US 20170086333A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2017/0086333 A1

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(43) Pub. Date: Mar. 23, 2017

(54) SYSTEMS AND METHODS FOR COOLING DATA CENTERS AND OTHER ELECTRONIC EQUIPMENT

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(21) Appl. No.: **15/365,603**

(22) Filed: **Nov. 30, 2016**

Related U.S. Application Data

(63) Continuation of application No. 13/651,319, filed on Oct. 12, 2012, which is a continuation of application No. 12/384,109, filed on Mar. 30, 2009, now Pat. No. 8,523,643, which is a continuation-in-part of application No. 12/138,771, filed on Jun. 13, 2008.

(60) Provisional application No. 61/040,636, filed on Mar. 28, 2008, provisional application No. 60/944,082, filed on Jun. 14, 2007.

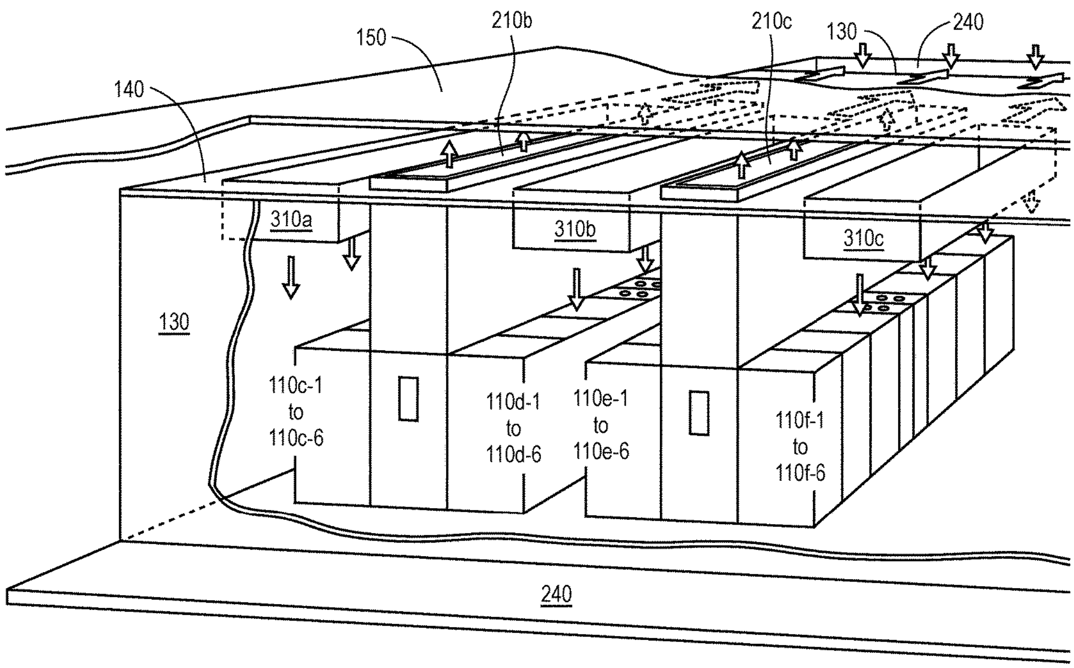
Publication Classification

(51) **Int. Cl.**
H05K 7/20 (2006.01)
F25B 25/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/20745*** (2013.01); ***F25B 25/005*** (2013.01); *F25B 2700/173* (2013.01)

(57) **ABSTRACT**

Described herein is an integrated data center that provides for efficient cooling, as well as efficient wire routing.



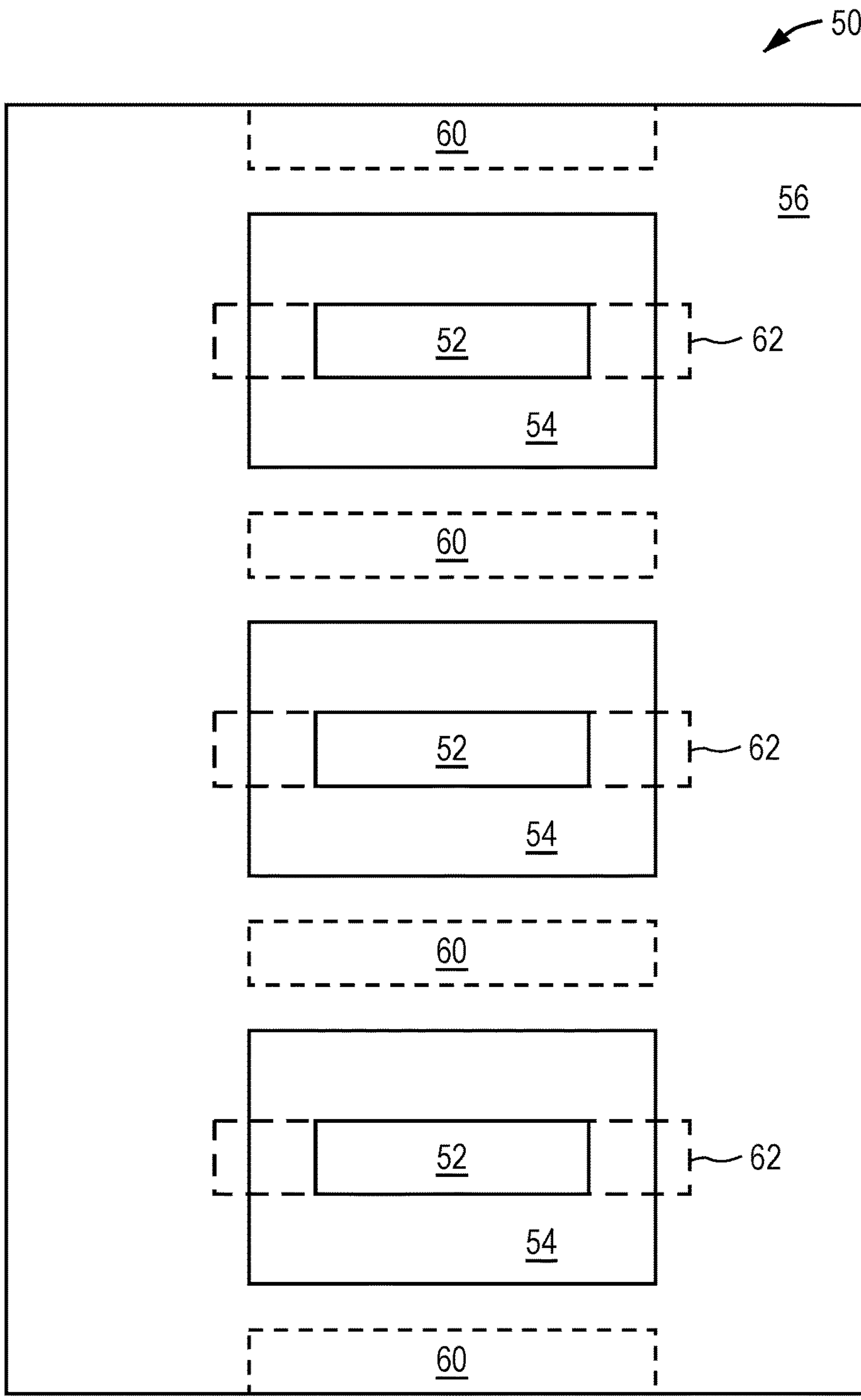


FIG. 1A

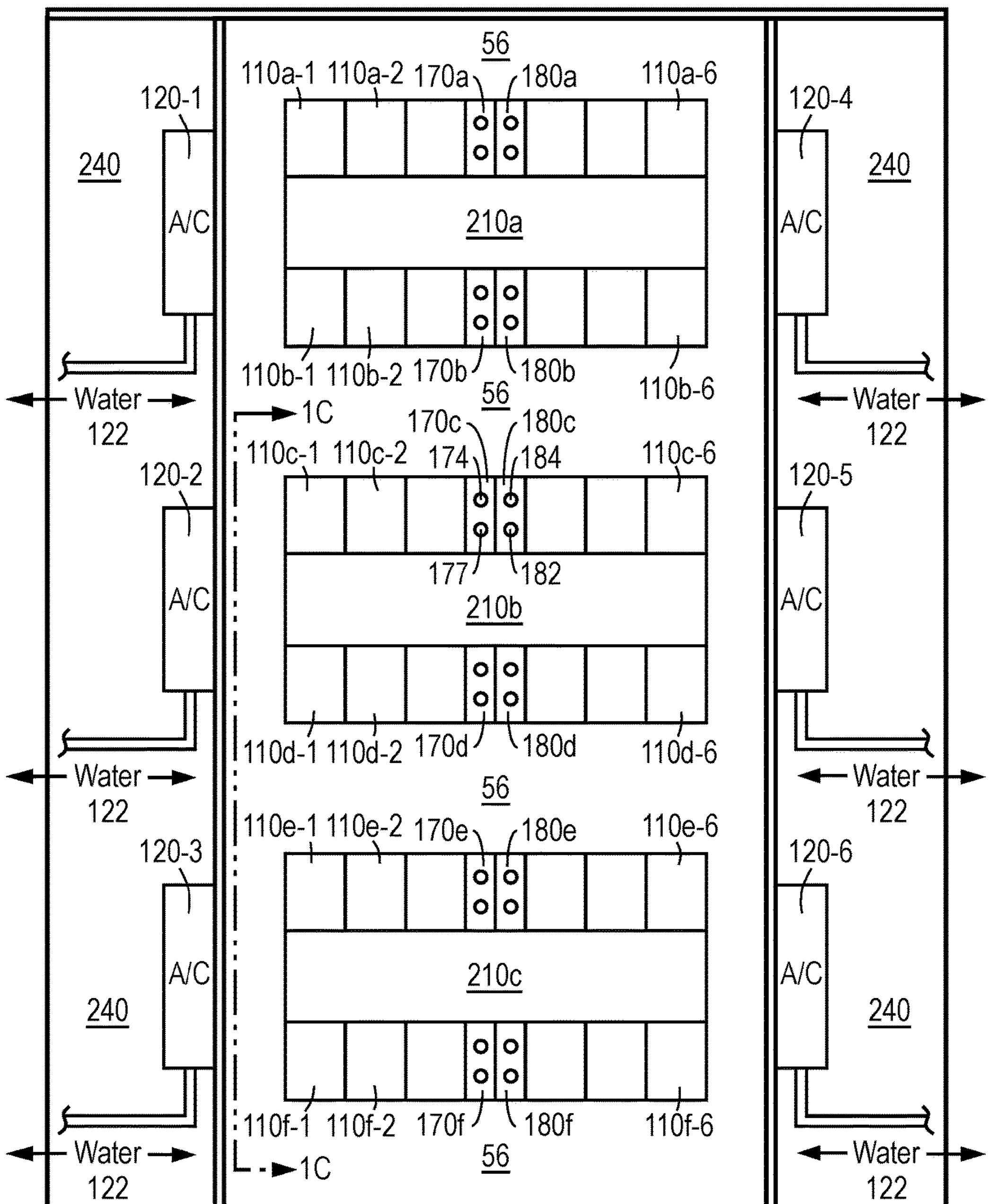

56
110a-1
110a-2
170a
180a
110a-6
120-1
120-4
240
A/C
210a
110b-1
110b-2
170b
180b
110b-6
Water
122
1C
170c
180c
110c-1
110c-2
174
184
110c-6
120-2
120-5
177
182
210b
110d-1
110d-2
170d
180d
110d-6
110e-1
110e-2
170e
180e
110e-6
120-3
120-6
210c
110f-1
110f-2
170f
180f
110f-6

FIG. 1B

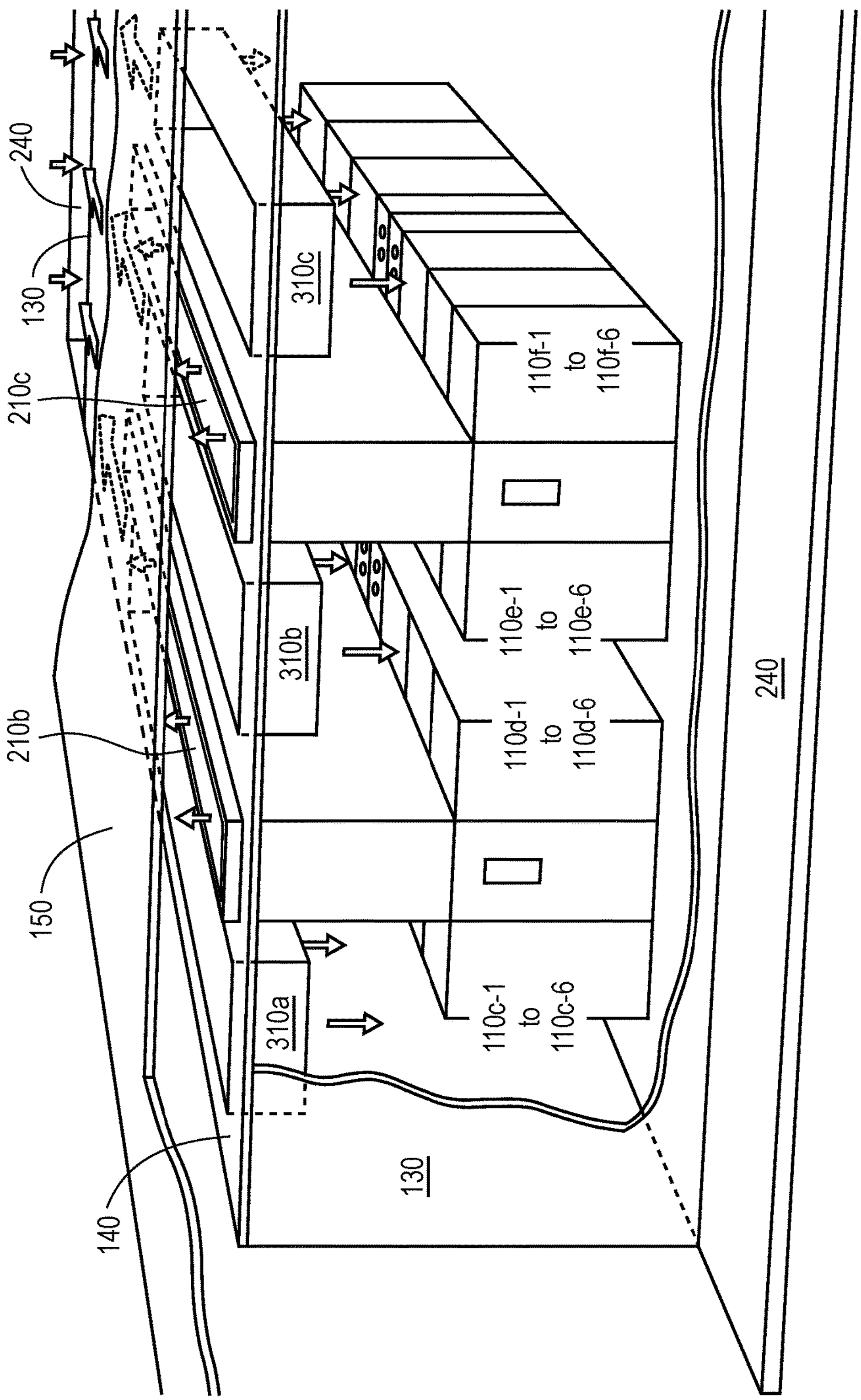

240
130
210c
210b
150
140
310c
310b
310a
110f-1 to 110f-6
110e-1 to 110e-6
110d-1 to 110d-6
110c-1 to 110c-6
130
240

