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(19) **United States**(12) **Patent Application Publication****Crosby, JR. et al.**(10) **Pub. No.: US 2017/0196125 A1**(43) **Pub. Date:****Jul. 6, 2017**(54) **SIDEWALL-CONNECTED HVAC UNITS FOR MODULAR DATACENTER FACILITIES**(71) Applicant: **Compass Datacenters LLC**, Dallas, TX (US)(72) Inventors: **Christopher J. Crosby, JR.**, Dallas, TX (US); **Jose Alberto Ruiz**, Frisco, TX (US)(21) Appl. No.: **15/464,059**(22) Filed: **Mar. 20, 2017****Related U.S. Application Data**

(63) Continuation-in-part of application No. 14/463,474, filed on Aug. 19, 2014, now Pat. No. 9,603,281, which is a continuation-in-part of application No. 13/792,948, filed on Mar. 11, 2013, now Pat. No. 8,839,569, Continuation-in-part of application No. 14/041,351, filed on Sep. 30, 2013.

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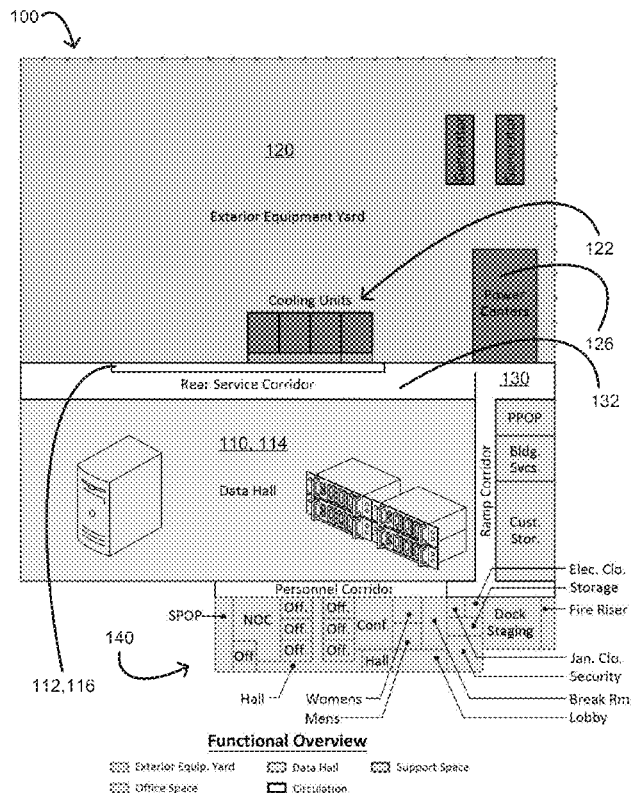
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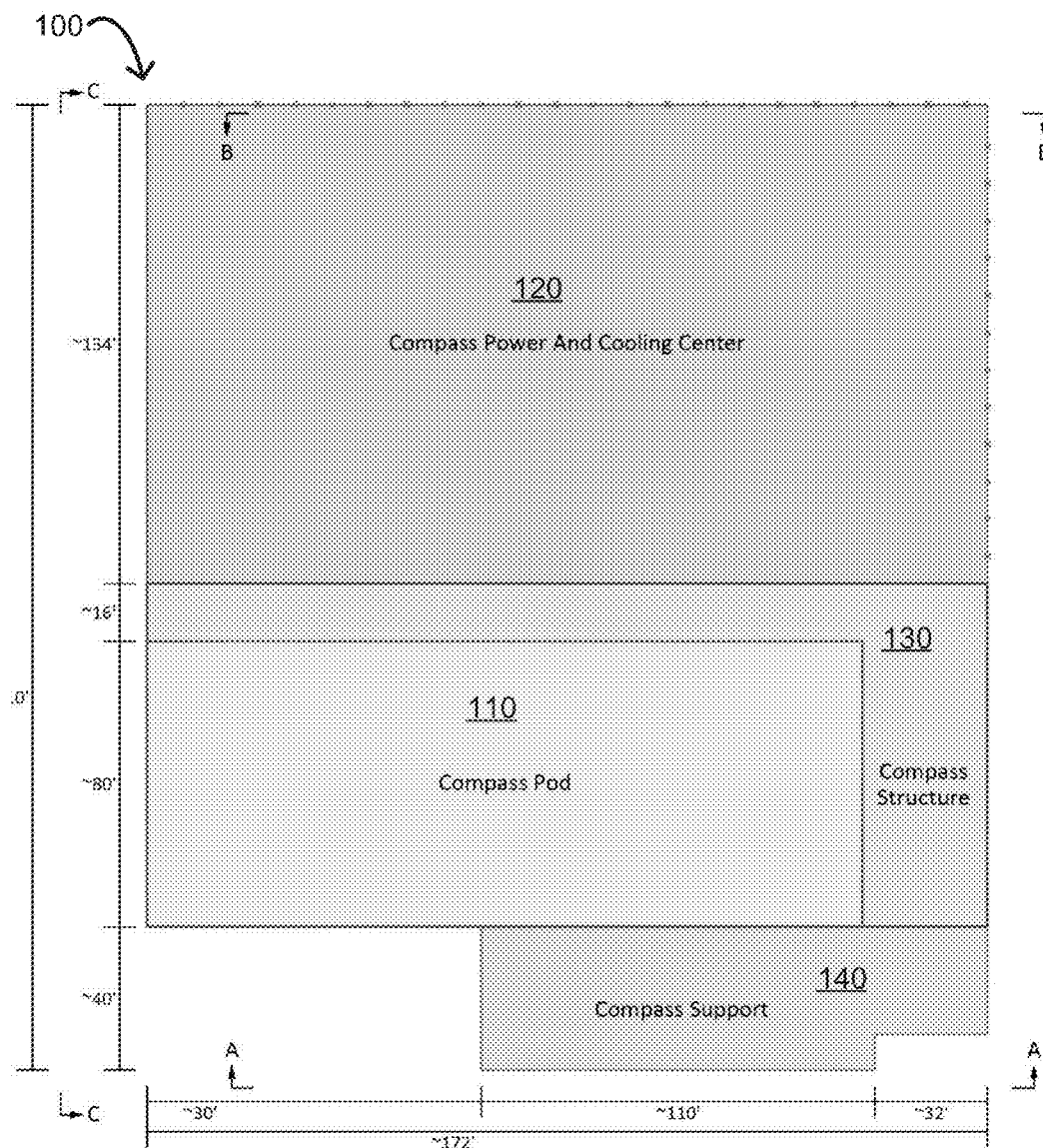
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ABSTRACT

A modular datacenter facility and a method thereof is provided in accordance with some embodiments. The module datacenter facility can be constructed with an initial set of building modules of different types of functionality. A first building module can be a data-floor building module. A first set of sidewall-connected heating, ventilation, and air conditioning ("HVAC") units can connect to a sidewall of the modular datacenter facility and use electrical power provided by a first electrical power distribution building module to supply conditioned air into an air-supply plenum of the sidewall to cool computing systems housed in the data-floor building module. The first set of the sidewall-connected HVAC units allow for fewer penetrations in a roof of the data-floor building module, thereby minimizing an amount of leaks potentially occurring in the roof of the ceiling, and thereby minimizing risk of any damage to the computing systems.





Modular Organization

-  Compass Power Center (Exterior Equipment Yard)
-  Compass Structure (incl. PPOF, Cust. Storage, Corridors, etc.)
-  Compass Support (incl. Office, Security, Etc.)
-  Compass Pod (Column Free Data Hall)

FIG. 1A

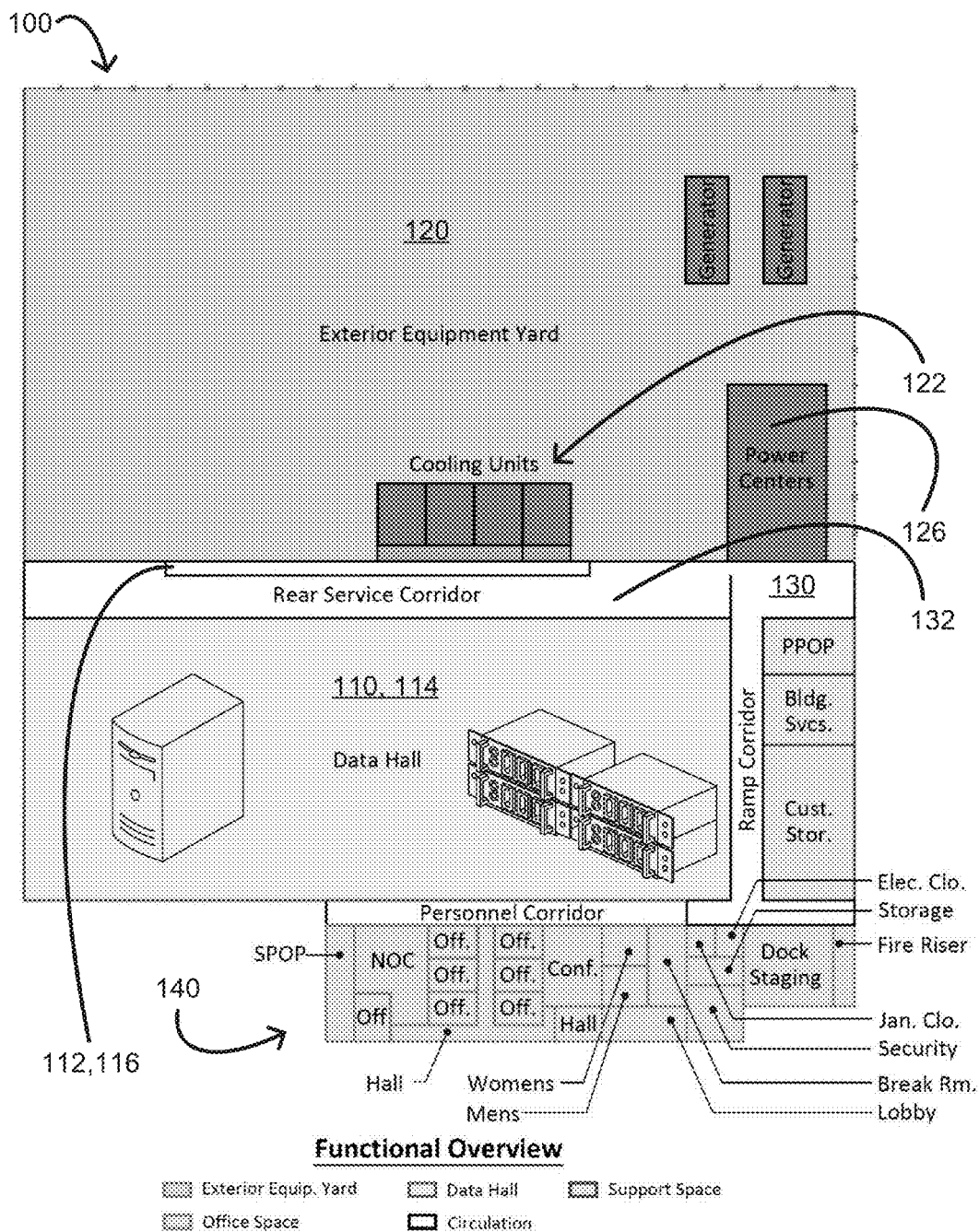


FIG. 1B

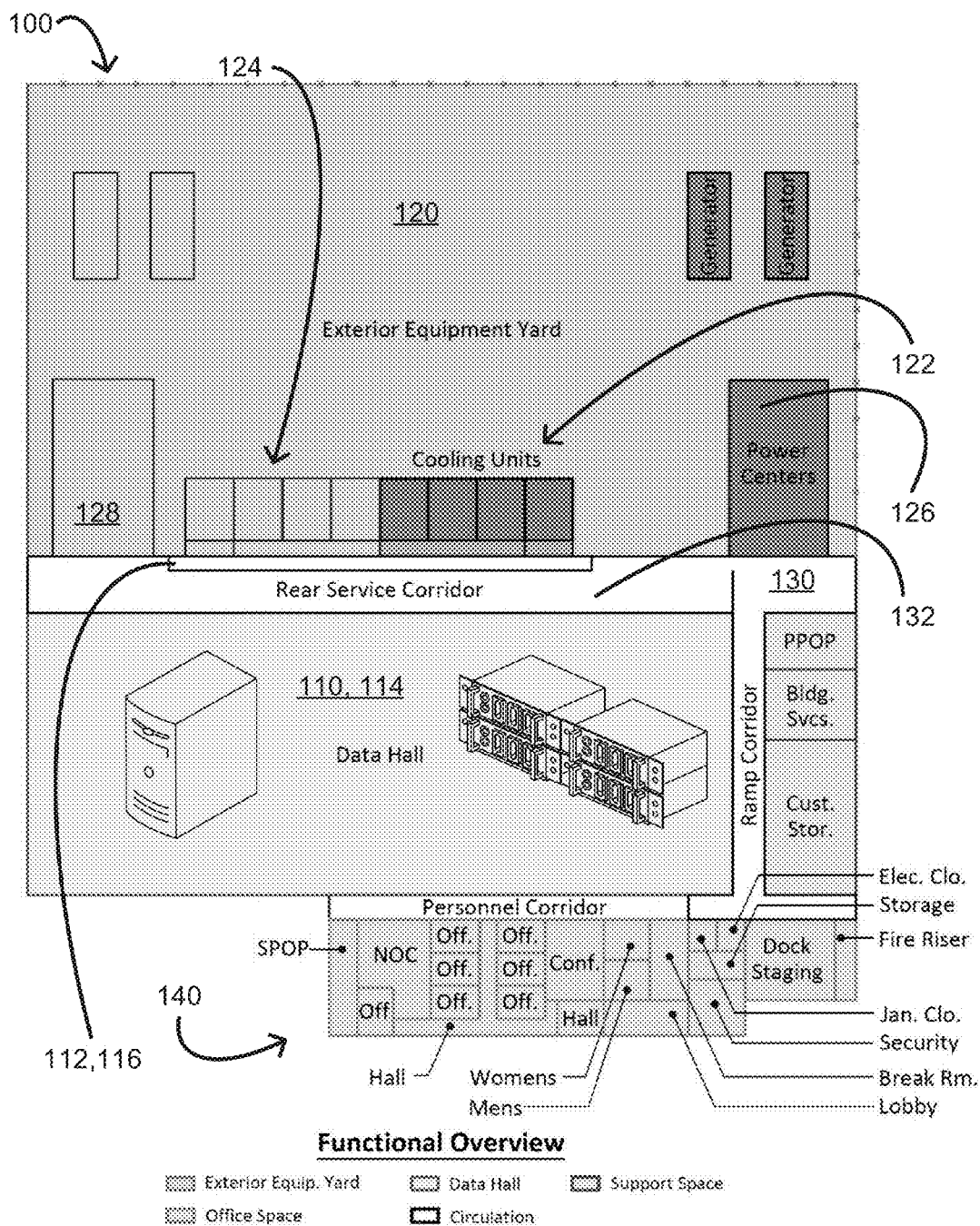
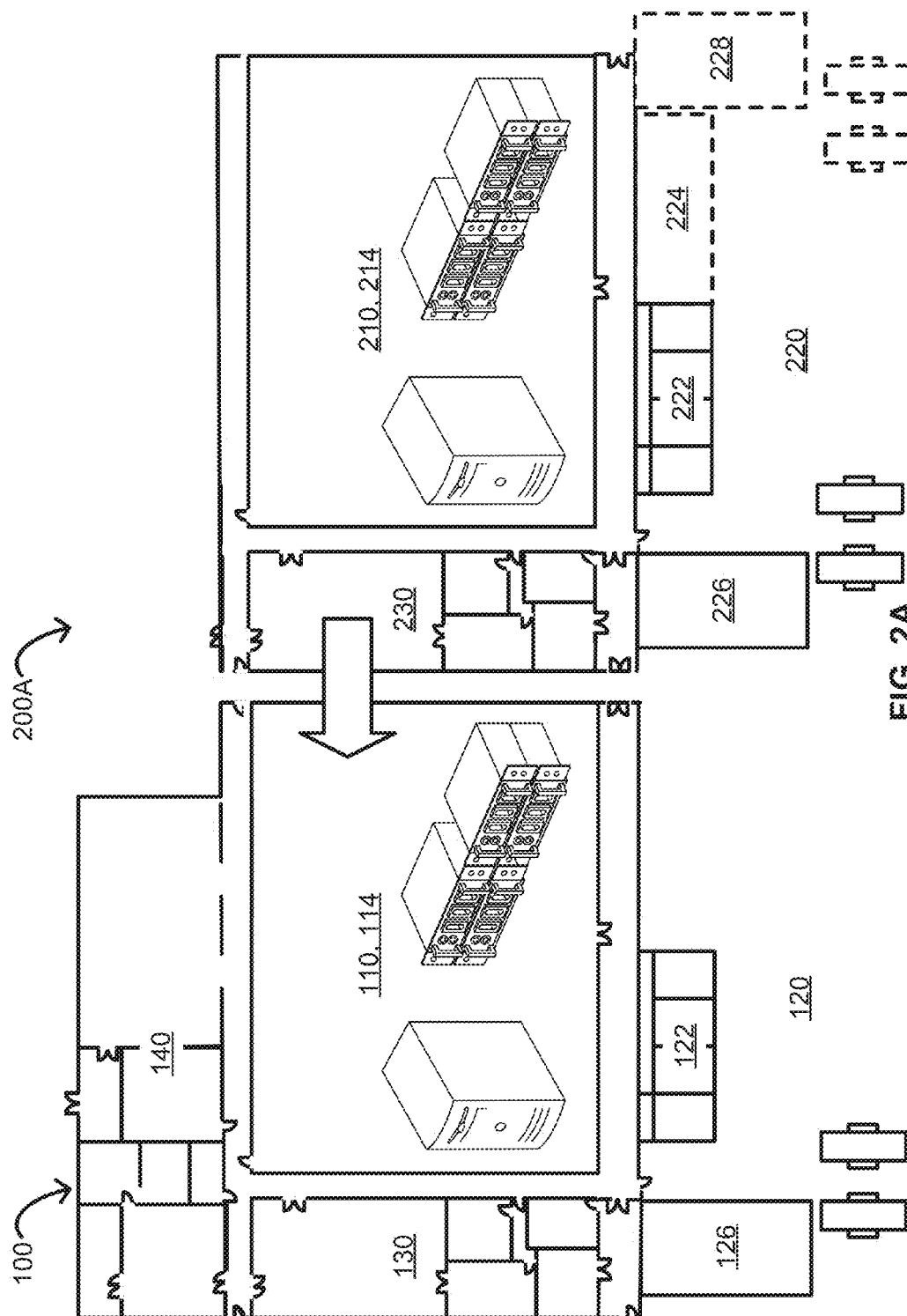


