



PATENTS

Since founding Switch in 2000, Rob Roy has transformed the way data center ecosystems are engineered and utilized.

As CEO, founder, chief inventor and designer of Switch data centers, he has been continually innovating and improving technologies to build smarter, stronger, faster, safer and more efficient data center elements.

With more than 700 issued and pending patent claims for mission critical facility systems, designs and related industry technologies, Rob Roy's inventions and thought leadership have changed the industry landscape and created a new standard of excellence for technology solutions ecosystems.

Switch's patented technology makes possible the world's only Tier 5[®] Platinum data centers.





US008523643B1

(12) **United States Patent
Roy/Rob**

(10) **Patent No.: US 8,523,643 B1**
(45) **Date of Patent: Sep. 3, 2013**

(54) **ELECTRONIC EQUIPMENT DATA CENTER
OR CO-LOCATION FACILITY DESIGNS AND
METHODS OF MAKING AND USING THE
SAME**

(75) Inventor: **Rob Roy**, Las Vegas, NV (US)

(73) Assignee: **Switch Communications Group LLC**,
Las Vegas, NV (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 1098 days.

(21) Appl. No.: **12/384,109**

(22) Filed: **Mar. 30, 2009**

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/138,771,
filed on Jun. 13, 2008.

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

Initial Filing June 14, 2007

(51) **Int. Cl.**
G06F 1/16 (2006.01)

(52) **U.S. Cl.**
USPC **454/184**

(58) **Field of Classification Search**
USPC **454/184**
See application file for complete search history.

(56) **References Cited**

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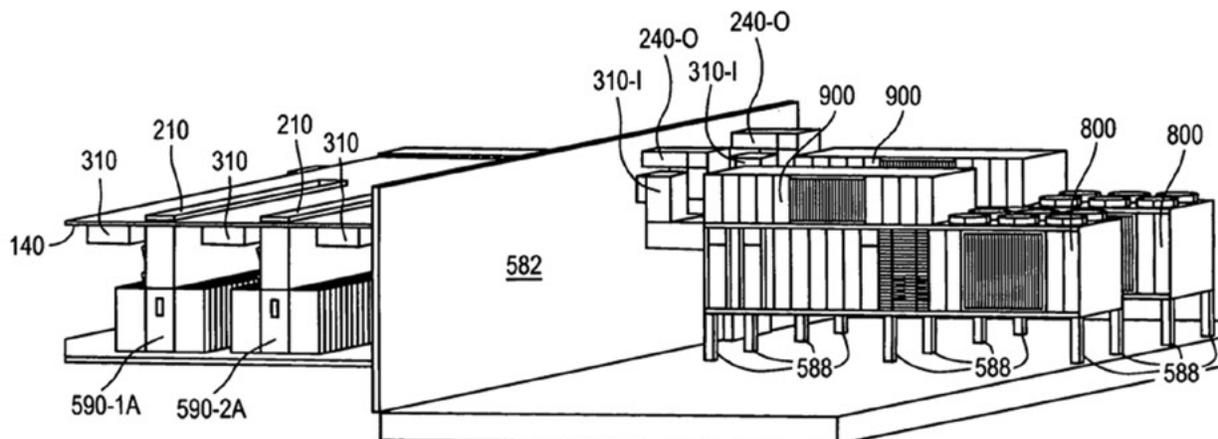
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Primary Examiner — Steven B McAllister
Assistant Examiner — Samantha Miller
(74) *Attorney, Agent, or Firm* — Pillsbury Winthrop Shaw
Pittman LLP

(57) **ABSTRACT**

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

12 Claims, 19 Drawing Sheets



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US008072780B1

(12) **United States Patent
Roy/Rob**

(10) **Patent No.: US 8,072,780 B1**
(45) **Date of Patent: Dec. 6, 2011**

(54) **INTEGRATED WIRING SYSTEM AND
THERMAL SHIELD SUPPORT APPARATUS
FOR A DATA CENTER**

(56) **References Cited**

(75) Inventor: **Rob Roy**, Las Vegas, NV (US)

(73) Assignee: **Switch Communications Group LLC**,
Las Vegas, NV (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 181 days.

(21) Appl. No.: **12/384,105**

(22) Filed: **Mar. 30, 2009**

Related U.S. Application Data

(63) 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,

Initial Filing June 14, 2007

(51) **Int. Cl.**
H02B 1/01 (2006.01)

(52) **U.S. Cl.** **361/825**

(58) **Field of Classification Search** **361/825**
See application file for complete search history.

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| 2007/0040263 | A1 | 2/2007 | Towada | |
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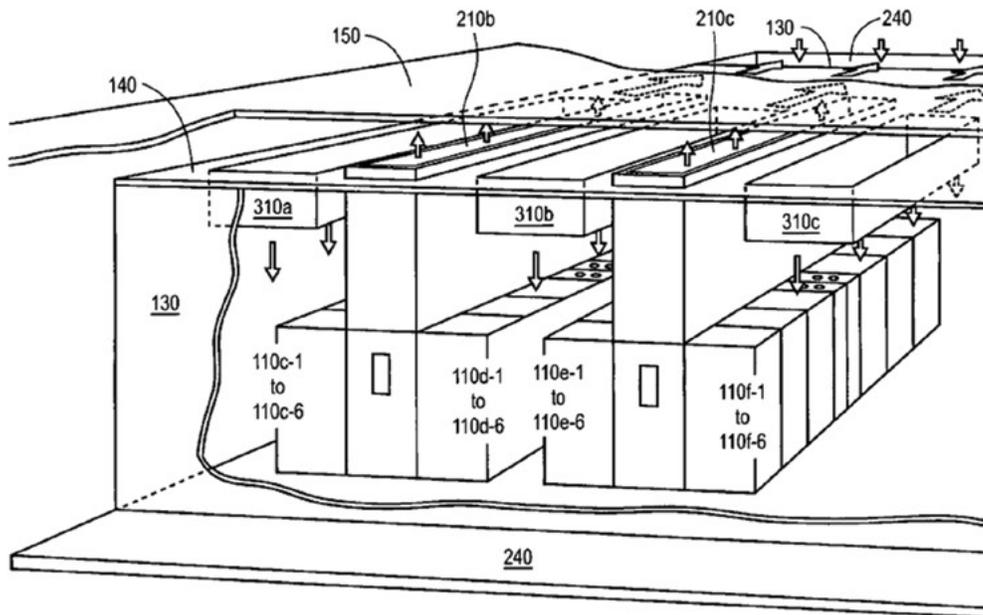
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Primary Examiner — Jeremy Norris
Assistant Examiner — Tremesha S Willis
(74) *Attorney, Agent, or Firm* — Pillsbury Winthrop Shaw
Pittman LLP

(57) **ABSTRACT**

Described herein is an integrated data center that provides for
efficient cooling, as well as efficient wire routing, and in
particular a support for a thermal shield, distribution wiring,
as well as cabinet cluster wiring.

8 Claims, 19 Drawing Sheets



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US008469782B1

(12) **United States Patent
Roy/Rob**

(10) **Patent No.: US 8,469,782 B1**
(45) **Date of Patent: Jun. 25, 2013**

- (54) **DATA CENTER AIR HANDLING UNIT**
- (75) Inventor: **Rob Roy**, Las Vegas, NV (US)
- (73) Assignee: **Switch Communications Group, LLC**, Las Vegas, NV (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 998 days.
- (21) Appl. No.: **12/384,102**
- (22) Filed: **Mar. 30, 2009**

Related U.S. Application Data

- (63) Continuation-in-part of application No. 12/138,771, filed on Jun. 13, 2008.
- (60) Provisional application No. 60/944,082, filed on Jun. 14, 2007, provisional application No. 61/040,636, **Initial Filing June 14, 2007**
- (51) **Int. Cl.**
F25B 23/00 (2006.01)
- (52) **U.S. Cl.**
USPC **454/187**; 454/184; 62/119
- (58) **Field of Classification Search**
USPC 454/184, 237, 238, 248; 62/119, 62/310, 314
See application file for complete search history.

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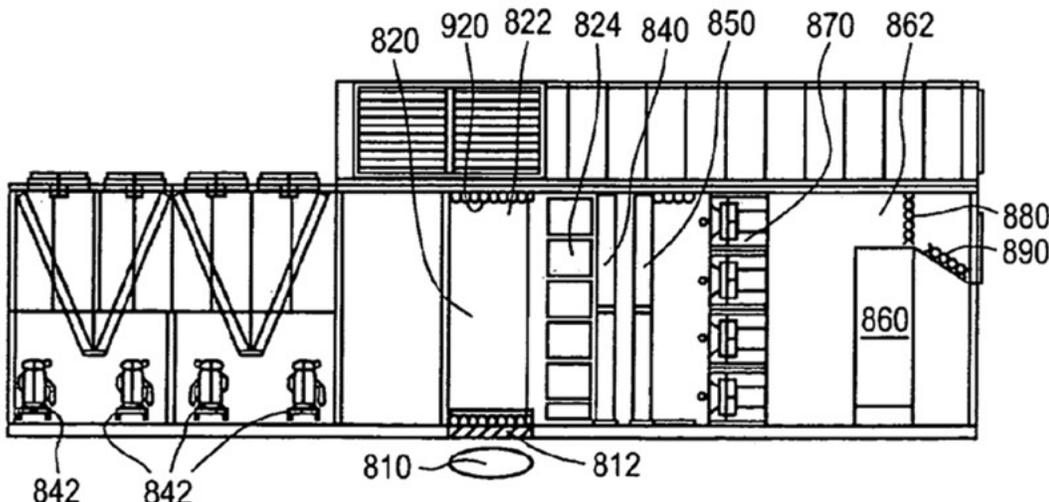
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Primary Examiner — Steven B McAllister
Assistant Examiner — Samantha Miller
(74) *Attorney, Agent, or Firm* — Pillsbury Winthrop Shaw Pittman LLP

(57) **ABSTRACT**

Described herein is an air handling unit for use in an integrated data center that provides for efficient cooling.

13 Claims, 19 Drawing Sheets



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US008180495B1

(12) **United States Patent
Roy/Rob**

(10) **Patent No.: US 8,180,495 B1**

(45) **Date of Patent: May 15, 2012**

(54) **AIR HANDLING CONTROL SYSTEM FOR A
DATA CENTER**

(56) **References Cited**

- (75) Inventor: **Rob Roy**, Las Vegas, NV (US)
- (73) Assignee: **Switch Communications Group LLC**,
Las Vegas, NV (US)
- (*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 149 days.
- (21) Appl. No.: **12/384,111**
- (22) Filed: **Mar. 30, 2009**

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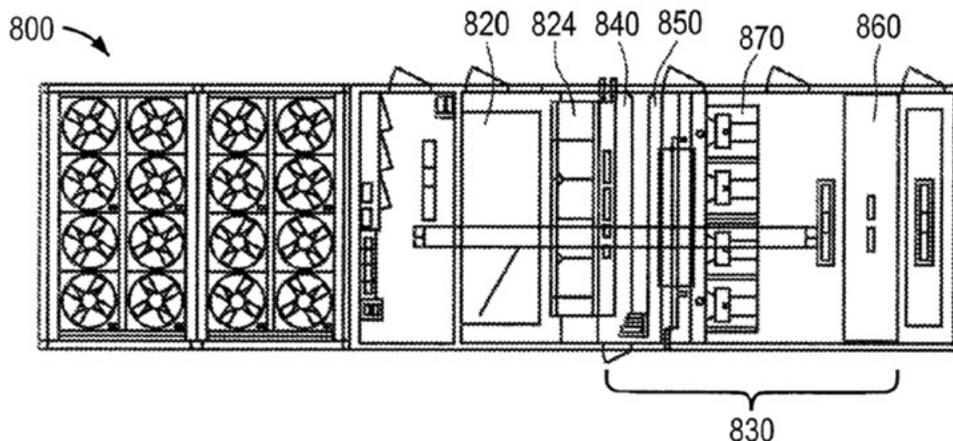
- (51) **Int. Cl.**
G05D 23/19 (2006.01)
- (52) **U.S. Cl.** **700/278**; 361/679.47; 361/691;
454/184; 165/67
- (58) **Field of Classification Search** 700/278;
361/679.47, 691; 454/184; 165/67
See application file for complete search history.

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Primary Examiner — Kakali Chaki
Assistant Examiner — Tejal Gami
 (74) *Attorney, Agent, or Firm* — Pillsbury Winthrop Shaw
 Pittman LLP

(57) **ABSTRACT**
 Described herein is an integrated data center that provides for
 efficient cooling, as well as efficient wire routing, and in
 particular a control system for controlling the temperature
 and pressure within the data center.

34 Claims, 19 Drawing Sheets



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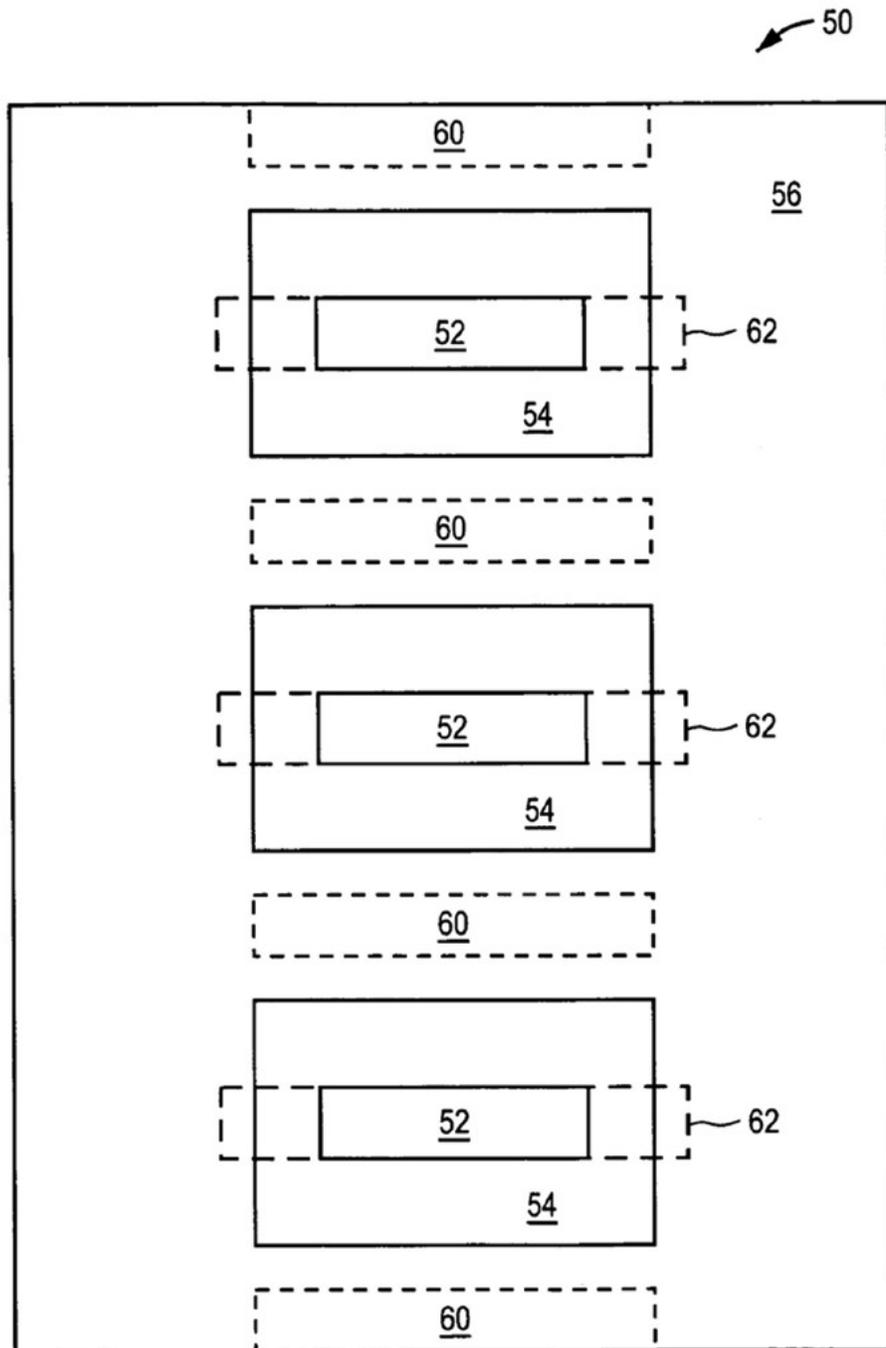


FIG. 1A

T-SCIF (Multi-Cabinet Heat Containment Rows)
Floor Layout and Segregation Designs

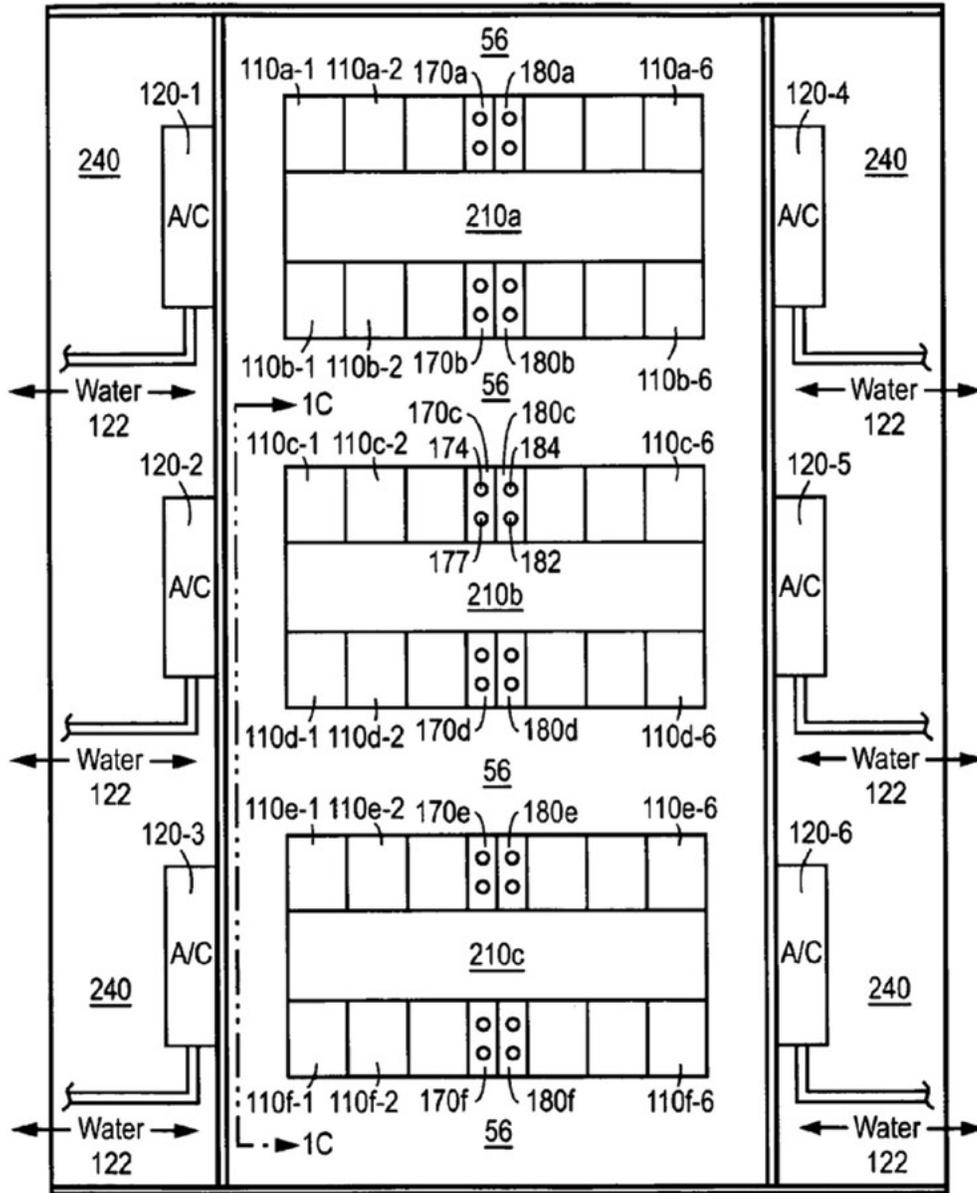


FIG. 1B

T-SCIF (Multi-Cabinet Heat Containment Rows)
Floor Layout and Segregation Designs Combined with Hot
Aisles and Separated C.R.A.C. Unit Locations

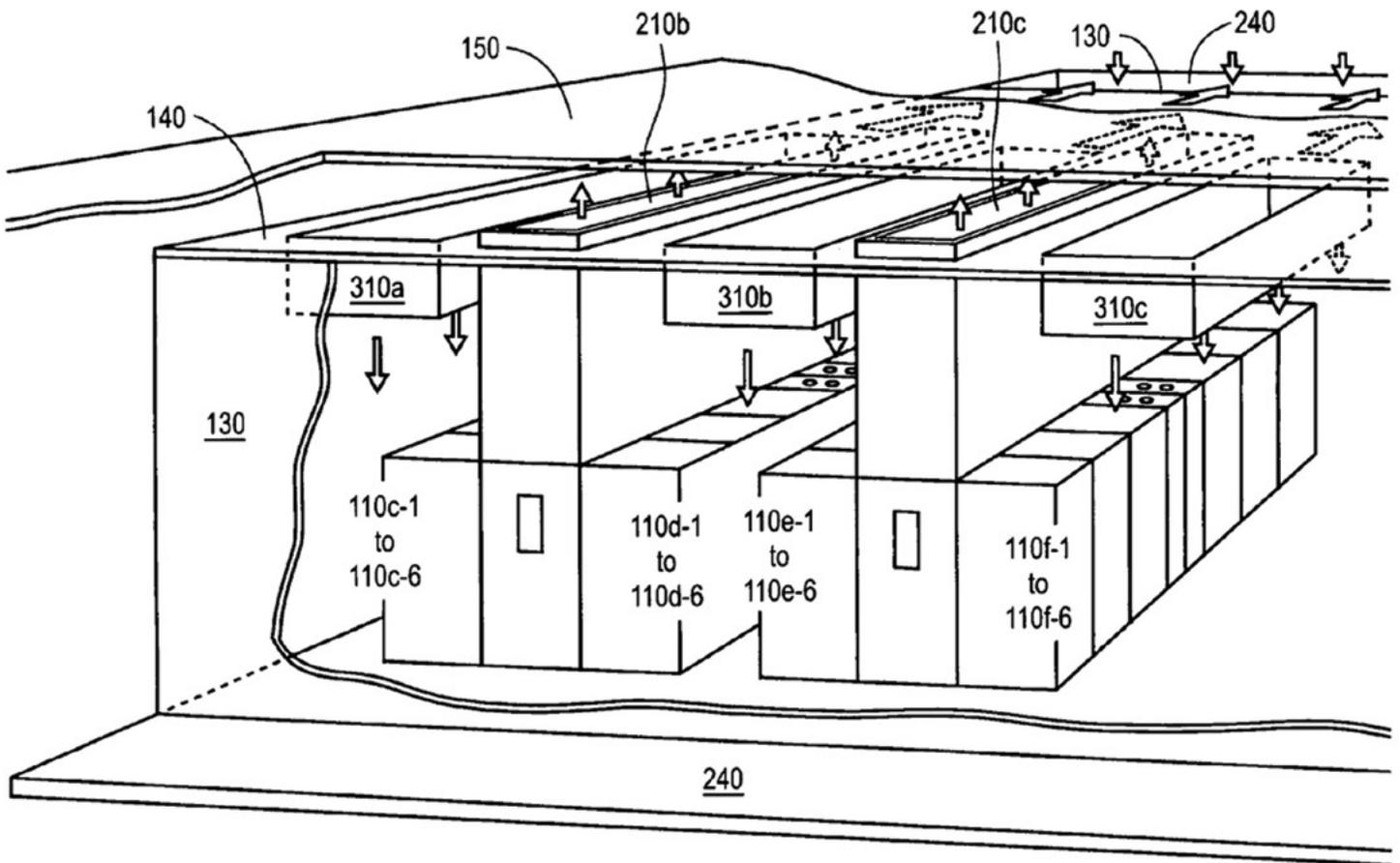
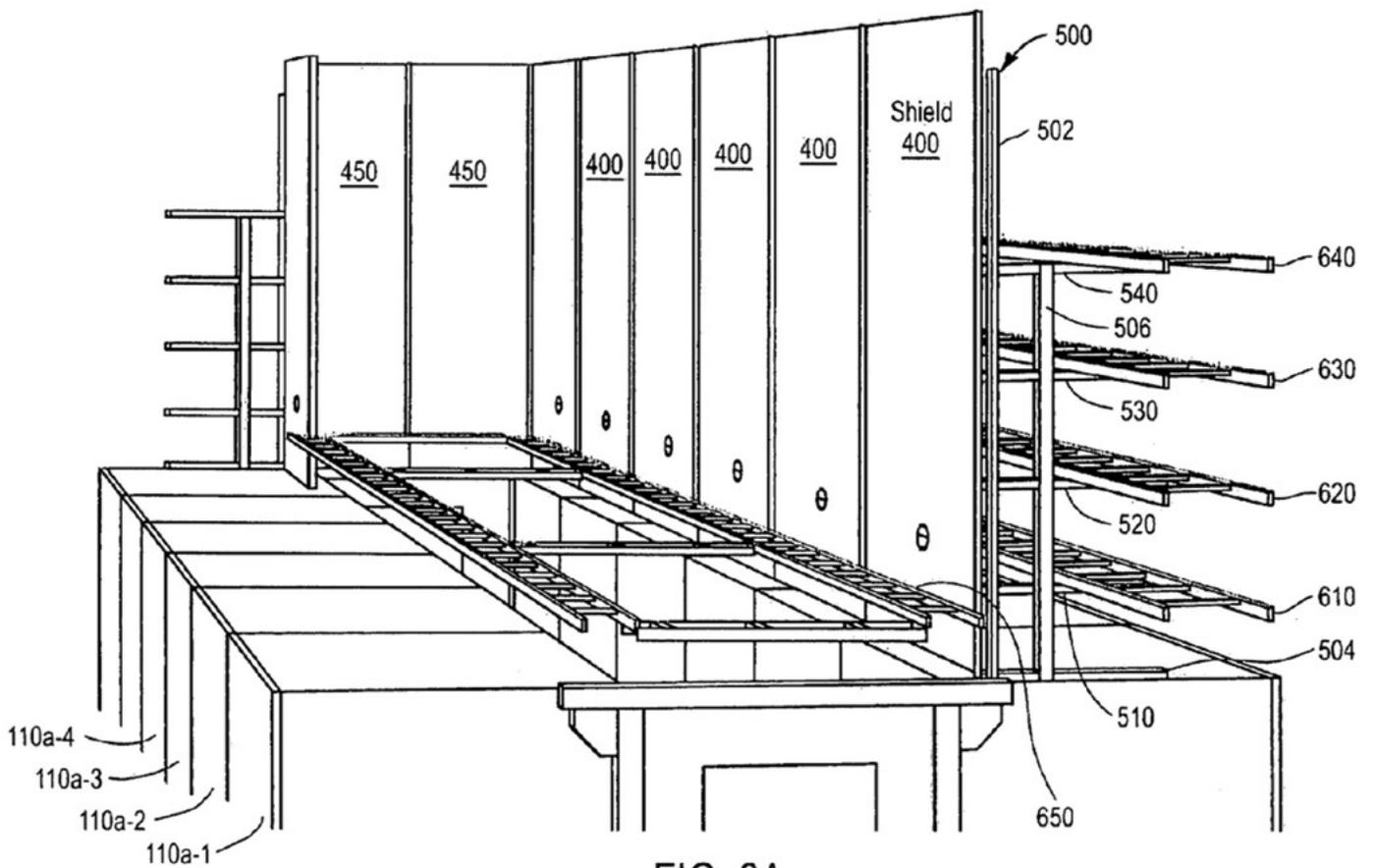