FIG. 1C

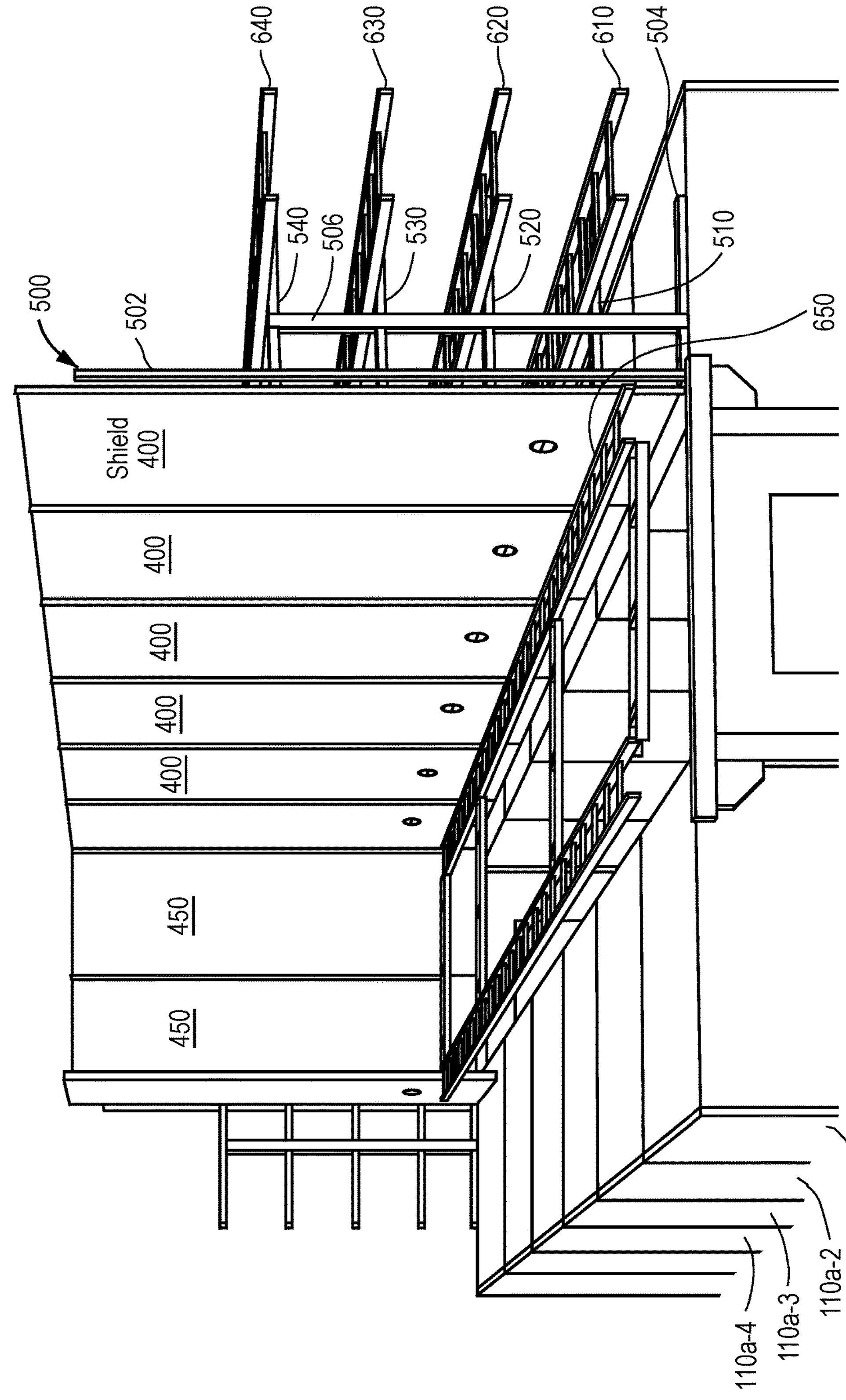

500
502
504
506
510
520
530
540
610
620
630
640
650
Shield 400
400
400
400
400
450
450
110a-1
110a-2
110a-3
110a-4