FIG. 1C



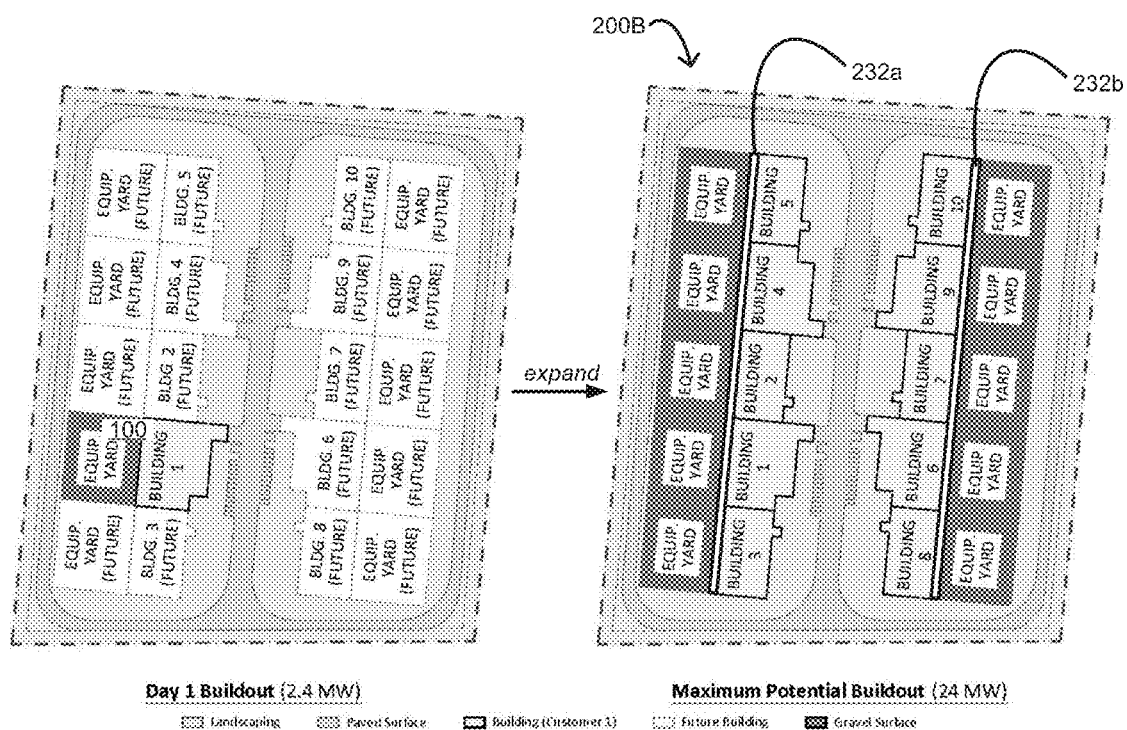


FIG. 2B

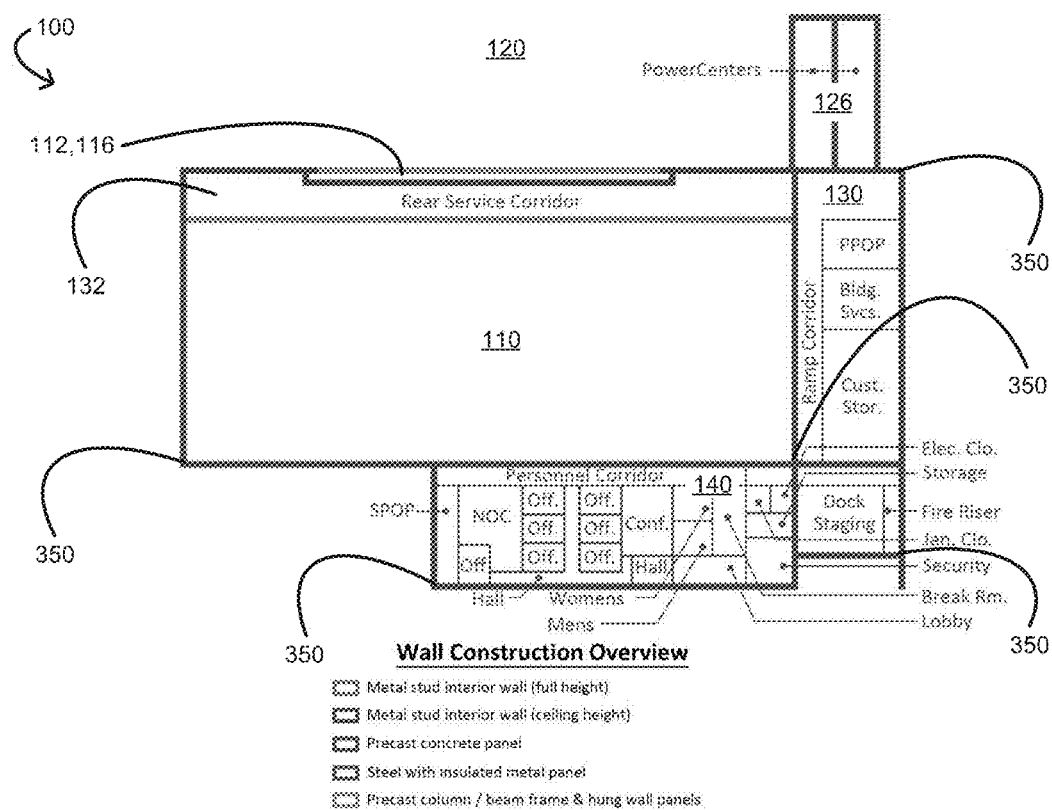
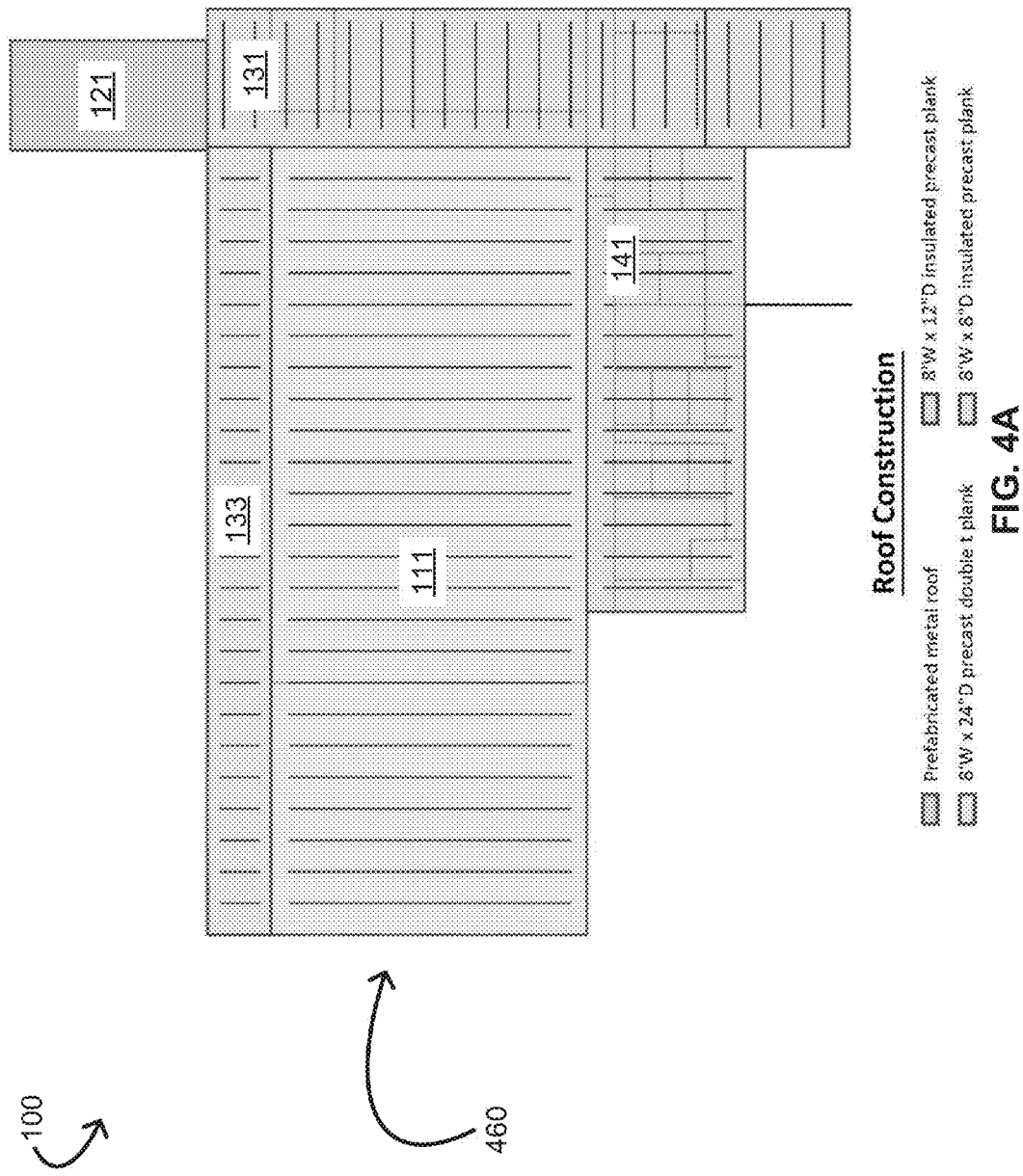
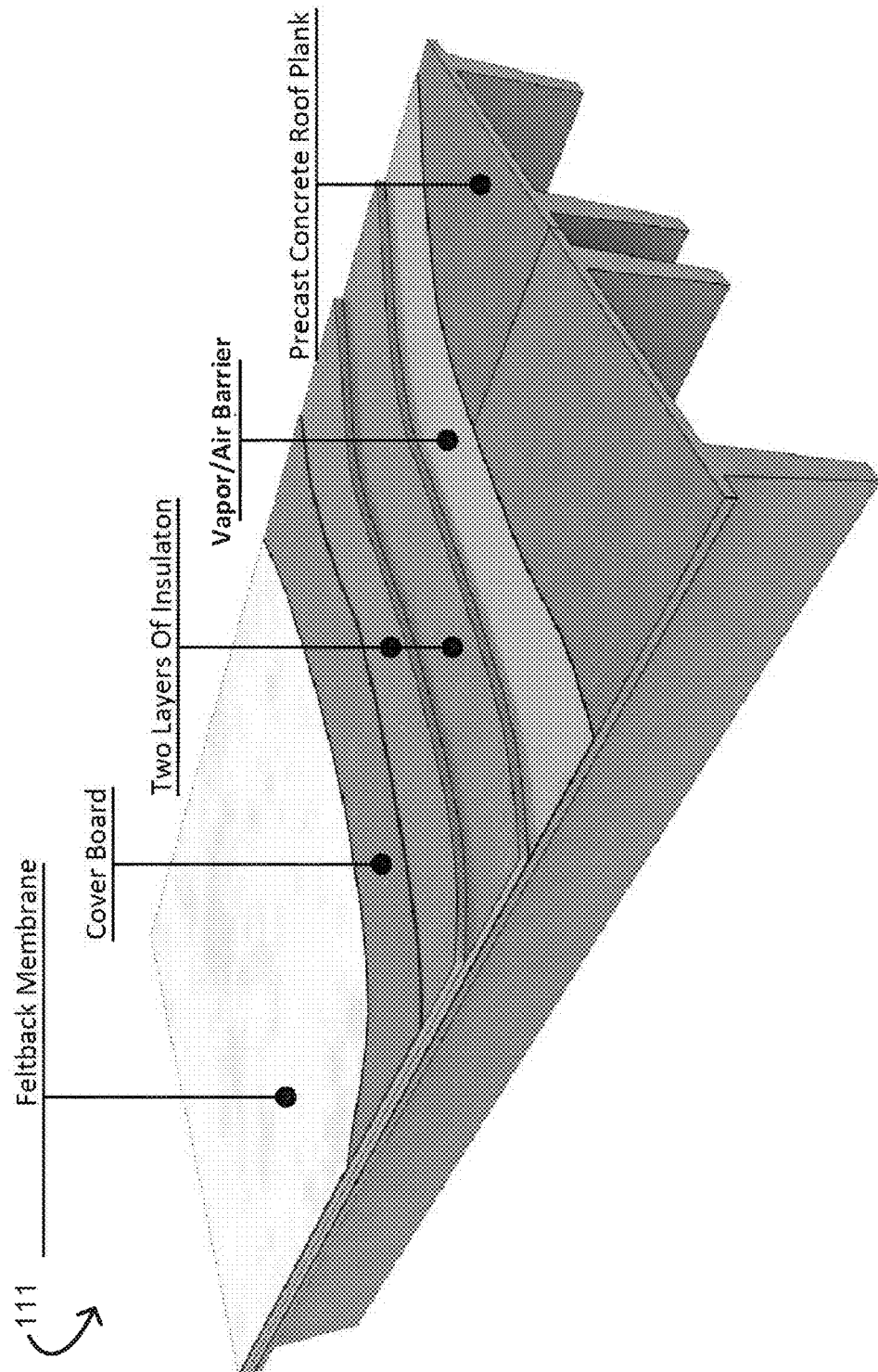
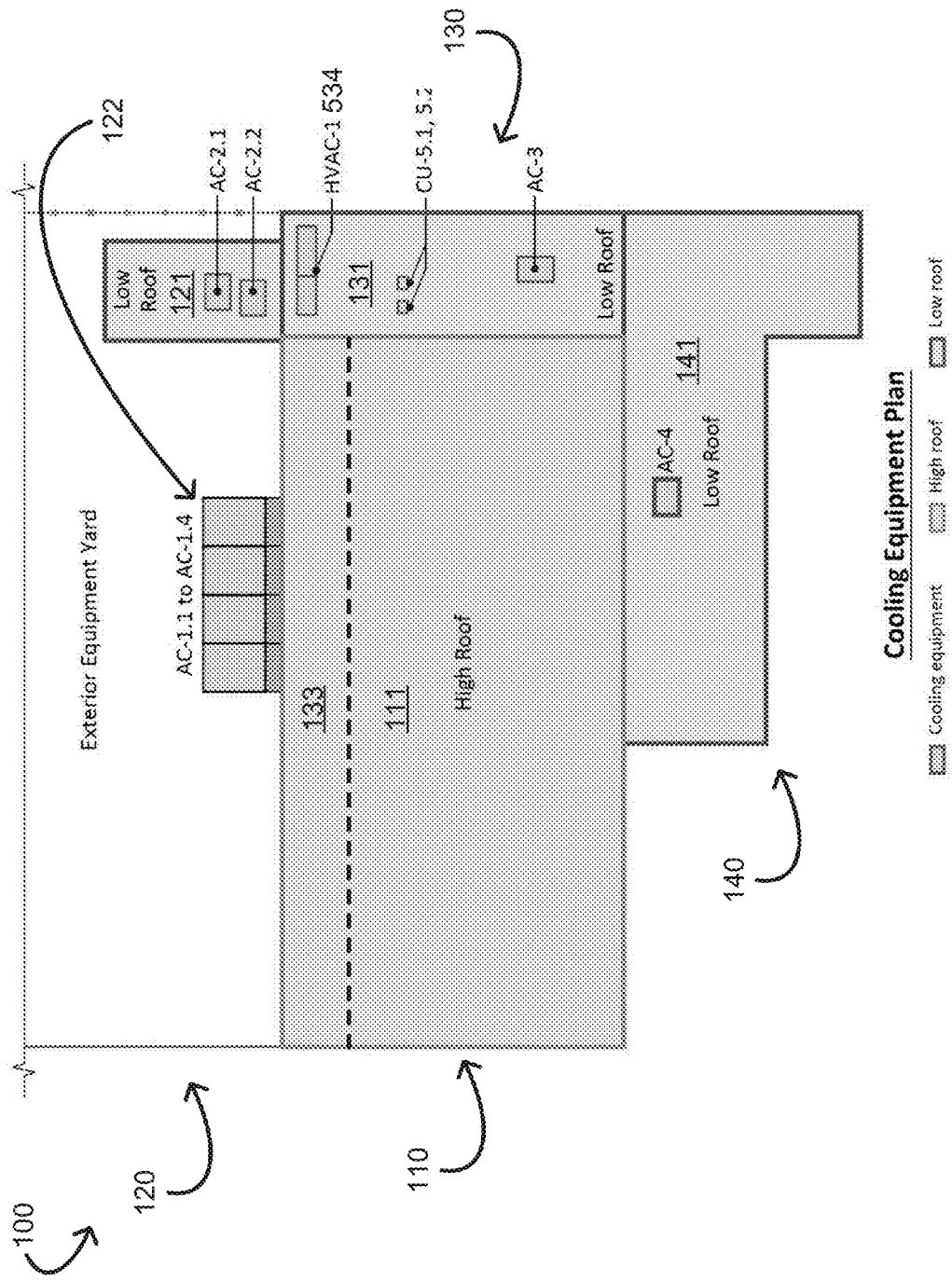