FIG. 1C

T-SCIF (Multi-Cabinet Heat Containment Rows) Heat Containment Pods
100% Heat and Cooling Separation Chambers (2006)



T-SCIF (Multi-Cabinet Heat Containment Rows) Heat Shield Designs

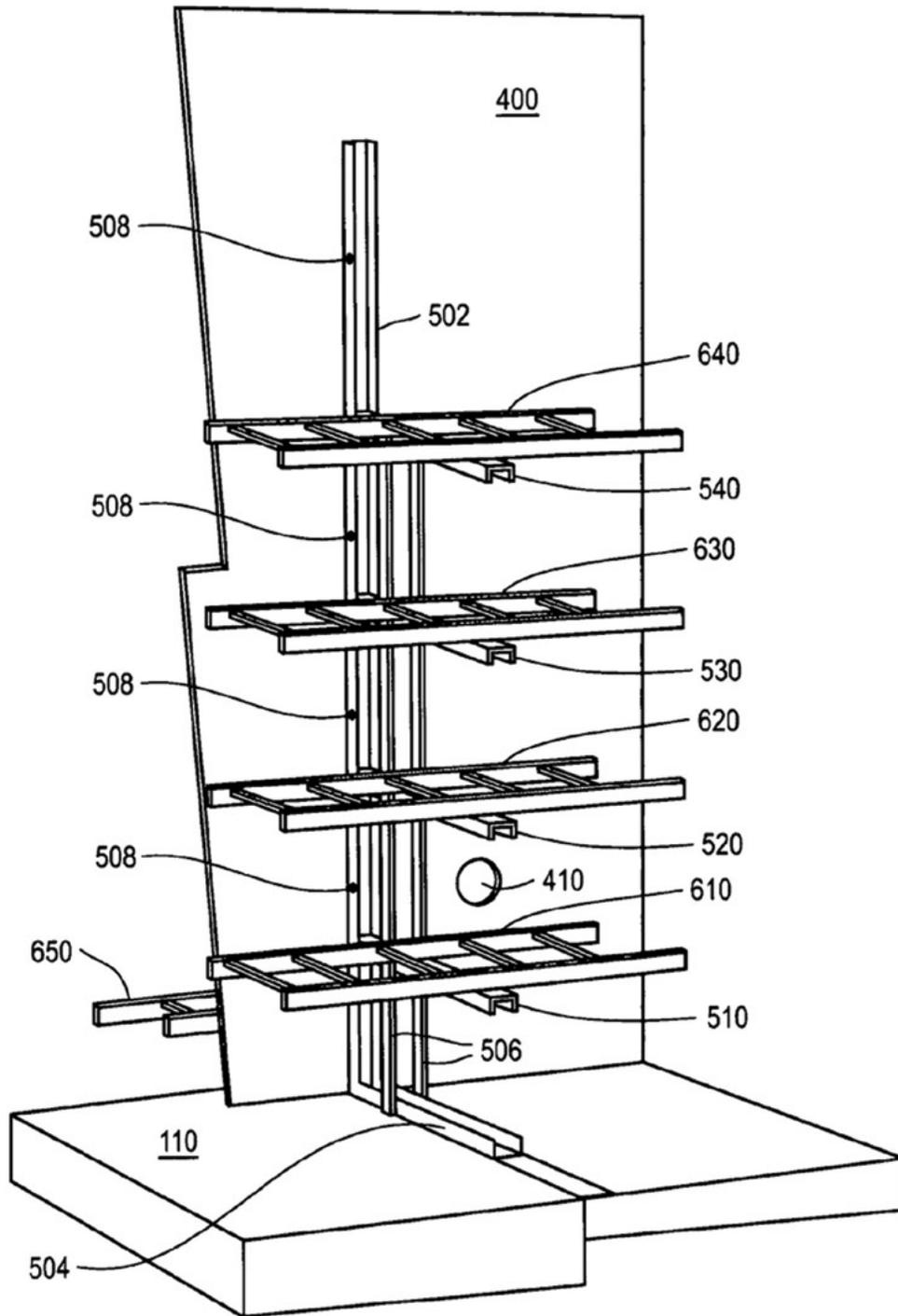


FIG. 2B

T-SCIF (Multi-Cabinet Heat Containment Rows) Heat Shield Designss

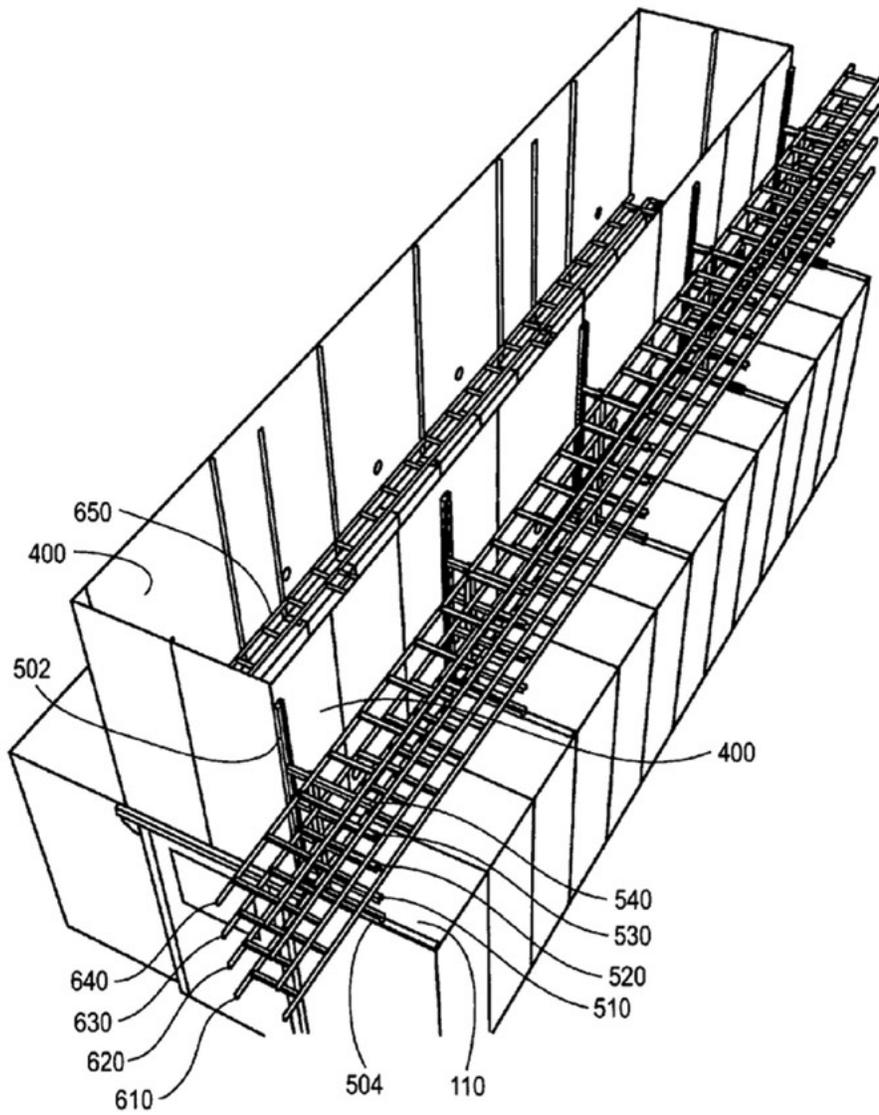


FIG. 2C

T-SCIF (Multi-Cabinet Heat Containment Rows) Heat Shield Designs

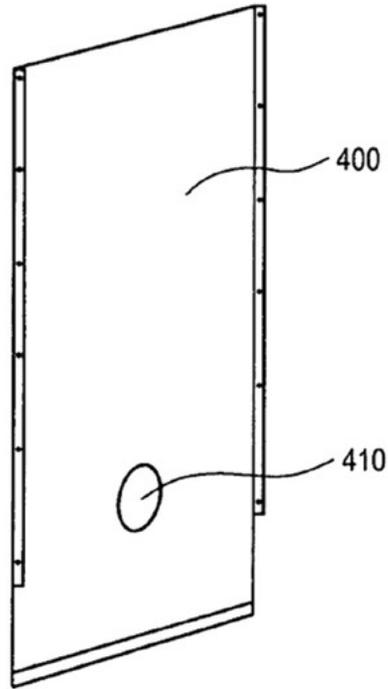


FIG. 3A

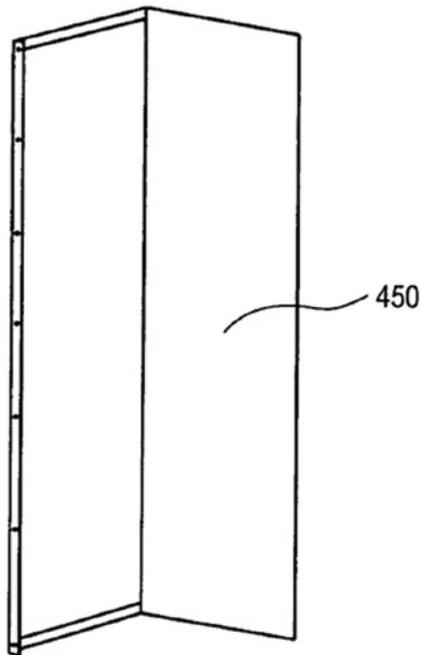


FIG. 3B

T-SCIF (Multi-Cabinet Heat Containment Rows) Heat Shield Designs

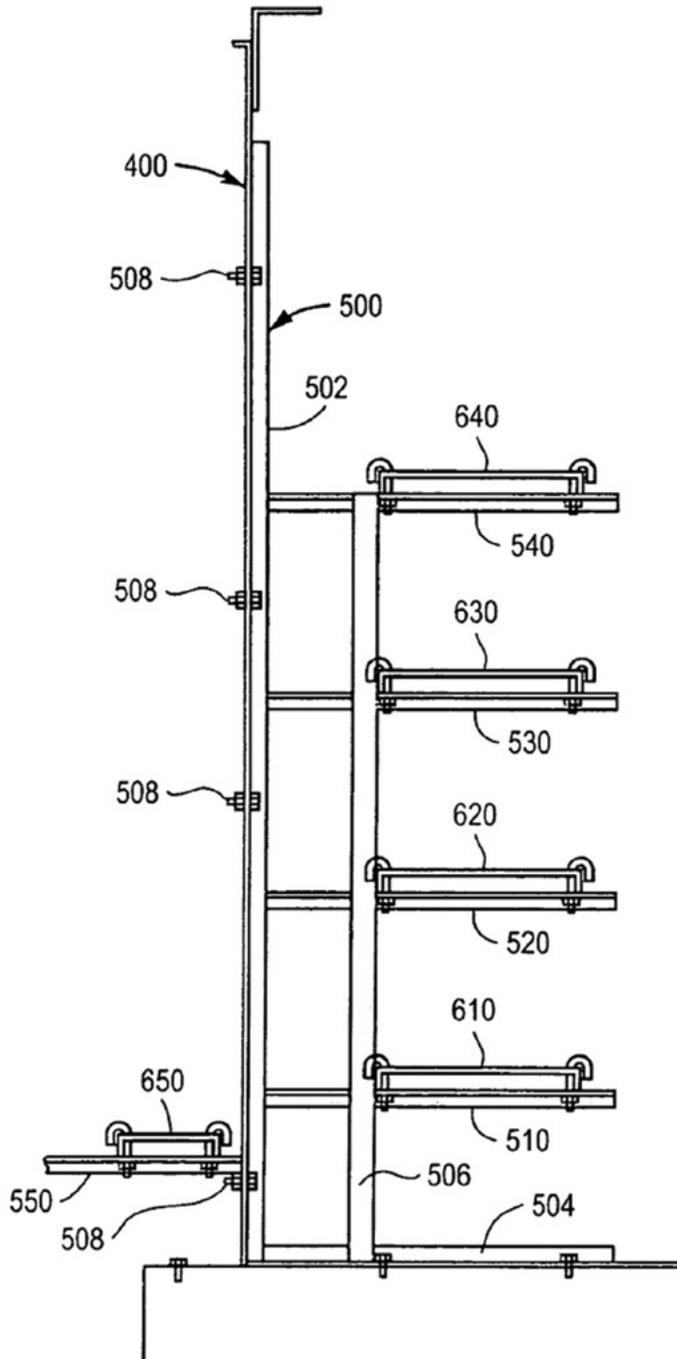


FIG. 4

Switch Station Support Design

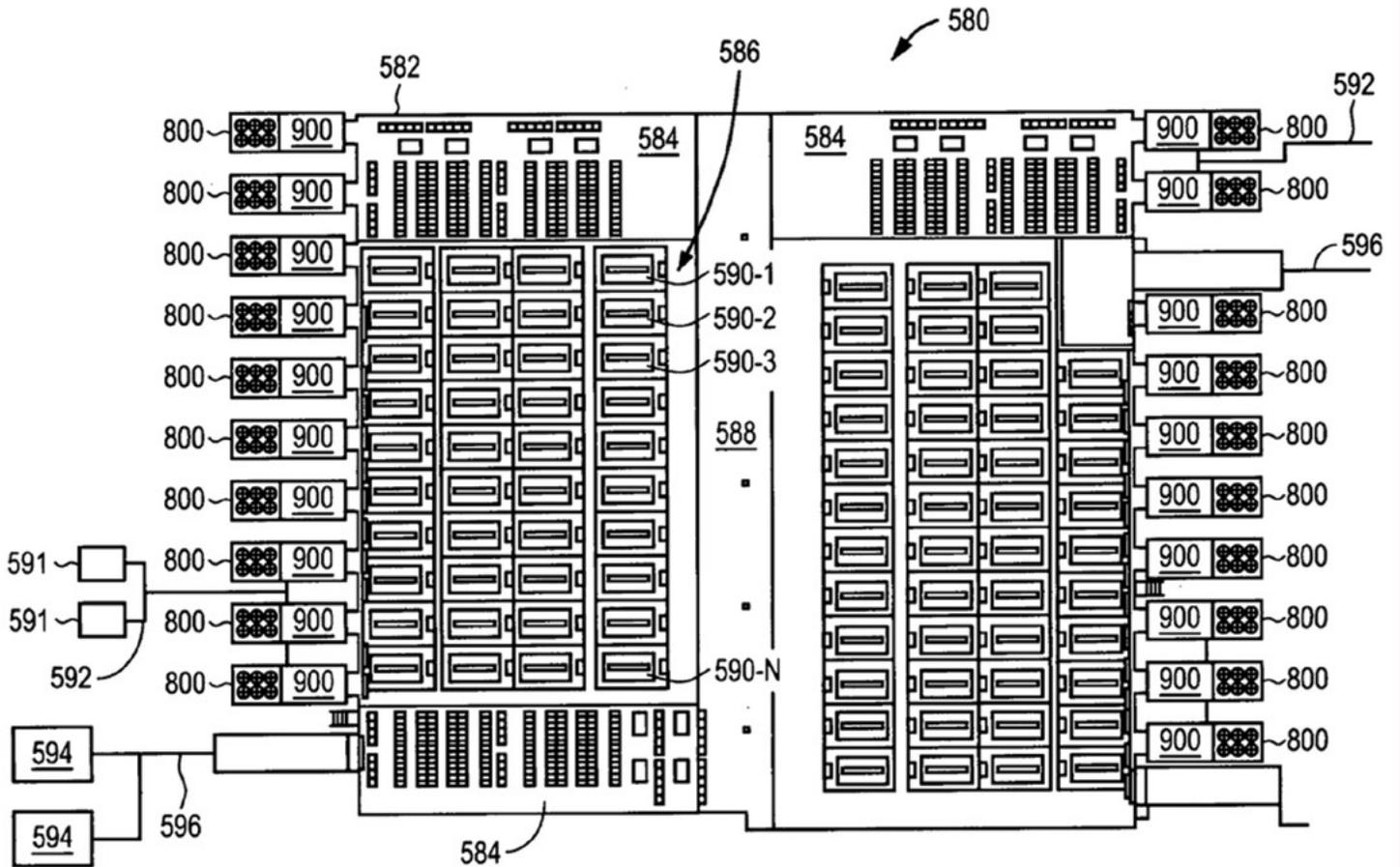


FIG. 5A

Switch MOD - W.D.M.D. (Wattage Density Modular Design)
Switch's Highly Efficient 100% Heat Segregated Data Center Ecosystem

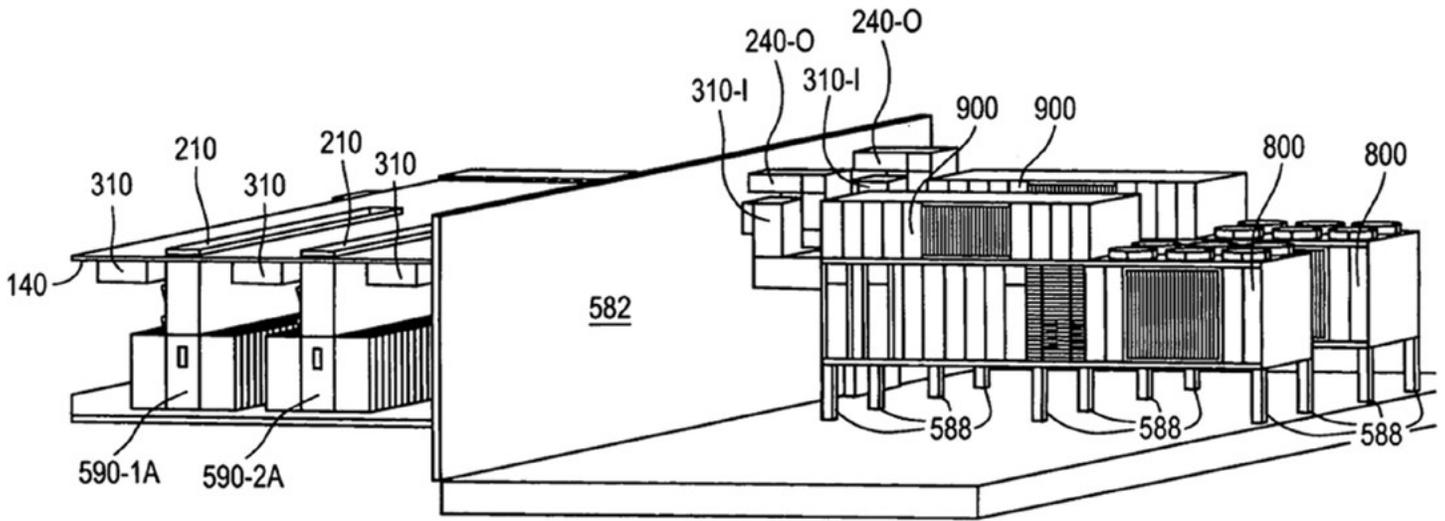


FIG. 5B1

TSC (Multi-System Exterior Wall Penetrating HVAC Units)
Shown Connected to the T-SCIF (Multi-Cabinet Heat Containment Rows)
Data Center Environment