FIG. 2A

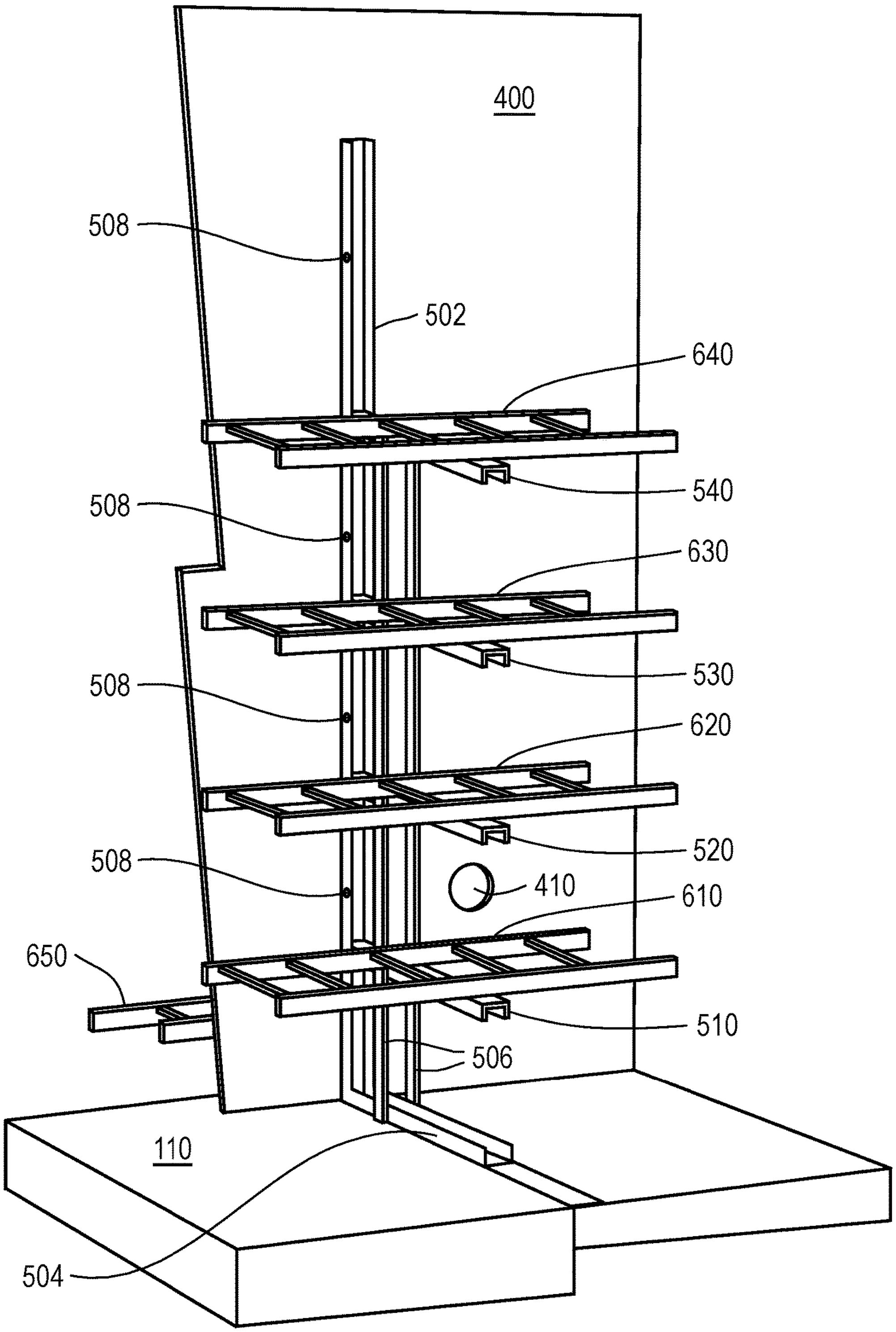

400
508
502
640
540
508
630
530
508
620
520
508
410
610
650
510
506
110
504

FIG. 2B

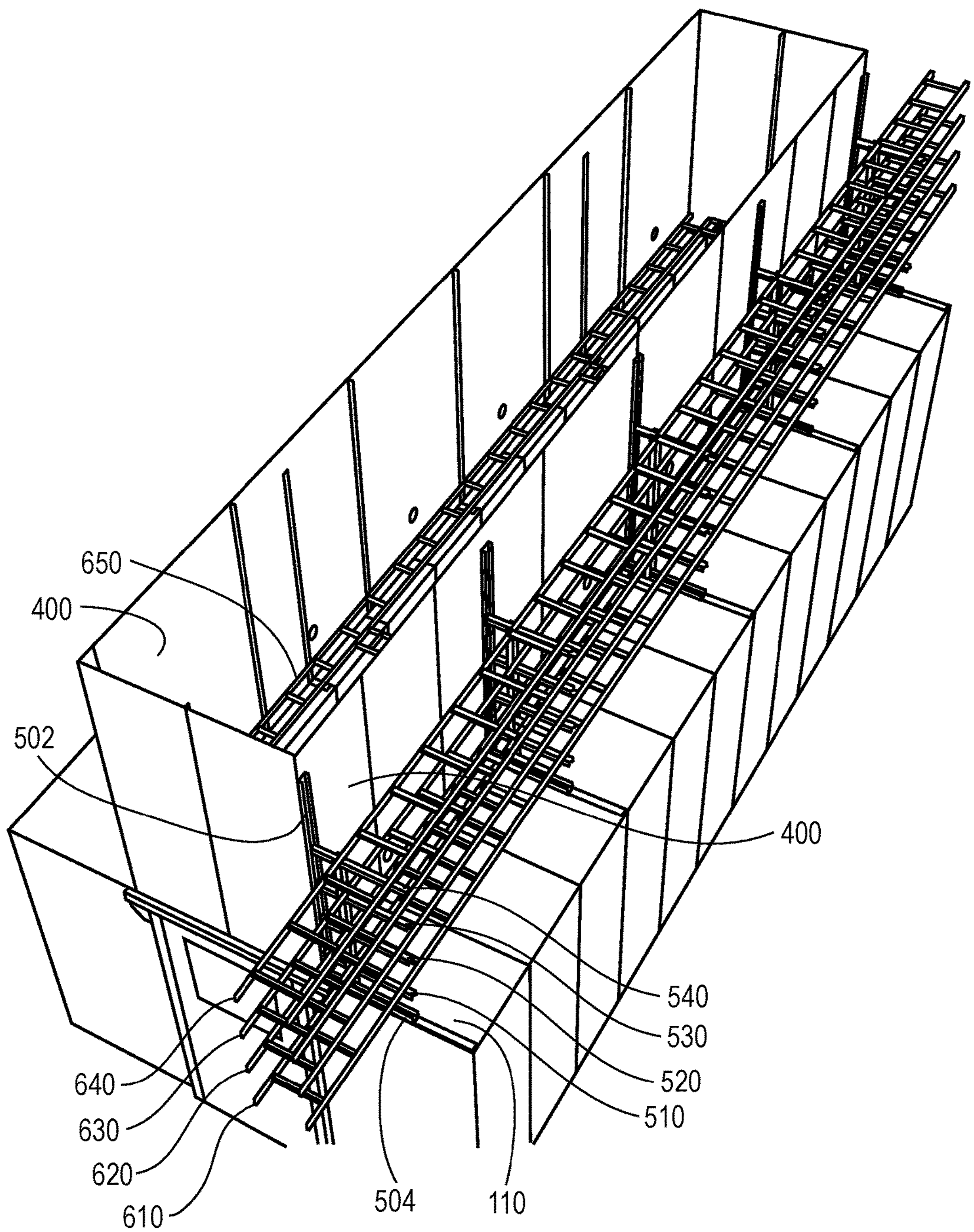


FIG. 2C

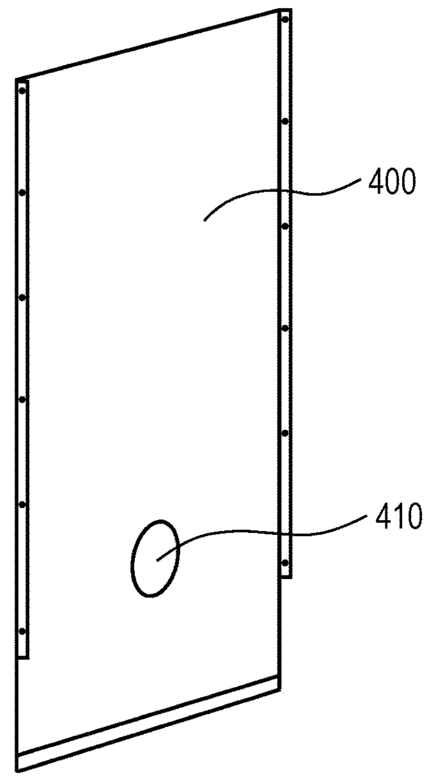


FIG. 3A

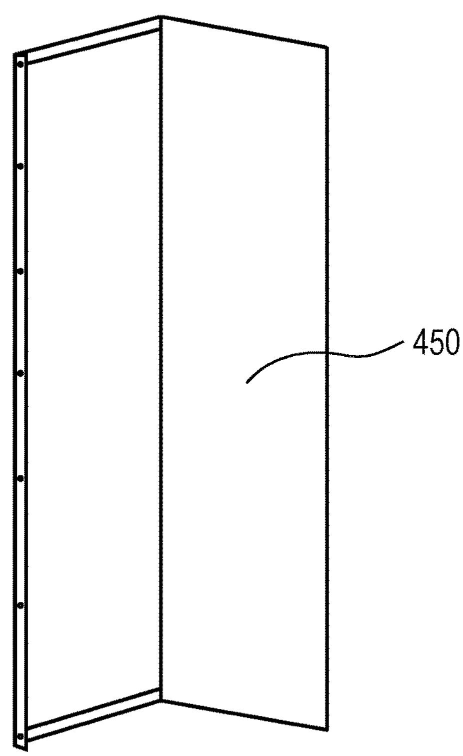


FIG. 3B

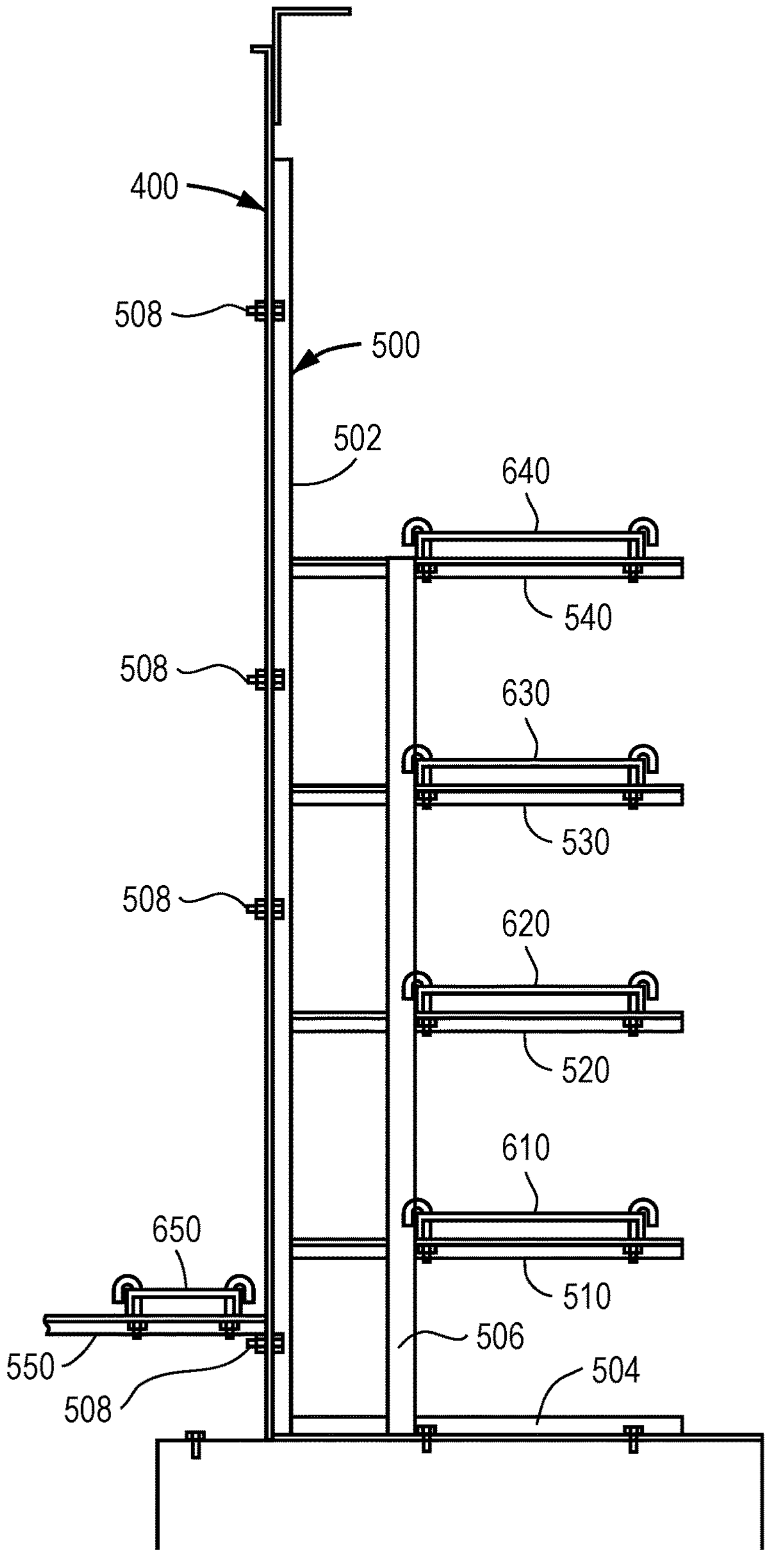

400
508
500
502
640
540
508
630
530
508
620
520
610
650
510
506
504
550
508

FIG. 4

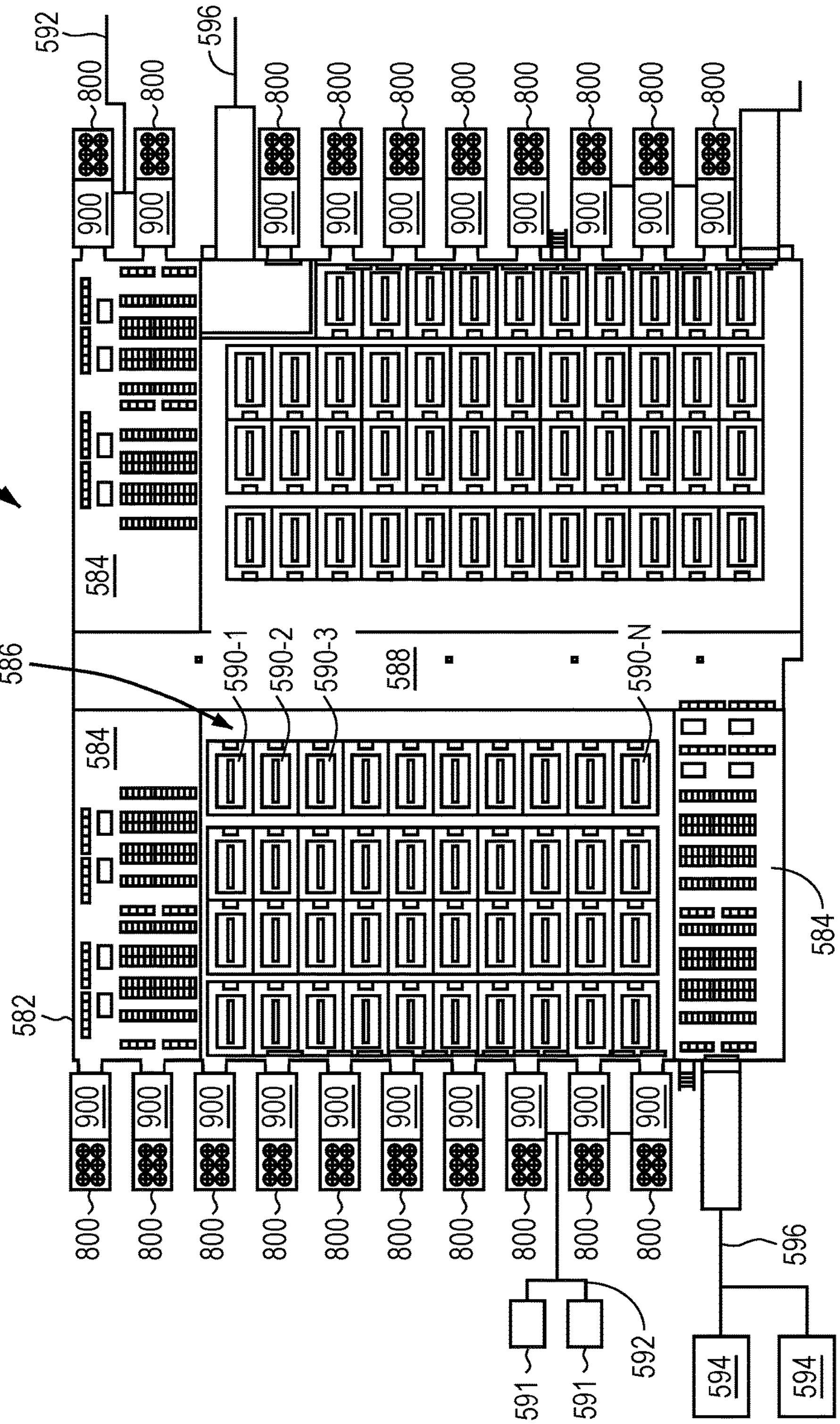


FIG. 5A

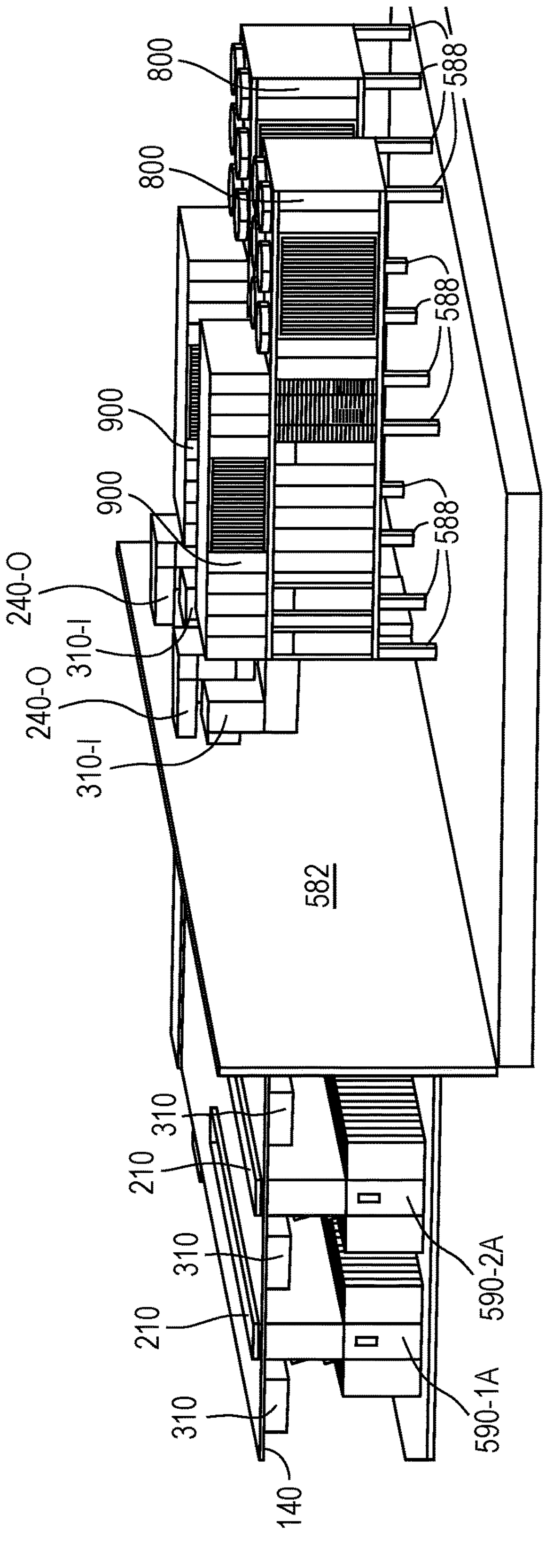

800
800
588
588
588
588
588
900
900
240-O
310-I
240-O
310-I
582
310