FIG. 3



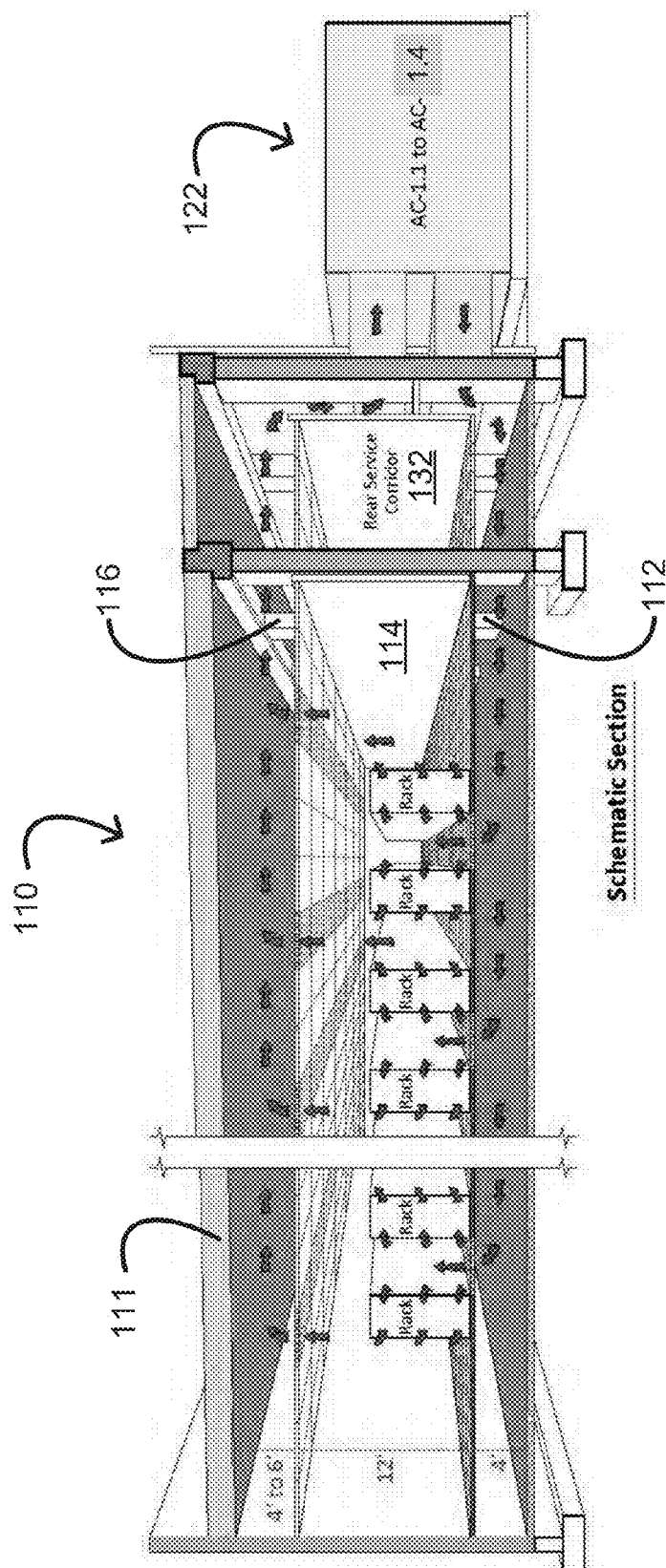


Roof Detail
FIG. 4B



Cooling Equipment Plan

FIG. 5



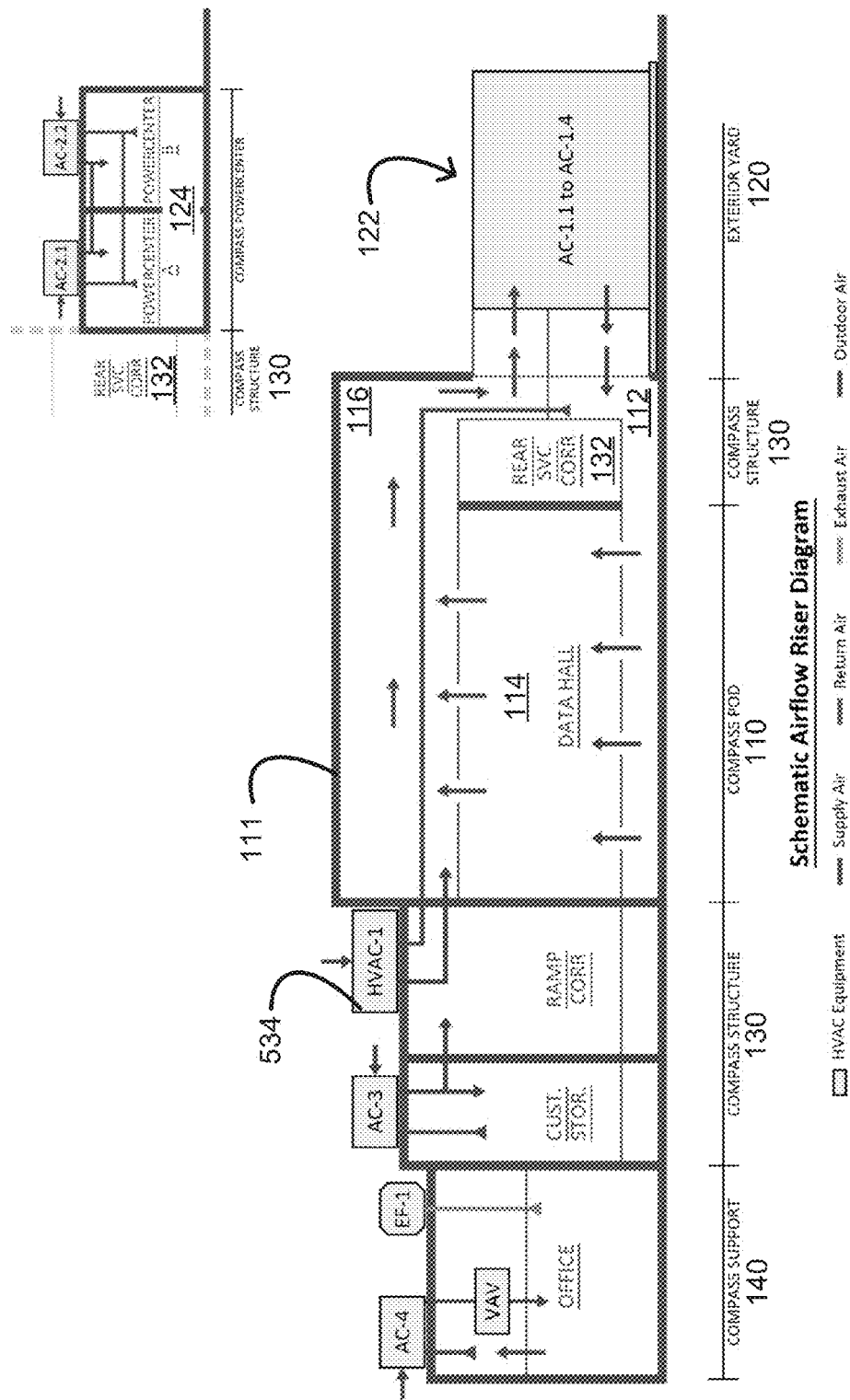
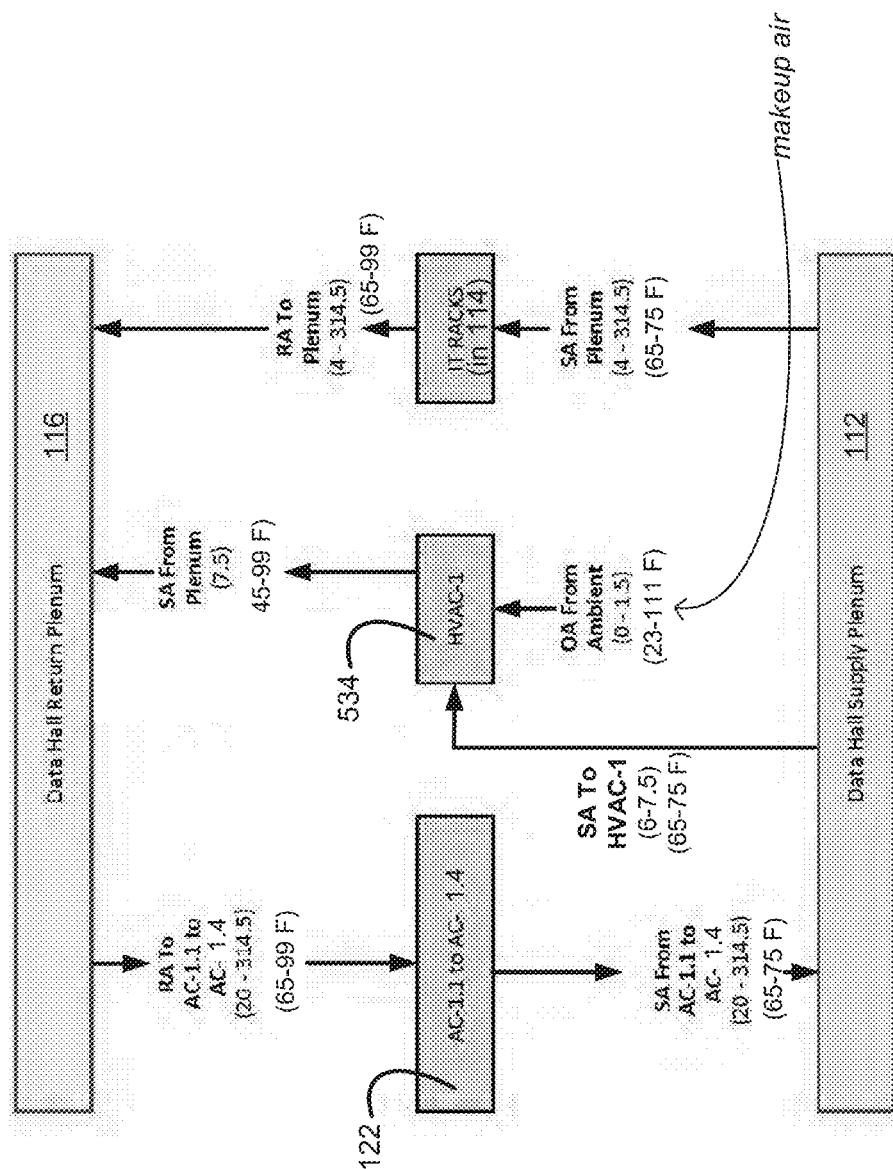
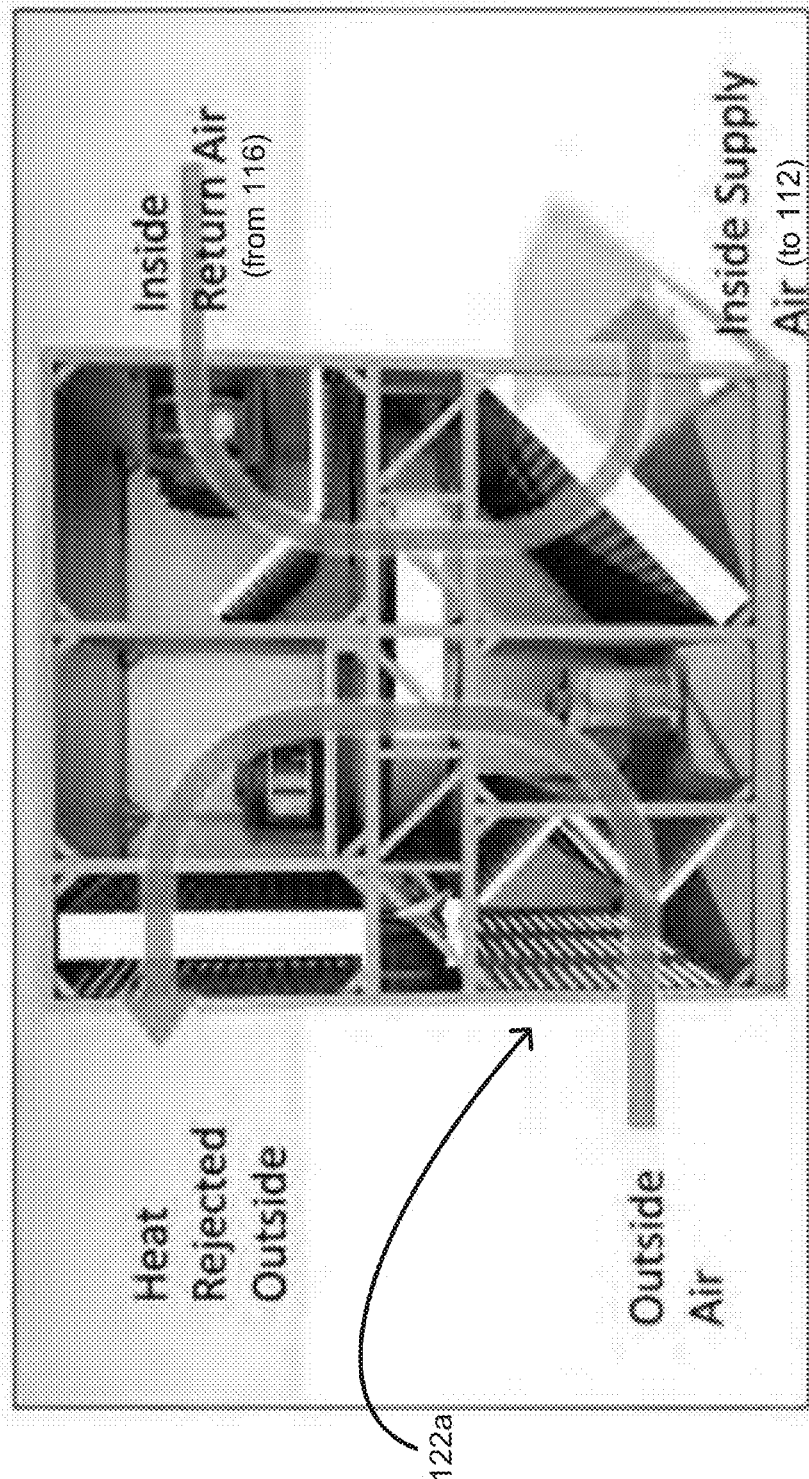


FIG. 6B



Data Hall Airflow Diagram
CFM in Thousands is Shown in Parentheses. For Example (4 - 314.5) = 4,000 to 314,500 CFM
FIG. 6C