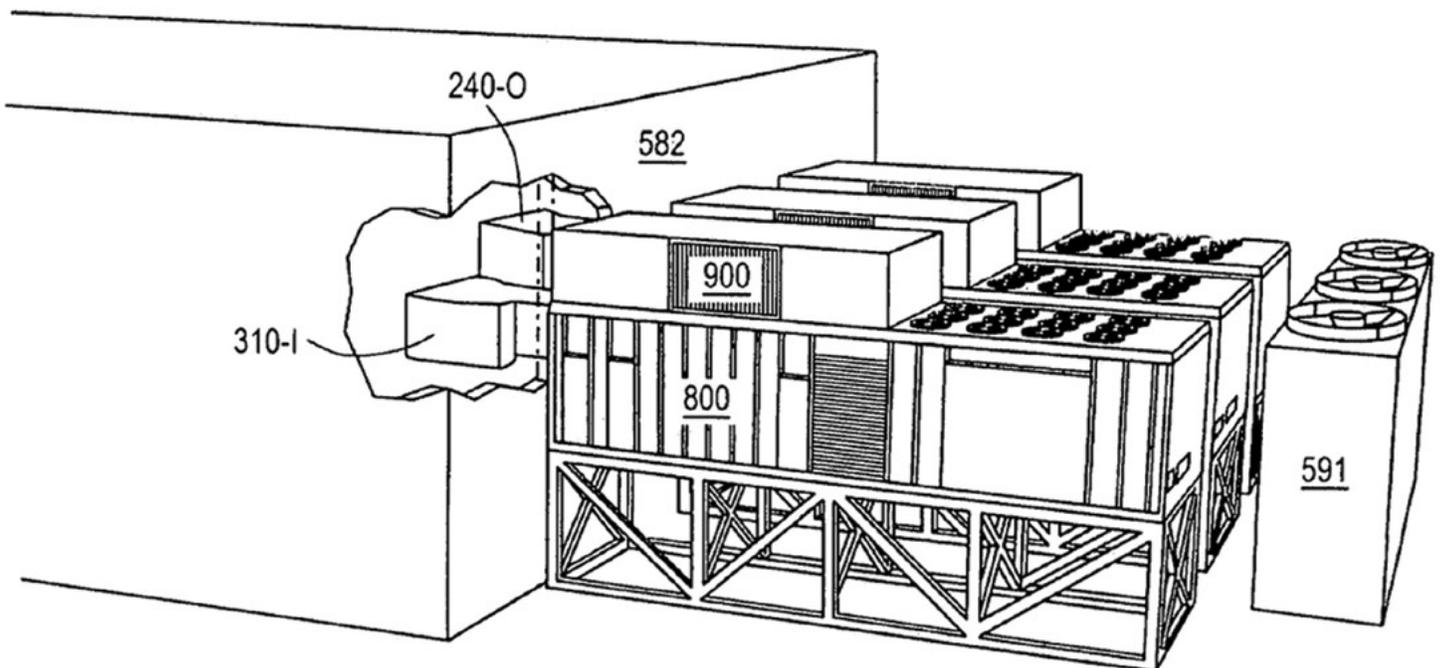
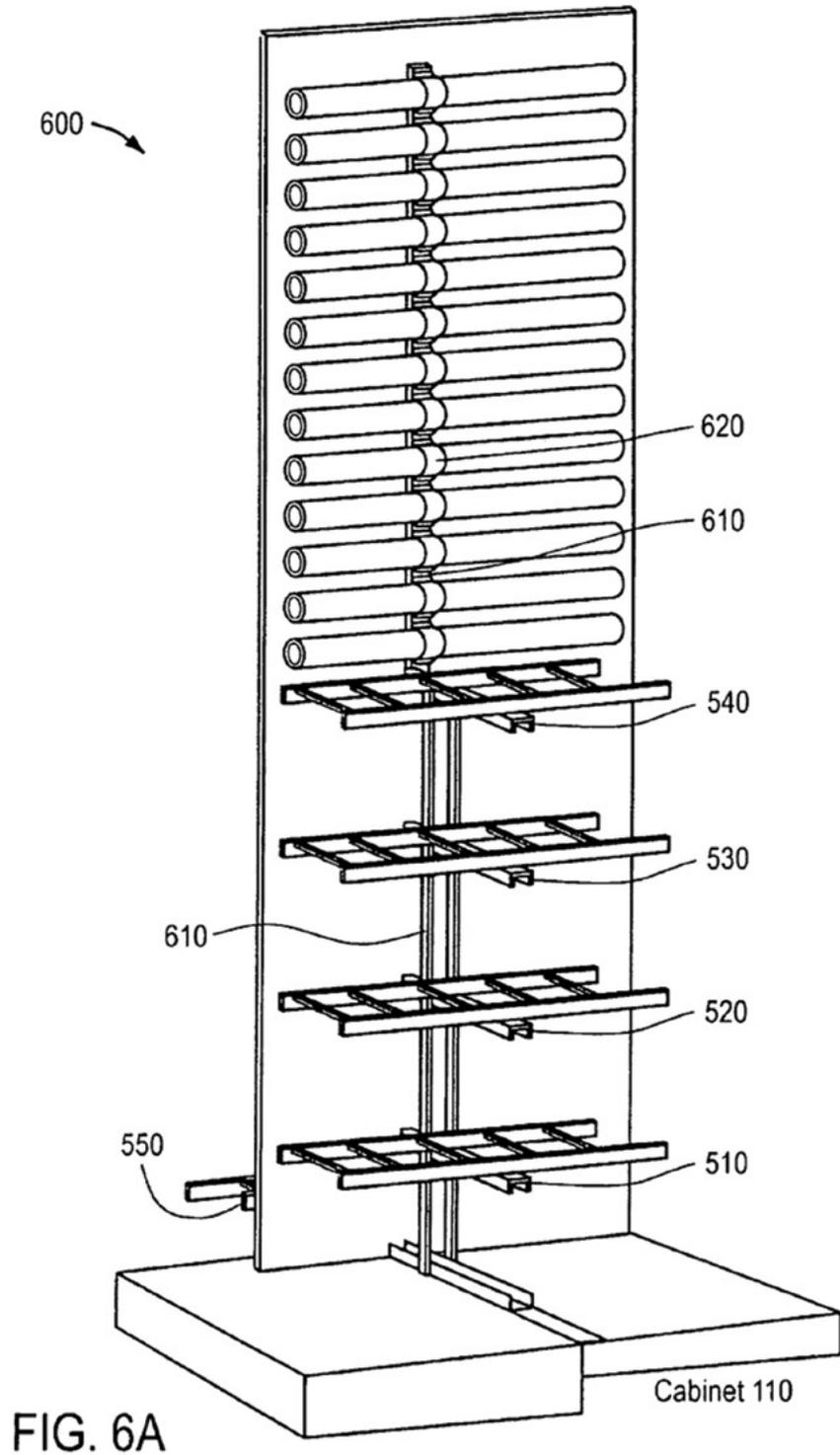
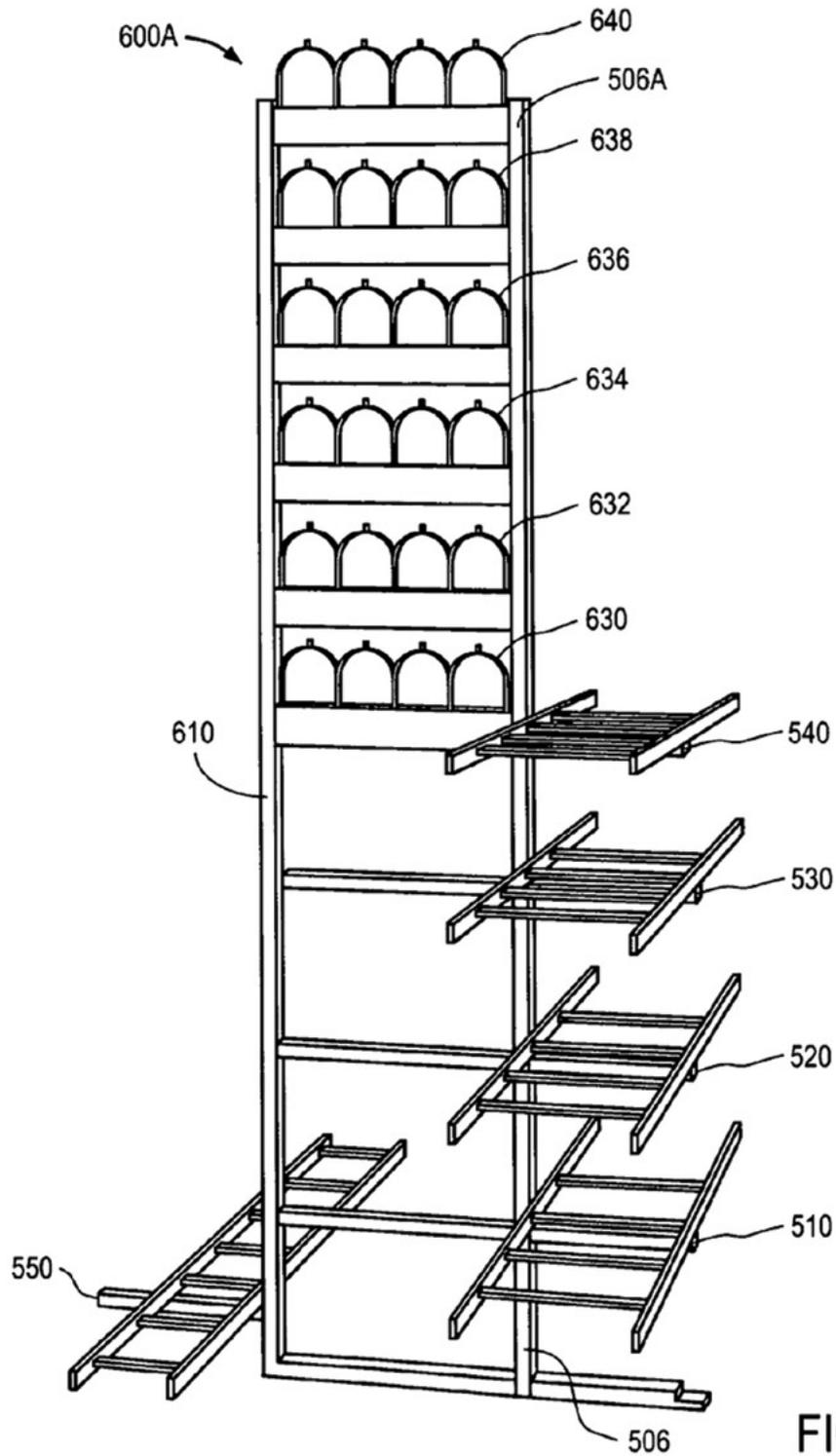


FIG. 5B2

TSC (Multi-System Exterior Wall Penetrating HVAC Units)
Switch's "Connect and Cool" Modular HVAC Designs



Switch Station Support Design Version 1



Switch Station Support Design Version 2

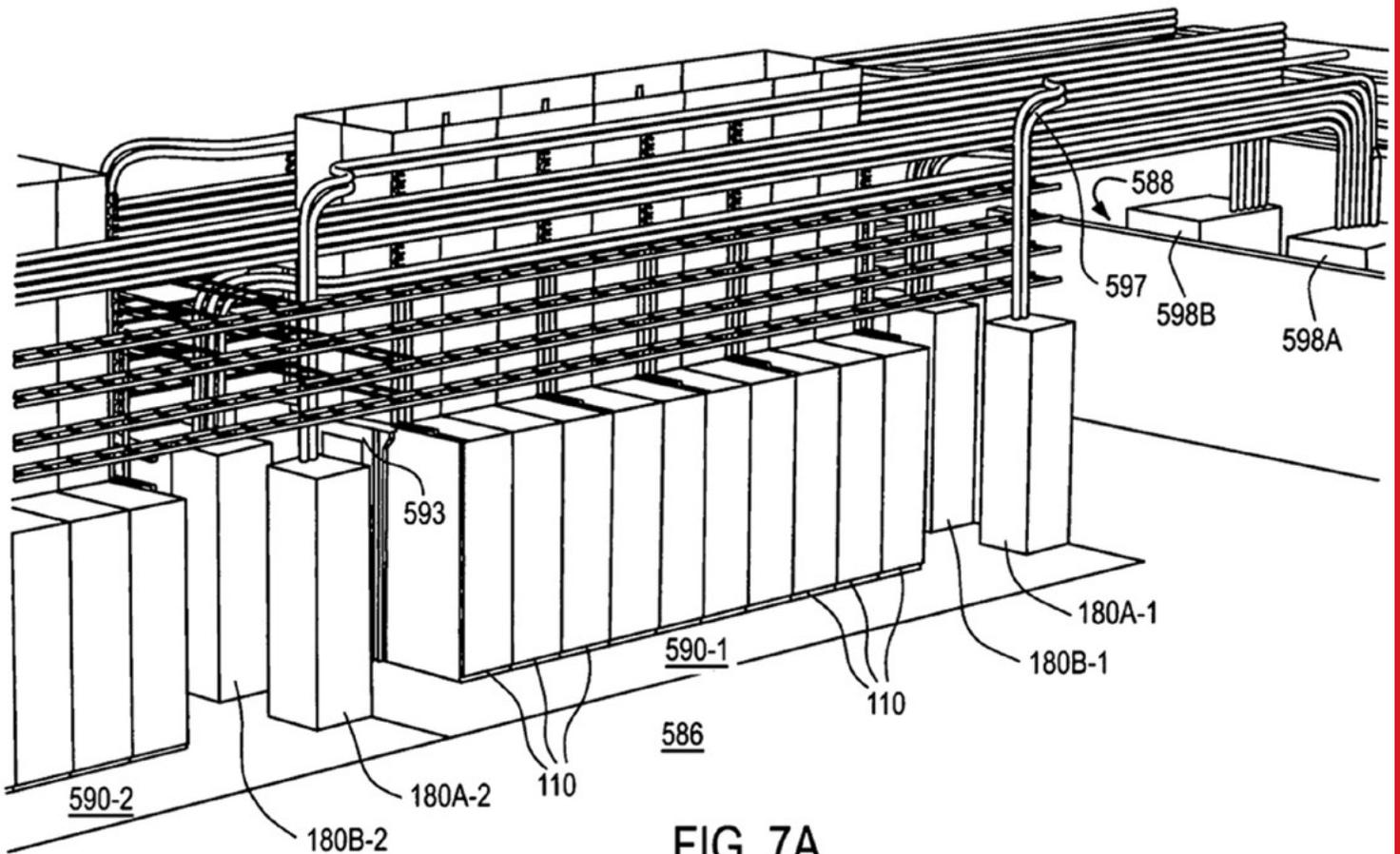


FIG. 7A

T-SCIF (Multi-Cabinet Heat Containment Rows) Heat Containment Pods
Power and Cabling Pathway Designs

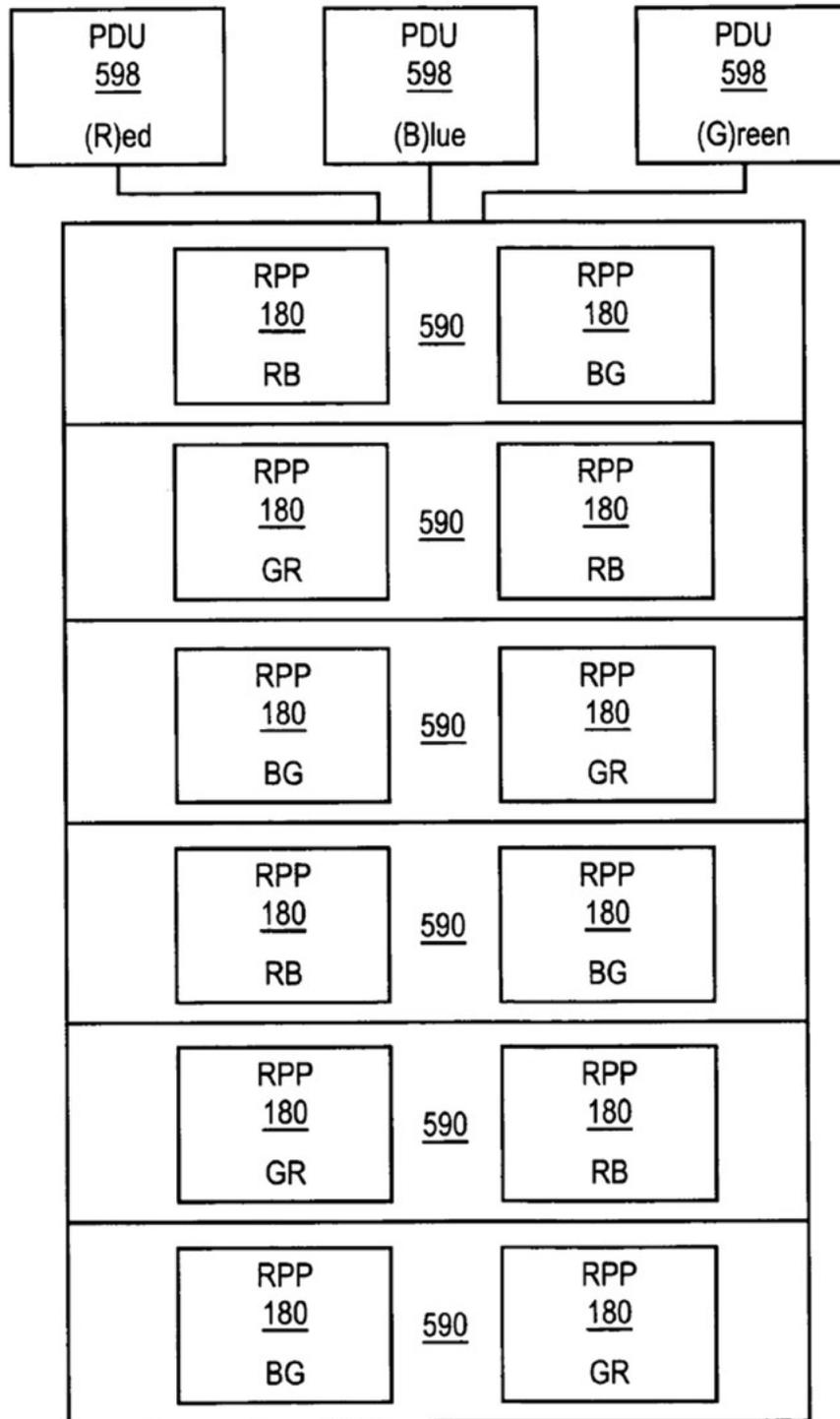
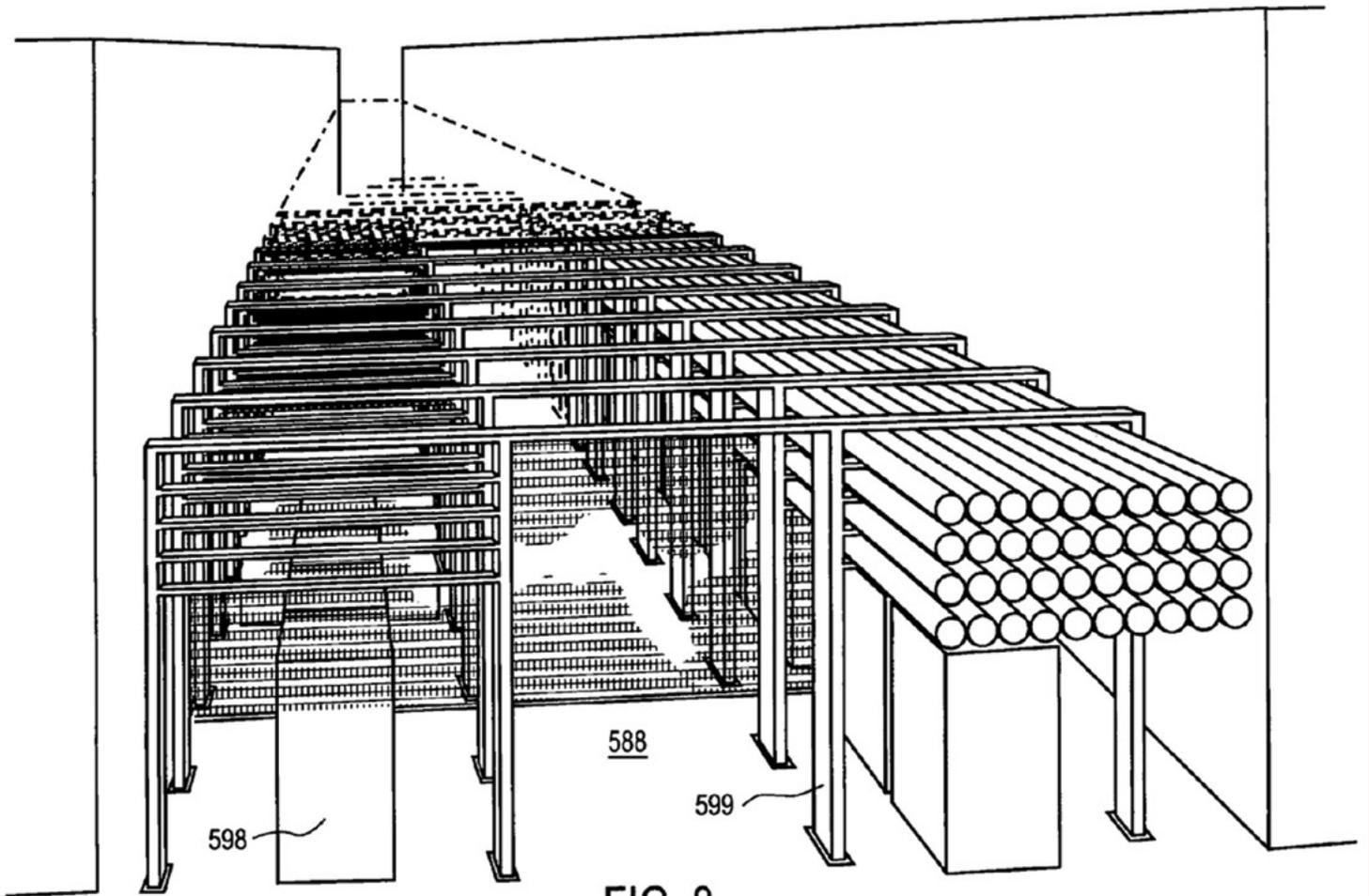


FIG. 7B

Tri-Redundant Power Layout and Color Segregation Designs and Concepts



The Switch Power Spine Design

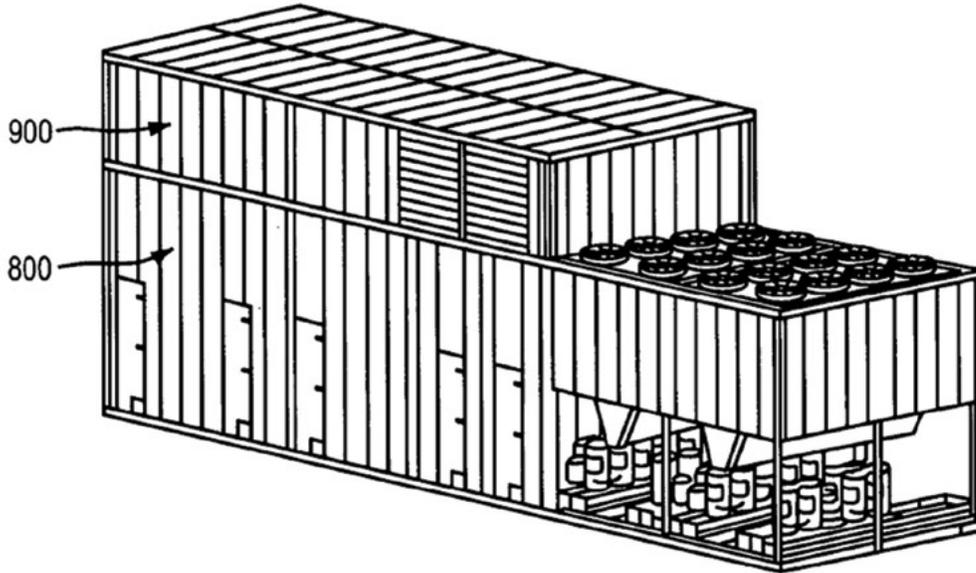


FIG. 9A

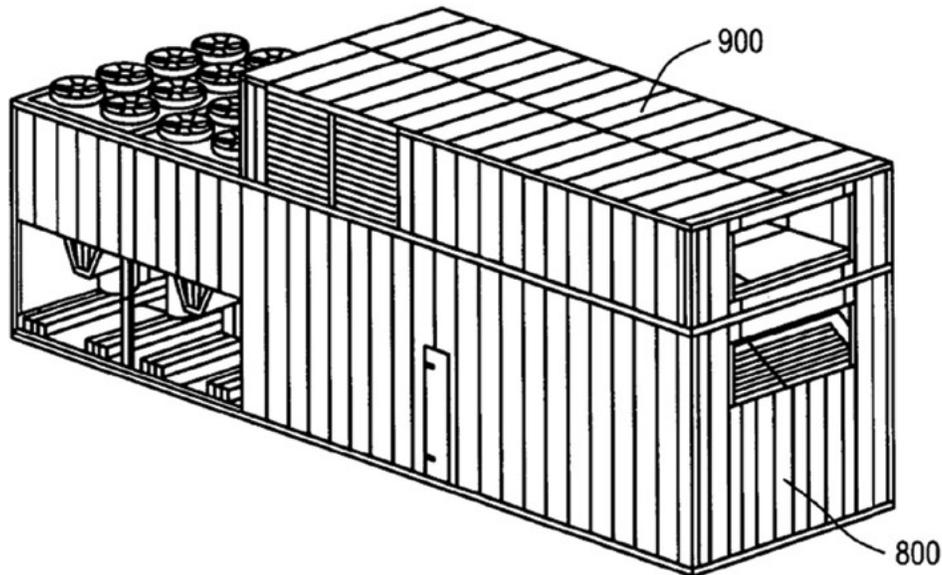


FIG. 9B

TSC (Multi-System Exterior Wall Penetrating HVAC Units)
Modular Design Specifications

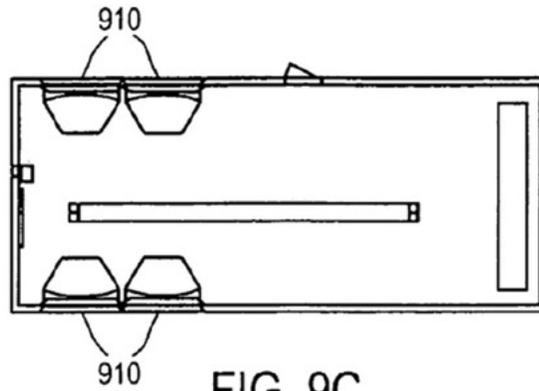


FIG. 9C

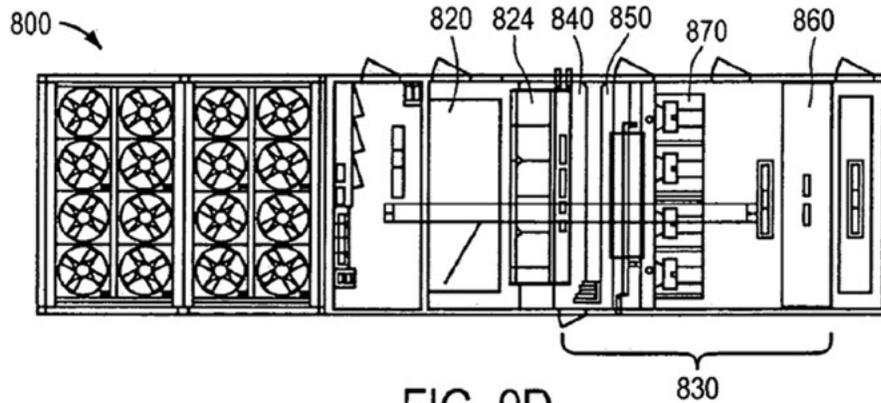


FIG. 9D

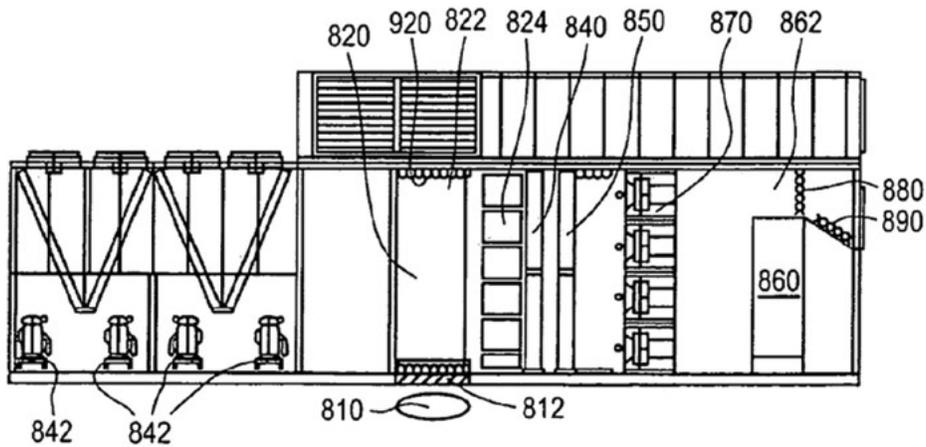


FIG. 9E

TSC (Multi-System Exterior Wall Penetrating HVAC Units)
Designs Showing Switch's Pioneering Multi-System HVAC Chambers