210
310
210
310
140
590-2A
590-1A

FIG. 5B1

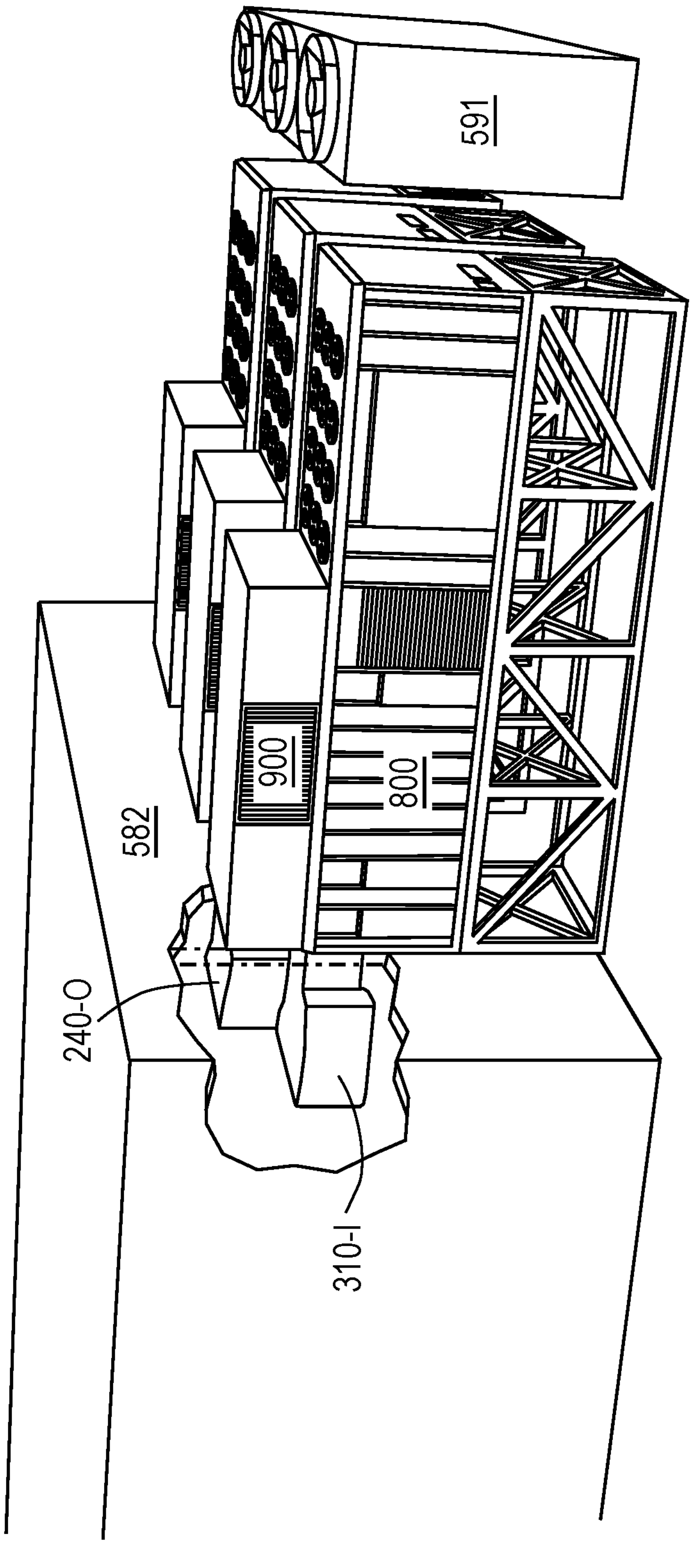


FIG. 5B2

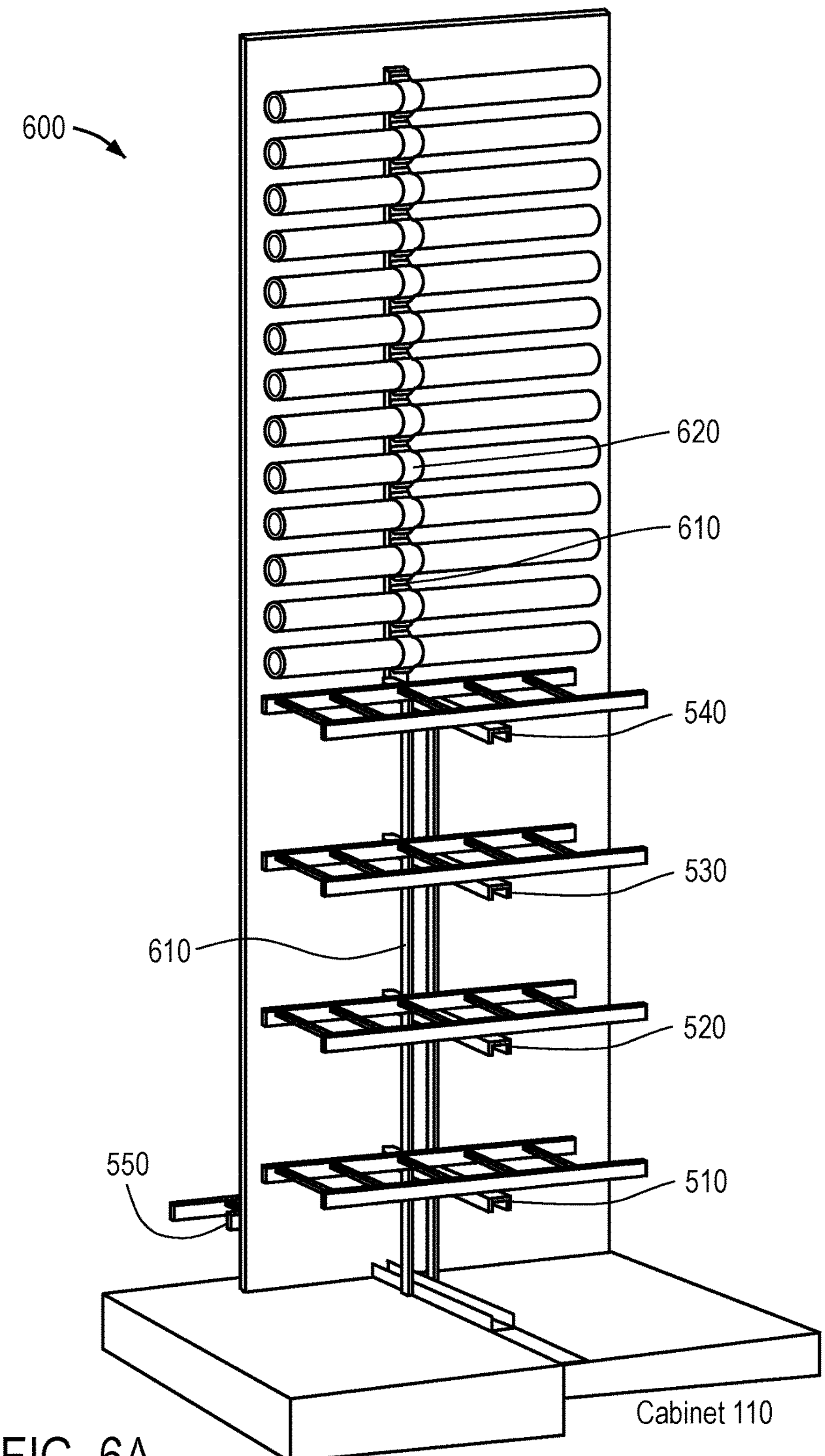


FIG. 6A

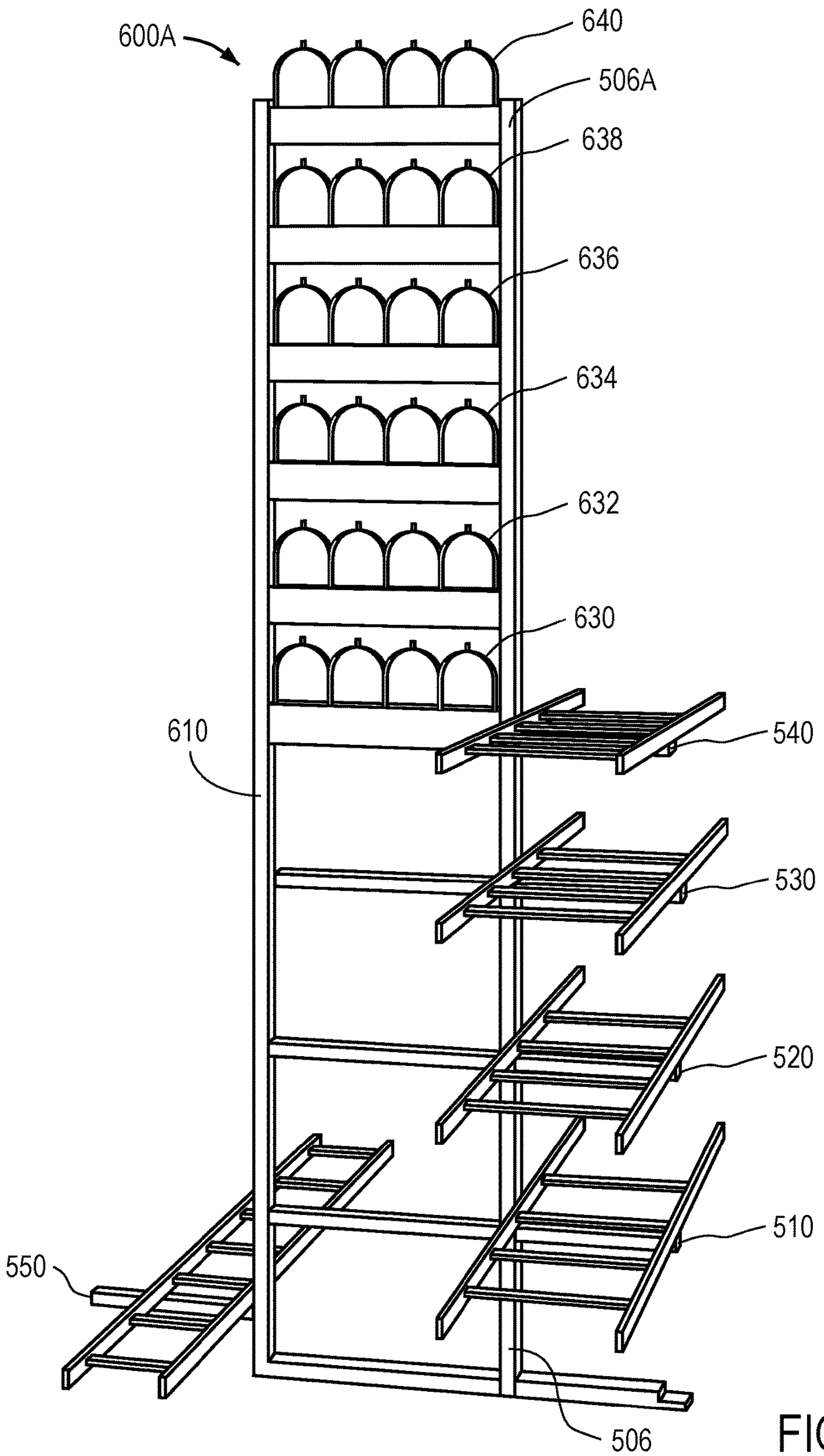


FIG. 6B

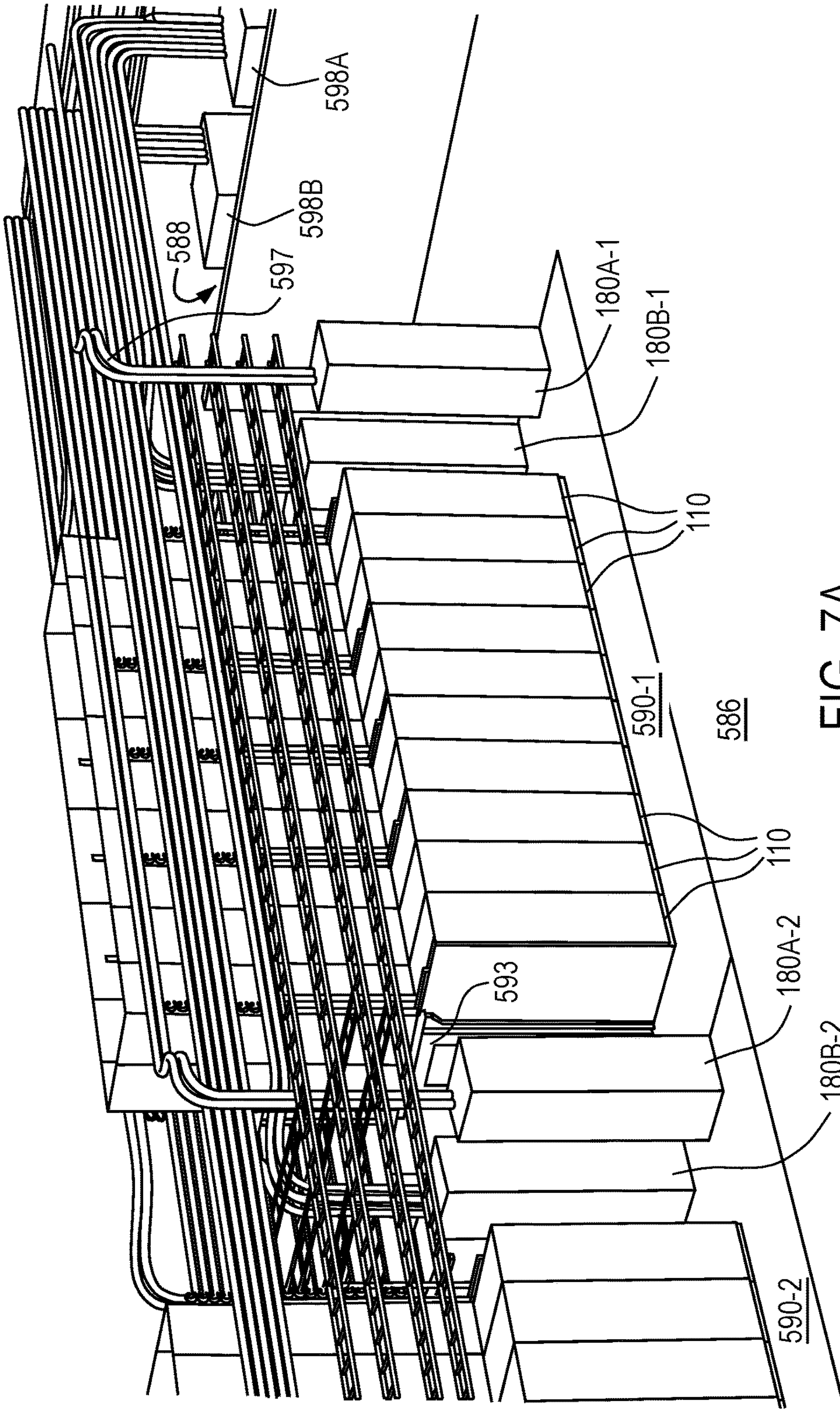

598A
598B
588
597
180A-1
180B-1
110
110
590-1
586
110
110
593
180A-2
180B-2
590-2

FIG. 7A

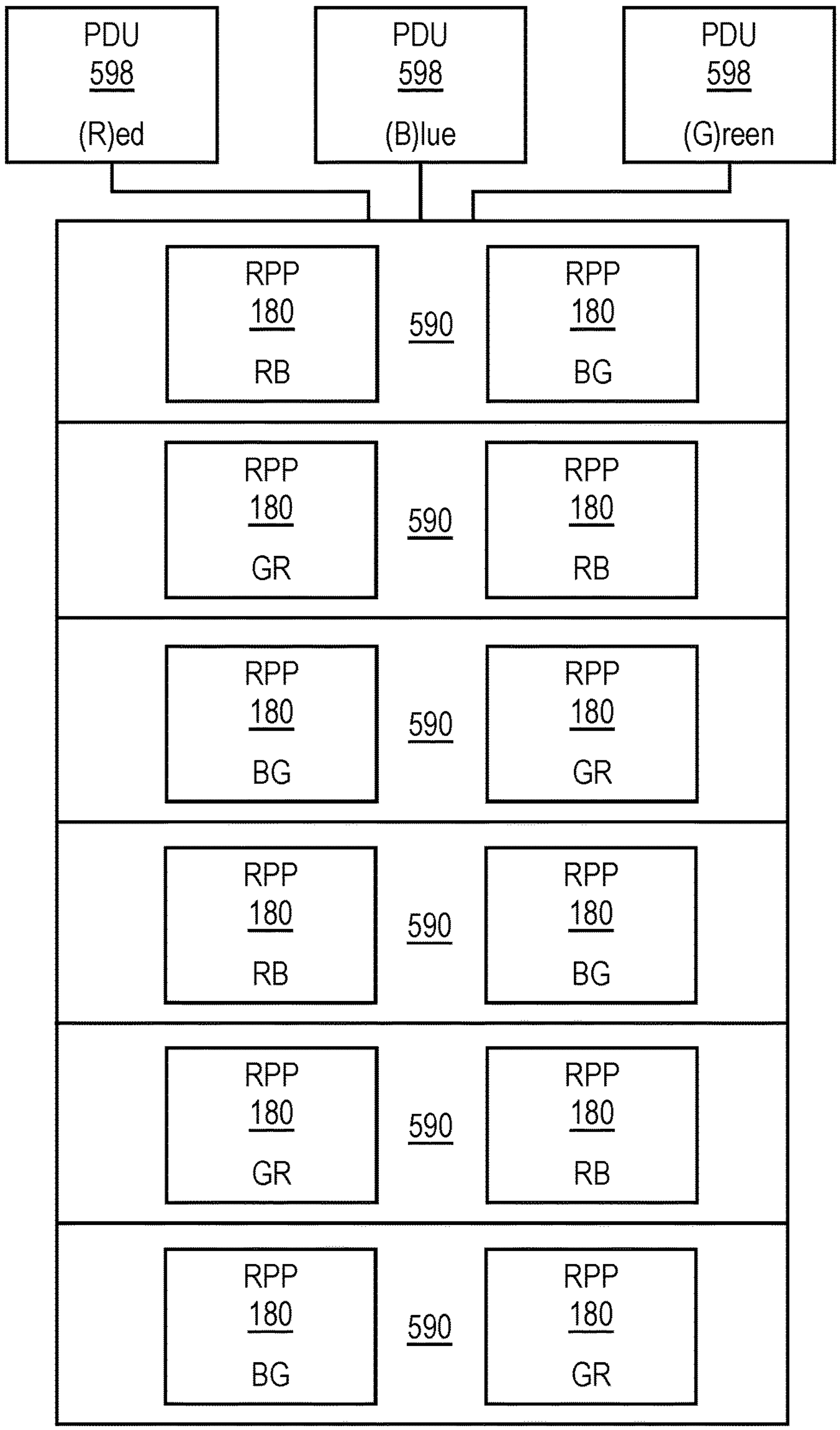

PDU
598
(R)ed
PDU
598
(B)lue
PDU
598
(G)reen
RPP
180
RB
590
RPP
180
BG
RPP
180
GR
590
RPP
180
RB
RPP
180
BG
590
RPP
180
GR
RPP
180
RB
590
RPP
180
BG
RPP
180
GR
590
RPP
180
RB
RPP
180
BG
590
RPP
180
GR