CompassPOD Air Handling Unit Overview
Airflow path through units

FIG. 7

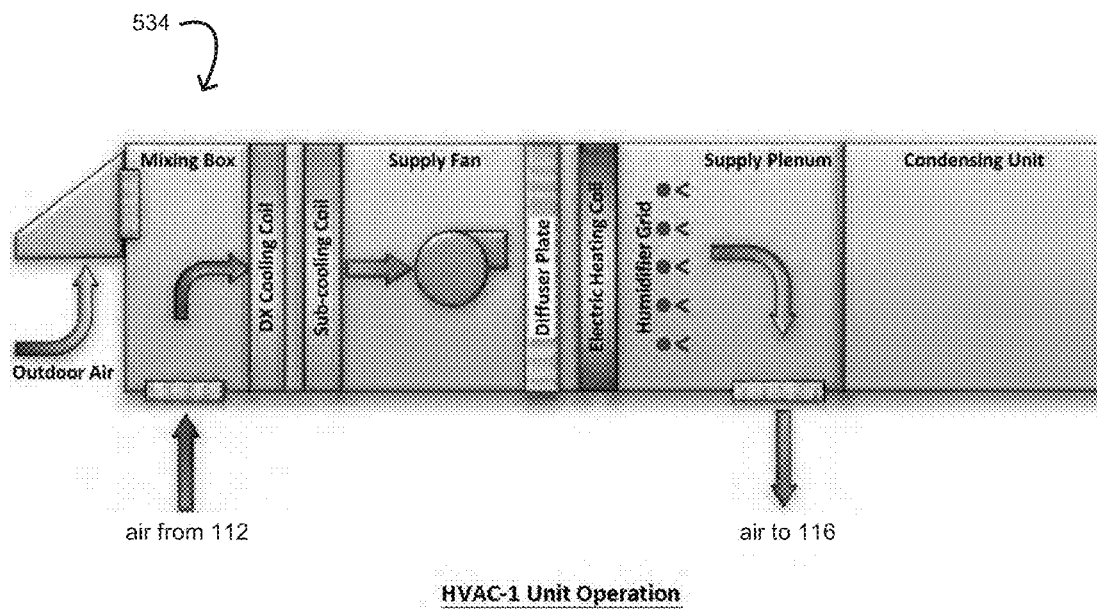


FIG. 8

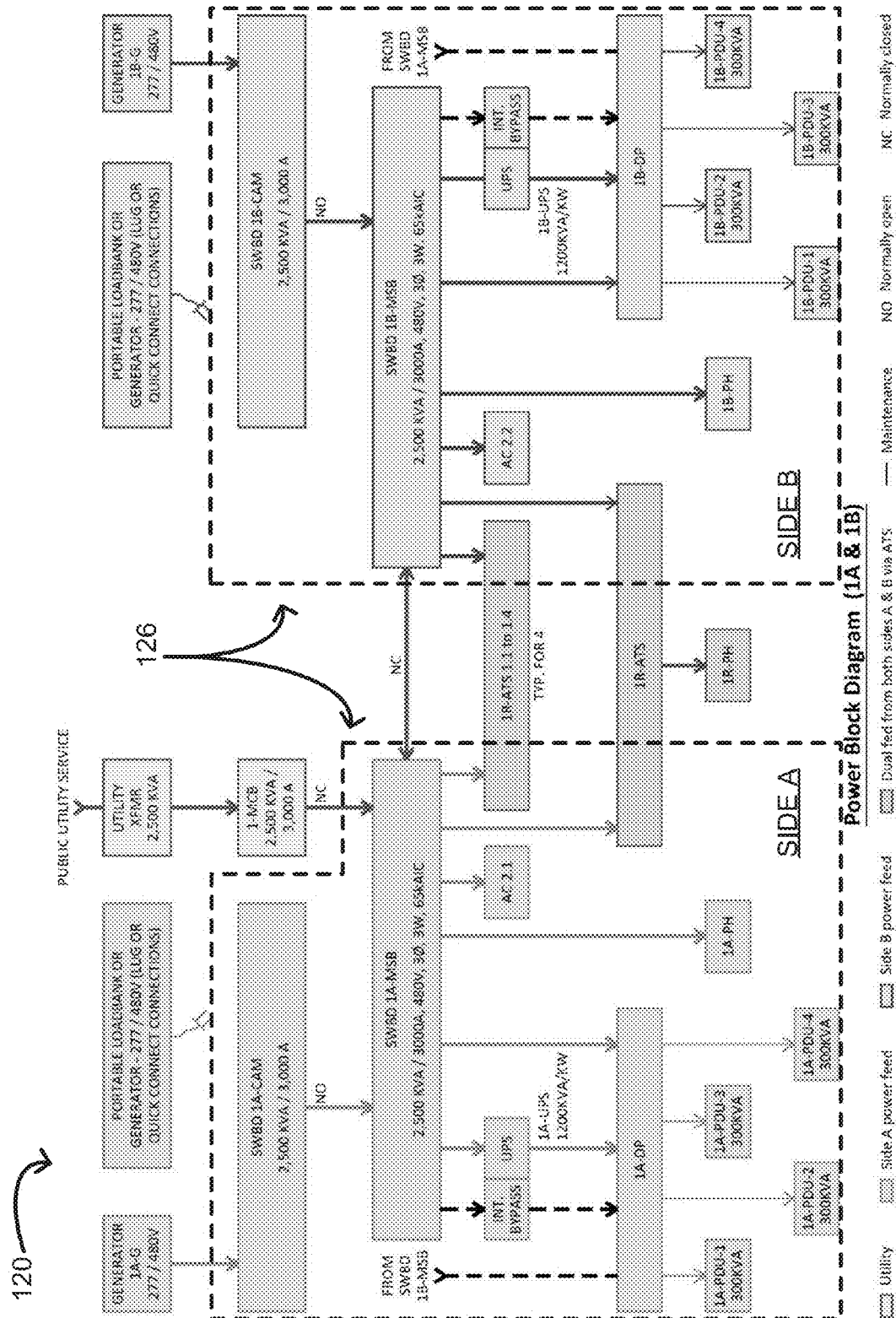


FIG. 9

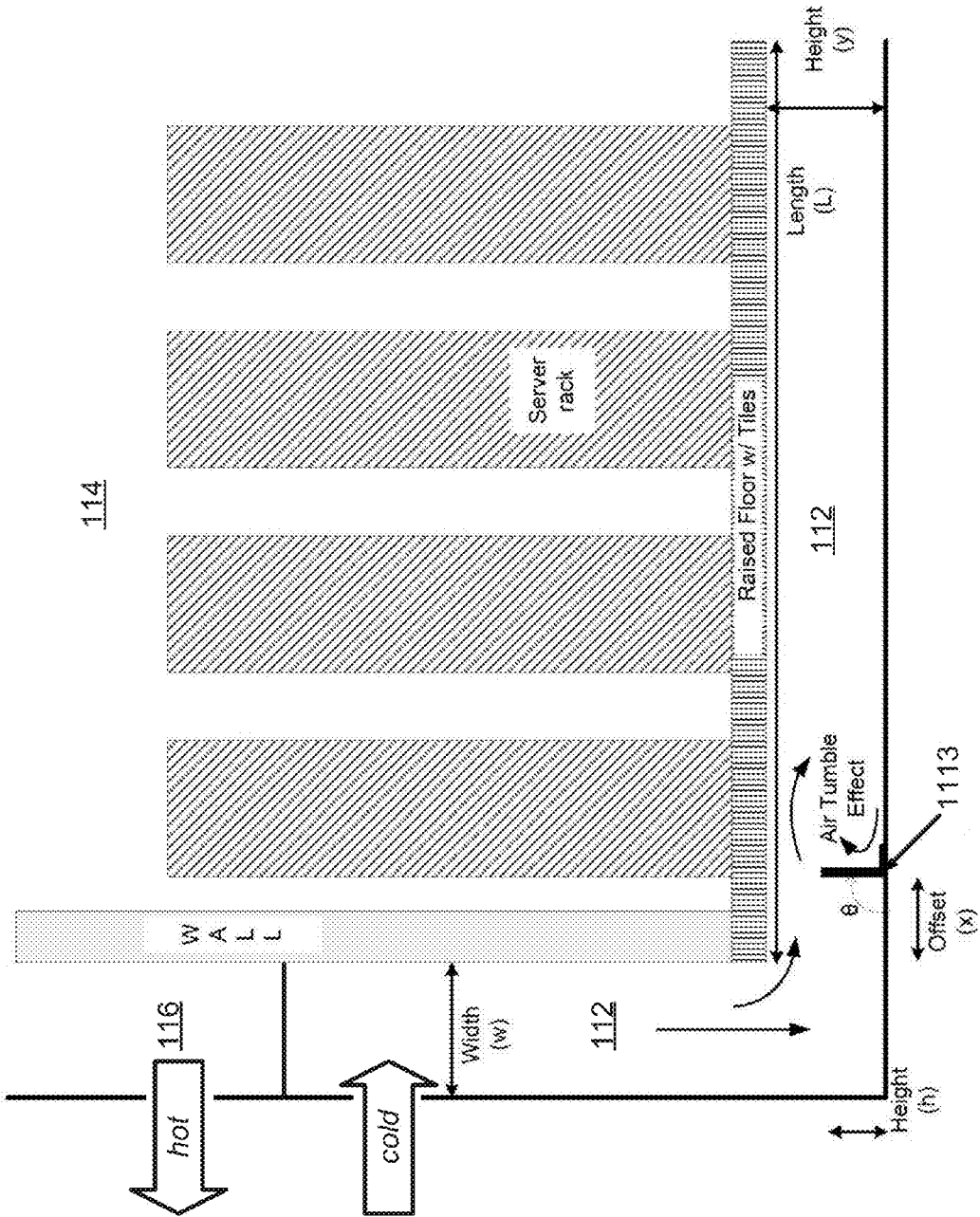
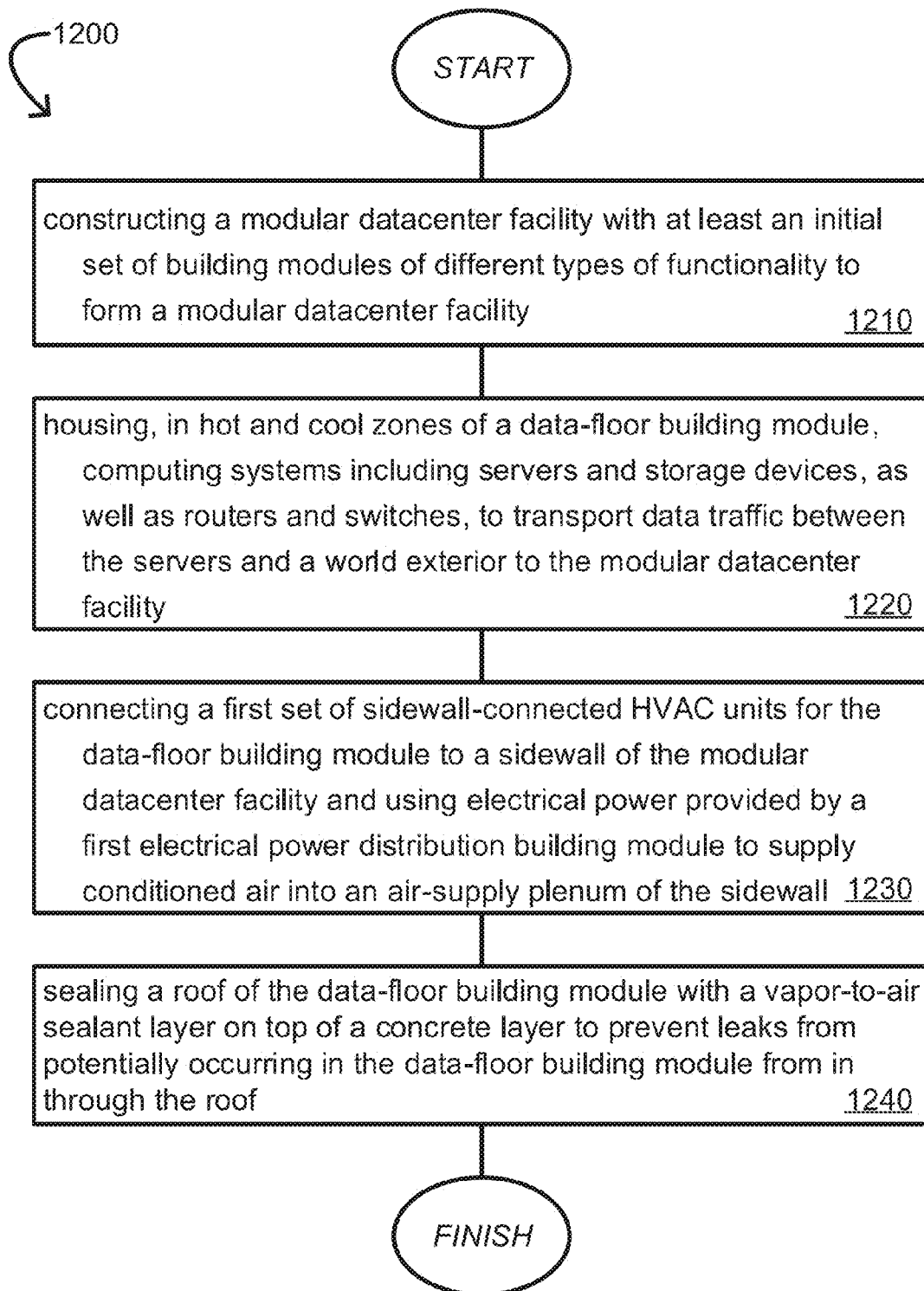


FIG. 11

**FIG. 12**

SIDEWALL-CONNECTED HVAC UNITS FOR MODULAR DATACENTER FACILITIES

CROSS REFERENCE

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 14/463,474, filed Aug. 19, 2014, now U.S. Pat. No. 9,603,281, which is a continuation-in-part of U.S. patent application Ser. No. 13/792,948, filed Mar. 11, 2013, now U.S. Pat. No. 8,839,569, which claims the benefit of U.S. Provisional Patent Application No. 61/609,812, filed Mar. 12, 2012, each of which applications is hereby incorporated herein by reference in its entirety.

[0002] This application is also a continuation-in-part of U.S. patent application Ser. No. 14/041,351, filed Sep. 30, 2013, now U.S. Pat. No. _____, which claims the benefit of U.S. Provisional Patent Application No. 61/709,429, filed Oct. 4, 2012, each of which applications is hereby incorporated herein by reference in its entirety.

BACKGROUND

[0003] Information Technology (“IT”) operations are a crucial aspect of most organizational operations in the western world. One of the main concerns is business continuity. Companies rely on their information systems to run their operations. If a system becomes unavailable, company operations may be impaired or stopped completely. It is necessary to provide a reliable infrastructure for IT operations, in order to minimize any chance of disruption. Information security is also a concern, and for this reason a datacenter has to offer a secure environment, which minimizes the chances of a security breach. A datacenter must therefore keep high standards for assuring the integrity and functionality of its hosted computer environment. Telcordia GR-3160, NEBS Requirements for Telecommunications Data Center Equipment and Spaces, provides guidelines for datacenter spaces within telecommunications networks, and environmental requirements for the equipment intended for installation in those spaces.

[0004] Putting a large number of electrical components into a single enclosed space, such as a room, creates a ventilation problem as the area must be maintained at a desired operating temperature, while having a large number of heat sources. Traditional systems may create custom ducting to direct supply air into desired locations within a datacenter facility. Alternatively, through floor or ceiling supply paths may be created by forcing air in through grated floor or ceiling sections. However, existing designs suffer from localized heating and cooling caused by inadequate air distribution through the space.

SUMMARY

[0005] In an embodiment, a modular datacenter facility is provided, constructed with at least an initial set of building modules of different types of functionality to form the modular datacenter facility. Each type of building module in the set of building modules can have a collection of functionality associated with the type of building module. Each building module of the set of building modules can be a pre-engineered, standardized building block having a pre-approved architectural design and layout. A first type of building module in the modular datacenter facility can be a data-floor building module that is pre-engineered and has the pre-approved architectural design and layout to house com-

puting systems. The computing systems include servers and storage devices housed in hot and cool zones of the data-floor building module, and routers and switches can be configured to transport data traffic between the servers as well as transport traffic to a world exterior to the modular datacenter facility. A first set of sidewall-connected heating, ventilation, and air conditioning (“HVAC”) units for the data-floor building module can connect to a sidewall of the modular datacenter facility and use electrical power provided by a first electrical power distribution building module to supply conditioned air into an air-supply plenum of the sidewall, which can be a sidewall of the data-floor building module or a service corridor, in order to cool the computing systems including the servers, storage devices, routers, and switches, and other electronic components housed in the data-floor building module of the modular datacenter facility. The first set of the sidewall-connected HVAC units can be configured for cooling of the computing systems and the other electronic components allowing for more server units to consume electrical power during their operation inside the data-floor building module without raising a temperature in the data-floor building module high enough to overheat the computing systems and the other electronic components. The first set of the sidewall-connected HVAC units connecting to the sidewall allow for fewer penetrations in a roof or ceiling of the data-floor building module, thereby minimizing an amount of leaks potentially occurring in the roof of the ceiling, and thereby minimizing risk of any damage to the computing systems and the other electronic components housed in the data-floor building module from the leaks. The roof can include a vapor-to-air sealant layer on top of a concrete layer to further prevent leaks from potentially occurring in the data-floor building module from in through the roof.

[0006] In an embodiment, a method is provided for constructing a modular datacenter facility with at least an initial set of building modules of different types of functionality to form the modular datacenter facility. Each type of building module in the set of building modules can have a collection of functionality associated with the type of building module. Each building module of the set of building modules can be a pre-engineered, standardized building block having a pre-approved architectural design and layout. A first type of building module in the modular datacenter facility can be a data-floor building module that is pre-engineered and has the pre-approved architectural design and layout to house computing systems. The method can include housing, in hot and cool zones of the data-floor building module, the computing systems including servers and storage, as well as routers and switches configured to transport data traffic between the servers as well as transport traffic to a world exterior to the modular datacenter facility. The method can include connecting a first set of sidewall-connected HVAC units for the data-floor building module to a sidewall of the modular datacenter facility and, using electrical power provided by a first electrical power distribution building module, supplying conditioned air into an air-supply plenum of the sidewall, which can be a sidewall of the data-floor building module or a service corridor, in order to cool the computing systems including the servers, storage devices, routers, and switches, and other electronic components housed in the data-floor building module of the modular datacenter facility. The first set of the sidewall-connected HVAC units can be configured for cooling of the computing systems and the

other electronic components allowing for more server units to consume electrical power during their operation inside the data-floor building module without raising a temperature in the data-floor building module high enough to overheat the computing systems and the other electronic components. The first set of the sidewall-connected HVAC units connecting to the sidewall allow for fewer penetrations in a roof or ceiling of the data-floor building module, thereby minimizing an amount of leaks potentially occurring in the roof of the ceiling, and thereby minimizing risk of any damage to the computing systems and the other electronic components housed in the data-floor building module from the leaks. The method can include sealing the roof with a vapor-to-air sealant layer on top of a concrete layer to further prevent leaks from potentially occurring in the data-floor building module from in through the roof.

DRAWINGS

[0007] The drawings refer to embodiments of the design in which:

[0008] FIGS. 1A, 1B, and 1C illustrate block diagrams modular datacenter facilities constructed with sets of building modules of different types of functionality to form entire datacenter facilities having standardized pre-approved architectural designs and layouts in accordance with some embodiments.

[0009] FIG. 2A illustrates expansion of a modular datacenter facility in accordance with some embodiments.

[0010] FIG. 2B illustrates expansion of a modular datacenter facility in accordance with some embodiments.

[0011] FIG. 3 illustrates a hardened-structure building module of a modular datacenter facility in accordance with some embodiments.

[0012] FIG. 4A illustrates a roofing system of a modular datacenter facility in accordance with some embodiments.

[0013] FIG. 4B illustrates layers of a roof of a roofing system of a modular datacenter facility in accordance with some embodiments.

[0014] FIG. 5 illustrates an HVAC system of a modular datacenter facility in accordance with some embodiments.

[0015] FIGS. 6A, 6B, and 6C illustrate air flow through a data-floor building module of a modular datacenter facility in accordance with some embodiments.

[0016] FIG. 7 illustrates heat exchange-based cooling of HVAC units in accordance with some embodiments.

[0017] FIG. 8 illustrates an HVAC system of a modular datacenter facility in accordance with some embodiments.

[0018] FIG. 9 illustrates a power-center building module of a modular datacenter facility in accordance with some embodiments.

[0019] FIG. 10 illustrates a diagram of an embodiment of four magnetic blocking tiles placed on perforated tiles or open areas, in an area where electronic equipment, including various computing systems, is designed and planned to be located but currently is not installed.

