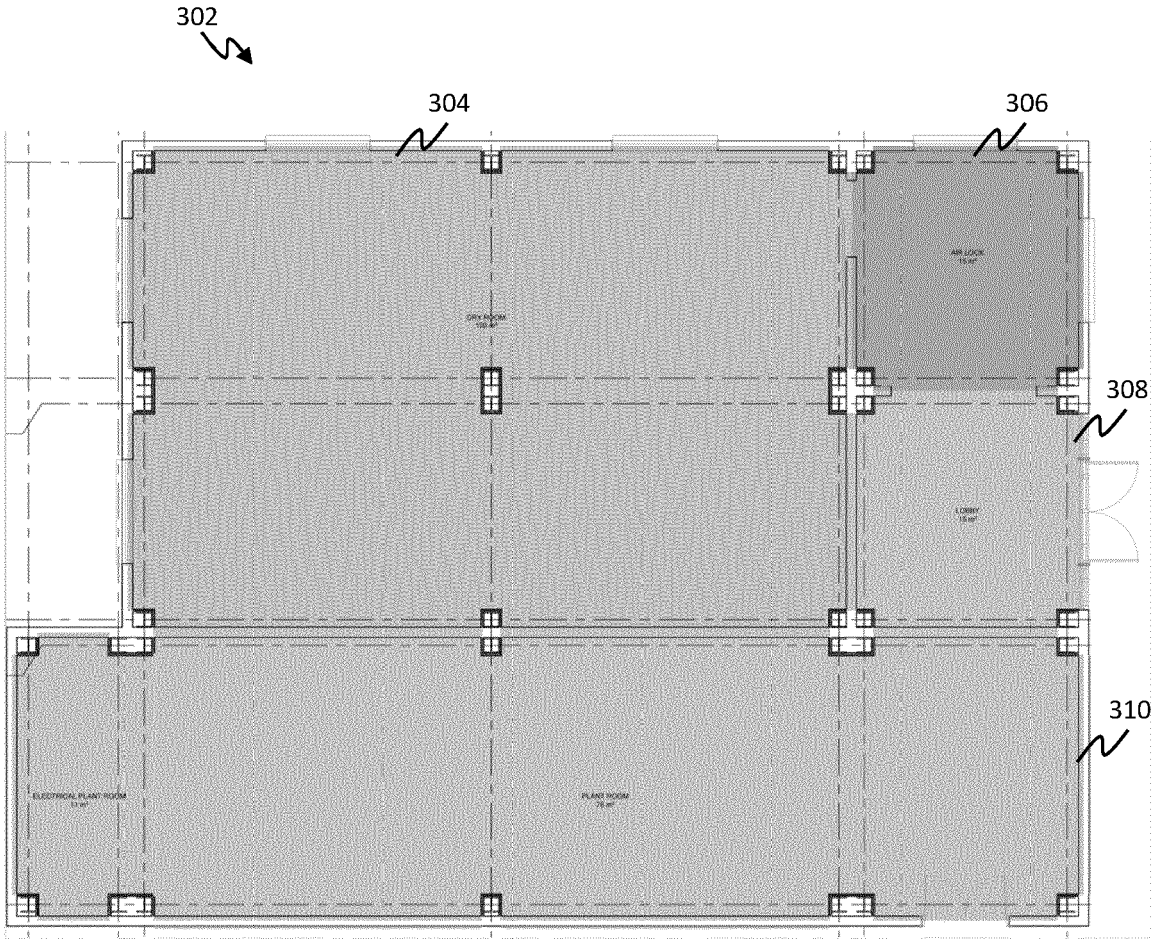
302
304
306
308
310
AIR LOCK
LOBBY
ELECTRICAL PLANT ROOM
PLANT ROOM

Fig 16