FIG. 7B

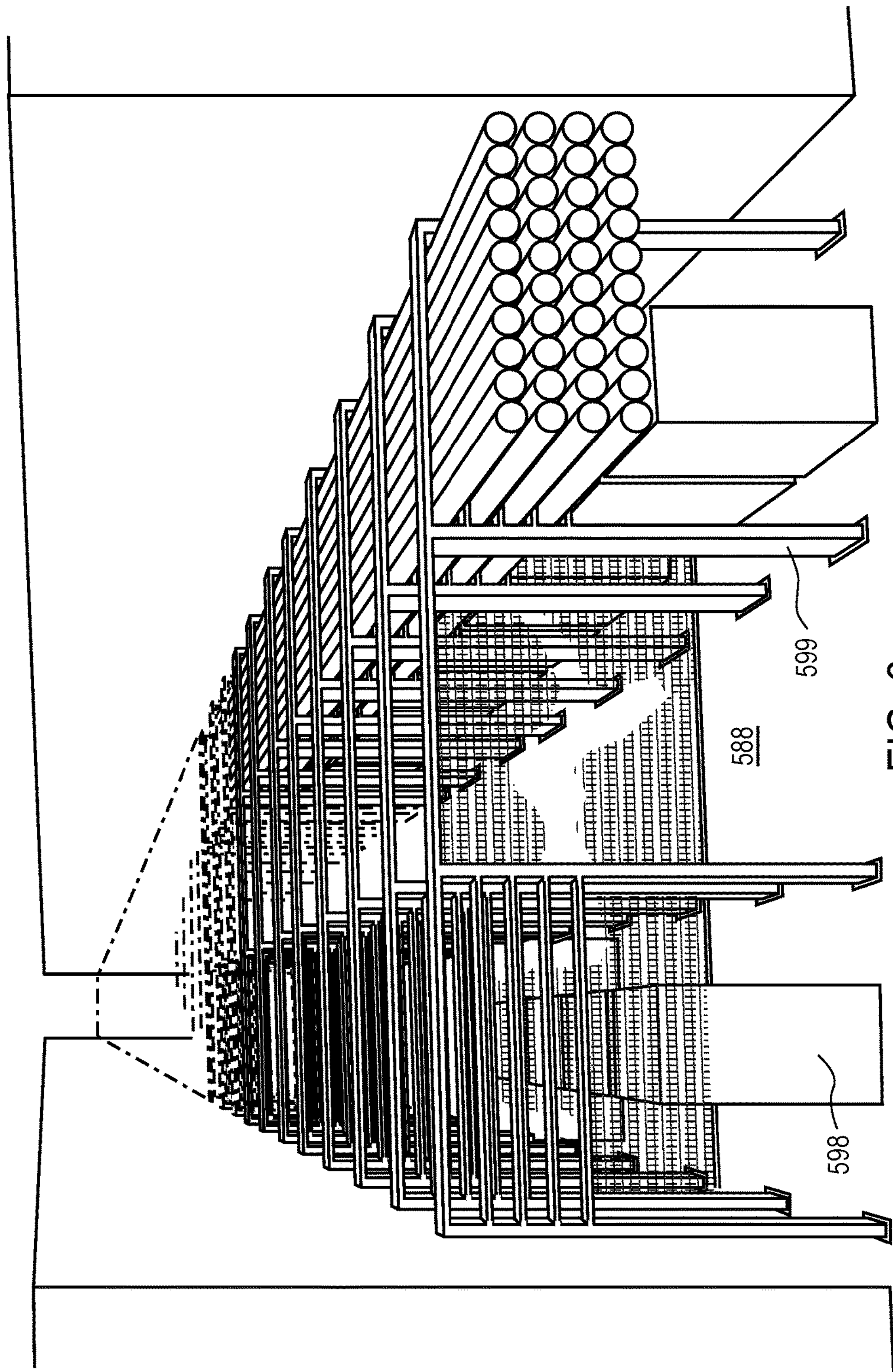


FIG. 8

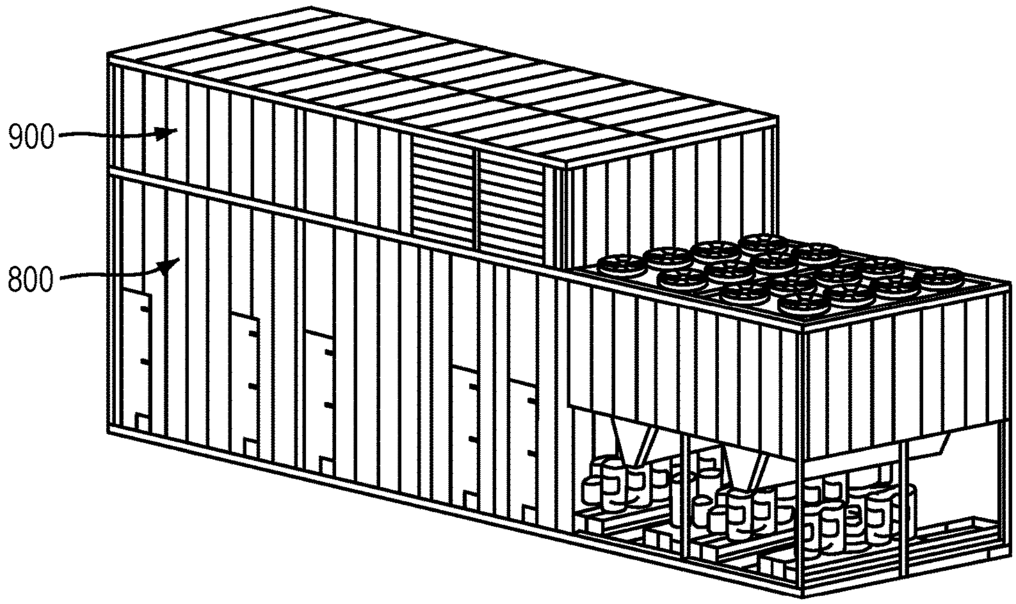


FIG. 9A

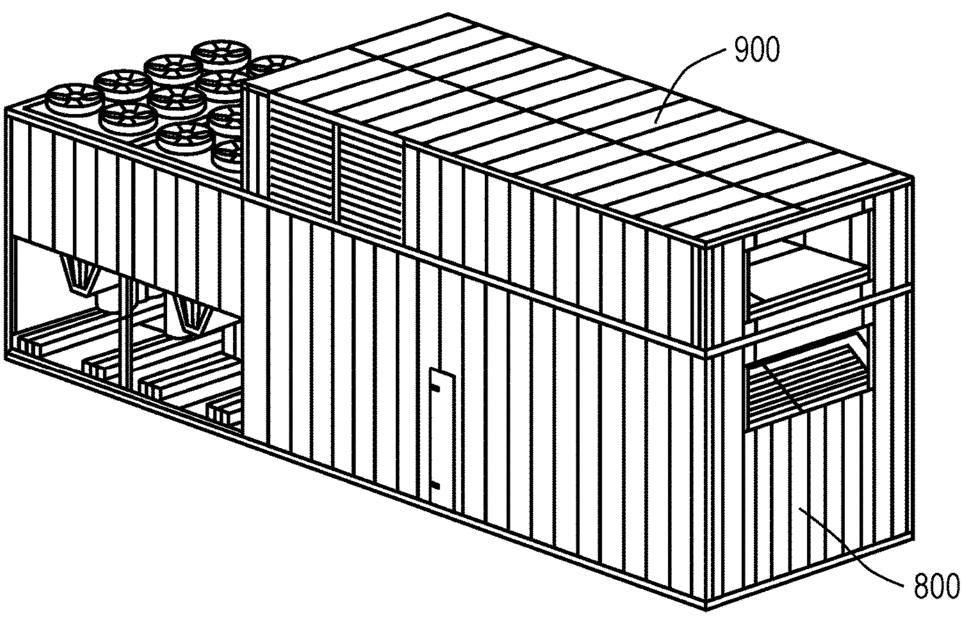


FIG. 9B

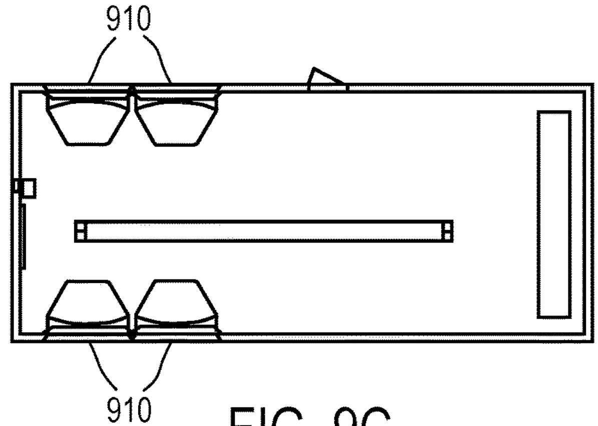


FIG. 9C

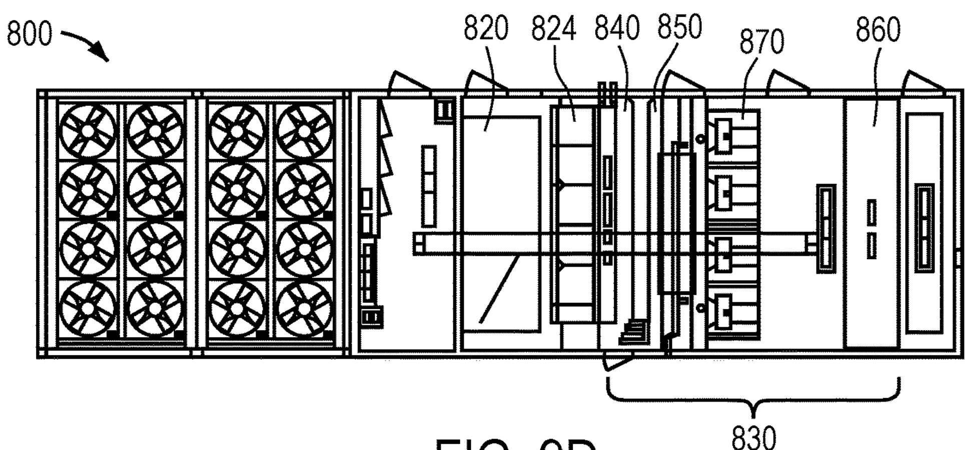


FIG. 9D

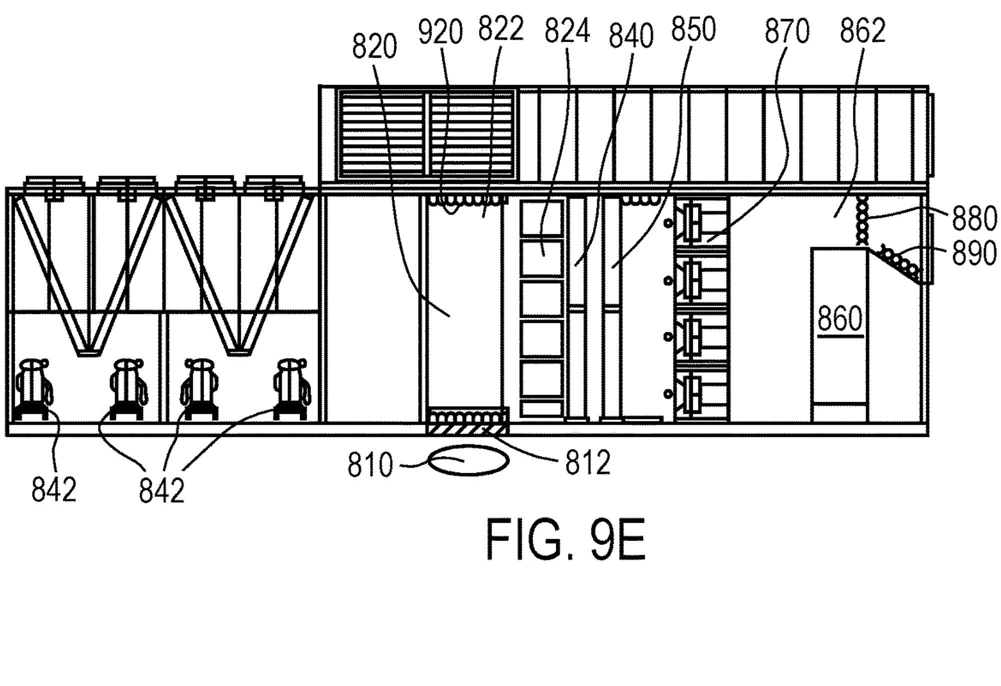


FIG. 9E

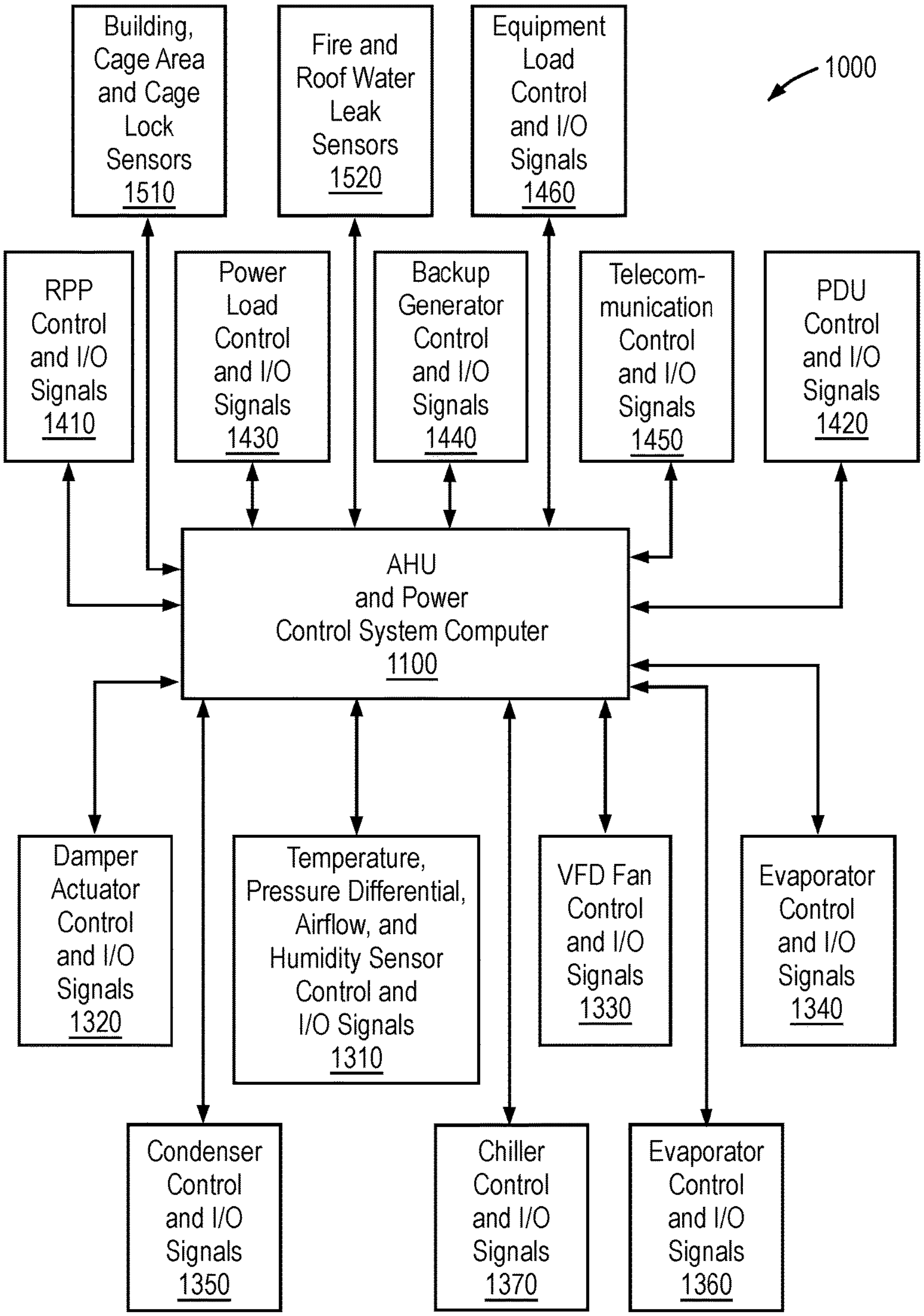

1000
Building, Cage Area and Cage Lock Sensors 1510
Fire and Roof Water Leak Sensors 1520
Equipment Load Control and I/O Signals 1460
RPP Control and I/O Signals 1410
Power Load Control and I/O Signals 1430
Backup Generator Control and I/O Signals 1440
Telecom-munication Control and I/O Signals 1450
PDU Control and I/O Signals 1420
AHU and Power Control System Computer 1100
Damper Actuator Control and I/O Signals 1320
Temperature, Pressure Differential, Airflow, and Humidity Sensor Control and I/O Signals 1310
VFD Fan Control and I/O Signals 1330
Evaporator Control and I/O Signals 1340
Condenser Control and I/O Signals 1350
Chiller Control and I/O Signals 1370
Evaporator Control and I/O Signals 1360

FIG. 10

SYSTEMS AND METHODS FOR COOLING DATA CENTERS AND OTHER ELECTRONIC EQUIPMENT

[0001] This application claims priority to and is a continuation of U.S. Utility application Ser. No. 13/651,319 entitled "Facility Including Externally Disposed Data Center Air Handling Units," filed on Oct. 12, 2012 as a continuation of U.S. Utility application Ser. No. 12/384,109 entitled "Electronic Equipment Data Center or Co-Location Facility Designs and Methods of Making and Using the Same," filed on Mar. 30, 2009, which claims priority to U.S. Provisional Application No. 61/040,636 entitled "Electronic Equipment Data Center or Co-Location Facility Designs and Methods of Making and Using the Same," filed on Mar. 28, 2008. Application Ser. No. 12/384,109 is also a continuation-in-part and claims priority to U.S. Utility application Ser. No. 12/138,771 entitled "Electronic Equipment Data Center or Co-location Facility Designs and Methods of Making and Using the Same" filed Jun. 13, 2008, which application claims priority to U.S. Provisional Application Ser. No. 60/944,082 entitled "Electronic Equipment Data Center or Co-location Facility Designs and Methods of Making and Using the Same" filed Jun. 14, 2007.

BACKGROUND

[0002] Field of the Invention

[0003] The present invention relates to electronic equipment data center or co-location facility designs and methods of making and using the same in an environmentally aware manner.

[0004] Background of the Invention

[0005] Data centers and server co-location facilities are well-known. In such facilities, rows of electronics equipment, such as servers, typically owned by different entities, are stored. In many facilities, cabinets are used in which different electronics equipment is stored, so that only the owners of that equipment, and potentially the facility operator, have access therein. In many instances, the owner of the facilities manages the installation and removal of servers within the facility, and is responsible for maintaining utility services that are needed for the servers to operate properly. These utility services typically include providing electrical power for operation of the servers, providing telecommunications ports that allow the servers to connect to transmission grids that are typically owned by telecommunication carriers, and providing air-conditioning services that maintain temperatures in the facility at sufficiently low levels in order for the

[0006] There are some well-known common aspects to the designs of these facilities. For example, it is known to have the electronic equipment placed into rows, and further to have parallel rows of equipment configured back-to back so that each row of equipment generally forces the heat from the electronic equipment toward a similar area, known as a hot aisle, as that aisle generally contains warmer air that results from the forced heat from the electronics equipment. In the front of the equipment is thus established a cold aisle.