[0020] FIG. 11 illustrates a geometry of an air dam configured with respect to the data room, raised floor, and supply air plenum in accordance with some embodiments.

[0021] FIG. 12 illustrates a method of a modular datacenter facility in accordance with some embodiments.

[0022] While the design is subject to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and will herein be described in detail. The design should be

understood to not be limited to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the design.

DESCRIPTION

[0023] In the following description, numerous specific details are set forth, such as examples of specific heights and dimensions, named components, connections, types of offices, etc., in order to provide a thorough conceptual understanding. It will be apparent, however, to one skilled in the art that the invention provided herein can be practiced without these specific details. In other instances, well known components or methods have not been described in detail but rather in a block diagram in order to avoid unnecessarily obscuring the invention. Thus, the specific details set forth are merely examples. The specific details may be varied from and still be within the spirit and scope of the invention. Example processes for and apparatuses to manage cooling for a datacenter facility are described. The following drawings and text describe various example implementations of the design.

[0024] In general, a modular datacenter facility and a method thereof is provided in accordance with some embodiments. The module datacenter facility can be constructed with an initial set of building modules of different types of functionality. A first building module can be a data-floor building module. A first set of sidewall-connected HVAC units can connect to a sidewall of the modular datacenter facility and use electrical power provided by a first electrical power distribution building module to supply conditioned air into an air-supply plenum of the sidewall to cool computing systems housed in the data-floor building module. The first set of the sidewall-connected HVAC units allow for fewer penetrations in a roof of the data-floor building module, thereby minimizing an amount of leaks potentially occurring in the roof of the ceiling, and thereby minimizing risk of any damage to the computing systems.

[0025] A modular datacenter facility can have all instances of a particular type of building module with approximately the same floor plan and architectural design. An initial set of building modules can be built upon a parcel of land, and then as needs of space and additional capacity of the modular datacenter facility increase, then at a future point in time additional building modules of the different types can be rapidly added to the initial set of building modules. (See, for example, FIGS. 2A and 2B, in which additional building modules of the different types are added to an initial set of building modules (e.g., "Building 1") forming modular datacenter facilities **200A** and **200B**.) The building modules of the different types use one or more connecting corridors architected into at least a first type of building module and corresponding aligned doorways between both building modules to interconnect two building modules adjacent and abutted to each other.

[0026] FIGS. 1A, 1B, and 1C illustrate block diagrams of embodiments of a modular datacenter facility **100** constructed with a set of building modules of different types of functionality to form the modular datacenter facility **100** having a standardized pre-approved architectural design and layout.

[0027] As shown, the modular datacenter facility **100** can be constructed with a modular organization. The modular datacenter facility **100** can be constructed with a set of

building modules of different types of functionality to form or make up the modular datacenter facility **100** having a standardized pre-approved architectural design and layout. Each type of building module in the set has a specific collection of functionality associated with that type of building module. Each type of building module, such as a data-floor building module **110**, a power-center building module **120**, a facility-support building module **130**, and an office-support building module **140**, has a specific set of functionality associated with that building module. Each building module of the different types is a pre-engineered, standardized building block containing architectural features to allow easy configuration and integration with the other building modules that form the modular datacenter facility **100**. All instances of a particular building module with that type of functionality will have approximately a same floor plan and architectural design. Small changes can be made to the interior of a given building modules design but in general, the floor plan and architectural design remain the same. Components making up each of the building modules **110**, **120**, **130**, and **140** are prefabricated and shipped to the parcel of land.

[0028] The modular datacenter facility **100** can house computing systems in a data-floor building module **110**. The computing systems includes servers and storage devices housed in hot and cool zones, as well as routers and switches that transport data traffic between the servers as well as transport traffic to a world exterior to the modular datacenter facility **100**. The modular datacenter facility **100** also includes redundant or backup power supplies, redundant data communications connections, environmental cooling controls, and security devices.

[0029] The data-floor building module **110** is the principal module of the datacenter as it provides the hardened environment for the computing systems that includes the server room. The data-floor building module **110** can be approximately 10,000 square feet and works in unison with the power-center building module **120** to provide one MW of UPS power at a 2N redundancy. This power-center building module **120** is pre-fabricated off site and it includes everything in the design electrical system. Each power-center building module **120** includes Switchgear, an Uninterruptible Power Supply, Power Controls, and each power-center building module **120** is associated with a data-floor building module **110**. The data-floor building module **110** structure also supports the N+1 mechanical system that features airside economization and delivers high-efficiency cooling via 2 air chases along the walls of the data-floor building module, the main datacenter, and a 36-inch raised floor system.

[0030] The data-floor building module **110** is the heart of the datacenter environment as it contains the computing systems. The data-floor building module **110** supports racks of servers having densities varying in power consumption from 2 kW to 20 kW without containment walls between the racks of servers of varying power consumption density.

[0031] The data-hall building module **110** (e.g., the data-hall building module **110** of the initial set of the building modules) can include a steel-based joist or concrete beam that horizontally connects two parallel sections of wall of the data-hall building module **110** to eliminate a need for support columns on a raised floor of the data-hall building module **110** for supporting the computing systems and the other electronic components. For example, the data-floor

building module **110** can have a multitude of 80' steel joists horizontally connecting parallel sections of wall of the building module to eliminate a need for support columns being located on the 10,000 square feet of raised 36-inch floor that supports the computing systems. The steel-based joist or concrete beam can create an open floor space and ensure that users of the data-floor building module **110** have a sufficient degree of flexibility to accommodate a number of server-rack configurations for racks of the servers having varying power consumption densities in the hot and the cool zones of the data-hall building module **110**. The raised floor houses the computing systems and other electronic components as well as creates a single, under-floor plenum configured for supplying the conditioned air under the raised floor to an interior of the data-hall building module and returning heated air to a return plenum or return ducts in a ceiling above the data-floor building module for return of the heated air to the first set of sidewall-connected HVAC units. In some embodiments, the raised floor is a 36-inch floor that houses the computing systems as well as creates a dual plenum for air supply with cooling supply air being supplied underneath the raised floor as well as a ceiling plenum for hot air return.

[0032] The data-floor building module **110** containing the computing systems can be connected to a grade-mounted cooling system or HVAC units **122** powered by power center **126** that features airside economization. In an example embodiment, the data-floor building module **110** uses packaged air handlers to control the air temperature and moisture of the data floor environment. As shown in FIG. 1C, the cooling capacity of at least a first set of the grade-mounted HVAC units **122** can be doubled by doubling the number of air-handler units (e.g., adding a second set of grade-mounted HVAC units **124**) and adding an additional power center such as power center **128**.

[0033] The building modules of the different types **110**, **120**, **130**, and **140** use one or more connecting corridors architected into at least a first type of building module such as a rear service corridor **132** of the facility-support building module **130**, and corresponding aligned doorways between any two of such building modules can interconnect the two building modules adjacent and abutted to each other.

[0034] FIG. 2A illustrates a block diagram of an embodiment of a physical composition and geographic arrangement of building modules matched to a current capacity and space needs of a user of a modular datacenter facility **200A** as well as to a geography of a parcel of land that the modular datacenter facility **200A**.

[0035] An example 1-MW datacenter facility (e.g., the modular datacenter facility **100**) with all four building modules (e.g., the building modules of the different types **110**, **120**, **130**, and **140**) can be expanded to a 2-MW datacenter facility with the addition of another data-floor building module **210** having data floor **214**, a power-center building module **220**, a facility-support building module **230**, and an optional office-support building module **240** (not shown). A hardened-structure building module such as the hardened-structure building module **350** described herein can further be added. The power-center building module **220** can include a power center **226** to power at least the data-floor building module **210** and a first set of HVAC units **222** to control the air temperature of the data floor **214**. The cooling capacity of the first set of HVAC units **222** can be at least doubled by doubling the number of air handlers to

include a second set of HVAC units **224** and adding additional power via at least an additional power center **228**. In some embodiments, the power-center building module **220** has one generator and the swing generator of the first instance of the power-center building module (e.g., the power-center building module **120**) is electrically coupled to supply backup power to either set of building modules.

[0036] The building connecting methodology via a connecting corridor makes datacenter expansion simple. Each step of expansion consisting of adding another data-floor building module, a power-center building module, a facility-support building module, an optional office-support building module, and a hardened-structure building module includes building adjacent an existing module with connections via the service corridor (e.g., the service corridor **132**) and a personnel corridor. Conduits may be run diversely down the service and personnel corridors for network connectivity. A major advantage of this model is you are never constructing in the same building footprint as your original datacenter facility. A 1-MW modular datacenter facility site can expand to, for example, a 4-MW modular datacenter facility by adding three additional sets of building modules. The number of sets of building modules making up the modular datacenter depends on the size of the parcel of land (more land=more datacenters).

[0037] Both a physical composition and geographic arrangement of a first configuration of building modules in the initial set can be different than a second configuration of building modules in the initial set; thus, the set of building modules can be matched to a current capacity and space needs of a user of the modular datacenter facility as well as to a geography of the parcel of land that the modular datacenter facility will be located on. Each expansion set of building modules can be built adjacent an existing one with connections via the service corridor and the personnel corridor.

[0038] Aligned doors for the connecting corridors may be walled off or sealed off to become part of a permanent wall when the interconnection point is desired to be removed for security or other purposes. The aligned doors can be configured to swing in an opposite direction of the building module they are connecting to in order to allow easier access between the distinctly different building modules abutted together, which are also then interconnected, via a flange, a link, or other interconnection mechanism, to each other to form a single modular datacenter facility. Each building type includes the interconnection mechanism to optional component additions of additional building modules. The aligned doors connecting to another building module typically also have key card access readers installed to control operation of that doors locking mechanism.

[0039] In an embodiment, at least one of 1) electrical fiber conduits and 2) network fiber conduits are run diversely down the connecting corridors for network connectivity between adjacent building modules to facilitate interconnecting two building modules adjacent and abutted to each other. Alternatively, the modular datacenter facility may use the outside plant conduit infrastructure for electrical or network connectivity.

[0040] In instances where multiple customers use the datacenter facility, while the building modules abut each other, neither building module may have access to the other building module, as the connecting corridors would be walled off. However, if it is merely the same client expand-

ing, then the connecting fiber conduits and service corridors makes the two constructed building modules one larger extended module.

[0041] FIG. 2B illustrates an expansion of the modular datacenter facility **100** in accordance with some embodiments.

[0042] Initially, all four types of building modules **110**, **120**, **130**, and **140** can be built onto a given geographic plot of land providing, for example, "Building 1" and an associated equipment yard as shown in FIG. 2B forming at least the modular datacenter **100** (e.g., a 2.4-MW modular datacenter facility). At a later or future point in time, the expansion can occur, as described, thereby forming the modular datacenter facility **200A** (e.g., now a 4.8-MW modular datacenter facility) in an expanded form. At a number of later or future points in time, expansion can further occur, thereby forming the modular datacenter facility **200B** (e.g., now a 24-MW modular datacenter facility) in the expanded form. This occurs by adding different building module types to support one or more new or existing customers on the same existing parcel of land or expand for a current customer. In general, the expansion **200B** can share one or more of the previously fabricated and installed building module types **110**, **120**, **130**, and **140** or build its own instance of that building module type. When shared, each rear service corridor of each facility-support building module **130** can connect forming one or more shared rear service corridors for the expansion such as the shared rear service corridors **232a** and **232b**. Doorways between the building modules of the different types can interconnect at least two building modules adjacent and abutted to each other.

[0043] FIG. 3 illustrates a hardened-structure building module **350** of the modular datacenter facility **100** in accordance with some embodiments.

[0044] The initial datacenter built in a parcel of land (e.g., "Building 1" of FIG. 2B) can include the set of four building modules of different types of functionality: the data-floor building module **110**; the power-center building module **120**; the facility-support building module **130**; and the office-support building module **140**. The hardened-structure building module **350** can support the building integrity structure of the modular datacenter facility **100**.

[0045] The building module types **110**, **120**, **130**, and **140**, as well as the hardened-structure building module **350** make up various embodiments of the modular datacenter facility **100**, which can be approximately 20,680 square feet in some embodiments. The modular datacenter consists of the above modules connected together, working in unison. This module synergy provides a unique facility layout that results in a highly efficient datacenter.

[0046] Each building module type in the set of building modules of different types of functionality can be architected and formed as a totally separated building that is interconnected to another building module via aligned doors between these building modules and the connecting corridor **232** 1) behind the data floor containing the servers and storage devices housed in hot and cool zones in a data-floor building module **110** and 2) in front of the power center building module **120**, which connecting corridor **232** can be considered part of the office-support building module **130**.

[0047] Service corridors such as the service corridor **132**, as well as personnel corridors, can run a length of at least some of the initial set of building modules connected in the

modular datacenter facility **100**. Such corridors can further run a length of at least some of a subsequent set of building modules connected in a modular datacenter facility (e.g., the service corridors **232a** and **232b** of the modular datacenter facility **200**). Likewise, a hardened-structure building module of the subsequent set of building modules can include a hardened shell and one or more service or personnel corridors between a first instance of the hardened-structure building module and a second instance of the hardened-structure building module connecting to and abutting the first instance of the hardened-structure building module. The one or more service or personnel corridors can be laid out between an interior wall and an exterior wall of the hardened-structure building module forming the hardened shell of the hardened-structure building module.

Roof

[0048] FIG. 4A illustrates a roofing system **460** of the modular datacenter facility **100** in accordance with some embodiments.

[0049] Each building module type in the set of building modules of different types of functionality can have one or more types of roof over the building module or at least a portion of the building module, and the roofs, together, can form the roofing system **460**. As shown, the data-floor building module **110** can have a roof **111**; the power-center building module **120** can have a roof **121**; the facility-support building module **130** can have a first roof **131** and a second roof **133**; and the office-support building module **140** can have a roof **141**.

[0050] Each building module type in the set of building modules of different types of functionality can have a same or different roof as one or more of the other building modules. For example, as shown in FIG. 4A, the first roof **131** of the facility-support building module **130** can be the same as the first roof **141** of the office-support building module **140**, which roofs **131** and **141** can be different than the roof **111** of the data-floor building module **110**, the roof **121** of the power-center building module **120**, and the second roof **133** of the facility-support building module **130**.

[0051] In some embodiments, one or more of the roofs are precast planks (e.g. precast concrete planks). For example, each roof of the roof **111** of the data-floor building module **110**, the roofs **131** and **133** of the facility-support building module **130**, and the roof **141** of the office-support building module **140** can be precast planks. The roof **111** of the data-floor building module **110** can be a precast double-tee plank.

[0052] In some embodiments, one or more of the roofs are prefabricated metal roofs. For example, the roof **121** of the power-center building module **120** can be a prefabricated metal roof.

[0053] FIG. 4B illustrates layers of a roof of the roofing system of the modular datacenter facility **100** in accordance with some embodiments.

[0054] Any one or more of the roofs can have a multilayer construction. As shown in FIG. 4B, the precast-plank roofs can have a multilayer construction in which the precast roof plank is covered by a vapor-to-air sealant layer, which vapor-to-air sealant layer, in turn, is covered by one or more layers of insulation, a cover board, and a feltback membrane. From a top of the foregoing roof down to the precast plank, the multilayer construction of the roof can include the feltback membrane over the cover board, the cover board

over the one or more layers of insulation, the insulation over the vapor-to-sealant layer, and vapor-to-sealant layer over the precast plank. The vapor-to-air sealant layer over or on top of the precast plank or concrete layer can further prevent leaks from potentially occurring in the data-floor building module from in through the roof.

Sidewall-Connected HVAC Systems

[0055] FIG. 5 illustrates an HVAC system of the modular datacenter facility **100** in accordance with some embodiments.

[0056] As shown, the HVAC system of the modular datacenter facility **100** can include the grade-mounted cooling system **122**, a roof-mounted HVAC system **534** on the roof **131** of the facility-support building module **130** (not the roof **133** above the rear-service corridor **132** of the facility-support building module **130** or the roof **111** of the data-hall building module **110**), and a number of additional, optionally roof-mounted cooling systems for comfort cooling of the modular datacenter facility **100** such as for cooling the power-center building module **120**, the facility-support building module **130**, and the office-support building module **140**.

[0057] The data-floor building module **110** can use the grade-mounted cooling system or the first set of HVAC units **122** to control the air temperature of the data floor environment. Again, as shown in FIG. 1C, the cooling capacity of the first set of HVAC units **122** can be at least doubled by at least doubling the number of air handlers and adding additional power via at least an additional power center such as the power center **128** of the power-center building module **120**.

[0058] As described in more detail with reference to FIGS. 6A, 6B, and 6C, the first set of grade-mounted HVAC units **122** for the data-floor building module **110** can connect to a sidewall of the modular datacenter facility **100** and use electrical power provided by a first electrical power distribution building module such as the power center **126** of the power-center building module **120** to supply conditioned air into an air-supply plenum of the sidewall (e.g., an air-supply plenum **112**). The sidewall can be a sidewall of the data-floor building module **110** or a sidewall of a service corridor such as the service corridor **132**. The first set of the sidewall-connected HVAC units **122** connecting to the sidewall allow for fewer penetrations in the roof **111** of the data-floor building module **110**, thereby minimizing an amount of leaks potentially occurring in the roof **111** or a ceiling thereunder, and thereby minimizing risk of any damage to the computing systems and the other electronic components housed in the data-floor building module **110** from the leaks.

[0059] The supply of conditioned air into an air-supply plenum of the sidewall (e.g., the air-supply plenum **112**) can cool the computing systems including the servers, storage devices, routers, and switches, and other electronic components housed in the data-floor building module **110** of the modular datacenter facility **100**. As such, the first set of the sidewall-connected HVAC units allows for cooling of the computing systems and the other electronic components allowing for more server units to consume electrical power during their operation inside the data-floor building module without raising a temperature in the data-floor building module high enough to overheat the computing systems and

the other electronic components. The HVAC units **122** can be connected in parallel via the supply plenum to cool 100% of a critical IT load.