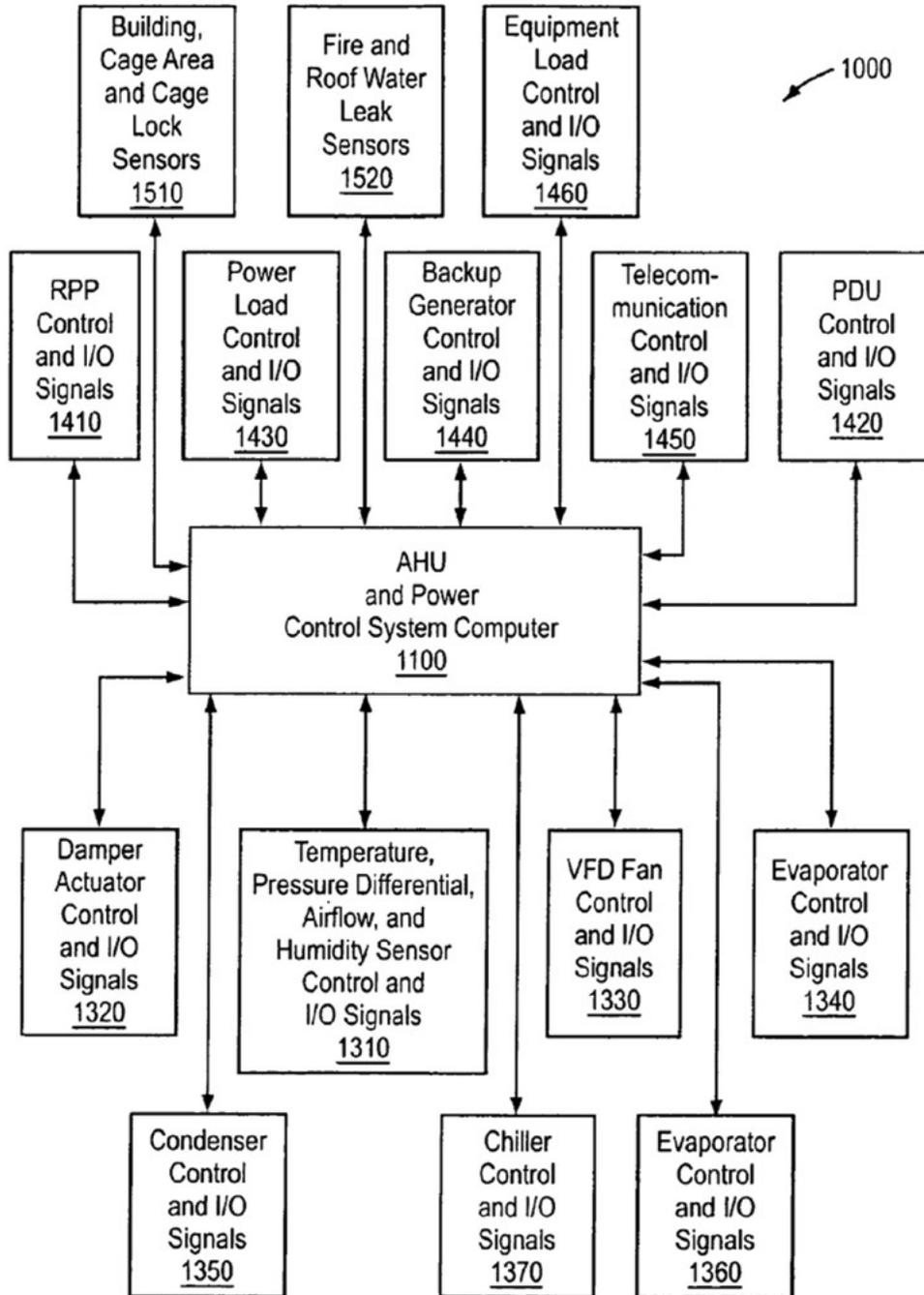


FIG. 10

Designs for Switch's "Living Data Center"
Data Center Building Management System

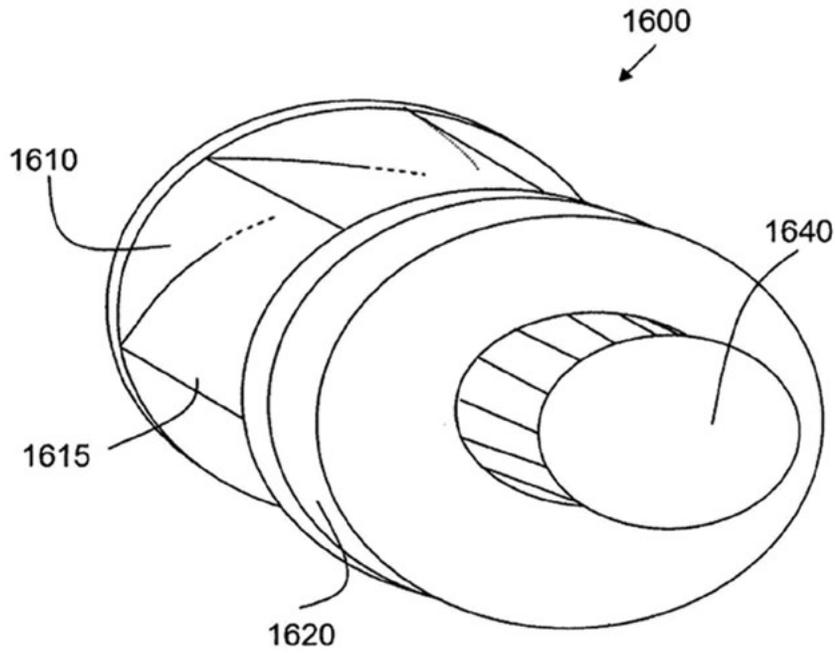


FIG. 11A

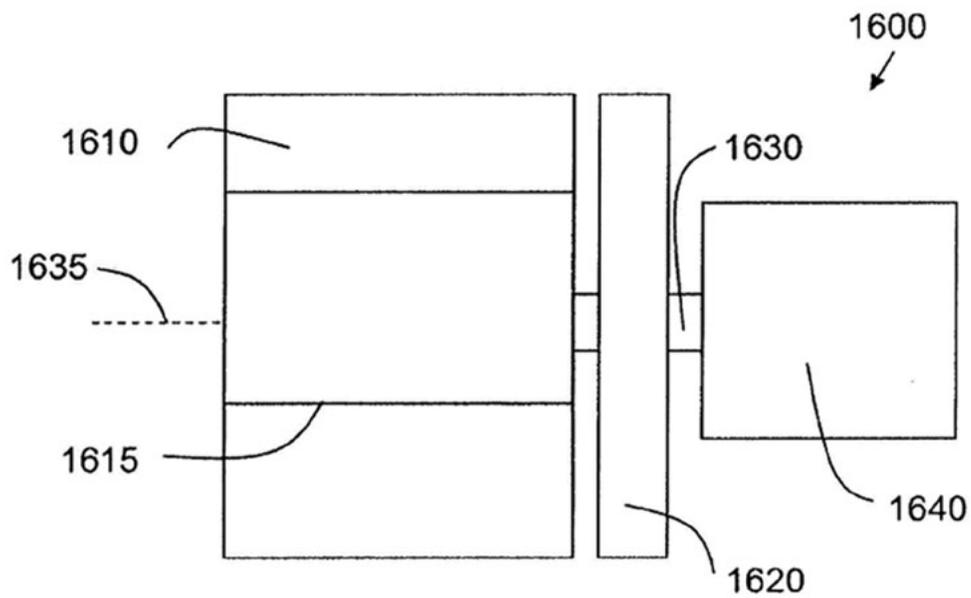


FIG. 11B

Centri - Fan ROTOFLY System

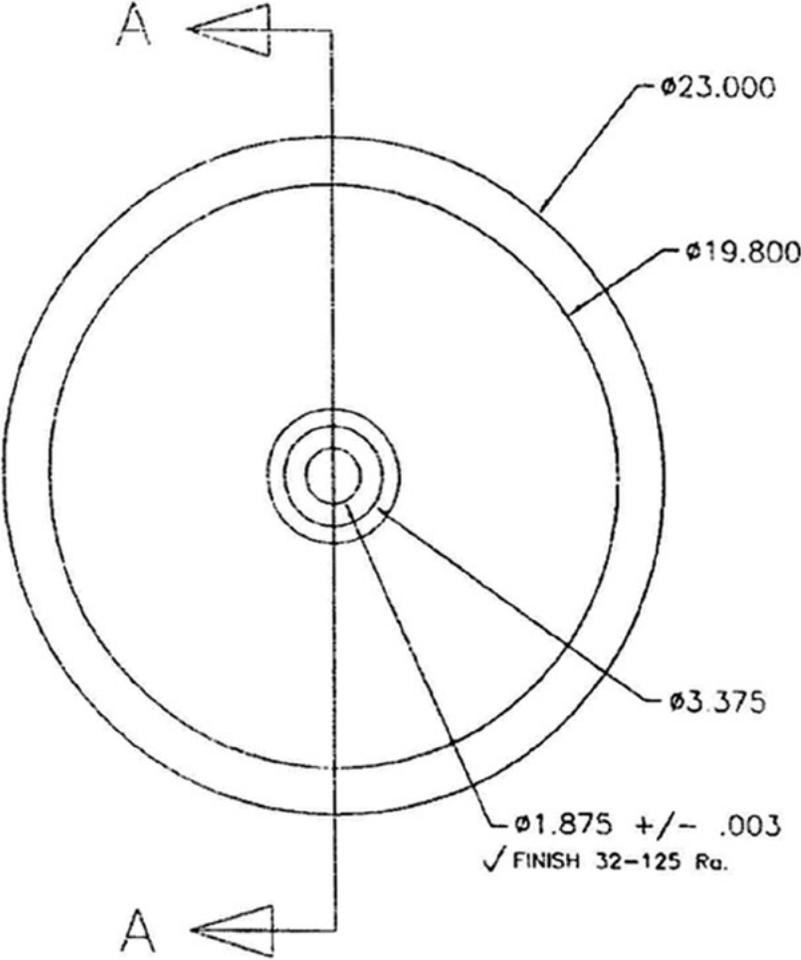


FIG. 12A

ROTOFLY Weight

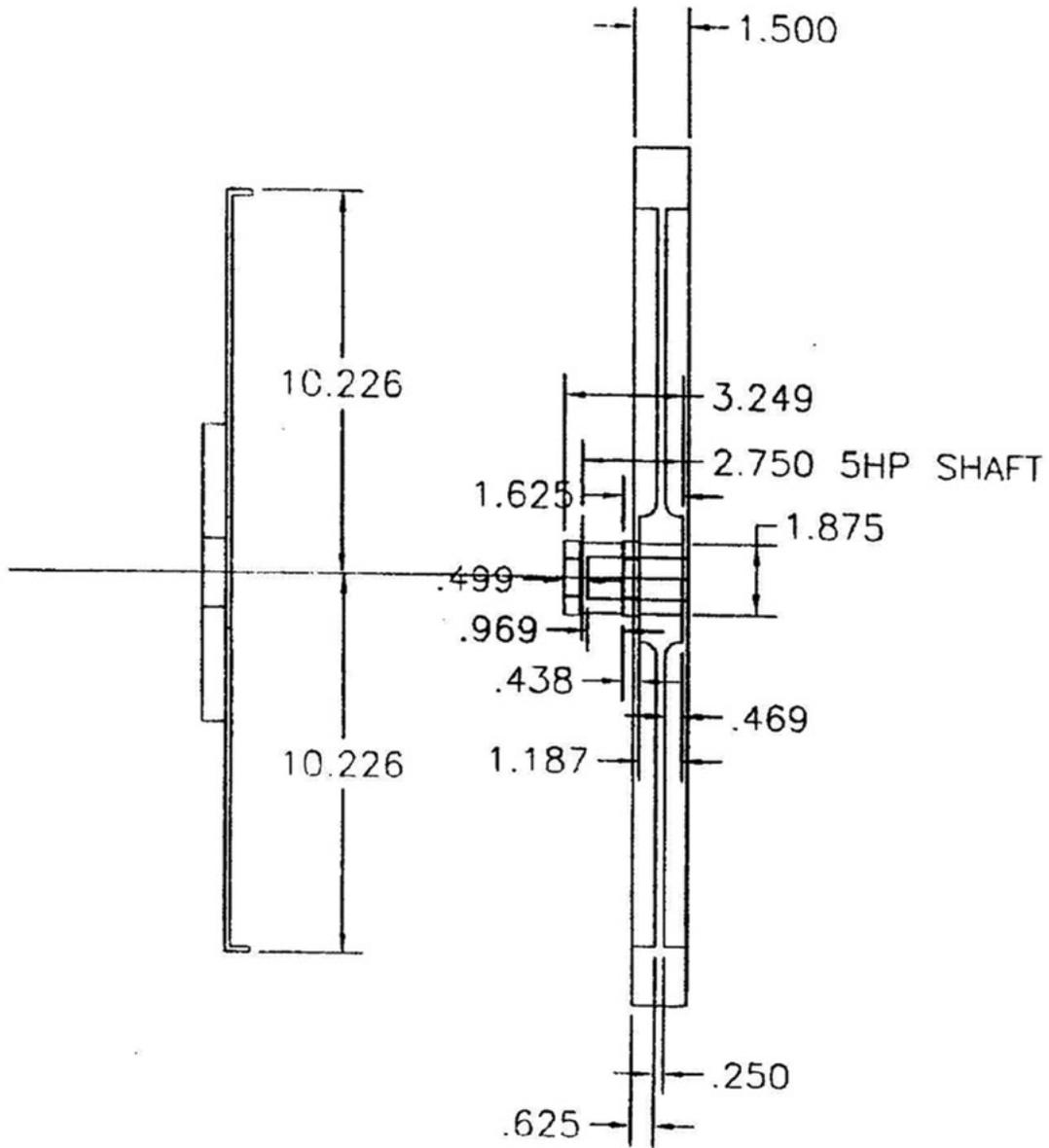


FIG. 12B

ROTOFLY Weight

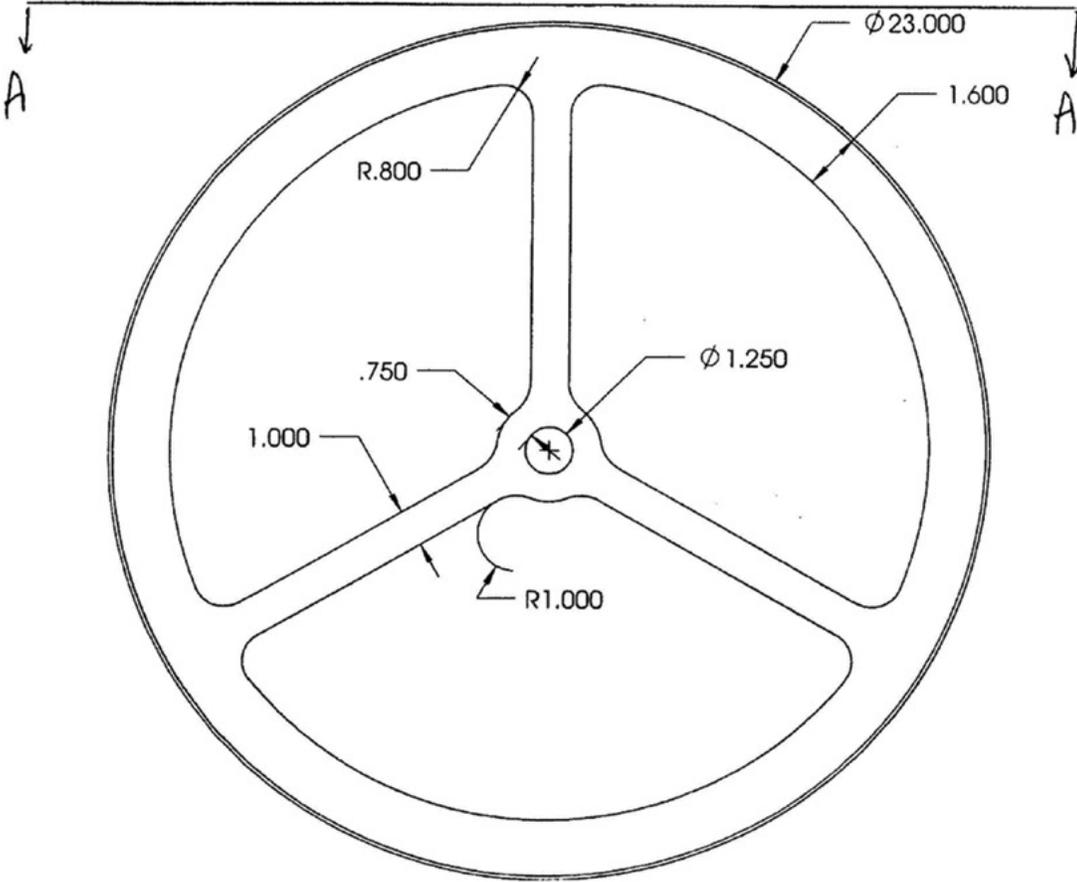


FIG. 13A

ROTOFLY Weight

SW-050 1/5

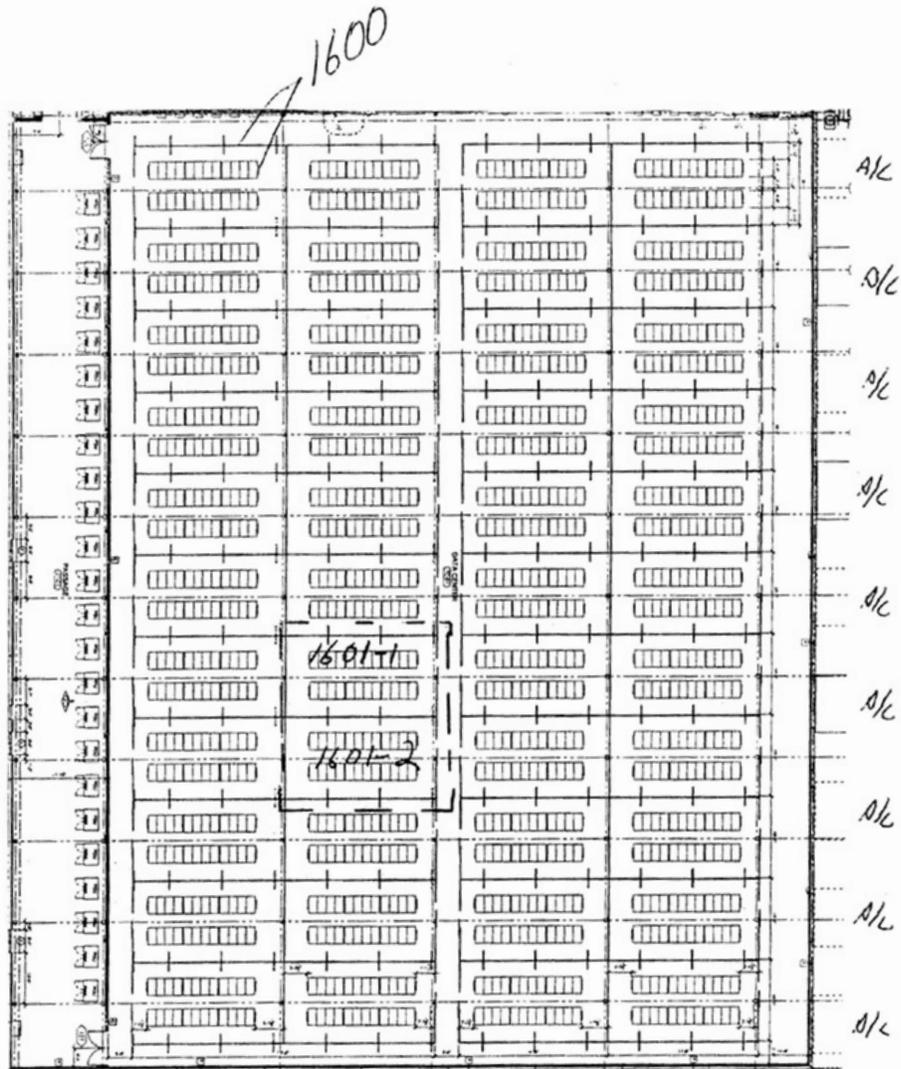


FIG. 14A1

Floating T-SCIF Layout

SW-050 2/5

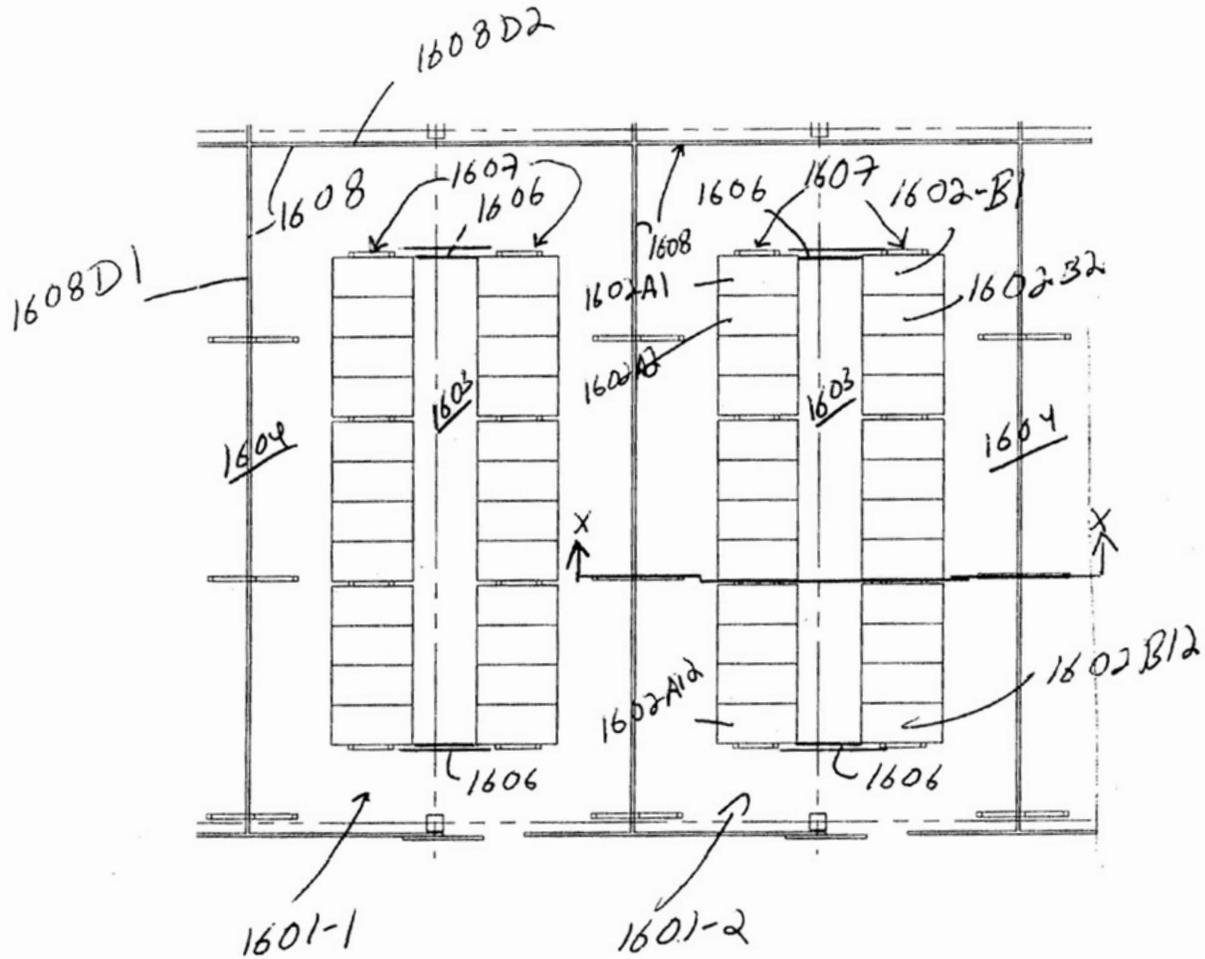


FIG. 14A2

Floating T-SCIF

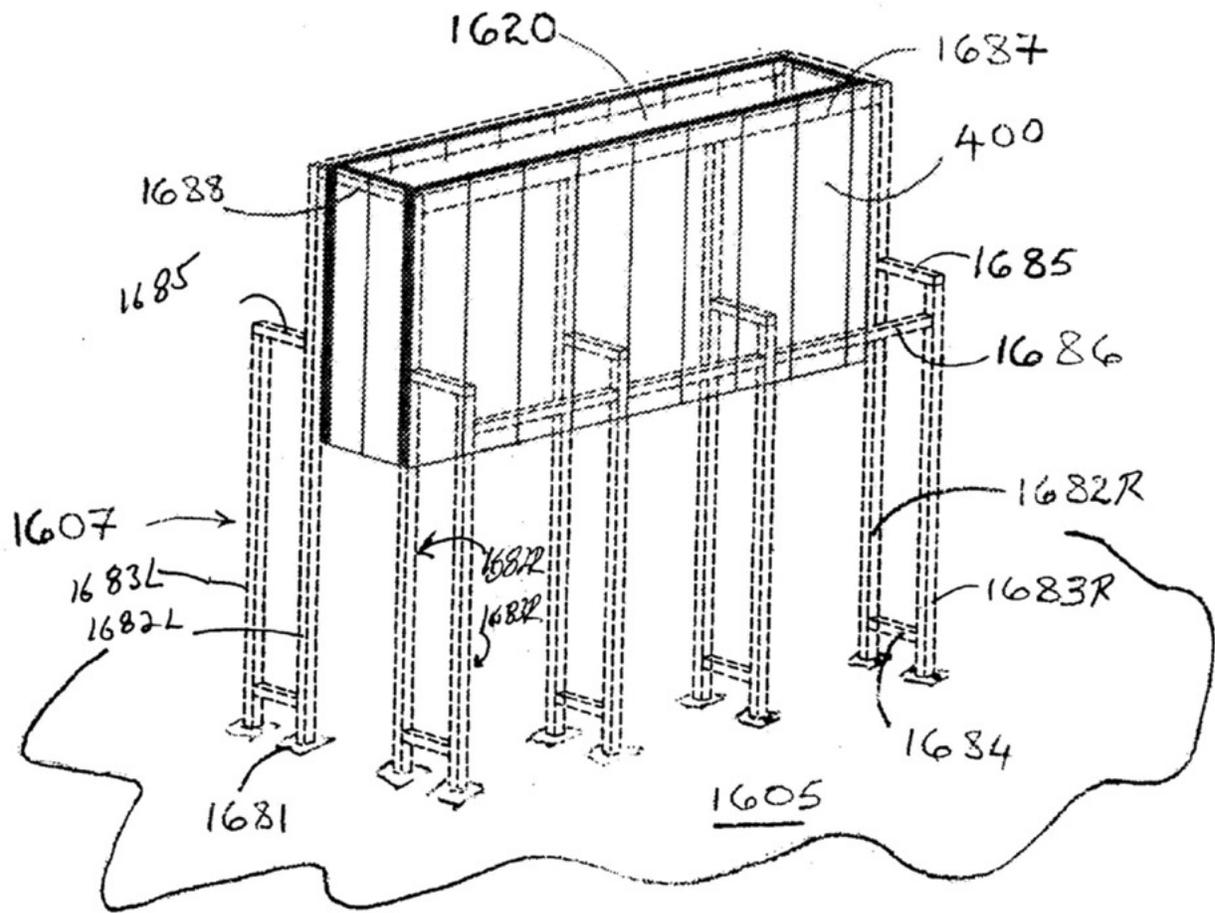


FIG. 15

Floating T-SCIF Version 1

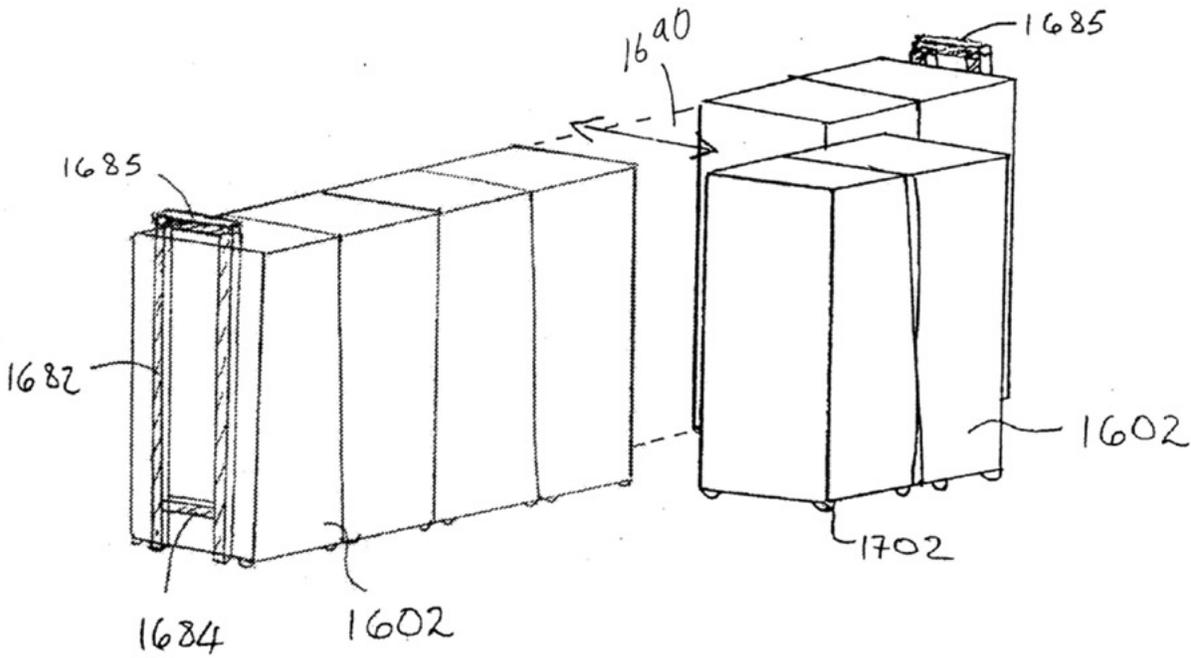


FIG. 16

Plug & Play Full Cabinet Refresh Layout

Data Center
100

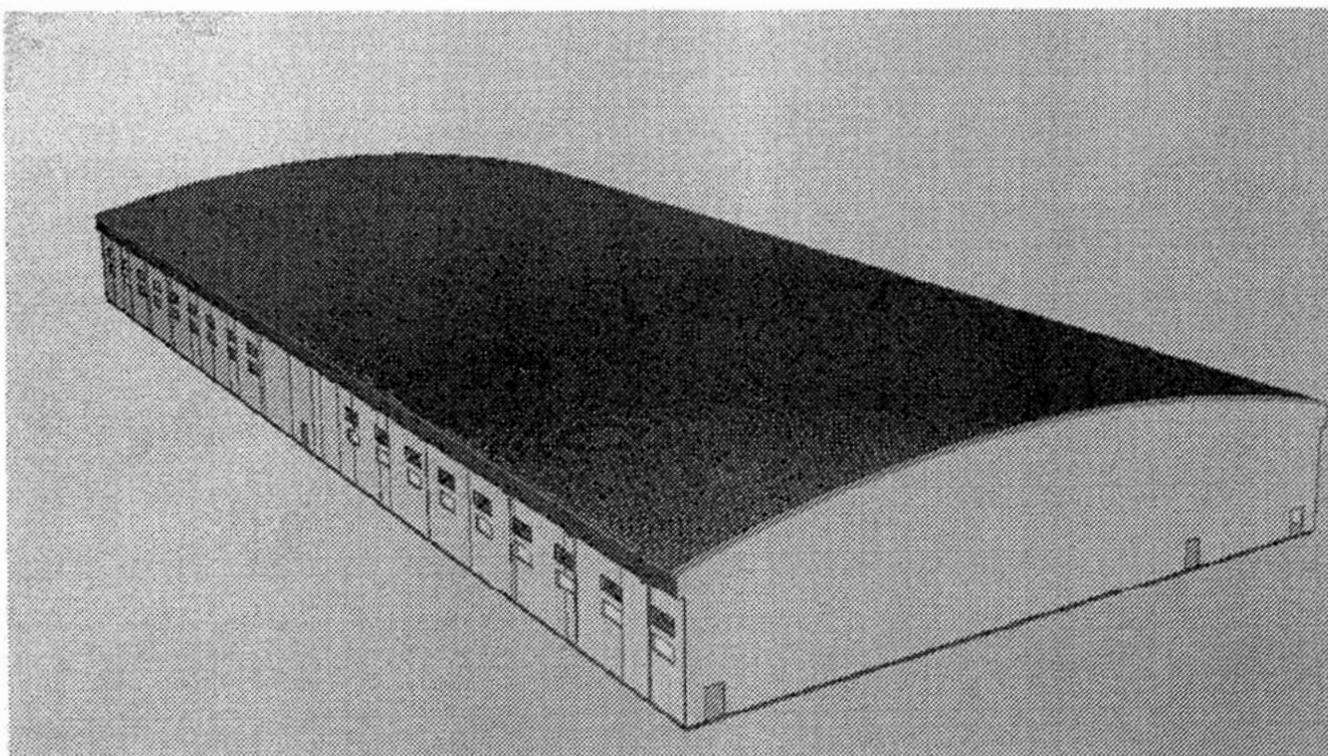


FIG. 17

SwitchMOD Shell – Dual Roofs - Zero Roof Penetrations

Data Center (Side View)
200

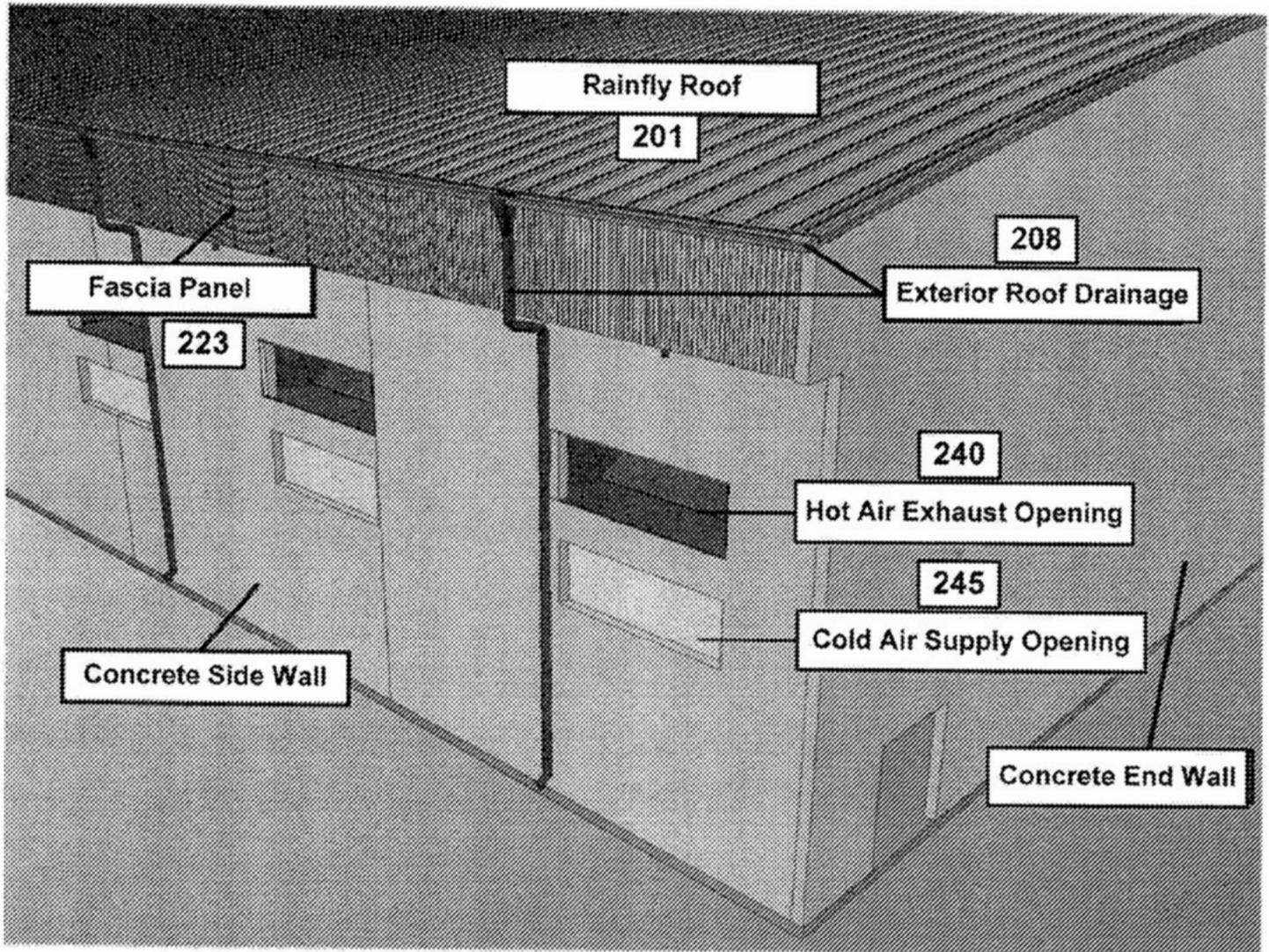


FIG. 18

SwitchMOD Shell Design

System
300

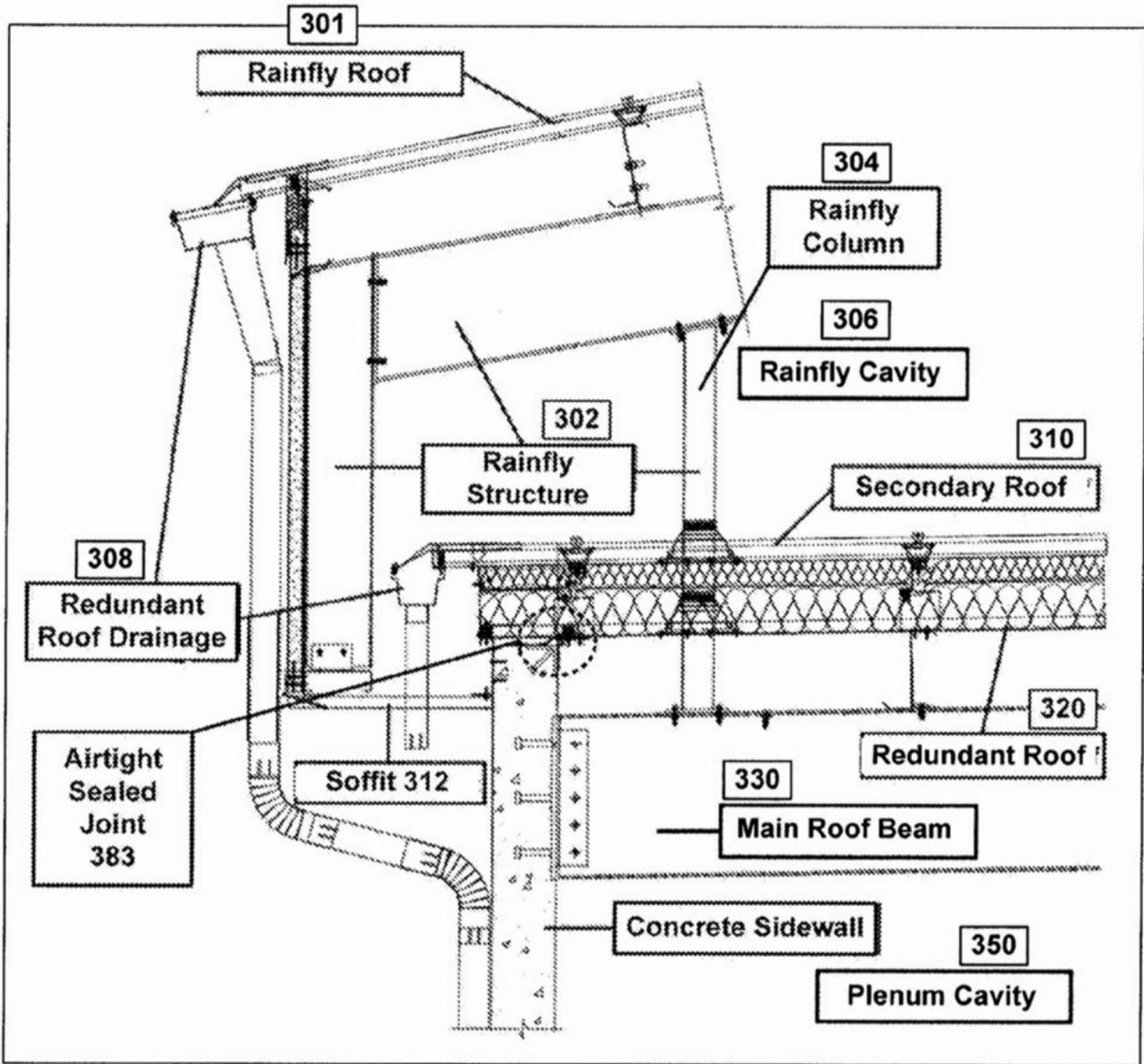


FIG. 19

**Switch SHIELD Dual 200 MPH Roof System
Redundant Roof Side View**

Data Center
(Side View)
400

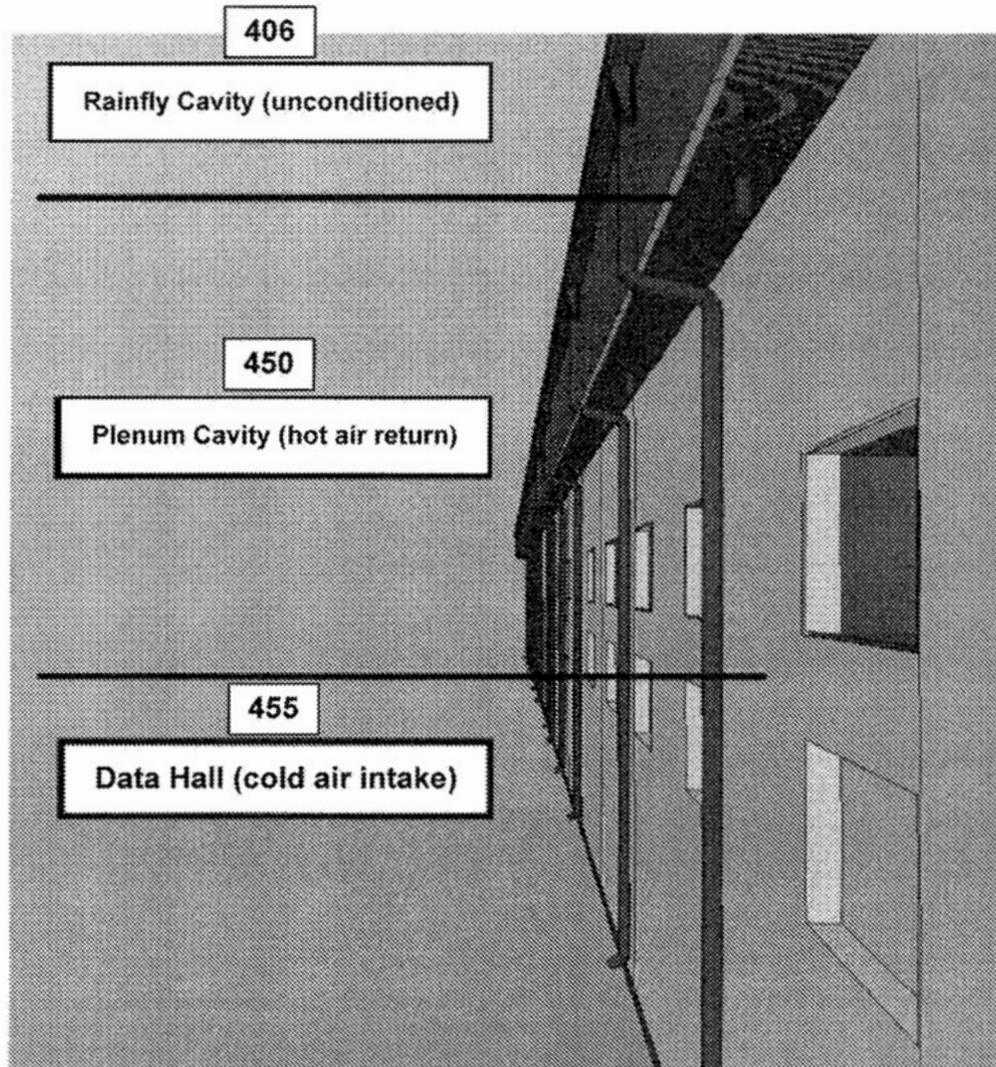


FIG. 20

SUPERNAP Shell

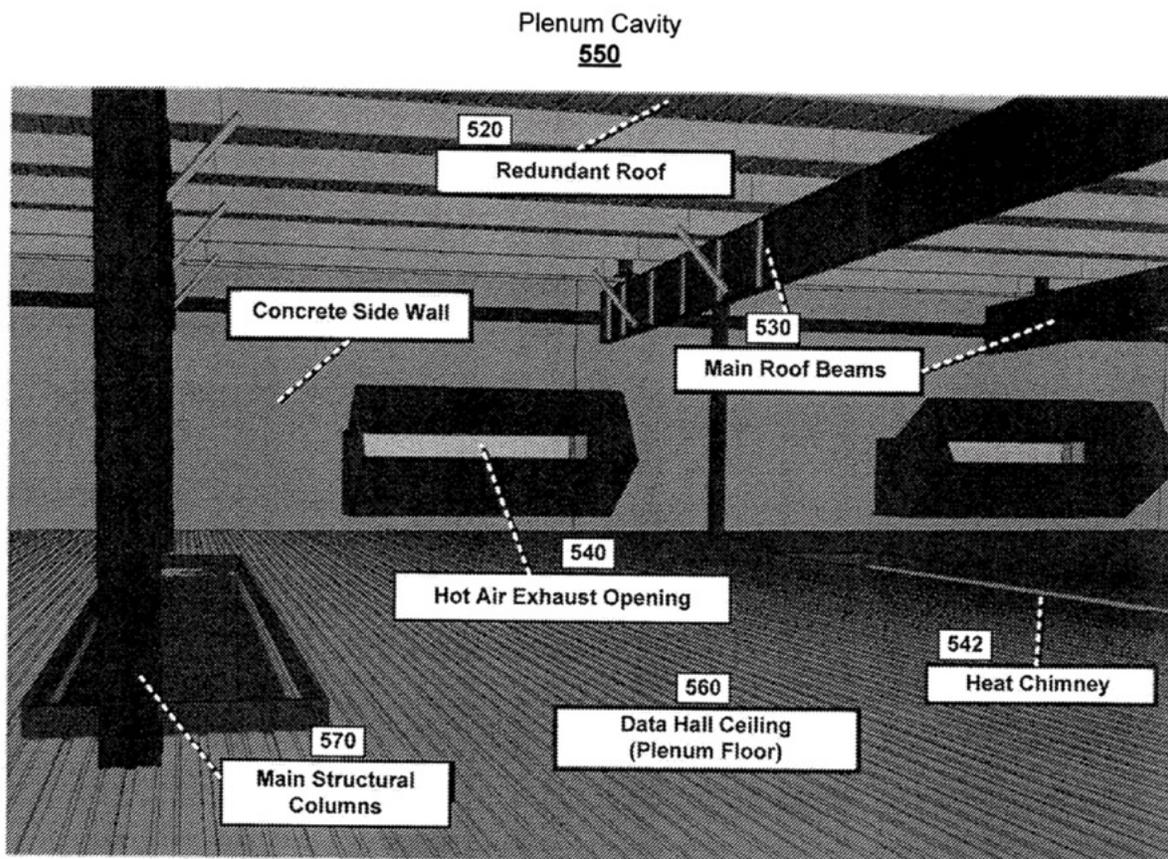


FIG. 21

SwitchMOD Heat Chamber

Rainfly Cavity
606

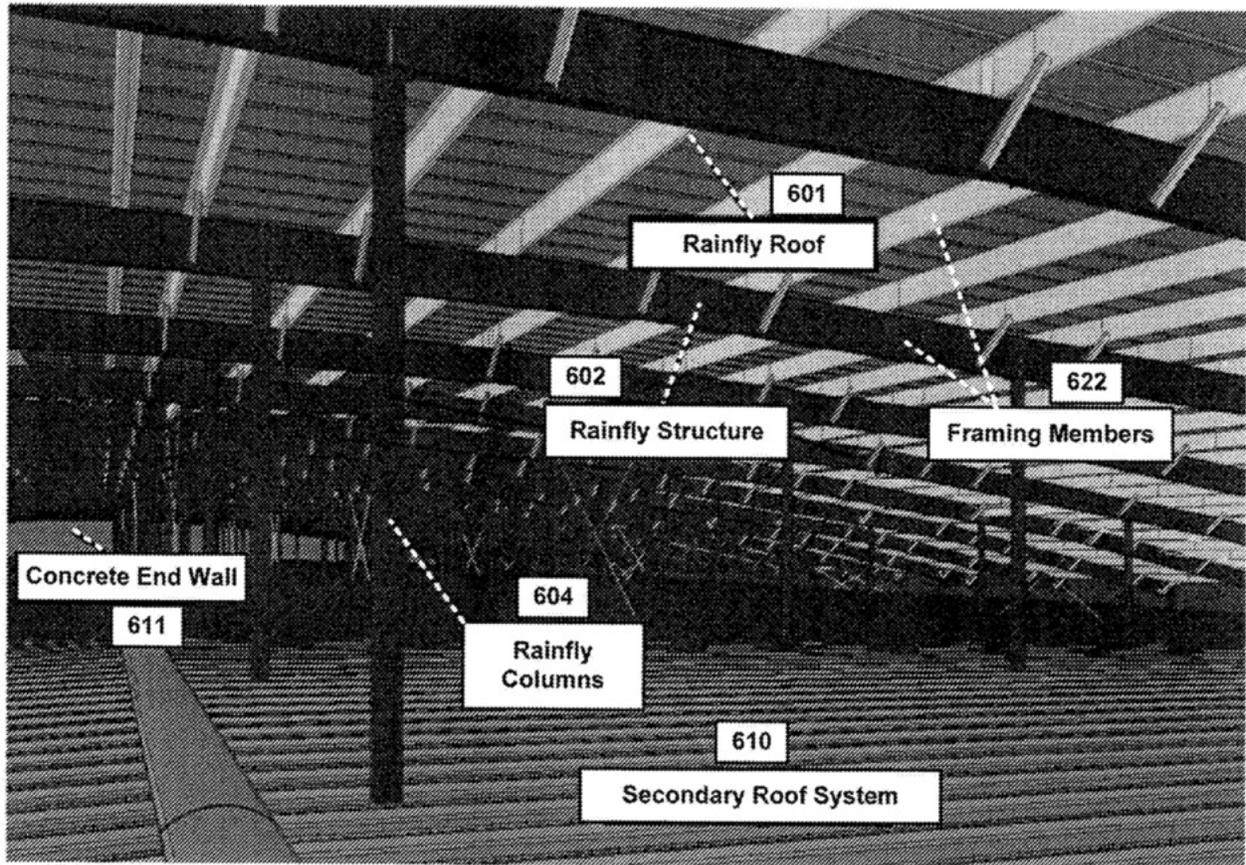


FIG. 22A

**Switch SHIELD Dual 200 MPH Roof System – Zero Roof Penetrations
Redundant Roof System**

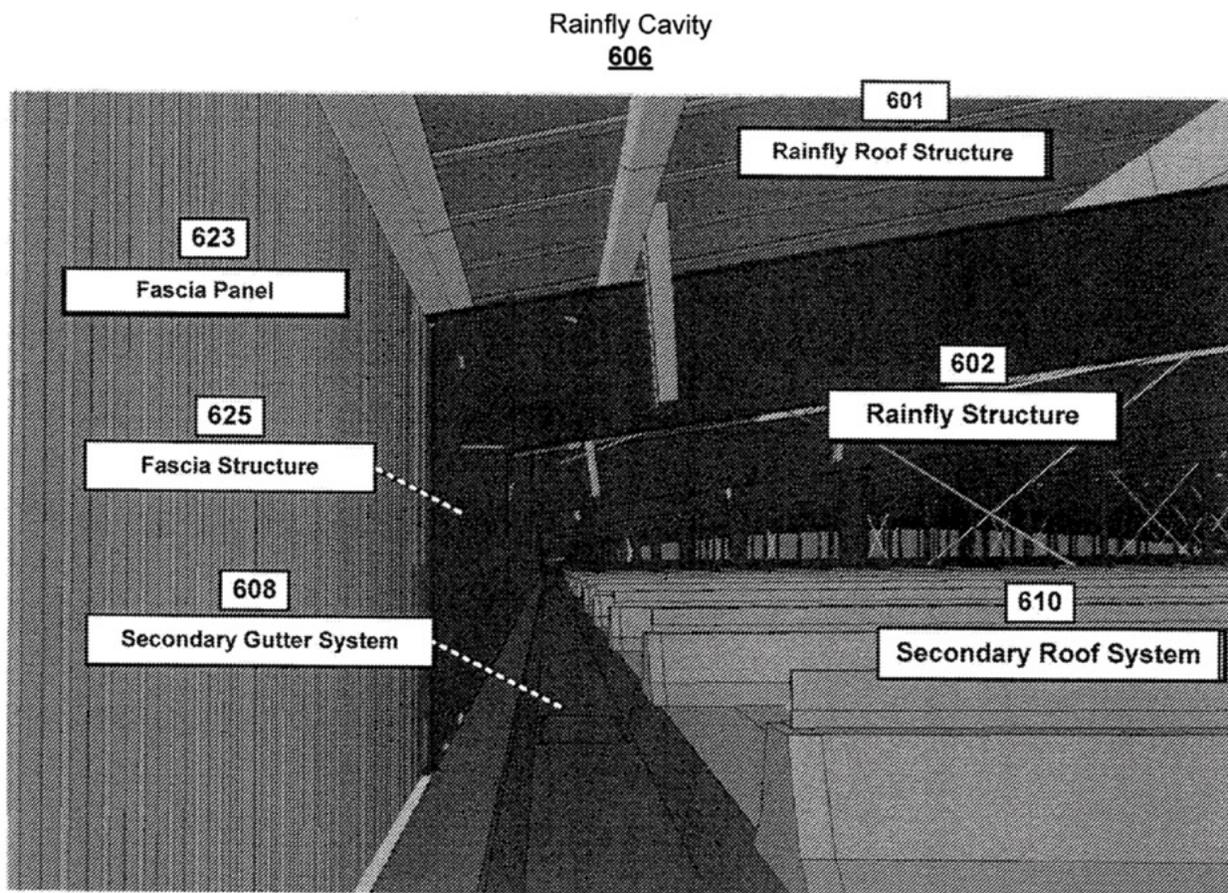


FIG. 22B

Switch SHIELD Dual Roof Chamber

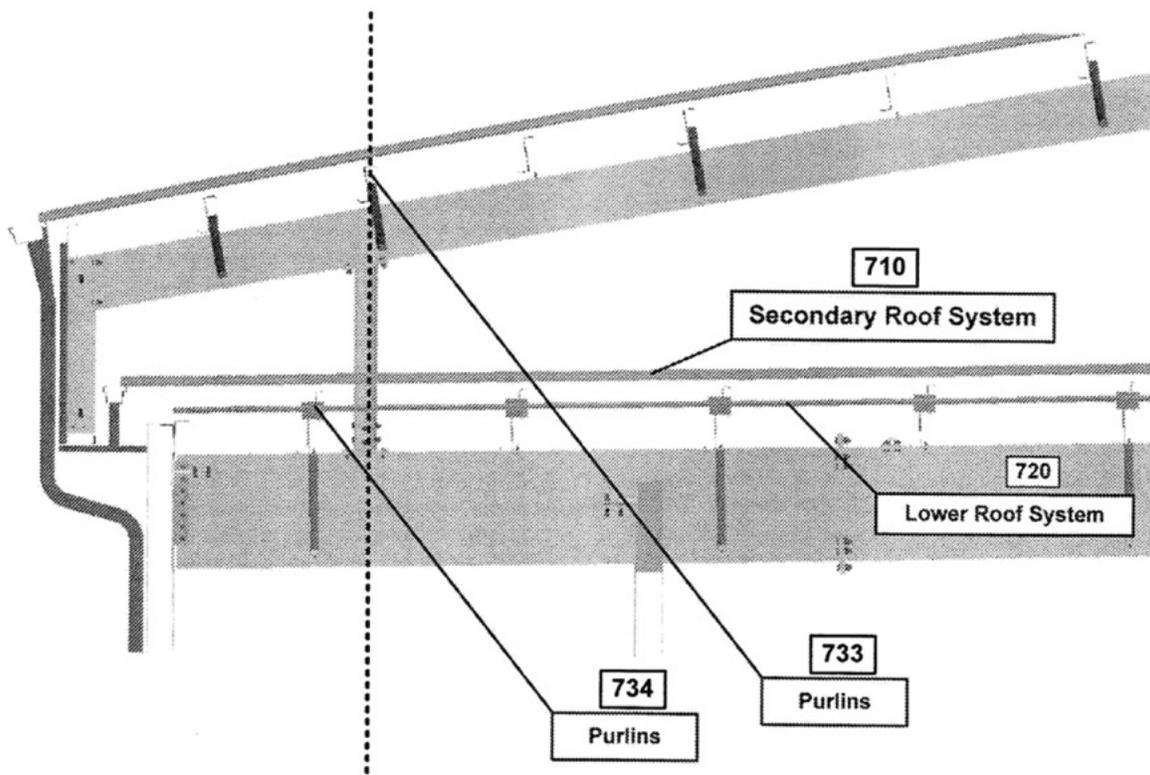


FIG. 23

Switch SHIELD Purlin Layout

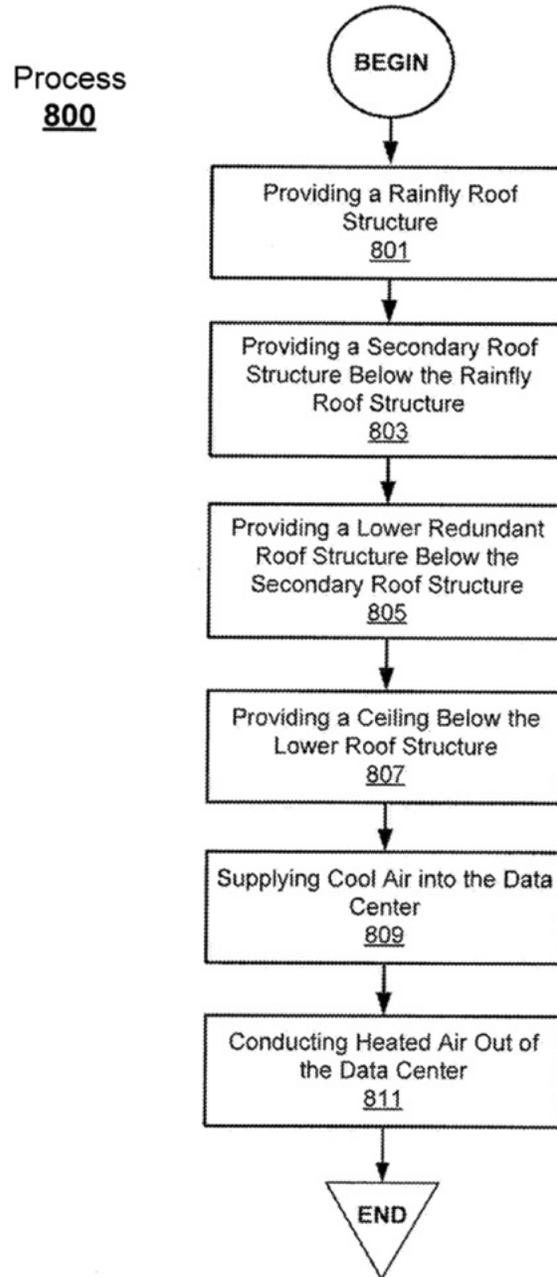


FIG. 24

SwitchMOD
Data Center Containment Process

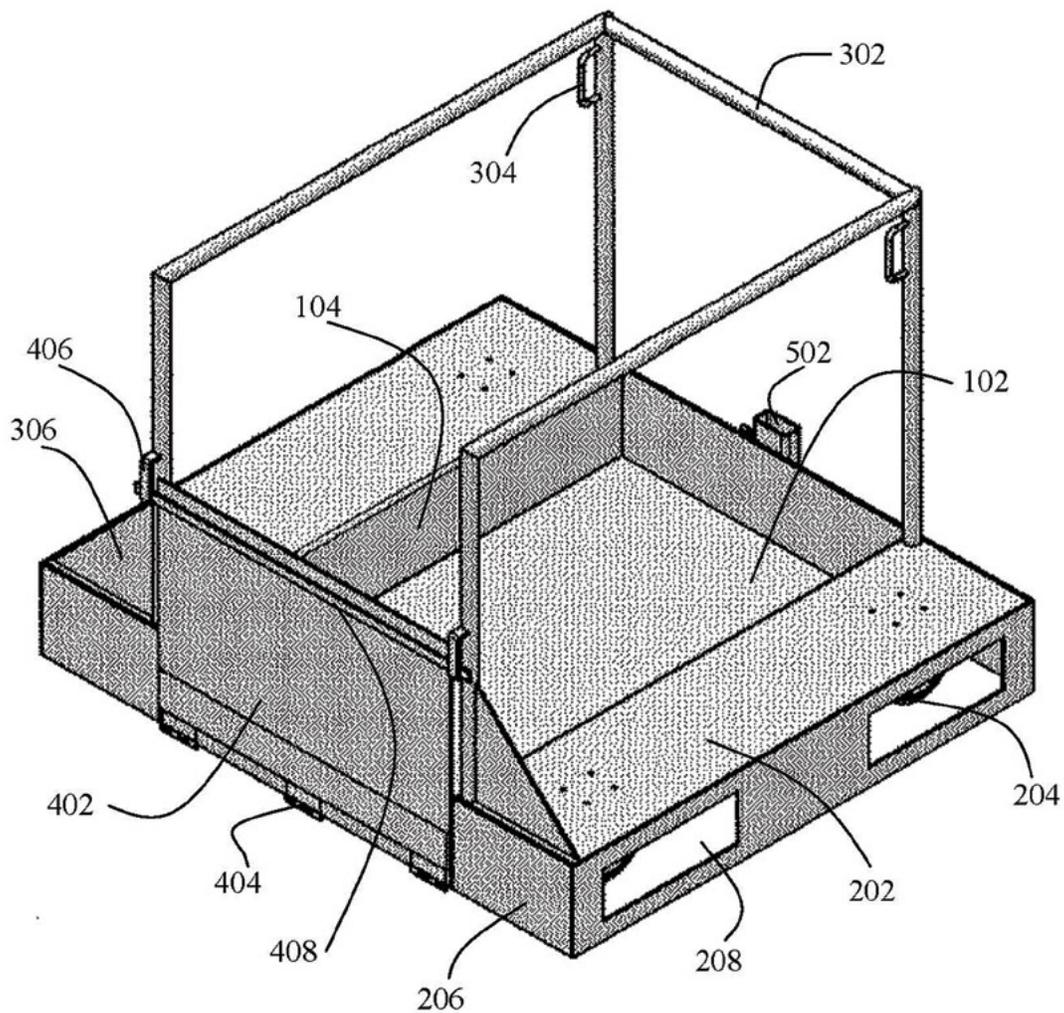


FIG. 25A

Quick Swap Heavy Cabinet Transport Cart

2/6

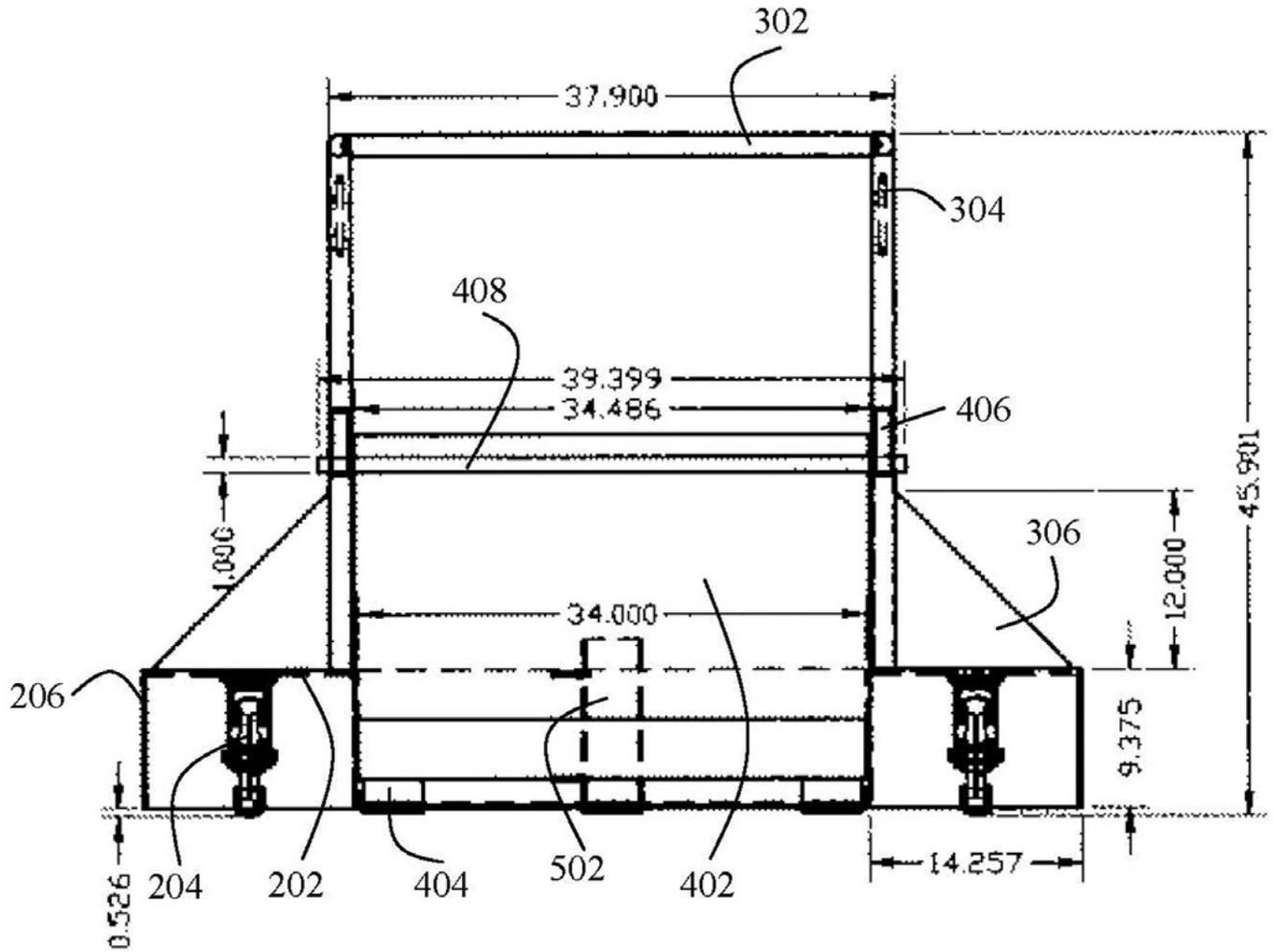


FIG. 25B

SwitchCART Design

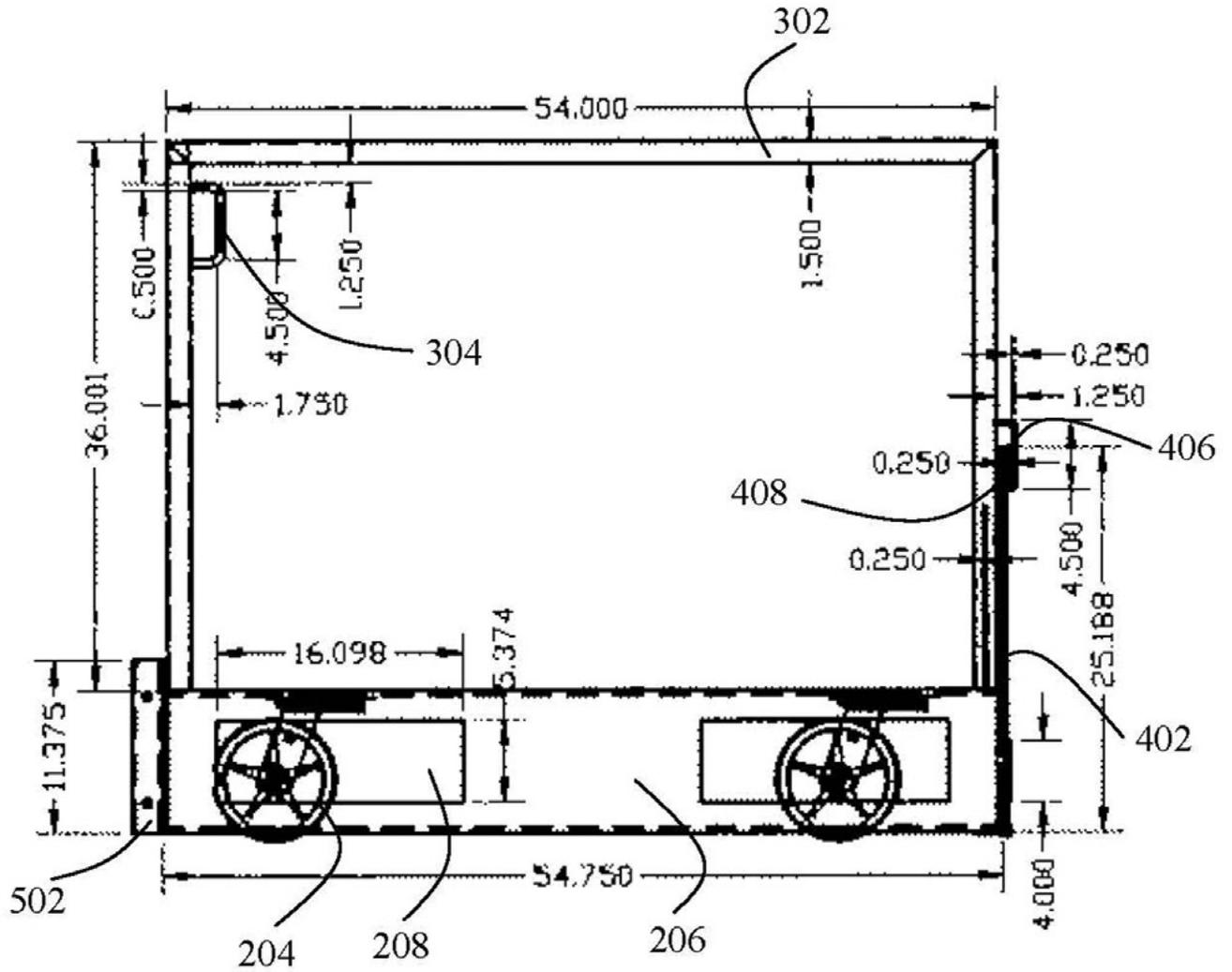


FIG. 25C

SwitchCART Design

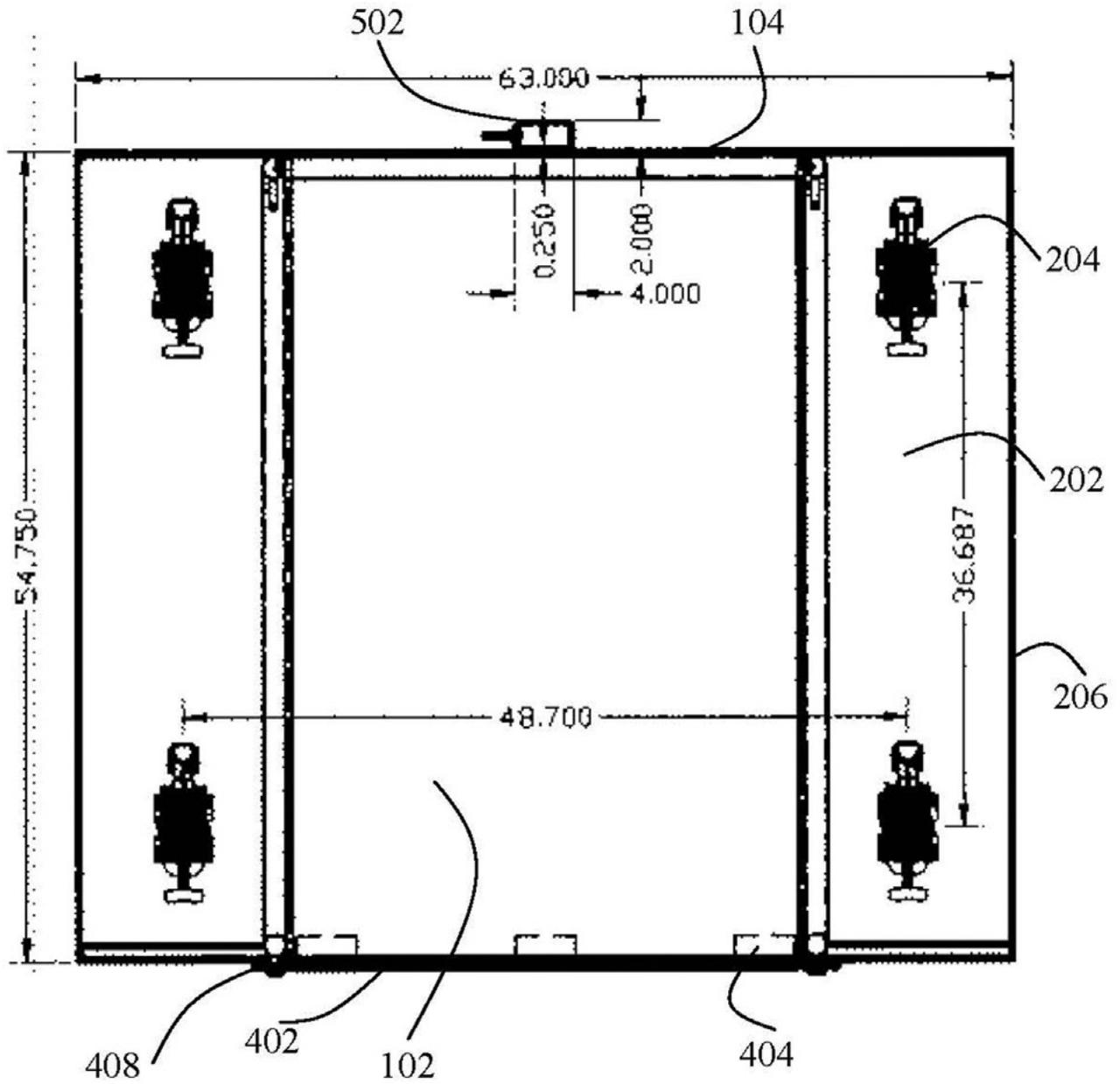


FIG. 25D

SwitchCART Design

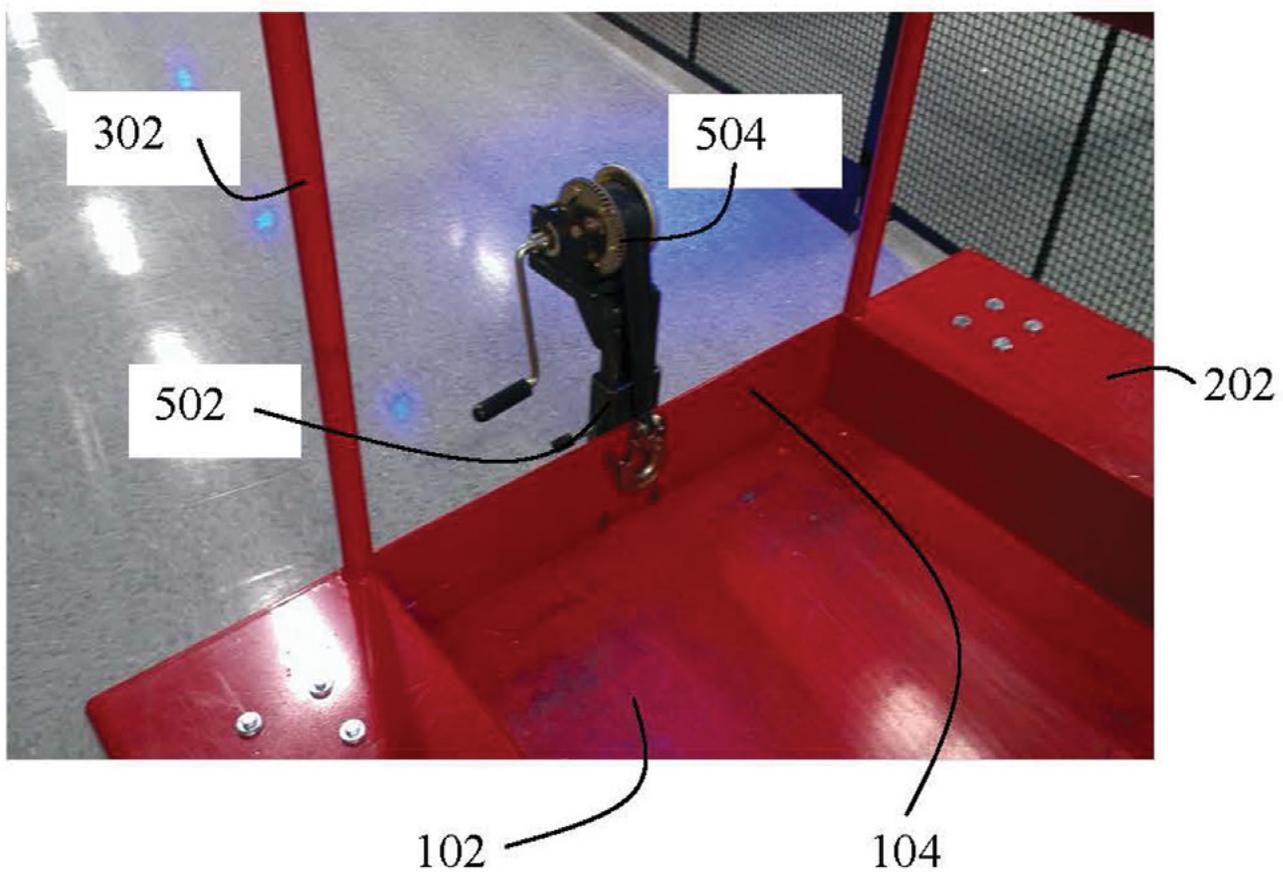


FIG. 26

SwitchCART Design

Patent Claims

1 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 comprising:

i a building that includes an exterior load wall separating the internal area and the external area;

ii a plurality of exterior wall openings in the exterior load wall;

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

iv 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;

v 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;

- vi** 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;
- vii** 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;
- viii** 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;
- ix** 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;
- x** and 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,

xi wherein the plurality of rows within each cabinet cluster is two separated rows disposed in a back-to-back configuration thereby establishing the central hot air area in between the two separated rows, such that the electronic equipment therein emit the heated air through a backside of the cabinet toward the central hot air area; and

xii wherein the false ceiling provides a barrier to prevent the heated air from passing therebelow, and wherein an opening exists in the false ceiling corresponding to the hot air containment chamber through which the heated air passes, and wherein a top edge of the thermal shield for each cabinet cluster connects to the false ceiling to further prevent the heated air from escaping.

2 The facility according to claim 1 wherein the plurality of cabinet clusters are arranged in an array, so that the cold aisles associated with each of the plurality of cabinet clusters are parallel to each other.

3 The facility according to claim 1 wherein the power distribution wiring and conduit provides for redundant power to each of a plurality of power units associated with each cabinet cluster.

4 The facility according to claim 3 further including a plurality of distribution power units that supply power to the plurality of power units via the power distribution wiring and conduit, wherein substantially all of the power distribution wiring and conduit between the plurality of power units and the plurality of distribution power units is above the plurality of cabinets.

- 5 The facility according to claim 4 wherein the thermal shield for each cabinet cluster is supported by the portion of the plurality of support brackets within that cabinet cluster, and the plurality of brackets each include:
 - i a plurality of tiered ladder rack supports having ladder racks thereover to establish a plurality of different tiers outside the contiguous wall, so that each of the different tiers is adapted to hold the electronic equipment power wires and conduits and the communication wiring, and
 - ii a plurality of conduit holders disposed above the plurality of tiered ladder rack supports, each of the conduit holders in each of the plurality of support brackets aligned with corresponding ones of conduit holders in the other plurality of support brackets, for holding a plurality of different distribution power wires and conduits disposed above each of the tiered ladder rack supports.

- 6 The facility according to claim 5 wherein a plurality of tiered ladder rack supports having the ladder racks thereover include at least four ladder rack supports, wherein:
 - i a first bottom ladder rack support and associated ladder rack hold the communication wiring,
 - ii a second ladder rack support and associated ladder rack disposed above the first ladder rack support and associated ladder rack hold the first electronic equipment power wiring and conduit that connect between a first power unit and the associated electronic equipment within the cabinet cluster, and

- iii** a third ladder rack support and associated ladder rack disposed above the second ladder rack support and associated ladder rack hold third electronic equipment power wiring and conduit that connects between a second power unit and the associated electronic equipment within the cabinet cluster, and wherein the second power unit provides power redundant to the first power unit.
- 7** The facility according to claim 6 wherein the plurality of tiered ladder rack supports having the ladder racks thereover for the distribution power wiring and conduits, the electronic equipment power wiring and conduits, and the communication wiring are all overhead the plurality of cabinets and provide for running the distribution power wiring and conduits, the electronic equipment power wiring and conduits, and the communication wiring parallel to each other.
- 8** The facility according to claim 1 further including physical fencing around a periphery of the cabinet cluster, which physical fencing includes a lockable door.
- 9** The facility according to claim 1 wherein the plurality of air conditioning units further receive outside air.
- 10** The facility according to claim 1 wherein the electronic equipment and power wiring for each cabinet cluster is maintained within the cabinet cluster in which it is located, and not in any adjacent cabinet cluster.
- 11** The facility according to claim 1 further including a plurality of backup electric generators operable upon a gas fuel and which provide a gaseous exhaust, the backup electric generators providing backup electricity in case of a powerdown condition, the back electricity being used to power the electrical equipment; and