[0007] There are different systems for attempting to collect hot air that results from the electronics equipment, cooling that hot air, and then introducing cool air to the electronics equipment. These air-conditioning systems also must co-exist with power and communications wiring for the electronics equipment. Systems in which the electronics equipment is raised above the floor are well-known, as installing the communications wiring from below the electronics equipment has been perceived to offer certain advantages. Routing wiring without raised floors is also known—though not with systematic separation of power and data as described herein.

[0008] In the air conditioning units that are used in conventional facility systems, there are both an evaporator unit and a condenser unit. The evaporator units are typically located inside a facility and the condenser units are typically disposed outside of the facility. These units, however, are not located in standardized, accessible and relatively convenient positions relative to the facility should any of the units need to be accessed and/or removed for repair or replacement. Further, these units are not themselves created using an intentionally transportable design.

SUMMARY

[0009] The present invention provides an integrated data center that provides for efficient cooling, as well as efficient wire routing.

[0010] In one aspect is provided a facility with an internal area and an external area in an external environment for maintaining electronic equipment disposed in a plurality of cabinet clusters in the internal area at a cool temperature, the facility comprises:

[0011] a building that includes an exterior load wall separating the internal area and the external area;

[0012] a plurality of exterior wall openings in the exterior load wall;

[0013] a floor within the internal area of the building on which the plurality of cabinet clusters are disposed;

[0014] a plurality of cabinets for holding the electronic equipment therein, the plurality of cabinets positioned in a plurality of rows within each of a plurality of cabinet clusters so that the electronic equipment disposed within the cabinets emit heated air from the cabinets in each row of each cabinet cluster toward a central hot air area associated with each cabinet cluster;

[0015] a plurality of support brackets within each cabinet cluster, disposed along each of the plurality of rows, that together provide support for distribution power wiring and conduits, electronic equipment power wiring and conduits, and communication wiring, wherein a portion of each of the support brackets is disposed above the plurality of cabinets within each cabinet cluster, and wherein some of the distribution power wiring and conduits string across other cabinets in other cabinet clusters;

[0016] a thermal shield supported by the at least some of the plurality of support brackets, the thermal shield providing a contiguous wall around the central hot air area and defining a hot air containment chamber that traps the heated air within the central hot air area and causes substantially all the heated air within the central hot air area to rise up within the hot air containment chamber;

[0017] a plurality of air conditioning units disposed in the external area outside the building that each receive heated air, emit cooled air, and emit vented air, wherein the vented air is released into the external environment;

[0018] a warm air escape gap within the building disposed above the hot air containment chamber, the warm air escape channel feeding the heated air to the plurality of air conditioning units, the warm air escape gap being lowerly bounded by a false ceiling;

[0019] cool air ducts within the building that couple the plurality of air conditioning units and the cold aisles, the cool air ducts being disposed below the false ceiling and delivering cool air from the plurality of air conditioning units toward the plurality of rows of cabinets within each of the plurality of cabinet clusters; and

[0020] warm air connectors and cool air duct connectors that respectively connect the warm air escape channel and the cold air ducts to the plurality of air conditioning units, and which pass through the plurality of exterior wall openings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] These and other aspects and features of the present invention will become apparent to those of ordinary skill in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures, wherein:

[0022] FIG. **1**(*a*) illustrates a floor design used in a data center or co-location facility according to the present invention.

[0023] FIG. **1**(*b*) illustrates floor-based components disposed over the floor design according to the present invention.

[0024] FIG. **1**(*c*) illustrates a perspective cut-away view along line c-c from FIG. **1**(*a*) of FIG. **1**(*a*) according to the present invention.

[0025] FIGS. **2**(*a*)-(*c*) illustrate various cut-away perspective views of the thermal compartmentalization and cable and conduit routing system according to the present invention.

[0026] FIGS. **3**(*a*) and (*b*) illustrate modular thermal shields used in the thermal compartmentalization and cable and conduit routing system according to the present invention.

[0027] FIG. **4** illustrates illustrate a telecommunication bracket used in the thermal compartmentalization and cable and conduit routing system according to the present invention.

[0028] FIG. **5**(*a*) illustrates a top view of a data center or co-location facility according to another embodiment of the present invention.

[0029] FIG. **5**(*b*)**1-2** illustrate a cut-away perspective views of an exterior and interior portion of the data center or co-location facility according to other embodiments of the present invention.

[0030] FIGS. **6**(A-B) illustrates other telecommunication brackets used in the thermal compartmentalization and cable and conduit routing system according to the present invention.

[0031] FIGS. **7**A-B illustrate a section of a distribution area and the data area within a facility according to an embodiment of the present invention.

[0032] FIG. **8** is a power spine that can also be used with the preferred embodiment.

[0033] FIGS. **9**A-E illustrate an air handling unit according to a preferred embodiment.

[0034] FIG. **10** illustrates a control system used by the data center.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] The present invention provides data center or co-location facility designs and methods of making and using the same. The data center or co-location facility designs have certain features that will be apparent herein and which allow many advantages in terms of efficient use of space, efficient modular structures that allow for efficiency in the set-up of co-location facility and the set-up of the electronics equipment in the facility, as well as efficient air-conditioning within the facility. Each of these features has aspects that are distinct on their own, and combinations of these features also exist that are also unique.

[0036] FIG. **1**(*a*) illustrates a floor design used in a data center or co-location facility according to the present invention. The preferred embodiment discussed herein uses parallel rows of equipment configured back-to back so that each row of equipment generally forces the heat from the electronic equipment towards a hot aisle, thus also establishing a cold aisle in the front of the equipment. The cold aisles in FIG. **1**(*a*) are illustrated at the dotted line block **60**, wherein the hot aisles are illustrated at the dotted line block **62**. One feature of the present invention is the provision for marking the floor **50** to explicitly show the various areas of the facility. As illustrated, the hot aisle **62** has a central area **52** that is tiled, painted, taped or otherwise marked to indicate that it is center area of the hot aisle **62**, also referred to as a central hot air area. The typical dimensions of the central area **52** are typically in the range of 2'-4' across the width, with a row length corresponding to the number of electronic cabinets in the row. Marking with tiles is preferable as the marking will last, and tiles that are red in color, corresponding to the generation of heat, have been found preferable. Around this center area **52** is a perimeter area **54**, over which the cabinets are installed. This perimeter area **54** is marked in another manner, such as using a grey tile that is different in color from the center area **52**. Around the perimeter area **54** is an outside area **56**, which is marked in yet a different manner, such as using a light grey tile. The placement of these markings for areas **52**, **54** and **56** on the floor of the facility, preferably prior to moving any equipment onto the floor, allows for a visual correspondence on the floor of the various hot and cold aisles. In particular, when installing cabinets over the perimeter **54** are, the area that is for the front of the cabinet that will face the cold aisle, and thus the area for the back of the cabinet for the hot aisle, is readily apparent.

[0037] FIG. **1**(*b*) illustrates floor-based components disposed over the floor design of the co-location facility according to the present invention. FIG. **1**(*b*) also shows additional area of the floor, which in this embodiment is provided to illustrate interaction of the electronics equipment with the evaporators of the air conditioning units. In the embodiment described with respect to FIG. **1**(*b*), certain features are included so that conventional equipment, particularly conventional air conditioning equipment, can effectively be used while still creating the desired air flow patterns of the present invention as described herein.

[0038] Before describing the components in FIG. **1**(*b*), an aspect of the present invention is to isolate the hot air exhaust from the areas that require cooling as much as possible, and to also create air flows in which the air moves through the exhaust system, into the air conditioning system, through the air conditioning ducts and out to the cool equipment in a very rapid manner. In particular, the amount of circulation established according to the present invention moves air at a volume such that the entire volume of air in the facility recirculates at least once every 10 minutes, preferably once every 5 minutes, and for maximum cooling once every minute. It has been found that this amount of recirculation, in combination with the air flows established by the present invention, considerably reduce the temperature in the facility in an environmentally efficient manner.

[0039] Cabinets **110** shown in FIG. **1**(*b*) are placed generally over the sides of the perimeter **54** as described, in rows. Different rows are thus shown with cabinets **110**(*a-f*), with each letter indicating a different row. Also included within the rows are telecommunications equipment **170** to which the electronics equipment in each of the cabinets **110** connect as described further herein, as well as power equipment **180**, containing circuit breakers as is known to protect against energy spikes and the like, that is used to supply power along wires to the electronics equipment in each of the cabinets **110** connect as described further herein. Air conditioning units include the evaporator units **120** (1-6) that are shown being physically separated by some type of barrier from the area **56** described previously with respect to FIG. **1**(*a*). The condenser units of the air conditioning system that receive the warmed refrigerant/water along lines **122** and are disposed outside the walls of the facility are not shown. This physical separation is implemented in order to establish warm exhaust channel area **240** separate from the physical space, which warm air area will connect to a separate warm air area in the ceiling and allow the warm air to flow into the exhaust channel area **240** and enter into intake ducts of evaporator air conditioning equipment **120**, as will be described. This feature allows the usage of conventional evaporator air conditioning equipment that has air intakes at the bottom of the unit, as well as allows for usage of different air conditioning equipment types, while still maintaining an efficient airflow throughout the entire facility.

[0040] FIG. **1**(*c*) illustrates a perspective cut-away view along line c-c from FIG. **1**(*a*) of the FIG. **1**(*a*) co-location facility according to the present invention. Additionally illustrated are the false ceiling **140** and the actual ceiling **150**, which have a gap that is preferably at least 1.5-3 feet and advantageously at least 15 feet, as the higher the ceiling the more the warm air rises (and thus also stays further away from the equipment in the cabinets **110**). The false ceiling **140** is preferably made of tiles that can be inserted into a suspended ceiling as is known, which tiles preferably have are drywall vinyl tiles, which exhibit a greater mass than many conventional tiles. Also shown are arrows that illustrate the air flow being centrally lifted upward from the hot air area containment chamber **210** formed by the thermal shields **400** to the area between the false ceiling **140** and the actual ceiling **150**, and the flow within the ceiling toward the warm exhaust channel area **240**, and then downward into the warm exhaust channel area **240**. Also shown are arrows that take cold air from the cold air ducts **310** and insert the air into the cold aisles **60**.

[0041] Though the arrows in the drawing are directed straight downward, the vents themselves can be adjusted to allow for directional downward flow at various angles. In a preferred embodiment, each of the vents have a remote controlled actuator that allows for the offsite control of the vents, both in terms of direction and volume of air let out of each vent. This allows precise control such that if a particular area is running hot, more cold air can be directed thereto, and this can be detected (using detectors not shown), and then adjusted for offsite.

[0042] FIGS. **2**(*a*)-(*c*) illustrate various cut-away perspective views of the thermal compartmentalization and cable and conduit routing system according to the present invention. In particular, FIG. **2**(*a*) illustrates a cut away view of a portion of the hot air area containment chamber **210**, which rests on top of the cabinets **110**, and is formed of a plurality of the thermal shields **400** and **450**, which are modular in construction and will be described further hereinafter. Also illustrated are shield brackets **500** that are mounted on top of the cabinets **110**, and provide for the mounting of the shields **400** and **450**, as well as an area on top of the cabinets **110** to run power and telecommunications cables, as will be described further herein.

[0043] Before describing the cabling, FIG. **2**(*b*) and FIG. **4** illustrate the shield bracket **150**, which is made of structurally sound materials, such as steel with a welded construction of the various parts as described, molded plastic, or other materials. Ladder rack supports **510**, **520**, **530**, **540** and **550** are used to allow ladder racks **610**, **620**, **630**, **640**, and **650** respectively, placed thereover as shown. The ladder racks are intended to allow for a segregation of data and electrical power, and therefore an easier time not only during assembly, but subsequent repair. The ladder racks are attached to the ladder rack supports using support straps shown in FIG. **4**, which are typically a standard "j" hook or a variant thereof. As also illustrated in FIG. **4**, a support beams structure **506** provides extra support to the ladder rack, and the holes **508** are used to secure the shields **400** and **450** thereto. Horizontal support plate **504** is used to support the support **500** on the cabinets **110**.

[0044] With respect to the cabling and conduit, these are used to provide electrical power and data to the various servers in the facility. Conduit, containing wiring therein, is used to provide electricity. Cabling is used to provide data. In this system, it is preferable to keep the electrical power and the data signals separated.

[0045] Within the system, ladder rack **610** is used for data cabling on the cold aisle side of the thermal shields **400**. Ladder rack **620** is used for an A-source power conduit (for distribution of 110-480 volt power) on the cold aisle side of the thermal shields **400**. Ladder rack **630** is used for B-source power conduit (for distribution of 110-480 volt power), which is preferably entirely independent of A-source power conduit, on the cold aisle side of the thermal shields **400**. Ladder rack **640** is used for miscellaneous cabling on the cold aisle side of the thermal shields **400**. Ladder rack **650** is used for data cabling on the hot aisle side of the thermal shields **400**.

[0046] FIGS. **3**(*a*) and (*b*) illustrate modular thermal shields **400** and **450**, respectively, used in the thermal compartmentalization and cabling and conduit routing system according to the present invention. Both shields **400** and **450** are made of a structurally sound material, including but not limited to steel, a composite, or a plastic, and if a plastic, one that preferably has an air space between a front piece of plastic and a back piece of plastic for an individual shield **400**. Shield **400** includes a through-hole **410** that allows for certain cabling, if needed, to run between the hot and cold aisle areas, through the shield **400**. A through-hole cover (not shown) is preferably used to substantially close the hole to prevent airflow therethrough. Shield **450** has a 90 degree angle that allows the fabrication of corners.

[0047] It should be appreciated that the construction of the cabinets, the shields **400** and **450**, and the shield supports **500** are all uniform and modular, which allows for the efficient set-up of the facility, as well as efficient repairs if needed.

[0048] Other different embodiments of data center or co-location facilities according to the present invention also exist. For example, while the false ceiling **140** is preferred, many advantageous aspects of the present invention can be achieved without it, though its presence substantially improves airflow. Furthermore, the evaporation units for the air conditioning system can also be located outside the facility, in which case the chamber **240** is not needed, but hot air from the ceiling can be delivered to evaporation units that are disposed above the ceiling, which is more efficient in that it allows the warm air to rise. If the complete air conditioning equipment is located outside, including the evaporators, the refrigerant/water lines **122** that are used to exchange the refrigerant/water if the evaporators are disposed inside the facility is not needed, which provides another degree of safety to the equipment therein.

[0049] It is noted that aspects of the present invention described herein can be implemented when renovating an existing facility, and as such not all of the features of the present invention are necessarily used.

Data Management Center and Integrated Wiring System

[0050] In one aspect, the embodiments herein are directed to an overall data management center, including the building itself, interior aspects of the building, as well as equipment purposefully located outside yet in close proximity to the building, which equipment is used for purposes of providing both building cooling as well as supplemental power, as described further herein. In one particular aspect, the center core of the building that contains the electronics equipment is purposefully created in a manner that provides only essential equipment and ducts needed to provide power, communications, and air flow, while putting into periphery areas of the building and outside, other equipment that could interfere with the electronics equipment, whether due to that other equipment requiring extremely high power and/or water or other liquids to function, all of which can have a detrimental impact on the electronics equipment.