[0060] Controls for the HVAC units **122** allow an operator to manually vary the air temperature set point of cooling air supplied by the HVAC units **122**. The set point can be varied from 65° F. to 75° F. while still maintaining the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (“ASHRAE”) recommended temperature envelope. The temperature envelope can be difficult to maintain if the supply air temperature set point from an air-return plenum is outside, for example, a 75° F. to 99° F. range. Controls for the HVAC units **122** such as raised-floor differential-static pressure controls also allow an operator to vary the air-flow rate and volume of cooling air supplied by the HVAC units **122** to maintain an underfloor, static pressure set point.

[0061] The HVAC units **122** are configured such that the HVAC units **122** provide sensible cooling via indirect airside economizers without a dehumidification means. The capacity to dehumidify a humidity load, for example, caused by a rapid weather change, can be handled by the roof-mounted HVAC system **534**, which cooperates with the HVAC units **122** of the data-floor building module **110** to maintain a positive pressure in the data-hall building module **120**.

[0062] With respect to the roof-mounted HVAC system **534** on the roof **131** of the facility-support building module **130**, the HVAC system **534** can be configured to handle ventilation (introduction of outside air), temperature variation, pressurization, dehumidification, humidification, whereas the HVAC units **122** are primarily configured to handle temperature variation and pressurization.

[0063] FIGS. 6A, 6B, and 6C illustrate air flow through the data-floor building module **110** of the modular datacenter facility **100** in accordance with some embodiments.

[0064] As shown, the grade-mounted HVAC units **122** can supply the conditioned air to a data floor **114** of the data-floor building module **110** through the air-supply plenum **112** including a sidewall of the modular datacenter facility **100** (e.g., the sidewall of the of the facility-support building module **130**) and raised-floor cavity under the raised floor of the data-floor building module **110**. The conditioned air from the air-supply plenum **112** can then diffuse through perforated tiles or the like of the raised floor to cool the computing systems and the other electronic components. Heated air resulting from cooling the computing systems and the other electronic components can then diffuse through air grilles or the like of a ceiling above the data floor **114**. The grade-mounted HVAC units **122** can accept the return or heated air from the data floor **114** of the data-floor building module **110** through an air-return plenum **116** including a ceiling cavity above the data floor **114** of the data-floor building module **110** and the sidewall of the modular datacenter facility **100** (e.g., the sidewall of the of the facility-support building module **130**).

[0065] In view of the foregoing, an air channel, including any of a duct, a plenum, and a combination of one or more ducts and plenums, begins an air-flow path of the conditioned air at the first set of the sidewall-connected HVAC units **122**, through the air-supply plenum **112** of the sidewall, through an under-floor plenum portion of the air-supply plenum **112** positioned under a raised floor of the data-floor building module, through the raised floor of the data-floor building module **110**, through one or more perforated tiles

covering the raised floor, and into an interior **114** of the data-floor building module **110** for the cooling of the computing systems and the other electronic components housed in the data-floor building module. The air channel air-flow path of the conditioned air continues from the interior **114** of the data-floor building module **110**, through a ceiling of the of the data-floor building module, where one or more return ducts above the ceiling route heated air in the air-return plenum **116** from above the data-floor building module **110** down along the sidewall and back to an air intake of the first set of the sidewall-connected HVAC units **122**. The first set of the sidewall-connected HVAC units can subsequently remove heat from the heated air to provide the conditioned air for recirculation of the conditioned air through the air channel, including through the air-supply plenum **112** of the sidewall, through the under-floor plenum thereof, and through the raised floor of the data-floor building module **110** for the cooling of the computing systems and the other electronic components.

[0066] The air-supply plenum **112** and an air-return plenum **116** of the sidewall of the modular datacenter facility **100** are constructed with a pre-approved architectural design and layout for adding additional sidewall-connected HVAC units **122** at a later date from initial construction of the modular datacenter facility **100** with the initial set of building modules of the different types of functionality.

[0067] Adverting to FIG. 6C, FIG. 6C diagrammatically illustrates supply of the conditioned air to the data floor **114** and return of the heated air to the HVAC units **122** in accordance with some embodiments. As shown, the HVAC units **122** can supply the conditioned air to the air-supply plenum **112** at a rate of approximately 20,000-314,500 cubic feet per minute (“CFM”) and a temperature of approximately 65-75° F. The conditioned air from the air-supply plenum **112** can then diffuse through the perforated tiles or the like of the raised floor of the data-floor building module **110** at a rate of approximately 4,000-314,500 CFM and a temperature of approximately 65-75° F. Cooling the computing systems and the other electronic components can increase the temperature of the conditioned air from 65-75° F. to 65-99° F. depending upon the temperature of the IT load. The heated air can then diffuse through the air grilles or the like of the ceiling of the data-floor building module **110** at a rate of approximately 4,000-314,500 CFM. Simultaneously with the foregoing, the HVAC system **534** can draw outside air or makeup air from outside the modular datacenter facility **100** and mix it with some of the conditioned air from the air-supply plenum **112**, thereby diluting the outside air with already conditioned air for more efficient modification of the outside air with respect to temperature, humidity, and pollution such as particulate matter. In drawing the air into the HVAC system **534**, the outside air can be drawn at a rate of approximately 0-1500 CFM and the conditioned air can be drawn from the air-supply plenum **112** at a rate of approximately 6000-7500 CFM. Upon mixing the outside air (e.g., approximately 23-111° F.) and the conditioned air (e.g., approximately 65-75° F.) and subsequently modifying the resulting air mixture with respect to temperature, humidity, and pollution, the HVAC system **534** can supply the air mixture with the makeup air to the air-return plenum **116** at a rate of approximately 7,500 CFM and a temperature of approximately 45-99° F. where air mixture can further mix with the heated air from cooling the computing systems and the other electronic components.

The HVAC units **122** can subsequently draw the air mixture including the makeup air from the air-return plenum **116** for heat exchanger-based cooling and reintroduction of the conditioned air to the air-supply plenum **112** to cool the IT load and maintain at least a slight positive pressure compared to ambient pressure.

[0068] Arranging computer racks in hot and cold aisles focuses cold air delivery at the front intake of a rack and expels hot air at the back. Rack rows are arranged so the backs of rows face each other and hot air is collected above the row by a ceiling plenum (e.g., the air-return plenum **116**), which returns the air to the HVAC unit directly. The fronts of the racks face each other in a row that has vented tiles in the raised floor to deliver cold air to the rack fronts from the HVAC units.

[0069] FIG. 7 illustrates heat exchange-based cooling of HVAC units **122** in accordance with some embodiments.

[0070] As shown, the HVAC units **122** are configured such that the HVAC units **122** provide sensible heat exchange-based cooling via indirect airside economizers. In operation, heated air (e.g., approximately 65-99° F.) from cooling the computing systems and the other electronic components can be drawn from the air-return plenum **116** into a top portion of one of the HVAC units **122** where the heated air first comes in contact with the heat exchanger (e.g., plate heat exchanger). On the other side of the heat exchanger, outside air can be drawn into a bottom portion of the same one of the HVAC units **122** where the outside air first comes in contact with the heat exchanger. The heated air and the outside air can flow in opposite directions across opposites sides of the heat exchanger, during which a continuous thermal equilibrium process can cool the heated air and warm the outside air.

[0071] In view of the foregoing, the first set of the sidewall-connected HVAC units **122** are configured with heat exchangers (rather than louvers) to remove heat from recirculating conditioned air inside the data-floor building module **110** without introducing air from outside the data-floor building module **110**, thereby preventing outside air with humidity and potential pollution from mixing with the recirculating conditioned air inside the data-floor building module **110**, and thereby minimizing damage to the computing systems and the other electronic components housed in the data-floor building module **110**.

[0072] The HVAC units **122** are configured to provide the sensible heat exchange-based cooling without a dehumidification means. The dehumidification means is not needed in the HVAC units **122** as the outside air used to cool the heated air never mixes. The capacity to dehumidify a humidity load, for example, caused by a rapid weather change, can be handled by the roof-mounted HVAC system **534**, which cooperates with the HVAC units **122** of the data-floor building module **110** to provide dehumidified and pollutant-free makeup air, as well as maintain a positive pressure in the data-hall building module **120**.

[0073] The first set of the sidewall-connected HVAC units **122** are configured to allow the first set of the sidewall-connected HVAC units **122** to be installed during a first time period of the data-floor building module **100** to cool the computing systems and the other electronic components housed in the data-floor building module **100** during the first time period. At a second, later time period of the data-floor building module **100**, the first set of the sidewall-connected HVAC units **122** are configured to allow a second set of the

sidewall-connected HVAC units (e.g., the second set of the sidewall-connected HVAC units **124** of FIG. 1C) to be proximately installed and connected into the air-supply plenum **112** and the air-return plenum **116** of the sidewall to cool the computing systems and the other electronic components housed in the data-floor building module during **100** the second time period of the data-floor building module **100**.

[0074] The second set of the sidewall-connected HVAC units **124** can be installed with the pre-approved architectural design and layout selected from the group consisting of i) horizontally along the sidewall of the modular datacenter facility **100** in line with the first set of the sidewall-connected HVAC units **122**; ii) vertically up the sidewall of the modular datacenter facility **100** in a configuration on top of the first set of the sidewall-connected HVAC units **122**; and iii) a combination of horizontally along the sidewall of the modular datacenter facility **100** and vertically up the sidewall of the modular datacenter facility **100** in the configuration on top of the first set of sidewall-connected HVAC units **122**. Horizontally along the sidewall of the modular datacenter facility **100** is exemplified in FIGS. 1C and 2A by adjacently placed HVAC units **122** and **124** and HVAC units **222** and **224**, respectively. Vertically up the sidewall of the modular datacenter facility **100** includes, for example, stacking the HVAC units **122** and **124**.

[0075] FIG. 8 illustrates the HVAC system **534** of the modular datacenter facility **100** in accordance with some embodiments.

[0076] The HVAC system **534** can be a rooftop unit configured to deliver up to at least 5,000 CFM with a maximum of 15,000 CFM of outdoor air. As shown in FIG. 6B, one or more air supply ducts enable the HVAC system **534** to draw conditioned air from the air-supply plenum **112**, though, in some embodiments, the HVAC system **534** can alternatively draw heated air from the air-return plenum **116** or both the conditioned air from the air-supply plenum **112** and the heated air from the air-return plenum **116**. In addition, the HVAC system **534** can draw outside air or makeup air from outside the modular datacenter facility **100** to make up for losses in the recirculated conditioned air. The outside air can be mixed with some of the conditioned air from the air-supply plenum **112**, heated air from the air-return plenum **116**, or both, thereby diluting the outside air with already conditioned air for more efficient modification of the outside air with respect to temperature, humidity, and pollution such as particulate matter. As such the HVAC system **534** can include a humidity-control system and a pollution-control system configured to control the humidity and the potential pollution of the makeup air that enters the modular datacenter facility for the losses in the recirculated conditioned air.

[0077] As shown in FIG. 8, the outside air can first mix with the conditioned air in a mixing box of the HVAC system **534** to form an air mixture. The air mixture can subsequently be passed through a direct expansion (DX) cooling coil and a sub-cooling coil for cooling (if needed). The HVAC system **534** can include a refrigerant reheat (sub-cooling) coil to improve the efficient of the system. A supply fan downstream of the cooling coils can push the cooled air mixture through a diffuser plate, an electric heating coil for heating (if needed), and a humidifier grid for modification of the humidity in the air mixture. The air mixture subsequent to conditioning (e.g., modification with

respect to temperature, humidity, and pollution such as particulate matter) can then be supplied to the air-return plenum **116**, mixed with the heated air in the air-return plenum **116**, and cooled by the HVAC units **122**.

[0078] Even though the HVAC units **122** are primarily responsible for cooling the computing systems and the other electronic components on the data floor **114**, the HVAC system **534** can still provide substantial cooling (e.g., up to at least 70 kW) capacity if needed.

Power Centers

[0079] FIG. 9 illustrates the power-center building module **120** of the modular datacenter facility **100** in accordance with some embodiments.

[0080] FIG. 9 illustrates a block diagram of an embodiment of the power-center building module **120**, **220**, etc., which is at the heart of the modular datacenter power delivery mechanism for the building modules. With the power-center building module **120** as an example, the power-center building module **120** can be pre-fabricated off site to include electrical power generators, transformers, and modular pre-fabricated mechanical, electrical, and plumbing (“MEP”) rooms that house switchgear, Uninterruptable Power Supplies, power controls, etc. The power-center building module **120** can also provide the generator-backed power for the primary and secondary point of presence (“PPOP” and “SPOP”) rooms and the house power. The power center building module **120** can have hardened steel shell structure and one or more aligned doors fabricated into the building module in order to interconnect with the connecting corridor, which forms an outer layer of another building module that is adjacent and abutted to the power center building module. The power-center building module **120** can include one to two generators. Each of the generators can be a 2-MW diesel generator in an N configuration to provide back-up power in case of utility power failure, with the second generator as a swing generator. Each generator can be housed in a weatherproof enclosure. The customer has the option to install or not the additional generator to serve as the swing generator supplying backup electrical power to multiple data-floor building modules. The power-center building module **120** can include one or more Power Distribution Units (PDU’s). The data-floor building module **110** can have eight PDU’s that will serve as the electrical distribution point for the customer. The PDU’s can be prefabricated and shipped to the site.

[0081] A 2500 kVA outdoor transformer from the Utility Power Grid exists for each 1000 kW modular datacenter facility. The 2500 kVA transformer can provide power for each one of the building modules through dual (A/B) 3000 A switchboards controlled by a 5-breaker PLC in the power center building module **120**. The sequence of electrical power supply operation of the system can be controlled automatically through deployment of a programmable logic controller (“PLC”) control unit installed in the 3000 A main switchboard. The optional swing generator can be a third source of power available to each modular datacenter. Should the standby generator fail to come online after loss of power from the utility source, the optional swing generator can pick up the critical loads of the system.

[0082] The second set of sidewall-connected HVAC units **124** and **224** described herein can be powered by a second electrical power distribution building module **128** and **228** in order to allow an increase in power and cooling capability

over time for the data-floor building modules **100** and **200**, respectively. The second electrical power distribution building module can be a duplicate of the first electrical power distribution building module. For example, a 2500 kVA transformer can provide power for each one of the building modules through dual (C/D) 3000 A switchboards controlled by a 5-breaker PLC.

[0083] The sidewall of the modular datacenter facility can be constructed with the pre-approved architectural design and layout to add the second electrical power distribution module with electrical conduits and trays routed through the sidewall during the second time period of the data-floor building module.

Magnetic Blocking Tiles

[0084] Magnetic blocking tiles can be placed on a perforated tile or open area where air could flow through the floor to direct the air flow to areas in the datacenter where electronic equipment is designed to be located and actually is installed in the datacenter. This increases the efficiency of the cooling system of the datacenter facility. The placement of magnetic blocking tiles may cooperate with an air dam installed in the supply air system of the datacenter. FIG. 10 illustrates the placement of the magnetic blocking tiles over perforated tiles of the data hall **114**, and FIG. 11 illustrates an example air dam system that cooperate with the placement of magnetic blocking tiles.

[0085] FIG. 10 illustrates a diagram of an embodiment of four magnetic blocking tiles placed on perforated tiles or open areas, in an area where electronic equipment, including various computing systems, is designed and planned to be located but currently is not installed.

[0086] The magnetic blocking tiles are magnetic covers for perforated or slotted tiles that are safe for a computing environment such as a datacenter. The magnetic blocking tiles each have a top surface that is solid and a bottom surface. Each magnetic blocking tile may have an anti-static rating of at least 10,000 ohms and is made of or coated with a dust-resistant material. The one or more magnetic blocking tiles are designed to be placed on perforated tiles or open areas where air could flow in a datacenter to aid in controlling the air flow in a datacenter. The datacenter houses computing systems, where the computing systems includes servers and storage devices are arranged in hot and cool zones. The magnetic blocking tiles are placed on perforated tiles or open areas where air could flow through the floor. The perforated tiles include any tiles manufactured with slots, small holes, and other openings in the tile to allow air to flow through these openings. The magnetic blocking tiles are placed on these perforated tiles or these open areas, in an area where electronic equipment, including the computing systems, is designed and planned to be located but currently is not installed; and thus, the magnetic blocking tiles cut off the airflow to areas where the electronic equipment is designed and planned to be located but currently is not installed. The magnetic blocking tiles cut off the airflow to areas where the electronic equipment is not installed; and thus, enhances the airflow to areas in the datacenter where electronic equipment is designed to be located and actually is installed in the datacenter. For example, server racks #1 and #3 are still getting the cooling air flow to the area where they are installed. However the area between server racks #1 and #3 has magnetic blocking tiles placed over the perforated tiles in this area. The magnetic blocking tiles adhere

magnetically to either the floor or the perforated tiles in order to cut off the airflow to areas where the electronic equipment is not installed.

[0087] The magnetic blocking tiles may have a magnetic material incorporated into one of the layers of the magnetic blocking tiles. The magnetic material is used to adhere to either a metal floor or metal perforated tiles without an additional adhesive bonding agent being needed between the magnetic blocking tile and an underlay surface of the metal floor or metal perforated tile. The floor or perforated tile may be made out of a ferrous metal material and/or have a ferrous-metal based resin applied to the floor or perforated tile. The magnetic blocking tiles are configured for a magnetic action to be used to hold the magnetic blocking tile in place. Note, any of 1) a raised floor may be made of a ferrous metal, 2) the perforated tiles are made of a ferrous metal, and 3) a coating, on either of the perforated tiles or on the raised floor, incorporates loose ferrous metal material.