i wherein each of the plurality of air conditioning units further including further includes an outside air inlet that allows intake of outside air to a filter chamber, and a spring-loaded mechanical closing lever, the springloaded mechanical closing lever causing automatic closure of an outside air damper disposed within the outside air inlet upon a disruption in electrical power, thereby preventing intake of the outside air that contains the gaseous exhaust to the filter chamber upon the disruption in electrical power.

12 The facility according to claim 1 wherein the ladder racks and conduit supports for the distribution power wiring and conduits, the electronic equipment power wiring and conduits, and the communication wiring are all overhead the plurality of cabinets and provide for running the distribution power wiring and conduits, the electronic equipment power wiring and conduits, and the communication wiring parallel to each other.

DATA CENTER DESIGN - SWC-001U – (FIGURES 1-10)

13 Cool temperature using a plurality of air conditioning units, the plurality of air conditioning units receiving heated air and emitting cooled air, the facility comprising: a floor on which the plurality of cage cabinets are disposed so that a portion of each of the support bracket is disposed above the plurality of cage cabinets; the thermal shield providing a contiguous wall a space separated from the room in which the plurality of air conditioning units are disposed; an air escape channel disposed above the warm exhaust channel, the air escape channel feeding the air to the plurality of air conditioning units; and a air channel that connects between the air conditioning system and the aisle.

- 14 The facility according to claim 13 wherein the air escape channel is bounded; and wherein an opening exists in the false ceiling corresponding to the hot air area.
- 15 The facility according to claim 14 wherein a distance between the ceiling and the false ceiling exists.
- 16 The facility according to claim 14 further including marking on the floor.
- 17 The facility according to claim 17 wherein the marking further includes an outer area marking.
- 18 The facility according to claim 18 wherein the central area marking is one color and the another color.
- 19 The facility according to claim 14 wherein the plurality of support brackets each further include a plurality of tiered ladder rack supports the heated air.
- 20 The facility according to claim 14 wherein at least some of the plurality of electronic cabinets are disposed; and wherein the contiguous wall fully surrounds the aisle from the plurality of cage cabinets.
- 21 The facility according to claim 14, wherein the thermal shield is formed and each are supported by a shield support beam disposed on at least some of the plurality of support brackets.
- 22 The facility according to claim 21 wherein at least some of the thermal shields have a hole disposed therein.

23 The facility according to claim 13 further including marking on the floor, the marking including a central area marking.

24 The facility according to claim 23 wherein the marking further includes an area marking.

25 The facility according to claim 24 wherein the area marking is one color.

26 The facility according to claim 25 wherein the plurality of support brackets each further include ladder rack supports having ladder racks thereover to establish a plurality of different tiers so that each of the different tiers is adapted to hold a different type of transmission line.

27 The facility according to claim 13 wherein at least some of the plurality of electronic cabinets are disposed in two rows and wherein the contiguous wall fully surrounds the hot aisle from above the plurality of cage cabinets.

28 The facility according to claim 27 further including marking on the floor, the marking including a marking that corresponds to the air and a perimeter area marking that surrounds the central area and corresponds to a position near which the plurality of cage cabinets are installed.

29 The facility according to claim 13, wherein the thermal shield is formed from a plurality of thermal shield plates that are each supported by a support beam disposed on at least some of the plurality of support brackets.

30 The facility according to claim 29 wherein at least some have a hole disposed therein that allows for passage therethrough while being sufficiently small to only allow a small amount to pass therethrough.

31 An apparatus for separating air from air, the air being produced within an enclosure area bounded by a plurality of cage cabinets positioned so that electronic equipment disposed therein emit heated air into the enclosure area, the cage cabinets positioned in at least one row so that the electronic equipment disposed therein emit heated air from in each in a predetermined direction from the cage cabinets to establish a hot aisle, and an opposite side of the row establishing a cold aisle, the apparatus comprising: a plurality of support brackets disposed along the row, so that a portion of each of the support bracket is disposed above the plurality of cage cabinets; and a shield supported by the at least some of the plurality of support brackets, the shield providing a contiguous wall around an air area above the at least one row of electronic cabinets to define a warm exhaust channel that traps the heated air within the enclosure area and causes substantially all the heated air within the enclosure area to rise up within the channel.

32 The apparatus according to claim 31 wherein the plurality of support brackets each further include a plurality of tiered ladder rack supports having ladder racks thereover to establish a plurality of different tiers outside the contiguous wall, so that each of the different tiers is adapted to hold a different type of transmission line that is substantially shielded from the air.

33 The apparatus according to claim 31, wherein the shield is formed from a plurality of shield plates that are each supported by a shield support beam disposed on at least some of the plurality of support brackets.

34 The apparatus according to claim 33 wherein at least some of the shields have a hole disposed therein that allows for passage therethrough while being sufficiently small to only allow a small amount of airflow to pass therethrough.

35 A method of forming a facility for housing electrical equipment comprising the steps of: determining a location that will house the electrical equipment, the at least one row of cage cabinets defining an enclosure area; mounting a plurality of support brackets in relation to the row of cage cabinets so that at least a portion of each of the support brackets is disposed above the cage cabinets; and mounting a contiguous wall around the enclosure area above the cage cabinets using the support brackets to define the warm exhaust channel so that that substantially all warm air within the enclosure area rises up within the warm exhaust channel; and distributing wiring to at least some of the cage cabinets, the step of distributing separating each of a plurality of different types of wiring on each of a plurality of different ladder racks, each of the plurality of different ladder racks being mounted on a ladder rack support that connects to at least some of the plurality of support brackets.

DATA CENTER DESIGN – SWC-002C-1 – (FIGURES 1-10)

36 An air conditioned facility that is provided a high volume of air, the facility comprising:

i a building having a ground level floor and including an exterior load wall against the environment, the load wall including a plurality of air openings disposed adjacent to a corresponding plurality of return air openings