[0051] FIG. **5**(*a*) illustrates a top view of a portion of a data center or co-location facility **580** according to another embodiment of the present invention. In this embodiment, unlike the embodiment shown in FIG. **1**(*a*)-(*c*), the condenser air conditioning units **800** and heat expulsion chamber **900** are all disposed outside of the exterior walls **582** of the facility, as will be described further herein. There is also additional equipment disposed outside of the exterior walls **582**, including evaporation units **590** that feed cooled water along lines **592** to the air conditioning units **800** as described further herein, as well as backup diesel generators **594** for supplying backup power along a transmission line **596** in the case of power outage from remotely supplied power on the national power grid.

[0052] FIG. **5**(*b*)**1** illustrates a cut-away perspective view of an exterior and interior portion (with a 90° rotation for illustrative purposes of the interior portion) of the data center or co-location facility **580**, with the exterior wall **582** being explicitly illustrated. Shown are two of the cabinet clusters **590-1**A and **590-2**A, and the corresponding hot air area containment chambers **210** and cold air ducts **310**, which are respectively connected to the warm exhaust outlets **240-0** and cold duct inlets **310**-I. The warm exhaust outlets **240-0** and cold duct inlets **310**-I connect to condenser units **800** and heat expulsion chamber **900**, respectively.

[0053] FIG. **5**(*b*)**2** provides a slightly varied embodiment, in which the cold duct inlets **310**-I and warm exhaust outlets **240-0** are each at the same level as the condenser units **800** and heat expulsion chamber **900**, respectively, and the warm exhaust outlets **240-0** contain a 90° angled area, which allows for better hot air flow into the heat expulsion chambers **900**.

[0054] Within the facility there are provided distribution areas **584** and **588**, as shown in FIG. **5**(*a*), as well as data center equipment areas **586**, which equipment areas **586** each contain an array of cabinet clusters **590** (shown in one of the rows as cabinet clusters **590-1**, **590-2**, **590-3** . . . **590**-N), since within each cabinet cluster **590**, various cabinets **110** containing different electronic equipment are disposed in rows, thereby allowing each cabinet cluster **590** to be locked, as well as the cabinets **110** within the cabinet cluster **590**. It is apparent that three consecutive cabinet clusters, such as **590-1**, **590-2** and **590-3** correspond to the three identified clusters that are disposed around the associated hot air area containment chambers **210**(*a*), **210**(*b*) and **210**(*c*) in FIG. **1**(B). As is illustrated, the electronics equipment within each cabinet **110** of a cabinet cluster **590** is connected in a manner similar to that as described in FIGS. **2**(*a*)-(*c*) previously.

[0055] It is noted that the cabinet cluster may have an actual physical perimeter, such as a cage built with fencing that can be locked and still permits airflow therethrough, or alternatively need not have an actual physical perimeter, in which case the orientation of the cabinets **110** and corresponding other structures as described previously with reference to FIGS. **1**(*a-c*) can also define this same space.

[0056] The manner in which the distribution power wires and conduits, electronic equipment control wires and conduit, data cabling, and miscellaneous cabling is distributed to the cabinet clusters **590** from one of the distribution areas **584** or **588** will be described further hereinafter. As shown in FIG. **5**(*a*), telecommunications and power distribution equipment, further described herein, is used to then feed the appropriate signals and power to the telecommunications equipment and power equipment that is stored within each cabinet cluster **590** (i.e. telecommunications equipment **170** and power equipment **180** described in FIG. **1**(B)). The manner in which the distribution power wires and conduits, electronic equipment control wires and conduit, data cabling, and miscellaneous cabling is distributed to the cabinet clusters **590** from one of the distribution areas **584** and **588** will be described further hereinafter.

[0057] The array of cabinet clusters **590**, and the density of the cabinets **110** and the electronics equipment therein, require substantial amounts of power and transmission capacity, which in turns requires substantial amounts of wiring, particularly for power. As described herein, as a result there is described an improved telecommunication bracket **600**, which substantially rests over each of the cabinets in the cabinet clusters **590**, in order to more easily accommodate the distribution power wires and conduits, as well as telecommunication wires and conduits, as well as control wires and conduits, that are then distributed from the distribution areas **584** and **588** to the telecommunications equipment **170** and power equipment **180** that is within each of the different cabinet clusters **590**. As shown in FIG. **5**A and FIG. **8**, the distribution area **588** contains PDU's **598**, described in further detail elsewhere herein, and the distribution area **584** contains transformers to step down the power grid power that is normally at 12477 volts to a 480 volt level, for transmission of 480 volt power to the PDU's **598**. Also within distribution area **584** are uninterruptable power supplies in case an outage of power from the power grid occurs, as well as equipment for testing of the various power equipment that is conventionally known.

[0058] While FIG. **1**B illustrates one configuration of equipment with the cabinet cluster (with the telecommunications equipment **170** and the power equipment **180** within the center of a row), FIG. **7**A also shows an alternative configuration of equipment for a cabinet cluster **590**, which still contains the same cabinets **110**, telecommunication equipment **170** and power equipment **180**. In particular, rather than having the power equipment **180** centrally located within a row, in this alternate configuration the power equipment **180** is disposed at an end of each of the rows that are within a cabinet cluster **590**. The telecommunication equipment, within this embodiment, can be located anywhere within the row of cabinets **110**, within whichever one of the cabinets **110** makes most sense given the usage considerations for that cabinet cluster **590**.

[0059] In another variation of the FIG. **7**A embodiment, the power equipment **180**, instead of being somewhat separated from the cabinets **110** within a cluster **590**, instead abut right next to one of the cabinets **110**. This, along with the doors **593** shown in FIG. **7**A then being attached between adjacent power equipment at the end of the cabinet row instead of at the end cabinet, keep all the equipment in a tightly configured space. In any of the embodiments shown, whether FIG. **1**C, **7**A or as described above, the thermal shield **400** that creates the hot air area containment chamber **210** above the cabinets, coupled with the doors that seal off the area between the rows of cabinets **110** within a cluster **590**, provide an environment that prevents the hot air within the hot air area **52** from escaping out into the main data center floor, and ensures that the hot air instead travels up through the hot air area containment chamber **210** and into the gap disposed between the false ceiling **140** and the actual ceiling **150**.

[0060] Within equipment area **586** is thus established an array of cabinet clusters **590**, which cabinet clusters align with each other to allow for the overhead stringing of telecommunications and power wiring as described herein. Within each cabinet cluster **590**, as also shown in FIG. **1**B, is telecommunications equipment **170** to which the electronics equipment in each of the cabinets **110** connect, as well as power equipment **180** used to connect the electronics equipment to power. The array of cabinet clusters **590**, each also containing brackets, such as brackets **500** or **600**, as described herein. For a larger size data center as illustrated in FIG. **5**(*a*) that contains a very large array of cabinet clusters **590**, brackets **600** are preferable, as they allow for additional conduit support areas. These brackets **600**, discussed further herein with respect to FIGS. **6**(*a-b*), contain ladder racks **510**, **520**, **530** and **540** that are used for stringing power and telecommunication wiring within each cabinet cluster **590**, as well as contain additional vertical support with conduit clamps that are used to hold power and telecommunication lines that pass from each cabinet cluster **590** to other central telecommunication and power distribution areas, as discussed further herein, as well as to hold power and telecommunication lines that pass over certain of the cabinet clusters **590** in order to be strung to other of the cages areas **590**. Still further, these same brackets **600**, being preferably mounted over the cabinets **110**, and at least having a significant portion of the bracket disposed over the cabinets **110**, are used to mount the thermal shield within the cabinet cluster **590**, the thermal shield providing a contiguous wall around the central hot air area of the cabinet cluster **590**, and defining a warm exhaust channel that traps the heated air within the central hot air area and causes substantially all the heated air within the central hot air area to rise up within the warm exhaust channel. These brackets **600** also preferably span from the top of the cabinets **110** to the bottom of the false ceiling **140** to provide further stability.

[0061] It is apparent that the power and telecommunication lines that pass from each cabinet cluster **590** to other more central telecommunication and power distribution areas will necessarily pass, in some instances, over other cabinet clusters **590**. Since the vertical support **610** with conduit clamps **620** are above the ladder racks **510**, **520**, **530** and **540** for each of the brackets **600**, as well as above each of the cabinets **110**, this allows for long runs of power and telecommunication lines that pass from each cabinet cluster **590** to other more central telecommunication and power distribution areas to exist without interfering with the wiring that exists within each cabinet cluster **590**. Furthermore, by creating a sufficient area of vertical support and conduit clamps, it is then possible to run additional power and telecommunication lines from certain cabinet clusters **590** to other more central telecommunication and power distribution areas without having to re-work existing wiring. This makes expansion much simpler than in conventional designs.

[0062] FIGS. **6***a-b* illustrate in detail two different embodiments of the telecommunication bracket **600** referred to above that is used in the thermal compartmentalization and cable and conduit routing system according to the present invention. This bracket **600** serves the same purpose as the bracket **400** illustrated and described previously with respect to FIG. **4**, and as such similar parts of the bracket **600** are labeled the same and need not be further described herein. This bracket **600**, however, additionally provides additional vertical support **610** that allows for the running of additional wiring and conduits.

[0063] In FIG. **6**A, this additional vertical support **610** includes conduit clamps **620** that allow the clamping of the additional conduits to the additional vertical support **610**.

[0064] In FIG. **6**B, the bracket **600**A has in addition to the vertical support **610** a support beam **506**A (which extends upwards from the support beam **506** shown in FIG. **4**), and racks **630**, **632**, **634**, **636**, **638**, and **640** therebetween. Each of the racks **630**, **632**, **634**, **636**, **638**, and **640** have room for at least 4 different 4" conduits to run wiring or cabling therethrough. Whether the conduit clamps or additional conduit racks are used, both provide for conduit holding, and holding of the wires or cables within the conduits.

[0065] In both the brackets **600** of FIGS. **6***a-b*, the additional wiring/conduit is distribution power wires and conduits and other wire/conduit for control uses, for example. As explained hereafter, the distribution power wires and conduits can run from various power equipment units **180**

disposed in each of the cabinet clusters **590** to various other high power distribution units (PDUs) **598** disposed within the distribution area **588**, as shown in FIG. **7**A.

[0066] FIG. **7**A also illustrates the distribution of power PDUs **598** within a section of the distribution area **588** to power equipment **180** in an end cabinet cluster **590-1** within a section of the data equipment center area **586** via distribution power wires and conduit (one shown as **597**). In particular, as is shown, distribution power wires and conduit goes from each of the PDUs **598**A and **598**B to the power equipment unit **180**A within the end cabinet cluster **590-1**, and distribution power wires and conduit also goes from both the PDUs **598**A and **598**B to the power equipment unit **180**B within the end cabinet cluster **590-1**, so that redundant power can be provided to the electronic equipment within each row. Since power is provided to each piece of power equipment **180** from two different sources, these power equipment units can also be called redundant power panels, or RPP's. In addition, distribution power wires and conduit go from each of PDUs **598**A and **598**B over the end cabinet cluster **590-1** to further cabinet clusters **590-2**, **590-3** to **590**-N. The array of cabinet clusters **590** are aligned as shown in FIG. **5**(*a*) so that the brackets **600** in different cabinet clusters **590** nonetheless can together be used to string distribution power wires and conduit and other wires/fibers with conduits as needed.

[0067] In a preferred configuration of the power equipment **180** shown in FIG. **7**A provides redundant 120 volt AC power from each RPP **180** to the electrical equipment in each of the cabinets **110** within the row of the cabinet cluster **590**. Within the RPP **180** are circuit breakers as is known to protect against energy spikes and the like, as well as energy sensors associated with each circuit so that a central control system, described hereinafter, can monitor the energy usage at a per circuit level. In a typical implementation, there are 42 slot breaker panels that are associated each with 120 c/208 v power that is then supplied to each of the electronic components as needed, in wiring that uses one of the ladder racks **630** or **640** as discussed previously to the necessary cabinet **110**. Of course, other power configuration schemes are possible as well.

[0068] In a preferred configuration for a module of cabinet clusters **590**, as schematically shown in FIG. **7**B, there are three different PDUs **598** that each receive 480 vAC 3-phase power and provide 120 vAC 3-phase power service to each of 8 different RPPs **180** via the distribution power wires and conduits. This allows, for a completely used module, 6 different cabinet clusters **590** to be serviced from 12 RPP's **180**, two in each cage, and 3 different PDU's **598**. By providing redundancy of both RPP's **180** (×2) and PDUs **598** (×3), this allows for maximum power usage of the various components with sufficient redundancy in case any one of the PDU's **598** or any circuit on an RPP **180** fails.

[0069] A lock-related aspect of the present invention with respect to the RPPs **180** as well as the PDU's **598** is that since there are three circuits from the PDU's t the RPP's, within a dual RPP each side of the cabinet will have separate lock, such that all locks of a particular circuit can be opened by the same key, but that key cannot open locks of any of the other two circuits. This is an advantageous protection mechanism, as it prohibits a technician from mistakenly opening and operating upon a different circuit than a circuit he is supposed to service at that time.

[0070] FIG. **8** a power spine **599** that can also be used with the preferred embodiment to provide power from the power grid to each of the PDU's **598**. As illustrated, rather than running the power spine through the roof as is conventionally done, in this embodiment the power spine **599** is run along a corridor within the distribution area **588** that channels all of the main building wiring and electrical components. This advantageously reduces stress on the roof and building structure, as the weight of the power spine and related components are supported internally within the corridor structure as shown.

Data Center Air Handling Unit

[0071] Another aspect of the data center is the air handling unit that provides for efficient cooling.

[0072] As is illustrated in FIGS. **5**(*a*) and **5**(*b*)**1-2**, one condenser unit **800** is paired with one heat expulsion chamber **900**, and each are preferably independently movable. As is further illustrated, the condenser units **800** are built to a size standard that allows for transport along US state and interstate highways. Further, the heat expulsion chamber **900** is preferably sized smaller than the condenser unit **800**, but still having dimensions that allow for transport using a semi-trailer. When transported to the facility **500**, the condenser unit **800** is first placed into position, as shown here on posts **588**, but other platforms can also be used. As shown in this embodiment, the heat expulsion chamber unit **900** is placed over the condenser unit **800**, though other placements, such as adjacent or below, are also possible. Connections of power conduit, miscellaneous cabling, and water needed for proper operation of the condenser units **800** and expulsion chamber **900** is preferably made using easily attachable and detachable components.

[0073] With this configuration, the units **800** and **900** are located in standardized, accessible and relatively convenient positions relative to the facility **580** should any of the units **800/900** need to be accessed and/or removed for repair or replacement. Further, these units **800/900** are themselves created using an intentionally transportable design.

[0074] FIGS. **9**A-**9**E provide further details regarding the condenser unit **800** and its paired heat expulsion chamber **900**. In particular, as shown, the air conditioning apparatus includes the condenser unit **800** and its paired heat expulsion chamber **900**. The heat expulsion chamber **900** receives heated air, and emits vented air, and the vented air is released into the external environment, while the condenser unit **800** emits cooled air.

[0075] The heat exchange unit **900** contains an exhaust fan **910**, controlled by a VFD fan control and I/O signals block **1330** shown in FIG. **10**, that emits heat from the heated air as the vented air, thereby allowing return air to pass through a return damper **920**, which return damper **920** has a return damper actuator associated therewith.

[0076] The condenser unit **800** includes an outside air inlet **810**, and has associated an outside air damper **812**, thereby allowing outside air to pass therein. This outside air damper **812** is preferably coated with a neoprene seal to prevent pollution particles from passing through the damper **812** when in a closed position, as well as contains a spring-loaded mechanism closing lever that will automatically close the outside air damper **812** upon a removal of power, so that outside air is prevented from intake before backup generators **594** have to start, since after a power-grid power failure condition, before the back-up generators start, uninterruptable power supplies will supply building power, giving a period for the outside air damper **812** to close.