[0088] Each magnetic blocking tile may have a magnetic flux, of less than 0.4 Tesla or 1500 Oersted, at which value it is safe to assume that the magnetic field will not harm or alter data bits stored memory devices. Generally less than 1500 Oersted and/or less than 0.4 Tesla is a maximum defined value at which it is safe to assume that no data has had its value changed based on being exposed to the magnetic field. Past this exposure, data may have been altered by the magnetic field. Regardless of exposure to another magnetic force, a memory device such as a hard drive can (and does) lose data bits due to deterioration over time.

[0089] The magnetic blocking tiles may have a coating that has an anti-static rating of at least 1000 ohms to 10,000 ohms (or more) to prevent damage to any electronic circuit devices that cannot tolerate a sudden flow of static charge. The magnetic blocking tiles are anti-static to be suitable for use in computer rooms. Electrostatic discharge (ESD) is a problem for computer systems in a data floor. The scuff of a shoe or the scrape of a chair creates an electron imbalance and, while the human body may not feel it, it can have serious consequences. ESD can cause component or system failures, which may prove costly and perhaps even be dangerous. The magnetic blocking tiles may have a static electricity electrical propensity of less than 2 kV by having a conductive carbon based coating to create an anti-static property.

[0090] In an embodiment, the dust resistant coating or material of the magnetic blocking tile has a reduced tackiness of a top layer or covering to protect the surface from dust accumulation. The top layer may have small molecules that repel negatively charged dust or may repel dust that could have remained attached by sealing edges, joints, and seams that are vulnerable to dust molecules attaching to these seams, edges and joints.

[0091] The top surface of a magnetic blocking tile may have a sufficient friction coefficient of equal to or greater than a 0.30 dynamic coefficient of friction (DCOF) to be slip resistant and give some friction so a person does not easily slip. The top surface of a magnetic blocking tile may be made from material such as vinyl.

[0092] Placement the magnetic blocking tiles allows the datacenter operators to refine the heat load being cooled by the HVAC systems of the datacenter to focus on cooling computing systems actually currently installed in the one or

more data floors that are already constructed. The magnetic blocking tiles are configured to calibrate datacenter.

[0093] The magnetic blocking tiles are configured to cooperate with an air dam installed in the datacenter, where the air-supply plenum **112** includes an under-floor plenum to supply the cooling air to the data floor **114**. The air dam is positioned at an entry region of the under floor plenum to obstruct a flow of cooling air in order to cause a constant airflow through the perforations in the perforated tiles for an entire area of datacenter housing the computer systems.

Air Dam

[0094] FIG. **11** illustrates a geometry of an air dam **1113** configured with respect to the data room, raised floor, and supply air plenum in accordance with some embodiments.

[0095] As discussed, the placement of magnetic blocking tiles may cooperate with an air dam installed in the supply air system of the datacenter. The air dam **1113** works as an obstruction in the forced air flow path to cause the air passing through the opening between the top of the air dam **1113** and the bottom of the wall or raised floor to slow down the air entering the under floor space. The air on the opposing side of the air dam from the incoming air stream experiences a more even pressure distribution. The air dam also creates a positive air pressure over the air dam, thus reducing and eliminating negative pressures areas in the data room floor. The air dam is located under a raised floor building such as a datacenter and is typically located under the walls forming a room in the building in the flow path of forced air in that building. Additional localized air dams may be placed and orientated by high heat centers in a room to direct airflow to that localized hot spot. The air dam can be located between the slab of the foundation and the support structure for the raised floor.

[0096] FIG. **11** illustrates the air dam **1113** configured with respect to the air-supply plenum **112** along the full width of one vertical wall of the data floor **114** transitioning to the under-floor plenum between a perforated, raised floor and an actual floor of the data-floor building module **110**. The air-supply plenum **112** has a width (w) from an exterior wall of the modular datacenter facility **100** to an interior wall (e.g., a wall of the rear service corridor **132** or a wall of the data hall **114**), while the raised floor is raised by a height (y). The raised floor has a length (L) from the interior wall to an opposing interior wall of the data floor **114**. Dimensions include a width (w) of the air-supply plenum **112** and a height (y) of the raised floor of between 12 to 48 inches, preferably between 30 to 42 inches, and more preferably approximately 36 inches. These dimensions are not necessarily the same, but can be.

[0097] The air dam **1113** can be an angled bracket that includes two planar sides generally angled from each other. The first side secures the dam to the actual floor and is positioned parallel to the floor along one surface, while the second side projects from the floor at an angle θ into the under floor space. The air dam **1113** may be angled from the floor from between 45-135° and more generally between 45-90°. The angle of the air dam **1113** preferably positions the top edge of the air dam **1113** equal or closer to the exterior wall than a bottom portion of the air dam **1113** that projects into the under floor space (i.e. less than or equal to 90° when measured from the exterior side of the air dam **1113**).

[0098] However, the size and shape of the air dam **1113** may vary. In some embodiments, the air dam may have an 'L' type shape with the height of the L section being roughly half the height of the raised floor. The size and shape of the air dam causes a constant pressure through the perforated tiles when entering into the data floor to cool its electronic equipment. The angle of the vertical section of the air dam may vary between 45° and 120°, with a preferred angle of 90° or less, measured from the floor on the exterior side of the air dam. The placement of the air dam may be offset relative to the wall starting that room by a given distance of between approximately 6 to 18 inches. The size and shape of the air dam is formed to cause a turbulent airflow effect underneath the raised floor and then through the perforations in tiles on a surface of the raised floor in order to create the constant pressure through the perforated tiles. In some embodiments, the air dam may be a planar surface of generally equal thickness along the projection, such that the projection is generally rectangular in cross section. The thickness of planar surface may also be tapered or reverse tapered toward the upper edge, such that the planar surface is thicker or thinner along a bottom portion of the surface than toward a top edge of the surface, such that the surfaces creates a generally triangular or trapezoidal cross section. The taper may also be non-linear such that the surface is non-planar, concave or convex toward the incoming air stream. In some embodiments, the air dam **1113** is a planar or generally planar projection from the floor toward the raised floor perpendicularly oriented from the floor at approximately half of the height between the floor to the underside of the raised floor.

[0099] The air dam may be made of one or more plastic, metal, carbon, polymer, composites or combinations thereof. The air dam should be sufficiently rigid to maintain its shape and orientation against the force and pressure of the incoming air stream.

[0100] The top edge of the air dam projects into the under floor space of the under floor plenum. The air dam **1113** creates a barrier or obstacle to the air flow as it transitions from the air-supply plenum **112** to the under floor plenum portion of the air-supply plenum **112**. The air dam **1113** is positioned to obstruct the air flow and generally reduce the velocity of the air flow entering the under floor plenum. Accordingly, the top edge of the air dam is positioned between 25% to 75%, and preferably between 40% to 60% and more preferably about 50% of the height of the under floor plenum from the actual floor toward the raised floor. Therefore, an air passage is created over the top of the air dam **1113** between the air dam and the raised floor. The air dam has a maximum height (h) measured from the actual floor toward the raised floor. The air dam **1113** height (h) may be approximately 12-24 inches, preferably 16 to 20 inches, and more preferably 18 inches.

[0101] The air dam **1113** may be positioned at an offset from the exterior side of the interior wall toward the under floor plenum, i.e. toward the interior of the data floor **114** or away from an exterior wall of the modular datacenter facility **100**. In an embodiment, the air dam **1113** may be offset from the exterior side of the interior wall by 0-5% of the length of raised floor length (L), and more specifically from 0.5 to 1.5% of the length of the raised floor. Alternatively, the air dam **1113** may be offset from the exterior side of the interior wall by a distance equal to or less than the width (w) of the air-supply plenum **112** and/or the height (y) of the under

floor plenum portion of the air-supply plenum **112**. Preferably, the air dam **1113** is offset (x) by approximately ¼ to ½ of the air-supply plenum width (w) and/or air-supply plenum height (y). In an embodiment, the air dam **1113** may be offset from the exterior side of the interior wall by 0 to 24 inches, 6 to 18 inches, or preferably 10 to 14 inches.

[0102] The offset placement tends to control where the constant air pressure and thus air flow in cubic feet per minute (CFM) begins. The constant airflow caused by the air dam through the under floor system to the entire room of the data floor tends to minimize or eliminate hotspots from occurring inside the room. This allows greater freedom of placement and arrangement of electrical equipment inside the data room than ever before. Additionally, a layout of electrical equipment can be altered and changed in the future without having to potentially change any HVAC ducting, HVAC cooling units, etc. and potentially with only a minimal amount of switching around or adding of perforated tiles to affect the airflow in that area of the data floor room. The even air pressure distribution caused by the air dam in the under floor plenum, which results in a constant airflow through the perforated floor system, allows an electrical equipment layout in the data floor with even smaller dimensions for hot and cold aisles than standard configurations. For example, 3 foot or less hot aisles and/or 4 foot or less cold aisles may be achieved with embodiments described herein. Thus, the placement of electrical equipment such as servers, storage devices, etc. can be freely placed in any geographical area in the data room rather than having to set up the equipment in a prescribed/pre-designed manner.

[0103] The air dam **1113** is configured and positioned to create a generally even distribution of pressure in the under floor plenum across the entirety of the raised floor. Alternatively, embodiments as described herein may be used to control the pressure distribution across a majority of or substantial portion of the raised floor. For example, the pressure distribution at the raised floor on the under floor plenum side of the air dam may be controlled for generally constant pressure. Accordingly, approximately 90-100%, and preferably 95-100% of the floor length experiences constant pressure distribution of the injected air. The portion of generally constant pressure may be measured across the entire raised floor. Generally, even distribution of pressure is understood to be a pressure distribution more homogeneous than that achieved without an air dam. For example, the desired pressure distribution across the raised floor is maintained at or above 0.04 inches of water, and preferably between 0.04 to 0.07 and more preferably between 0.05 and 0.06. Accordingly, the pressure distribution across the raised floor may vary in embodiments by 0.04 inches of water, and more preferably by 0.02 inches of water across the entire raised floor. The pressure distribution across a majority of substantial portion of the raised floor may vary by 0.01 inches of water or less and more preferably by 0.05 inches of water. Embodiments as described herein may achieve a positive pressure distribution across the entire raised floor with a pressure variation of less than 25% of an average pressure across the raised floor, and more preferably of less than 20%, 10%, or 5%.

[0104] Embodiments as described herein may achieve more efficient distribution of air into the data room. For the same amount of energy to supply an incoming air source at a given velocity and/or pressure, the pressure achieved within the data room without the air dam is substantially

reduced. For example, for the same source velocity and pressure, the air pressure across the raised floor may be improved by 2-3 times. Thus, pressures of only 0.02 to 0.03 inches water may be achieved with contemporary systems without an air dam, while pressures of 0.06 to 0.07 inches water may be achieved with the same source supply conditions with a system incorporating embodiments described herein.

[0105] The HVAC cooling units **122**, **124**, **222**, **224**, etc. and cooling system overall perform better to consume less electrical energy to supply a given amount of cooling for a given amount of electrical consumption by the electrical equipment contained inside the data floor room. For example, due to the constant airflow and consistent pressure, a 10,000 square-foot data room can fit **500** racks of electrical equipment in multiple layouts and arrangements inside that data room floor space of 10,000 feet. The same HVAC units and air dam placement can be used to support those multiple configurations of electrical equipment within the data floor of the datacenter.

Methods

[0106] FIG. **12** illustrates a method **1200** of the modular datacenter facility **100** in accordance with some embodiments.

[0107] In a first step **1210** of the method, the method can include constructing a modular datacenter facility with at least an initial set of building modules of different types of functionality to form the modular datacenter facility. Each type of building module in the set can have a specific collection of functionality associated with that type of building module. Each building module of the set can be a pre-engineered, standardized building block having a standardized, pre-approved architectural design and layout. A first type of building module in the modular datacenter facility can be a data-floor building module that is pre-engineered and has the pre-approved architectural design and layout to house computing systems.

[0108] In a second step **1220** of the method, the method can include housing, in hot and cool zones of a data-floor building module, computing systems including servers and storage devices, as well as routers and switches, to transport data traffic between the servers and a world exterior to the modular datacenter facility.

[0109] In a third step **1230** of the method, the method can include connecting a first set of sidewall-connected HVAC units for the data-floor building module to a sidewall of the modular datacenter facility and using electrical power provided by a first electrical power distribution building module to supply conditioned air into an air-supply plenum of the sidewall. The sidewall can be a sidewall of the data-floor building module or a service corridor. The conditioned air can be supplied in order to cool the computing systems including the servers, storage devices, routers, and switches, and other electronic components housed in the data-floor building module of the modular datacenter facility. The first set of the sidewall-connected HVAC units can allow for cooling of the computing systems and the other electronic components allowing for more server units to consume electrical power during their operation inside the data-floor building module without raising a temperature in the data-floor building module high enough to overheat the computing systems and the other electronic components. The first set of the sidewall-connected HVAC connecting to the

sidewall units can allow for fewer penetrations in a roof of the data-floor building module, thereby minimizing an amount of leaks potentially occurring in the roof of the ceiling, and thereby minimizing risk of any damage to the computing systems and the other electronic components housed in the data-floor building module from the leaks.

[0110] In a fourth step **1240** of the method, the method can include sealing a roof with a vapor-to-air sealant layer on top of a concrete layer to further prevent leaks from potentially occurring in the data-floor building module from in through the roof.

[0111] In such embodiments, the method can further include a fifth step including constructing an air channel, including any of a duct, a plenum, and a combination of one or more ducts and plenums for an air-flow path for the conditioned air beginning at the first set of the sidewall-connected HVAC units, through the air-supply plenum of the sidewall, through an under-floor plenum positioned under a raised floor of the data-floor building module, through the raised floor of the data-floor building module, through one or more perforated tiles covering the raised floor, and into an interior of the data-floor building module for the cooling of the computing systems and the other electronic components housed in the data floor building module.

[0112] In such embodiments, the method can further include a sixth step including constructing the air channel for the air-flow path of the conditioned air to continue from the interior of the data-floor building module and through a ceiling of the of the data-floor building module, where one or more return ducts above the ceiling route heated air from above the data-floor building module down along the sidewall and back to an air intake of the first set of the sidewall-connected HVAC units. The first set of the sidewall-connected HVAC units can remove heat from the heated air to provide the conditioned air for recirculation of the conditioned air through the air channel, including through the air-supply plenum of the sidewall, through the under-floor plenum, and through the raised floor of the data-floor building module for the cooling of the computing systems and the other electronic components.

[0113] In such embodiments, the method can further include a seventh step including configuring the first set of the sidewall-connected HVAC units with heat exchangers to remove heat from recirculating conditioned air inside the data-floor building module without introducing air from outside the data-floor building module, thereby preventing outside air with humidity and potential pollution from mixing with the recirculating conditioned air inside the data-floor building module, and thereby minimizing damage to the computing systems and the other electronic components housed in the data-floor building module. The first set of the sidewall-connected HVAC units can use the heat exchangers rather than louvers to remove the heat from the recirculating conditioned air supplied to the air channel from inside the data-floor building module.

[0114] In such embodiments, the method can further include an eighth step including configuring the first set of the sidewall-connected HVAC units with the heat exchangers to work with at least one other HVAC unit that brings in the outside air as makeup air to make up for losses in the recirculated conditioned air. The at least one other HVAC unit can include a humidity-control system and a pollution-control system configured to control the humidity and the

potential pollution of the makeup air that enters the modular datacenter facility for the losses in the recirculated conditioned air.

[0115] In such embodiments, the method can further include a ninth step including adding an additional one or more sets of the building modules of the different types to the initial set of the building modules upon a parcel of land when a need of space and additional capacity of the modular datacenter facility develops, thereby transforming the modular datacenter facility by a step-by-step approach carried out over time by addition of the additional one or more sets of the building modules of the different types. The ninth step can further include architecting one or more connecting corridors into the building modules of the different types. And the ninth step can further include aligning doorways between the building modules of the different types inter-connecting at least two building modules adjacent and abutted to each other.

[0116] In such embodiments, the method can further include a tenth step including constructing the air supply plenum and an air return channel of the sidewall of the modular datacenter facility. The air-supply plenum and the air-return plenum of the sidewall of the modular datacenter facility can have the pre-approved architectural design and layout for adding additional sidewall-connected HVAC units at a later date from initial construction of the modular datacenter facility with the initial set of building modules of the different types of functionality.

[0117] In such embodiments, the method can further include a eleventh step including configuring the first set of the sidewall-connected HVAC units to allow the first set of the sidewall-connected HVAC units to be installed during a first time period of the data-floor building module to cool the computing systems and the other electronic components housed in the data-floor building module during the first time period. At a second, later time period of the data-floor building module, the eleventh step can further include configuring the first set of the sidewall-connected HVAC units to allow a second set of the sidewall-connected HVAC units to be proximately installed and connected into the air-supply plenum and the air-return plenum of the sidewall to cool the computing systems and the other electronic components housed in the data-floor building module during the second time period of the data-floor building module.

[0118] In such embodiments, the method can further include a twelfth step including installing the second set of the sidewall-connected HVAC units with the pre-approved architectural design and layout selected from the group consisting of i) horizontally along the sidewall of the modular datacenter facility in line with the first set of the sidewall-connected HVAC units, ii) vertically up the sidewall of the modular datacenter facility in a configuration on top of the first set of the sidewall-connected HVAC units, or iii) in a combination of horizontally along the sidewall of the modular datacenter facility and vertically up the sidewall of the modular datacenter facility in the configuration on top of the first set of sidewall-connected HVAC units. The twelfth step can further include powering the second set of sidewall-connected HVAC units by a second electrical power distribution building module in order to allow an increase in power and cooling capability over time for the data-floor building module. The sidewall of the modular datacenter facility can be constructed with the pre-approved architectural design and layout to add the second electrical power

distribution module with electrical conduits and trays routed through the sidewall during the second time period of the data-floor building module.