ii a plurality of outlets ducts, each of the outlet ducts formed through one of the plurality of air openings;

- iii** a plurality of air inlet ducts, each of the air inlet ducts formed through one of the plurality of return air openings; and
- iv** a plurality of air conditioning apparatus disposed in the external environment, external to the building, and parallel to one another along the exterior load wall, each of the plurality of air conditioning apparatus being supported by a ground level support structure, each of the air conditioning apparatus including:
- v** a fully enclosed cabinet disposed on the ground level support structure including insulated cabinet walls, cabinet floor and cabinet ceiling that prevent return air passing through the insulated cabinet walls of the fully enclosed cabinet;
- vi** a unit disposed within an expulsion section of the fully enclosed cabinet, the expulsion unit including:
- vii** a air exhaust opening that receives heated air from one of the exhaust outlet ducts,
- viii** an opening, the air opening containing a damper disposed therein,
- ix** a damper disposed within the opening and being electronically controlled;
- x** an exhaust opening that emits from the air as vented air from the expulsion unit into the external environment; and
- xi** an exhaust fan disposed in the exhaust opening that assists in moving the vented air;

- xii** a filter disposed within the fully enclosed cabinet, the filter including:
- xiii** an air intake section that is isolated from the expulsion section except via the return opening coupled to the exchange unit;
- xiv** an air inlet that allows intake of the air into the air intake section;
- xv** an air inlet damper disposed within the air inlet; and
- xvi** an air filter, the filter chamber being configurable to receive the return air based upon a return damper position, the air based upon an air damper position, as well as a mixture of the air and the outside air based upon the air damper position and the outside air damper position, the filter chamber providing air;
- xvii** a condenser unit coupled to the filter and including
- xviii** an air area disposed within the fully enclosed cabinet near where the filtered air passes to create the filtered air; and
- xix** a direct coil disposed within air area and filled with a gas over which the filtered air passes, the gas being circulated through a condenser disposed to the fully enclosed cabinet in the environment;
- xx** a fan disposed within the air area operable push the filtered air through the air area and toward the air inlet duct;

xi a air inlet opening that emits the air into one of the air inlet ducts; and

xvii an outlet damper disposed within the air inlet opening operable to control an amount of the air delivered from the air area to the air inlet duct.

37 The facility according to claim 36 wherein the condenser unit further includes:

i an indirect coil disposed within air area and filled with water over which the filtered air passes, the air being circulated through an evaporation unit disposed external to the fully enclosed cabinet in the external environment,

ii an evaporator disposed within air area that provides a water wall through which the air can pass; and

iii a bypass disposed within an air area allowing all or some of the filtered air to bypass the evaporator, and a bypass damper associated therewith;

38 The facility according to claim 36, wherein the exchange unit is disposed above the filter chamber and the air area of the unit.

39 The facility according to claim 38, wherein each of the plurality of air openings are disposed above each of the corresponding plurality of air openings.

40 The facility according to claim 38, wherein the building further includes:

i a roof disposed near the plurality of air openings; and

ii a ceiling disposed near the building that provides a barrier to prevent air from passing the ceiling including a ceiling edge that connects to the exterior load wall between each of the plurality of air openings and the corresponding plurality of air openings, thereby forming a air escape gap above the ceiling and below the roof, the ceiling further including a plurality of opening therein corresponding to exhaust channels through which the air passes from below the ceiling.

41 The facility according to claim 40 wherein the plurality of ducts connect together within the building, near the ceiling.

42 The facility according to claim 41 further including:

i another load wall opposite the load wall,

ii another plurality of exhaust outlets ducts and another corresponding plurality of air inlet ducts are included in the another load wall,

iii then another plurality of exhaust outlets ducts and the another plurality of air inlet ducts configured the same as the plurality of exhaust outlets ducts and the plurality of air ducts, respectively; and

iv another plurality of air conditioning apparatus are disposed in the environment, to the building, and parallel to one another along the another load wall, each of the another plurality of air conditioning apparatus being supported by another level support structure,

v and each of the another plurality of air conditioning apparatus being formed as each of the air conditioning apparatus.

43 The facility according to claim 42, wherein the ceiling further includes another edge that connects to the another load wall between each of the another plurality of air openings and the corresponding plurality of air openings, thereby forming a air escape gap near the ceiling

44 The facility according to claim 36 wherein the heat exchange unit is contained within a first housing, the filter chamber and the air cooling area of the condenser unit are contained within a second housing and the return opening is disposed between the first housing and the second housing, and wherein the first housing and the second housing together comprise the fully enclosed cabinet.

45 The facility according to claim 44 wherein the first housing is attachable to the second housing using bolts and wherein the insulated cabinet walls, cabinet floor and cabinet ceiling include welded steel to prevent air leakage.

46 The facility according to claim 45 wherein the first housing is disposed near the housing.

47 The facility according to claim 46, wherein the exhaust fan within the heat exchange unit is disposed, and in a location directly above the return opening, the return opening being positioned in a floor of the first housing and a ceiling of the second housing.

48 The facility according to claim 36 further including a control system, the control system operable to automatically control each of the fan, the damper, the air damper, the condenser, the fan and the outlet damper.

49 The facility according to claim 48 wherein the outside air damper further includes a lever, the closing lever causing closure of the outside air damper upon a disruption in electrical power.

50 The facility according to claim 49 further including a first sealable entry door from the external environment to the air entry area of the filter chamber and an entry door from the environment to the air cooling area of the condenser unit, each of the doors being sized to permit access therethrough.

51 The facility according to claim 50 wherein the air meets a wall comprised of a plurality of filters.

52 The facility according to claim 51 wherein the fan is comprised of a plurality of fans, the fan wall being placed near the filter wall and the air cooling area.

MOTHER PATENT -