[0077] A filter chamber **820**, which includes an air intake area **822** coupled to the heat expulsion unit **900** and the outside air inlet **810**, is configurable, via the AHU control system **1000**, described hereinafter, to receive the return air, the outside air, as well as a mixture of the return air and the outside air, the filter chamber resulting in filtered air. In a preferred implementation of the filters **824** within the filter chamber **820** are included a MERV 7 screen filter **824**A with a MERV 16 bag filter **824**B therebehind, which allows replacement of the screen filter **824**A without replacement of the bag filter **824**B, and vice-versa.

[0078] The condenser unit **800** includes an air cooling area **830** over which the filtered air passes to create the cooled air. For ease of nomenclature, all of the air within the air cooling area **830** is referred to as filtered air, and only upon emission from the condenser unit is it referred to as cooled air. That notwithstanding, it is understood that along various stages of the air cooling area **830**, the filtered air will get progressively cooler in temperature.

[0079] The air cooling area **830** of the condenser unit **800** includes a direct cooling coil **840** filled with a gas for direct expansion, such as R134 gas, over which the filtered air passes, the gas being circulated through a condenser **842** disposed in another area of the condenser unit housing, but still in the external area, outside of the building.

[0080] The air cooling area **830** also includes an indirect cooling coil **850** filled with cooled water over which the filtered air passes, the cooled water being circulated through an evaporation unit **590** also disposed in the external area, via a water line **592** as shown in FIG. **5**(*a*). Optionally, though not shown, another coil that is cooled by a chiller could be included.

[0081] Also shown in FIGS. **9**A-**9**E is that the air cooling area also has an evaporator **860** that provides a water wall through which the filtered air can pass. An evaporator bypass **862** allows all or some of the filtered air to bypass the evaporator **860**, and a bypass damper **880** is opened to allow 100% bypass of the evaporator **860**, in which case the evaporator damper **890** is then fully closed. Filtered air can also be partially bypassed, or all go through the evaporator **860**, depending on the percentage opening of each of the dampers **880** and **890**.

[0082] Also within the air cooling area **830** is a fan **870**, shown as a fan array of multiple fans, operable push the filtered air through the air cooling area **830**, as well as an outlet damper **880** controllable by an actuator and operable to control an amount of the cooled air delivered from the air cooling area **830**.

[0083] As shown and mentioned previously the heat exchange unit **900** is contained within a first housing, and the condenser unit **900** is contained within a second housing.

[0084] Furthermore, and with reference to FIG. **10**, overall air conditioning system for the data center **500** includes a control system **1000**. The control system **1000** contains an air handling unit (AHU) and power control system computer **1100**, which is operable to automatically control each of the exhaust fan **910**, the return damper actuator, the outside air damper actuator, the condenser **842**, the bypass damper actuator, the fan **870**, and the outlet damper actuator.

Air Handling Control System

[0085] As referenced previously, and shown explicitly in FIG. **10**, the data center **500** includes a control system **1000**. The control system includes a air handling unit (AHU) and power control system (PCS) computer **1100**, which as shown obtains signals from many different units, and sends signals to many different units, based upon various software routines run by the AHU/PCS computer **1100**. These routines can be integrated with each other, as well as be discrete modules which operate on their own, or a combination of both.

[0086] A significant aspect of the present invention is the placement of sensors **1200** that can monitor for each/all of temperature, pressure differential, airflow, and humidity. Sensors that monitor these different aspects are placed in different locations throughout the data center.

[0087] In particular, having temperature sensors inside the thermal shield **400** (preferably redundant ones at the two ends and the middle of the cluster at least), and at different levels (such as at the middle and top of a cabinet **110**, as well as at the middle and top of the thermal shield **400**), as well as in stratified locations in the gap between the false ceiling **140** and the actual ceiling **150** (spaced at intervals of between 2-4 feet, as well as outside the thermal shield area, at the outside of cabinets in the cold aisles, allows for precise temperature gradient information throughout the facility.

[0088] Humidity sensors are helpful to have at locations that are the same as the temperature sensors, though fewer are needed, as humidity data need not be as precise for overall control of the building thermal environment.

[0089] Pressure differential sensors are also preferably located, redundantly, a number of different areas. These include within the thermal shield below the false ceiling **140**, outside the thermal shield below the false ceiling **140**, at different locations in the gap between the false ceiling **140** and the actual ceiling **150** (spaced at intervals of between 2-4 feet), at various locations within the cold aisle ducts **310**, particularly a header plenum that has a main cold air area to which many of the different condenser units connect, shown best along **310**-I in FIG. **5**B2 and then distribute cool air to the cooling ducts **310** that form the cold aisles. This allows for sensing of the pressure at various locations, and in particular within the hot air containment chamber **210**, outside the hot air containment chamber **210** above the cabinets **110**, within the gap between the false ceiling and the actual ceiling **150**, and within the cold aisle ducts. This allows for modification of the air handing units **800/900** by the control system **1100**. Overall pressure control between the hot air containment chamber **210**, the cold aisle, and the gap between the false ceiling and the actual ceiling **150** is achieved by adjusting the air handling units **800/900** so that the pressure is maintained in these different areas. within a predetermined range of each other, for example. This also allows for running the facility at a positive pressure differential when outside air is used, at ranges of 1% to 6%, such that as in essence the building breathes out.

[0090] Airflow sensors are also preferably located in each of the areas where the pressure differential sensors are noted as being required, in order to ensure that the airflow is stable, as amounts of airflow that are too great, just as pressure differentials that are too great, can adversely affect the electronic equipment.

[0091] Areas where these differentials occur the most in the embodiments described herein are at the barrier caused by the thermal shield **400** within each cabinet cluster **590**, between the false ceiling and the gap thereover, since heated air from each of the different hot aisle areas **210**, associated with each cabinet cluster **590**, vent to this large gap area.

[0092] Signals from these sensors **1200**, as shown by Temperature, Pressure Differential, Airflow, and Humidity Sensor Control and and input/output (I/O) signals block **1310** can then be used to provide damper actuator control **1320**, VFD fan control and I/O signals block **1330**, evaporator control and I/O signals **1340**, condenser control and I/O signals block **1350**, evaporator control and I/O signals block **1360**, and optionally chiller control and I/O signals block **1370**. Within the Damper actuator control block is included the dampers associated with the cold aisle ducts, which dampers can be automatically adjusted to fully open, fully closed, or in-between amounts based upon sensing of the current conditions, as described previously.

[0093] Still furthermore, the AHU/PCS computer **1100** also monitors power consumption and power production, depending on the devices, to assess overall power usage. As such, electrical energy monitor sensors within the RPP **180** are operated upon by the RPP control and I/O signals block **1410**, and provide an indication of the power usage of the electronics devices in the cabinets **110**. The PDU **598** is monitored, as is known, and operated upon by the PDU control and I/O signals block **1420**. Power load control and I/O signals block **1430** provides monitoring of the transformers and uninterruptable power supplies within the distribution area **584**. Backup generator control and I/O signals block **1440** is used for the control of the backup generator **594**, whereas telecommunication control and I/O signals block **1450** is used for the control of the telecommunications equipment. Equipment load control and I/O signals block **1460** controls and monitors energy consumption of other equipment within the data center facility

[0094] The above control blocks can contain software written to both act upon input signals obtained from other sensors or other units, and ensure that the various different units operate together. The usage of the term I/O signals is intended to convey that for any of the associated sensors, actuators for dampers, VFD for fans, and other mechanisms, that depending on the model used, such devices may output signals, input signals or both.

[0095] It is also noted that what occurs with one device will alter which other devices operate. Thus, for example malfunction of a particular circuit in an RPP **180** will cause the AHU/PCS computer **1100** to switch over to the redundant circuit in the same RPP **180** until that circuit is fixed.

[0096] It is particularly noted that the above system can monitor and control for certain situations that are particularly significant for data centers. For example, the air flow patterns that are caused, with the inclusion of the false ceiling **140** as shown in FIG. **1**C, require assessment of high and low pressure areas. The AHU/PCS computer **1100** can monitor for this, and as a result maintain a balance, thus ensuring that fans and other components that are within the electronics equipment stored in the cabinets **110** isn't damaged.

[0097] Also shown in FIG. **10** are building cabinet cluster and cage lock sensors block **1510**. This allows for the detection of which cabinet clusters **590**, as well as which cabinets **110**, are open, based upon sensors that are placed at each of these areas.

[0098] Fire and roof water detection leak sensors module **1520** is also shown, as this can be used in conjunction with known systems, and interfaced with the other blocks referred to herein, to ensure that if a fire or leak is detected, that appropriate shut down of equipment in the preferred sequence to avoid damage is done.

[0099] Although the present invention has been particularly described with reference to embodiments thereof, it should be readily apparent to those of ordinary skill in the art that various changes, modifications and substitutes are intended within the form and details thereof, without departing from the spirit and scope of the invention. Accordingly, it will be appreciated that in numerous instances some features of the invention will be employed without a corresponding use of other features. Further, those skilled in the art will understand that variations can be made in the number and arrangement of components illustrated in the above figures.

What is claimed is:

1. A method of controlling an environment within an enclosed space, the method comprising:

supplying a supply air stream from an environmental control assembly to the enclosed space;

returning at least a portion of the supply air stream to the environmental control assembly as a return air stream;

controlling a temperature of the supply air stream with the environmental control assembly based at least in part on a temperature associated with the enclosed space;

detecting a pressure differential between a hot aisle of the enclosed space and a cold aisle of the enclosed space with a differential pressure sensor; and

controlling a flow rate of the supply air stream with the environmental control assembly based at least in part on the pressure differential, wherein the enclosed space utilizes hot aisle containment to separate the hot aisle from the cold aisle, and further wherein the method includes maintaining a pressure in the hot aisle to be less than a pressure in the cold aisle.

2. The method of claim **1**, wherein controlling the temperature of the supply air stream and controlling the flow rate of the supply air stream includes controlling the temperature of the supply air stream independently from controlling the flow rate of the supply air stream.

3. The method of claim **2**, wherein controlling the temperature of the supply air stream independently from controlling the flow rate of the supply air stream includes controlling the temperature of the supply air stream without varying the flow rate of the supply air stream, and further wherein controlling the temperature of the supply air stream independently from controlling the flow rate of the supply air stream includes controlling the flow rate of the supply air stream without varying the temperature of the supply air stream.

4. The method of claim **1**, wherein the environmental control assembly includes an indirect evaporative cooling assembly (IECA) that includes a variable rotational frequency IECA fan configured to provide an IECA scavenger air stream in fluid communication with an IECA water stream to indirectly cool the supply air stream, wherein controlling the temperature of the supply air stream includes controlling a rotational frequency of the variable rotational frequency IECA fan, wherein the method includes increasing the rotational frequency of the variable rotational frequency IECA fan responsive at least in part to the temperature associated with the enclosed space being greater than a threshold temperature, wherein the method further includes decreasing the rotational frequency of the variable rotational frequency IECA fan responsive to the temperature associated with the enclosed space being less than the threshold temperature, and further wherein the controlling the rotational frequency of the variable rotational frequency IECA fan is independent from the controlling the flow rate of the supply air stream.

5. The method of claim **4**, wherein the environmental control assembly further includes a supplemental cooling assembly, wherein the supplemental cooling assembly includes at least one of a direct expansion cooling assembly and a cold water cooling assembly, and further wherein controlling the temperature of the supply air stream includes controlling the operation of the supplemental cooling assembly.

6. The method of claim **5**, wherein the supplemental cooling assembly includes a plurality of supplemental cooling assemblies including at least a first supplemental cooling assembly and at least a second supplemental cooling assembly, and further wherein controlling the temperature of the supply air stream includes transitioning the first supplemental cooling assembly from a supplemental cooling assembly inactive state to a supplemental cooling assembly active state responsive at least in part to the rotational frequency of the variable rotational frequency MCA fan being greater than an IECA fan maximum rotational frequency threshold.

7. The method of claim **6**, wherein controlling the temperature of the supply air stream includes transitioning the second supplemental cooling assembly from the supplemental cooling assembly inactive state to the supplemental cooling assembly active state responsive at least in part to the first supplemental cooling assembly being in the supplemental cooling assembly active state and the rotational frequency of the variable rotational frequency IECA fan being greater than the IECA fan maximum rotational frequency threshold.

8. The method of claim **7**, wherein controlling the temperature of the supply air stream includes transitioning the second supplemental cooling assembly from the supplemental cooling assembly active state to the supplemental cooling assembly inactive state responsive at least in part to the first supplemental cooling assembly being in the supplemental cooling assembly active state and the rotational frequency of the variable rotational frequency IECA fan being less than an IECA fan minimum rotational frequency threshold.

9. The method of claim **8**, wherein controlling the temperature of the supply air stream includes transitioning the first supplemental cooling assembly from the supplemental cooling assembly active state to the supplemental cooling assembly inactive state responsive at least in part to the second supplemental cooling assembly being in the supplemental cooling assembly inactive state and the rotational frequency of the variable rotational frequency IECA fan being less than the IECA fan minimum rotational frequency threshold.

10. The method of claim **1**, wherein the environmental control assembly includes a variable rotational frequency fluid drive assembly configured to provide a motive force to the supply air stream and further wherein controlling the flow rate of the supply air stream includes increasing the flow rate of the air supply stream by increasing a rotational frequency of the variable rotational frequency fluid drive assembly responsive at least in part to the pressure differential between the hot aisle and the cold aisle being less than a threshold pressure differential and decreasing the flow rate of the air supply stream by decreasing the rotational frequency of the variable rotational frequency fluid drive assembly responsive at least in part to the pressure differential between the hot aisle and the cold aisle being greater than the threshold pressure differential.

11. The method of claim **1**, wherein the supplying includes supplying the supply air stream to an intake region of the enclosed space, wherein the intake region includes the cold aisle, and further wherein the method includes:

cooling electronic equipment, which is present within the enclosed space, with the supply air stream by flowing the supply air stream from the intake region, through the electronic equipment, and to an exhaust region to generate an exhaust stream, wherein the exhaust region includes the hot aisle; and

fluidly separating the hot aisle from the cold aisle with a partition such that the supply air stream flows through the electronic equipment responsive to the pressure differential between the hot aisle and the cold aisle.

12. The method of claim **11**, wherein the detecting includes detecting the pressure differential across the partition.

13. The method of claim **11**, wherein the detecting includes detecting the pressure differential between the intake region and the exhaust region.

14. The method of claim **11**, wherein the returning includes receiving the exhaust stream with an exhaust conduit and providing the exhaust stream to the environmental control assembly, via the exhaust conduit, as the return air stream, wherein the exhaust conduit fluidly separates the exhaust stream from the intake region.

15. An environmental control assembly, comprising:

a fluid drive assembly configured to control the flow rate of a supply air stream;

a cooling assembly configured to control the temperature of the supply air stream; and

a controller programmed to:

supply a supply air stream from an environmental control assembly to the enclosed space;

return at least a portion of the supply air stream to the environmental control assembly as a return air stream;

control the temperature of the supply air stream with the environmental control assembly based at least in part on a temperature associated with the enclosed space;

detect a pressure differential between a hot aisle of the enclosed space and a cold aisle of the enclosed space with a differential pressure sensor; and

control the flow rate of the supply air stream with the environmental control assembly based at least in part on the pressure differential, wherein the enclosed space utilizes hot aisle containment to separate the hot aisle from the cold aisle, and further wherein a pressure in the hot aisle is maintained to be less than a pressure in the cold aisle.

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