[0119] In such embodiments, the method can further include a thirteenth step including horizontally connecting two parallel sections of wall of a data-hall building module of the initial set of the building modules with a steel-based joist or concrete beam to eliminate a need for support columns on a raised floor of the data-hall building module to support the computing systems and the other electronic components. The steel-based joist or concrete beam can ensure that users of the data-floor building module have a sufficient degree of flexibility to accommodate a number of server-rack configurations for racks of the servers having varying power consumption densities in the hot and the cool zones of the data-hall building module. The raised floor can house the computing systems and other electronic components as well as create a single, under-floor plenum configured for supplying the conditioned air under the raised floor to an interior of the data-hall building module and returning heated air to a return plenum or return ducts in a ceiling above the data-floor building module for return of the heated air to the first set of sidewall-connected HVAC units.

[0120] In such embodiments, the method can further include a fourteenth step including constructing a service corridor and a personnel corridor along a length of at least some of the initial set of building modules connected in the modular datacenter facility. A hardened-structure building module of the initial set of building modules can include a hardened shell and one or more service or personnel corridors between a first instance of the hardened-structure building module and a second instance of the hardened-structure building module connecting to and abutting the first instance of the hardened-structure building module. The one or more service or personnel corridors can be laid out between an interior wall and an exterior wall of the hardened-structure building module forming the hardened shell of the hardened-structure building module. The roof further can include an insulation layer and a cover-board layer on top of the vapor-to-air sealant layer.

[0121] While some specific embodiments of the design have been shown, the design is not to be limited to these embodiments. The design is to be understood as not limited by the specific embodiments described herein, but only by the scope of the appended claims. Moreover, specific components and various embodiments have been shown and described. It should be understood that the invention covers any combination, sub-combination, or re-combination, including duplicating components, subtracting components, combination components, integrating components, separating components, and/or dividing components.

[0122] The terms “approximately” and “about” are used interchangeably to indicate that the disclosed and suggested values do not require exact precision. The relative inclusions of values around each value depends on the error in building, manufacturing, and installing the components, as is generally practiced by a person of skill in the art. Even without the specific identification of approximation (i.e. the term “about” or “approximate”), all of the dimensions disclosed are examples only and include equivalent or approximate values to the stated value to achieve similar, equal, or better benefits or effects to those of the disclosed dimensions. “Majority” is understood to be more than 50% of the floor

area, while “substantial” is understood to be at least more than 75% of the floor and preferably more than 85% of the floor area.

What is claimed is:

1. An apparatus, comprising:

a modular datacenter facility constructed with at least an initial set of building modules of different types of functionality to form the modular datacenter facility, wherein each type of building module in the set has a specific collection of functionality associated with that type of building module,

wherein each building module of the set is a pre-engineered, standardized building block having a standardized, pre-approved architectural design and layout,

wherein a first type of building module in the modular datacenter facility is a data-floor building module that is pre-engineered and has the pre-approved architectural design and layout to house computing systems,

wherein the computing systems include servers and storage devices housed in hot and cool zones of the data-floor building module and routers and switches to transport data traffic between the servers as well as transport traffic to a world exterior to the modular datacenter facility,

wherein a first set of sidewall-connected heating, ventilation, and air conditioning (“HVAC”) units for the data-floor building module connect to a sidewall of the modular datacenter facility and use electrical power provided by a first electrical power distribution building module to supply conditioned air into an air-supply plenum of the sidewall, which can be a sidewall of the data-floor building module or a service corridor, in order to cool the computing systems including the servers, storage devices, routers, and switches, and other electronic components housed in the data-floor building module of the modular datacenter facility,

wherein the first set of the sidewall-connected HVAC units allow for cooling of the computing systems and the other electronic components allowing for more server units to consume electrical power during their operation inside the data-floor building module without raising a temperature in the data-floor building module high enough to overheat the computing systems and the other electronic components,

wherein the first set of the sidewall-connected HVAC units connecting to the sidewall allow for fewer penetrations in a roof of the data-floor building module, thereby minimizing an amount of leaks potentially occurring in the roof of the ceiling, and thereby minimizing risk of any damage to the computing systems and the other electronic components housed in the data-floor building module from the leaks, and

wherein the roof includes a vapor-to-air sealant layer on top of a concrete layer to further prevent leaks from potentially occurring in the data-floor building module from in through the roof.

2. The apparatus of claim 1,

wherein an air channel, including any of a duct, a plenum, and a combination of one or more ducts and plenums, begins an air-flow path of the conditioned air at the first

set of the sidewall-connected HVAC units, through the air-supply plenum of the sidewall, through an under-floor plenum positioned under a raised floor of the data-floor building module, through the raised floor of the data-floor building module, through one or more perforated tiles covering the raised floor, and into an interior of the data-floor building module for the cooling of the computing systems and the other electronic components housed in the data-floor building module.

3. The apparatus of claim 2,

wherein the air channel air-flow path of the conditioned air continues from the interior of the data-floor building module, through a ceiling of the of the data-floor building module, where one or more return ducts above the ceiling route heated air from above the data-floor building module down along the sidewall and back to an air intake of the first set of the sidewall-connected HVAC units, and

wherein the first set of the sidewall-connected HVAC units remove heat from the heated air to provide the conditioned air for recirculation of the conditioned air through the air channel, including through the air-supply plenum of the sidewall, through the under-floor plenum, and through the raised floor of the data-floor building module for the cooling of the computing systems and the other electronic components.

4. The apparatus of claim 1,

wherein the first set of the sidewall-connected HVAC units are configured with heat exchangers to remove heat from recirculating conditioned air inside the data-floor building module without introducing air from outside the data-floor building module, thereby preventing outside air with humidity and potential pollution from mixing with the recirculating conditioned air inside the data-floor building module, and thereby minimizing damage to the computing systems and the other electronic components housed in the data-floor building module, and

wherein the first set of the sidewall-connected HVAC units use the heat exchangers rather than louvers to remove the heat from the recirculating conditioned air supplied to the air channel from inside the data-floor building module.

5. The apparatus of claim 4,

wherein the first set of the sidewall-connected HVAC units configured with the heat exchangers are further configured to work with at least one other HVAC unit that brings in the outside air as makeup air to make up for losses in the recirculated conditioned air, and

wherein the at least one other HVAC unit includes a humidity-control system and a pollution-control system configured to control the humidity and the potential pollution of the makeup air that enters the modular datacenter facility for the losses in the recirculated conditioned air.

6. The apparatus of claim 1,

wherein the initial set of the building modules form the modular datacenter facility upon a parcel of land, and, when a need of space and additional capacity of the modular datacenter facility develops, then an additional one or more sets of the building modules of the different types are rapidly added to the initial set of the building modules, thereby transforming the modular datacenter facility by a step-by-step approach carried

out over time by addition of the additional one or more sets of the building modules of the different types, wherein one or more connecting corridors are architected into the building modules of the different types, and wherein corresponding aligned doorways between the building modules of the different types interconnect at least two building modules adjacent and abutted to each other.

7. The apparatus of claim 1,

wherein the air-supply plenum and an air-return plenum of the sidewall of the modular datacenter facility are constructed with the pre-approved architectural design and layout to add additional sidewall-connected HVAC units at a later date from initial construction of the modular datacenter facility with the initial set of building modules of the different types of functionality, and wherein the first set of the sidewall-connected HVAC units are configured to allow the first set of the sidewall-connected HVAC units to be installed during a first time period of the data-floor building module to cool the computing systems and the other electronic components housed in the data-floor building module during the first time period, and then, at a second, later time period of the data-floor building module, the first set of the sidewall-connected HVAC units are configured to allow a second set of the sidewall-connected HVAC units to be proximately installed and connected into the air-supply plenum and the air-return plenum of the sidewall to cool the computing systems and the other electronic components housed in the data-floor building module during the second time period of the data-floor building module.

8. The apparatus of claim 7,

wherein the second set of the sidewall-connected HVAC units are installed with the pre-approved architectural design and layout selected from the group consisting of

- i) horizontally along the sidewall of the modular datacenter facility in line with the first set of the sidewall-connected HVAC units,
- ii) vertically up the sidewall of the modular datacenter facility in a configuration on top of the first set of the sidewall-connected HVAC units,
- iii) or a combination of horizontally along the sidewall of the modular datacenter facility and vertically up the sidewall of the modular datacenter facility in the configuration on top of the first set of sidewall-connected HVAC units,

wherein the second set of sidewall-connected HVAC units are powered by a second electrical power distribution building module in order to allow an increase in power and cooling capability over time for the data-floor building module, and

wherein the sidewall of the modular datacenter facility is constructed with the pre-approved architectural design and layout to add the second electrical power distribution module with electrical conduits and trays routed through the sidewall during the second time period of the data-floor building module.

9. The apparatus of claim 1,

wherein a data-hall building module of the initial set of the building modules includes a steel-based joist or concrete beam that horizontally connects two parallel sections of wall of the data-hall building module to eliminate a need for support columns on a raised floor

of the data-hall building module for supporting the computing systems and the other electronic components,

wherein the steel-based joist or concrete beam ensures that users of the data-floor building module have a sufficient degree of flexibility to accommodate a number of server-rack configurations for racks of the servers having varying power consumption densities in the hot and the cool zones of the data-hall building module, and

wherein the raised floor houses the computing systems and other electronic components as well as creates a single, under-floor plenum configured for supplying the conditioned air under the raised floor to an interior of the data-hall building module and returning heated air to a return plenum or return ducts in a ceiling above the data-floor building module for return of the heated air to the first set of sidewall-connected HVAC units.

10. The apparatus of claim 9,

wherein a service corridor and a personnel corridor run a length of at least some of the initial set of building modules connected in the modular datacenter facility, wherein a hardened-structure building module of the initial set of building modules includes a hardened shell and one or more service or personnel corridors between a first instance of the hardened-structure building module and a second instance of the hardened-structure building module connect to and abutting the first instance of the hardened-structure building module,

wherein the one or more service or personnel corridors are laid out between an interior wall and an exterior wall of the hardened-structure building module forming the hardened shell of the hardened-structure building module, and

wherein the roof further includes an insulation layer and a cover-board layer on top of the vapor-to-air sealant layer.

11. A method, comprising:

constructing a modular datacenter facility with at least an initial set of building modules of different types of functionality to form the modular datacenter facility, wherein each type of building module in the set has a specific collection of functionality associated with that type of building module,

wherein each building module of the set is a pre-engineered, standardized building block having a standardized, pre-approved architectural design and layout, and

wherein a first type of building module in the modular datacenter facility is a data-floor building module that is pre-engineered and has the pre-approved architectural design and layout to house computing systems;

housing, in hot and cool zones of the data-floor building module, the computing systems including servers and storage devices, as well as routers and switches, to transport data traffic between the servers and a world exterior to the modular datacenter facility;

connecting a first set of sidewall-connected heating, ventilation, and air conditioning ("HVAC") units for the data-floor building module to a sidewall of the modular datacenter facility and using electrical power provided by a first electrical power distribution building module to supply conditioned air into an air-supply plenum of

the sidewall, which can be a sidewall of the data-floor building module or a service corridor, in order to cool the computing systems including the servers, storage devices, routers, and switches, and other electronic components housed in the data-floor building module of the modular datacenter facility,

wherein the first set of the sidewall-connected HVAC units allow for cooling of the computing systems and the other electronic components allowing for more server units to consume electrical power during their operation inside the data-floor building module without raising a temperature in the data-floor building module high enough to overheat the computing systems and the other electronic components, and

wherein the first set of the sidewall-connected HVAC connecting to the sidewall units allow for fewer penetrations in a roof of the data-floor building module, thereby minimizing an amount of leaks potentially occurring in the roof of the ceiling, and thereby minimizing risk of any damage to the computing systems and the other electronic components housed in the data-floor building module from the leaks; and

sealing the roof with a vapor-to-air sealant layer on top of a concrete layer to further prevent leaks from potentially occurring in the data-floor building module from in through the roof.

12. The method of claim **11**, further comprising:

constructing an air channel, including any of a duct, a plenum, and a combination of one or more ducts and plenums for an air-flow path for the conditioned air beginning at the first set of the sidewall-connected HVAC units, through the air-supply plenum of the sidewall, through an under-floor plenum positioned under a raised floor of the data-floor building module, through the raised floor of the data-floor building module, through one or more perforated tiles covering the raised floor, and into an interior of the data-floor building module for the cooling of the computing systems and the other electronic components housed in the data floor building module.

13. The method of claim **12**, further comprising:

constructing the air channel for the air-flow path of the conditioned air to continue from the interior of the data-floor building module, through a ceiling of the of the data-floor building module, where one or more return ducts above the ceiling route heated air from above the data-floor building module down along the sidewall and back to an air intake of the first set of the sidewall-connected HVAC units,

wherein the first set of the sidewall-connected HVAC units remove heat from the heated air to provide the conditioned air for recirculation of the conditioned air through the air channel, including through the air-supply plenum of the sidewall, through the under-floor plenum, and through the raised floor of the data-floor building module for the cooling of the computing systems and the other electronic components.

14. The method of claim **11**, further comprising:

configuring the first set of the sidewall-connected HVAC units with heat exchangers to remove heat from recirculating conditioned air inside the data-floor building module without introducing air from outside the data-

floor building module, thereby preventing outside air with humidity and potential pollution from mixing with the recirculating conditioned air inside the data-floor building module, and thereby minimizing damage to the computing systems and the other electronic components housed in the data-floor building module,

wherein the first set of the sidewall-connected HVAC units use the heat exchangers rather than louvers to remove the heat from the recirculating conditioned air supplied to the air channel from inside the data-floor building module.

15. The method of claim **14**, further comprising:

configuring the first set of the sidewall-connected HVAC units with the heat exchangers to work with at least one other HVAC unit that brings in the outside air as makeup air to make up for losses in the recirculated conditioned air,

wherein at least one other HVAC unit includes a humidity-control system and a pollution-control system configured to control the humidity and the potential pollution of the makeup air that enters the modular datacenter facility the losses in the recirculated conditioned air.

16. The method of claim **11**, further comprising:

adding an additional one or more sets of the building modules of the different types to the initial set of the building modules upon a parcel of land when a need of space and additional capacity of the modular datacenter facility develops, thereby transforming the modular datacenter facility by a step-by-step approach carried out over time by addition of the additional one or more sets of the building modules of the different types;

architecting one or more connecting corridors into the building modules of the different types; and

aligning doorways between the building modules of the different types interconnecting at least two building modules adjacent and abutted to each other.

17. The method of claim **11**, further comprising:

constructing the air supply plenum and an air return channel of the sidewall of the modular datacenter facility,

wherein the air-supply plenum and the air-return plenum of the sidewall of the modular datacenter facility have the pre-approved architectural design and layout for adding additional sidewall-connected HVAC units at a later date from initial construction of the modular datacenter facility with the initial set of building modules of the different types of functionality, and

configuring the first set of the sidewall-connected HVAC units to allow the first set of the sidewall-connected HVAC units to be installed during a first time period of the data-floor building module to cool the computing systems and the other electronic components housed in the data-floor building module during the first time period, and then, at a second, later time period of the data-floor building module, configuring the first set of the sidewall-connected HVAC units to allow a second set of the sidewall-connected HVAC units to be proximately installed and connected into the air-supply plenum and the air-return plenum of the sidewall to cool the computing systems and the other electronic

components housed in the data-floor building module during the second time period of the data-floor building module.

18. The method of claim **17**, further comprising:
installing the second set of the sidewall-connected HVAC units with the pre-approved architectural design and layout selected from the group consisting of

- i) horizontally along the sidewall of the modular data-center facility in line with the first set of the sidewall-connected HVAC units,
- ii) vertically up the sidewall of the modular datacenter facility in a configuration on top of the first set of the sidewall-connected HVAC units, or
- iii) in a combination of horizontally along the sidewall of the modular datacenter facility and vertically up the sidewall of the modular datacenter facility in the configuration on top of the first set of sidewall-connected HVAC units; and

powering the second set of sidewall-connected HVAC units by a second electrical power distribution building module in order to allow an increase in power and cooling capability over time for the data-floor building module,

wherein the sidewall of the modular datacenter facility is constructed with the pre-approved architectural design and layout to add the second electrical power distribution module with electrical conduits and trays routed through the sidewall during the second time period of the data-floor building module.

19. The method of claim **11**, further comprising:
horizontally connecting two parallel sections of wall of a data-hall building module of the initial set of the building modules with a steel-based joist or concrete beam to eliminate a need for support columns on a raised floor of the data-hall building module to support the computing systems and the other electronic components,

wherein the steel-based joist or concrete beam ensures that users of the data-floor building module have a sufficient degree of flexibility to accommodate a number of server-rack configurations for racks of the servers having varying power consumption densities in the hot and the cool zones of the data-hall building module, and

wherein the raised floor houses the computing systems and other electronic components as well as creates a single, under-floor plenum configured for supplying the conditioned air under the raised floor to an interior of the data-hall building module and returning heated air to a return plenum or return ducts in a ceiling above the data-floor building module for return of the heated air to the first set of sidewall-connected HVAC units.

20. The method of claim **19**, further comprising:
constructing a service corridor and a personnel corridor along a length of at least some of the initial set of building modules connected in the modular datacenter facility,

wherein a hardened-structure building module of the initial set of building modules includes a hardened shell and one or more service or personnel corridors between a first instance of the hardened-structure building module and a second instance of the hardened-structure building module connect to and abutting the first instance of the hardened-structure building module, and

wherein the one or more service or personnel corridors are laid out between an interior wall and an exterior wall of the hardened-structure building module forming the hardened shell of the hardened-structure building module,

wherein the roof further includes an insulation layer and a cover-board layer on top of the vapor-to-air sealant layer.

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