U.S. PATENT NO. 8,180,495 - (FIGURES 1-10)

53 An apparatus for controlling a plurality of air conditioning units that each include an exhaust fan, and a cooling fan, and a plurality of actuators that control a plurality of dampers within the plurality of air conditioning units in order to control temperature and pressure, the apparatus comprising:

i a plurality of cabinets for holding 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;

ii a hot air containment chamber disposed over each of the plurality of cabinet clusters that traps the heated air within a 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;

- iii** a warm air escape gap within the building disposed above the hot air containment chamber, the warm air escape gap feeding the heated air to the air conditioning units, the warm air escape gap being lowerly bounded by a false ceiling;
- iv** cool air ducts within the building that connects between 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;
- v** the control system comprising a plurality of temperature sensors, at least one temperature sensor located inside each of the plurality of hot air containment chambers, at least one temperature sensor located outside each of the plurality of hot air containment chambers above the plurality of cabinets, and at least one temperature sensor located in the warm air escape gap;
- vi** a plurality of pressure differential sensors, at least one pressure differential sensor located inside each of the plurality of hot air containment chambers, at least one pressure differential sensor located outside each of the plurality of hot air containment chambers above the plurality of cabinets, and at least one pressure differential sensor located in the warm air escape gap;

vii and a computer system, the computer system receiving signals from each of the plurality of temperature sensors and each of the plurality of pressure differential sensors, and providing control signals to control the exhaust fan, the cooling fan, and the plurality of actuators that control the plurality of dampers within the plurality of air conditioning units in order to control the temperature and the pressure.

54 The apparatus according to claim 53 wherein the computer system controls pressure differentials that exists between an area within the hot air containment chamber for each of the cabinet clusters and outside air outside of each of the cabinet clusters.

55 The apparatus according to claim 53 wherein the cold air ducts include a header duct to which at least some of the plurality of air conditioning units emit cooled air into from a cool air entry; wherein the head duct has disposed therein, between various ones of the cool air entries, one of the plurality of pressure differential sensors.

56 The apparatus according to claim 55 wherein the computer system, based upon the signals from each of the plurality of temperature sensors and each of the plurality of pressure differential sensors, maintains a substantially uniform pressure within the header duct.

57 The apparatus according to claim 53 wherein the computer system controls the temperature within each of the cabinet clusters to maintain a predetermined temperature range based upon an average temperature for the plurality of cabinets within each cabinet cluster.

58 The apparatus according to claim 57 wherein a lower edge of the thermal shields abut an upper edge of certain cabinets within each cabinet cluster and wherein each hot air containment chamber has a rectangular shape.

59 The apparatus according to claim 53, wherein the plurality of clusters number at least three, and wherein the plurality of rows are two, such that each of the at least three clusters is formed of two rows of cabinets.

60 The apparatus according to claim 59 wherein each hot air containment chamber has a rectangular shape and is made of thermal shields.

61 The apparatus according to claim 60 wherein a lower edge of the thermal shields abut an upper edge of certain cabinets within each cabinet cluster.

62 The apparatus according to claim 59 wherein the cool air ducts extend below the ceiling to deliver the cool air from the plurality of air conditioning units toward the periphery of the plurality of rows of cabinets within each of the plurality of cabinet clusters, wherein at least some of the cool air ducts are disposed within a cool aisle that exists between adjacent cabinet clusters.

63 The apparatus according to claim 53 wherein the cool air ducts extend below the ceiling to deliver the cool air from the plurality of air conditioning units toward the periphery of the plurality of rows of cabinets within each of the plurality of cabinet clusters, wherein at least some of the cool air ducts are disposed within a cool aisle that exists between adjacent cabinet clusters.

64 The apparatus according to claim 53 wherein each cabinet cluster includes telecommunications equipment and power equipment, the telecommunications equipment providing an interface for communications to the electronic equipment disposed within the cabinet cluster, and the power equipment to assist in distributing electrical power to the electronic equipment disposed within the cabinet cluster.

65 The apparatus according to claim 53 wherein each cabinet cluster is surrounded by a lockable cage that permits airflow therethrough.

66 The apparatus according to claim 65 wherein each lockable cage includes a cage lock sensor, each cage block sensor signaling to the computer system which cabinet cluster is open.

67 The apparatus according to claim 53 wherein the cool air ducts extend below the ceiling to deliver the cool air from the plurality of air conditioning units toward the periphery of the plurality of rows of cabinets within each of the plurality of cabinet clusters, wherein at least some of the cool air ducts are disposed within a cool aisle that exists between adjacent cabinet clusters; and wherein the cool air ducts include a plurality of vents, each vent having a remote controlled actuator associated therewith, and each remote controlled actuator controlled by the control system and allowing for remote control of direction and volume of the cool air that is emitted from the vent.

68 The apparatus according to claim 53, wherein the at least one temperature sensor located inside each of the central hot air areas associated with each cabinet cluster includes at least three temperature sensors located inside each of the central hot air areas associated with each cabinet cluster, with a first temperature sensor located at one end of the cluster, a second temperature sensor located at an opposite end of the cluster, and a third temperature sensor located at a middle of the cluster.

69 The apparatus according to claim 68, wherein the at least one temperature sensor located in the warm air escape gap includes at least three temperature sensors each located at a different height interval within the warm air escape gap.

70 The apparatus according to claim 53, wherein the at least one temperature sensor located in the warm air escape gap includes at least three temperature sensors each located at a different height interval within the warm air escape gap.

71 The apparatus according to claim 53 further including a plurality of airflow sensors, each airflow sensor located proximate to one of the pressure differential sensors.

72 The apparatus according to claim 53, wherein the at least one temperature sensor located in the warm air escape gap includes at least three temperature sensors each located at a different height interval within the warm air escape gap.

73 An apparatus for cooling electronic equipment contained within a floor of a building, in conjunction with a plurality of air conditioning units that each create cool air and include an exhaust fan and a cooling fan and a plurality of actuators that control a plurality of dampers associated with the plurality of air conditioning units, the apparatus comprising:

i a plurality of cabinets disposed on the floor of the building 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;

ii a hot air containment chamber disposed within the building over each of the plurality of cabinet clusters that traps the heated air within a 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 and exit through a hot air escape opening of the associated hot air containment chamber

- iii** a warm air escape gap disposed within the building and disposed above each of the hot air containment chambers, the warm air escape gap collecting the heated air from each of the hot air containment chambers and feeding, the heated air to the air conditioning units, the warm air escape gap being lowerly bounded by a ceiling, wherein the ceiling contains ceiling openings that each align with one of the hot air escape openings in each of the hot air containment chambers;
- iv** cool air ducts disposed within the building that deliver the cool air from the plurality of air conditioning units toward a periphery of the plurality of rows of cabinets within each of the plurality of cabinet clusters; and
- v** a control system, the control system comprising:
- vi** a plurality of pressure differential sensors, at least one pressure differential sensor located inside each of the plurality of hot air containment chambers, at least one pressure differential sensor located outside each of the plurality of hot air containment chambers, and at least one pressure differential sensor located in the warm air escape gap;
- vii** and a computer system, the computer system receiving signals from each of the plurality of pressure differential sensors, and providing control signals to control a pressure differential that exists between an area within the hot air

containment chamber for each of the cabinet clusters and a different area outside of each of the cabinet clusters.

74 The apparatus according to claim 73 wherein the cold air ducts include a header duct to which at least some of the plurality of air conditioning units emit cooled air into from a cool air entry; wherein the header duct has disposed therein, between various ones of the cool air entries, one of the plurality of pressure differential sensors.

75 The apparatus according to claim 73 wherein each hot air containment chamber is made of thermal shields.

76 The apparatus according to claim 73 wherein a lower edge of the thermal shields abut an upper edge of certain cabinet within each cabinet cluster and wherein each hot air containment chamber has a rectangular shape.

77 The apparatus according to claim 73, wherein the plurality of clusters number at least three, and wherein the plurality of rows are two, such that each of the at least three clusters is formed of two rows of cabinets.

78 The apparatus according to claim 77 wherein each hot air containment chamber has a rectangular shape and is made of thermal shields.

79 The apparatus according to claim 78 wherein a lower edge of the thermal shields abut an upper edge of certain cabinets within each cabinet cluster.

80 The apparatus according to claim 77 wherein the cool air ducts extend below the ceiling to deliver the cool air from the plurality of air conditioning units toward the periphery of the plurality of rows of cabinets within each of the plurality of cabinet clusters, wherein at

least some of the cool air ducts are disposed within a cool aisle that exists between adjacent cabinet clusters.

81 The apparatus according to claim 73 wherein the cool air ducts extend below the ceiling to deliver the cool air from the plurality of air conditioning units toward the periphery of the plurality of rows of cabinets within each of the plurality of cabinet clusters, wherein at least some of the cool air ducts are disposed within a cool aisle that exists between adjacent cabinet clusters.

82 The apparatus according to claim 73 wherein each cabinet cluster includes telecommunications equipment and power equipment, the telecommunications equipment providing an interface for communications to the electronic equipment disposed within the cabinet cluster, and the power equipment to assist in distributing electrical power to the electronic equipment disposed within the cabinet cluster.

83 The apparatus according to claim 73 wherein each cabinet cluster is surrounded by a lockable cage that permits airflow therethrough.

84 The apparatus according to claim 83 wherein each lockable cage includes a cage lock sensor, each cage lock sensor signaling to the computer system which cabinet cluster is open.

85 The apparatus according to claim 73 wherein the cool air ducts extend below the ceiling to deliver the cool air from the plurality of air conditioning units toward the periphery of the plurality of rows of cabinets within each of the plurality of cabinet clusters, wherein at least some of the cool air ducts are disposed within a cool aisle that exists between adjacent cabinet clusters; and wherein the cool air ducts include a plurality of vents, each vent having a remote controlled

actuator associated therewith, and each remote controlled actuator controlled by the control system and allowing for remote control of direction and volume of the cool air that is emitted from the vent.

- 86** The apparatus according to claim 21 further including a plurality of airflow sensors each airflow sensor located proximate to one of the pressure differential sensors.

DATA CENTER AIR HANDLER – SWC-002C-2 – (FIGURES 1-10)

- 87** A facility for maintaining electronic equipment at the facility comprising:
- i** a building having a load wall disposed near the interior of the building and a periphery exterior, the periphery exterior being located outside;
 - ii** a plurality of air conditioning units each adjacent to the load wall and disposed on a level support structure, the plurality of air conditioning units receiving air and emitting air;
 - iii** a plurality of air openings disposed in the load wall, each air opening proximate to one of the plurality of air conditioning units;
 - iv** a plurality of return air openings disposed in the load wall, each air opening proximate to one of the plurality of air conditioning units;
 - v** plurality of exhaust outlet ducts, each exhaust outlet duct formed through one of the air openings;

- vi** a plurality of air inlet ducts, each air inlet duct formed through one of the air openings;
- vii** a plurality of cabinet clusters arranged in an array of at least four cabinet clusters, with the clusters sharing a common aisle, two cabinet clusters on one side of the common aisle and another two cabinet clusters on another side of the common aisle, and wherein a aisle area of each of the cabinet clusters are aligned and parallel to the aisle, and wherein the aisle enclosure area of each of the another cabinet clusters are aligned and parallel to the aisle, wherein each cabinet cluster including a plurality of cage cabinets positioned in a configuration in separated rows so that the electronic equipment disposed therein emit air in the aisle area between the separated rows of cage cabinets, and wherein an opposite side of the cage cabinets each establish the aisle, wherein the aisle enclosure area and the aisle of each of the plurality of cabinet clusters are aligned:
- viii** a floor within the interior of the building on which the plurality of cage cabinets in each of the plurality of cabinet clusters are disposed, the floor being within the interior space of the building in a room with an interior wall of the exterior load wall thereby defining an equipment area room;
- ix** a structurally sound shield providing a contiguous wall around a air area above the aisle enclosure area at a height above the separated rows of cage cabinets to define a channel that traps the air within the aisle enclosure area and causes substantially all the air within the aisle enclosure area to circulate up within the warm exhaust channel for each of the cabinet clusters, wherein the contiguous wall fully surrounds the aisle enclosure area from above each of the plurality of cabinet clusters;

- x** an air escape channel disposed above the exhaust channel, the air escape channel feeding the air to the plurality of air conditioning units through the plurality of exhaust outlet ducts; and
- xi** an air channel disposed within the building near the plurality of plurality of cabinet clusters that delivers air from the plurality of air conditioning units to the aisle through the plurality of air inlet ducts, the air channel including a plurality of aisle air ducts each having vents disposed proximate a cabinet cluster, wherein each of the plurality of aisle air ducts are parallel to each other and parallel to the aisle.
- 88** The facility according to claim 88, further including a thermal barrier at an end of each of the cabinet cages in each of the plurality of cabinet clusters, thereby maintaining a barrier, other than where the rows of cabinet cages are disposed, around each of the aisle enclosure areas, thereby further ensuring that substantially all the air within each of the aisle enclosure areas circulates within the exhaust channel.
- 89** The facility according to claim 89, wherein some of the barriers include a door that permits access into the aisle enclosure area of the associated cluster.
- 90** The facility according to claim 88 wherein the structurally sound shield is comprised of pieces having an air space therebetween.
- 91** The facility according to claim 88 wherein the plurality of aisle air ducts are disposed at a height that is below the structurally sound shield providing the contiguous wall around the air area for each of the plurality of cabinet clusters.

92 The facility according to claim 8 wherein the vents provide for directional downward flow at various angles.

93 The facility according to claim 93 wherein each of the vents for control of the corresponding vent.

94 The facility according to claim 94 further including detectors in various areas within each of the cabinet clusters, which adapt to control vents in a particular area corresponding thereto.

95 The facility according to claim 88, wherein the air escape channel is bounded by a ceiling that covers the room in its entirety and provides a barrier to prevent the air from passing therebelow, wherein an opening exists in the ceiling corresponding to each of the channels through which the air passes for each of the plurality of cabinet clusters, and wherein an edge of the shield connects to the ceiling to further prevent the air from escaping for each of the cabinet clusters.

96 The facility according to claim 96 wherein the air escape channel is further bounded by an upper ceiling, and wherein a distance between the upper ceiling and the ceiling is several feet.

97 The facility according to claim 96, further including a barrier at an end of each of the separated cages in each of the plurality of cabinet clusters, thereby maintaining a contiguous barrier, other than where the separated rows of cabinet cages are disposed, around each of the aisle enclosure areas, thereby further ensuring that substantially all the air within each of the aisle enclosure areas rises up within the exhaust channel.

98 The facility according to claim 97, wherein some of the barriers include a door that permits access into the aisle area of the associated cabinet cluster.

- 99** The facility according to claim 98 wherein the structurally sound shield is comprised of pieces having an air space therebetween.
- 100** The facility according to claim 99 wherein the plurality of cold aisle air ducts are disposed at a height that is below an upper edge of the structurally sound thermal shield providing the contiguous wall around the hot air area for each of the plurality of cabinet clusters.
- 101** The facility according to claim 96 wherein the vents provide for directional downward flow at various angles.
- 102** The facility according to claim 96 wherein each of the vents include an actuator that allows for offsite control the corresponding vent, both in direction of airflow and volume of airflow.
- 103** The facility according to claim 96 further including temperature detectors in various areas within each of the cabinet clusters, which adapt to automatically control vents in a particular area corresponding thereto.

T-SCIF - U.S. PATENT NO. 8,072,780 - (FIGURES 1-10)

- 104** An apparatus for maintaining a configuration of electronic equipment disposed in a plurality of cabinets, for supporting a thermal shield that defines a hot air containment chamber, and supporting distribution power wires and conduits, electronic equipment power wires and conduits, and communication wiring, the plurality of cabinets disposed on a floor, the floor being within an internal area of a building, the cabinets positioned in a two rows and separated by a hot aisle area so that the electronic equipment disposed in the plurality of cabinets emit heated air in a predetermined direction toward the hot aisle area between the two rows, the apparatus comprising: a plurality of

support brackets disposed along each of the two rows that support the distribution power wires and conduits, the electronic equipment power wires and conduits, and the communication wiring on one side of the plurality of support brackets, and support the thermal shield on another side plurality of support brackets, wherein a portion of each of the support brackets is adapted for connection above the plurality of cabinets, each of the support brackets including, in the portion adapted for connection above the plurality of cabinets: a plurality of tiered ladder rack supports on the one side to establish a plurality of different tiers outside of the hot air containment chamber, so that each of the different 5 tiers is adapted to hold the electronic equipment power wires and conduits and the communication wiring, and a plurality of conduit holders disposed on the one side above the plurality of tiered ladder rack supports, each of the conduit holders in each of the plurality of support 10 brackets aligned with corresponding ones of conduit holders in the other plurality of support brackets, for holding a plurality of the distribution power wires and conduits.

- 105** The apparatus according to claim 104 wherein the plurality of conduit holders are a plurality of conduit clamps disposed on each of the support brackets above the plurality of tiered ladder rack supports.
- 106** The apparatus according to claim 104 wherein the plurality of conduit holders are disposed on at least one conduit ladder rack support.
- 107** The apparatus according to claim 104 wherein the plurality of conduit holders are disposed on a plurality of tiered conduit ladder rack supports.
- 108** The apparatus according to claim 104 further including a plurality of ladder racks, each of the plurality of ladder racks being associated with one of the plurality of tiered ladder rack supports of the plurality of support brackets, such that each of the plurality of ladder racks is

horizontally disposed above the cabinets below and provides further support for the electronic equipment power wires and conduits and the communication wiring.

109 The apparatus according to claim 108 wherein each of the plurality of ladder rack supports is attached to a back vertical support bracket associated with each of the plurality of support brackets.

110 The apparatus according to claim 109 wherein at least some of the plurality of support brackets further includes, at a bottom of the back vertical support bracket, a horizontal support plate for attachment to a top of the cabinet therebelow.

111 The apparatus according to claim 110 wherein at least some of the plurality of support brackets further includes a top 20 support plate at a top of the bracket for attachment to a ceiling

T-SCIF METHOD – SWC-020C – (FIGURES 1-10)

112 A method of configuring equipment in a plurality of cabinets, and supporting power wires and conduits, electronic equipment power wires and conduits, and communication wiring, the method comprising the steps of:

i providing a plurality of cabinet clusters, each cabinet cluster including some of the plurality of cabinets, wherein the plurality of cabinets are disposed on a floor, the floor being within an internal area of a building, the some cabinets in each cabinet cluster positioned in rows and separated by an aisle area so that the electronic equipment disposed in the plurality of cabinets in each cabinet cluster emit air in a predetermined direction toward the aisle area near the separated rows associated with each cabinet cluster,

wherein the providing the plurality of cabinet clusters further arranges the plurality of cabinet clusters in an array of cabinet clusters such that the aisle area of each of the at least cabinet clusters is aligned in both a length and width direction with adjacent cabinet clusters in the length and width direction, thereby creating separated rows of cabinets;

- ii** providing, for each of the cabinet clusters, a plurality of support brackets disposed along each of the two separated rows that support the distribution power wires and conduits, the electronic equipment power wires and conduits, and the communication wiring on one side of the plurality of support brackets, wherein a portion of each of the support brackets is adapted for connection above the plurality of cabinets, each of the support brackets including, in the portion adapted for connection above the plurality of cabinets:
- iii** a plurality of tiered ladder rack supports on the one side to establish a plurality of different tiers outside of the air containment chamber, so that each of the different tiers is adapted to hold the equipment power wires and conduits and the wiring, and
- iv** a plurality of conduit holders disposed on the one side above the plurality of tiered ladder rack supports, each of the conduit holders in each of the plurality of support brackets aligned with corresponding ones of conduit holders in the other plurality of support brackets, for holding a plurality of the distribution power wires and conduits;
- v** providing, for each of the cabinet clusters, a plurality of ladder racks, each of the plurality of ladder racks being associated with one of the plurality of tiered ladder rack supports of the

plurality of support brackets, such that each of the plurality of ladder racks is horizontally disposed above the cabinets below and provides further support for the electronic equipment power wires and conduits and the communication wiring;

- vi** providing power wires and conduits along some of the plurality of conduit holders from a plurality of power units to the plurality of cabinet clusters to at least one power unit disposed in each of the cabinet clusters, wherein the power wires and conduits span adjacent cabinet clusters and are disposed in the plurality of conduit holders, so as to be located near the tiered ladder rack supports;
- vii** providing communication wiring near other ones of the plurality of conduit holders wiring from near the plurality of cabinet clusters to telecommunication equipment disposed in each of the cabinet clusters, wherein the communication wiring spans adjacent cabinet clusters and is disposed in the plurality of conduit holders, so as to be located above the tiered ladder rack supports;
- viii** providing first electronic equipment power wires from one circuit of the power unit disposed to each of the cabinets using one of the ladder racks within each cabinet cluster;
- ix** providing second electronic equipment power wires from a second circuit of the at least one power unit disposed in each of the cabinet clusters to each of the cabinets using a second of the ladder racks within each cabinet cluster, the power provided by the second circuit; and

- X** providing cabling from the equipment disposed in each of the cabinet clusters to each of the cabinets using a third of the ladder racks within each cabinet cluster.
- 113** The method according to claim 112, wherein the step of providing the plurality of ladder racks provides the third ladder racks closest to the plurality of cabinets, and the second ladder racks and the first ladder racks are disposed above the third ladder racks.
- 114** The method according to claim 113 wherein the step of providing the plurality of support brackets provides as the plurality of conduit holders a plurality of conduit clamps disposed on each of the support brackets above the plurality of tiered ladder rack supports.
- 115** The method according to claim 113 wherein the step of providing the plurality of support brackets provides as the plurality of conduit holders at least one conduit ladder racks support.
- 116** The method according to claim 114 wherein the step of providing the plurality of support brackets provides as the plurality of conduit holders a plurality of tiered conduit ladder rack supports.
- 117** The method according to claim 113 wherein the step of providing the plurality of support brackets provides each of the plurality of ladder rack supports attached to a back support bracket associated with each of the plurality of support brackets.
- 118** The method according to claim 117 wherein the step of providing the plurality of support brackets provides, for at least some of the plurality of support brackets, at a bottom of the back support bracket, a support plate for attachment to the cabinet.

- 119** The method according to claim 118 wherein the step of providing the plurality of support brackets provides, for at least some of the plurality of support brackets, a support plate of the bracket for attachment to a ceiling.
- 120** The method according to claim 113 further including the step of providing aisle ducts having vents in a location near the plurality of cabinets, in a direction parallel to and contiguous with the separated rows, with a first aisle duct disposed in a first aisle adjacent an outer row of the cabinets formed by cabinet clusters, with a second aisle duct disposed in a second aisle disposed between two separated rows of cabinets between two adjacent cabinet clusters, and with a third aisle duct disposed in a third aisle adjacent a row of the cabinets formed by the other cabinet clusters.
- 121** Claim 18. The method according to claim 113 wherein the distribution wires and conduits provide power, and wherein the first electronic equipment power wires and the second electronic equipment power wires each provide power.
- 122** Claim 19. The method according to claim 113 wherein the floor is within a room of a building that has at least one load wall and one interior wall and wherein another room is disposed on an opposite side of the one wall, and wherein the step of providing distribution power wires and conduits provides the distribution power wires and conduits from the plurality of distribution units located in the another room to the plurality of cabinet clusters located in the room.
- 123** Claim 20. The method according to claim 122 wherein the distribution power wires and conduits are provided from different power distribution units that each provide power independently.

**AIR HANDLING UNIT INTERNAL WORKINGS -
U.S. PATENT NO. 8,469,782**

124 An air conditioning system for a building requiring a high volume of cooled air, the building having a ground level floor and including an exterior wall that provides a barrier against the external environment and includes a heated air opening disposed adjacent to a return air opening, the system comprising:

i a warm exhaust outlet duct formed through the heated air opening;

ii a cool air inlet duct formed through the return air opening an air conditioning apparatus connected to and that receives heated air from the warm exhaust outlet duct, connected to and emits cooled air into the cool air inlet duct, and connected to and emits vented air into the external environment through an exhaust opening, the air conditioning apparatus disposed in the external environment, external to the exterior wall, and mounted adjacent the exterior wall on a ground level support structure, the air conditioning apparatus further including:

iii a heat exchange unit containing an exhaust fan disposed in the exhaust opening that emits heat from the heated air as the vented air, thereby allowing return air to pass through a return opening that contains a return damper disposed therein;

iv an outside air inlet including an outside air damper, thereby allowing outside air to pass through the outside air damper;

- v** a filter chamber, the filter chamber including an air intake area coupled to the heat exchange unit and the outside air inlet and an air filter, the filter chamber being configurable to receive the return air-based upon a return air damper position, the outside air based upon an outside air damper position, as well as a mixture of the return air and the outside air based upon the return air damper position and the outside air damper position, the filter chamber providing filtered air;
- vi** a condenser unit coupled to the filter chamber that has an air cooling area over which the filtered air passes to create the cooled air, the condenser unit including:
- vii** a direct cooling coil filled with a gas over which the filtered air passes, the gas being circulated through a condenser disposed in the external area;
- viii** an indirect cooling coil filled with cooled water over which the filtered air passes, the cooled air being circulated through an evaporation unit disposed in the external area; an evaporator that provides a water wall through which the filtered air can pass; and
- xi** an evaporator bypass allowing all or some of the filtered air to bypass the evaporator, and a bypass damper associated therewith;
- x** a fan operable push the filtered air through the air cooling area and toward the cool air inlet duct; and an outlet damper operable to control an amount of the cooled air delivered from the air cooling area to the cool air inlet duct.

- 125** The air conditioning system according to claim 124, wherein the heat exchange unit is disposed above the filter chamber and the condenser unit.
- 126** The air conditioning system according to claim 125 wherein the heat exchange unit is contained within a first housing, and the filter chamber and the condenser unit are contained within a second housing and the return opening is disposed between the first housing and the second housing.
- 127** The air conditioning system according to claim 124 further including a control system, the control system operable to automatically control each of the exhaust fan, the return damper, the outside air damper, the condenser, the bypass damper, the fan and the outlet damper.
- 128** The air conditioning system according to claim 127 wherein the outside air damper further includes a springloaded mechanical closing lever, the spring-loaded mechanical closing lever causing automatic closure of the outside air damper upon a disruption in electrical power.
- 129** The air conditioning system according to claim 126 wherein the first housing is attachable to and detachable from the second housing bolts.
- 130** The air conditioning system according to claim 129 wherein the first housing is disposed above the second housing.
- 131** The air conditioning system according to claim 130, wherein the exhaust fan within the heat exchange unit is disposed on a sidewall thereof, and in a location directly above the return opening, the return opening being positioned in a floor of the first housing and a ceiling of the second housing.

132 The air conditioning system according to claim 124 further including a first sealable entry door from the external environment to the filter chamber and as second sealable entry door from the external environment to the air cooling area, each of the first and second sealable doors being sized to permit adult human access therethrough.

133 The air conditioning system according to claim 132 wherein the air filter includes a plurality of filters.

134 The air conditioning system according to claim 133 wherein the fan is comprised of a plurality of fans, the plurality of fans being placed between the plurality of fans and the air cooling area.

135 The air conditioning system according to claim 124, further including another air conditioning apparatus according to claim 124 adjacent to the air conditioning apparatus that is further configured for connection to another warm exhaust outlet duct formed through another heated air opening in the exterior wall, and for connection to another cool air inlet duct formed through another return air opening in the exterior wall; and wherein the cool air duct and the another cool air duct connect together within the building.

136 The air conditioning system according to claim 135 further including a back-up generator disposed in the external environment, and electrically connected to and in close proximity to the air conditioning apparatus and the another air conditioning apparatus.

ROTOFLY AND CENTRI-FAN – SWC-040 - (FIGURES 11-13)

137 A method of preventing damage to electrical equipment, the electrical equipment being cooled with cool air from an electrically powered air conditioning unit during normal operation using grid power, the method comprising the steps of:

i rotating a fan using an electric motor powered with electricity from the grid power to cause at least a predetermined airflow, the fan including a weighted rotor assembly that includes a fan body and a plurality of fan blades, wherein the weighted rotor assembly creates energy;

ii directing the airflow to the equipment;

iii upon removal of the power to the fan, continuing to direct continued airflow to the electrical equipment for at least an interim period using the energy within the fan; and

iv before expiration of the interim period, continuing to rotate the fan using the motor powered with electricity from the back-up generator to cause further airflow to the equipment.

138 The method according to claim 137 wherein said interim period is lengthy and the weighted rotor assembly provides a mass moment of inertia.

139 The method according to claim 138 wherein said weighted rotor assembly includes a flywheel.

140 The method according to claim 139 wherein the fan is a centrifugal fan.

141 The method according to claim 138 wherein said fan is an array of fans, each fan in the array being configured with an assembly.

142 The method according to claim 138 wherein the step of rotating the fan includes controlling the fan using a control system; and further including the step of using the energy to generate electricity to power said control system in a reduced power mode for the period.

143 The method according to claim 137 wherein the motor used in the step of using the motor powered with electricity from the grid power is a motor; and further including the step of using the energy to generate electricity to power said motor in a reduced power mode for the period.

144 The method according to claim 143 wherein said interim period is several seconds and the rotor assembly provides a mass moment of inertia.

145 The method according to claim 144 wherein the airflow is directed through a venting system to the electrical equipment.

146 An air conditioning apparatus that receives air and emits air into a cabinet cluster containing equipment with fan modules therein and is powered by one of grid power and a back-up generator, the air conditioning apparatus including:

i an exchange unit containing an exhaust fan that emits the air as the vented air, thereby allowing return air to pass through a return damper;

ii an outside air inlet that allows outside air to pass therethrough;

iii a filter, the filter including an air intake area coupled to the return damper of the exchange unit and the air inlet, the air intake area being configurable to receive the return air and the outside air, as well as a mixture of the return air and the outside air, the filter chamber providing filtered air;

iv a cooling unit coupled to the filter chamber that creates an air cooling area over which the filtered air passes to create the cooled air, the cooling unit including; and

v a cooling unit fan operable to push the filtered air through the air cooling area and into the cabinet cluster;

vi wherein one or more of said exhaust fan and said cooling unit fan is configured with a weighted rotor assembly for storing energy during rotation of the one or more of said exhaust fan and said cooling unit fan, the energy being sufficient to deliver at least a predetermined flow of air from said cooling area into said cabinet cluster for an interim period between loss of the grid power to said air conditioning apparatus and the back-up generator coming on-line.

147 The air conditioning apparatus according to claim 10 wherein said interim period is several seconds and the weighted rotor assembly provides a mass moment of inertia.

148 The air conditioning apparatus according to claim 10 wherein said weighted rotor assembly includes a flywheel.

149 The air conditioning apparatus according to claim 146 wherein said cooling unit fan is configured with the weighted rotor assembly and is a centrifugal fan.

- 150** The air conditioning apparatus according to claim 146 wherein said cooling unit fan is configured with the weighted rotor assembly and is an array of fans, each fan in the array configured with the weighted rotor assembly.
- 151** The air conditioning apparatus according to claim 146 further including a control system, the control system operable to automatically control each of the heat exchange unit, the cooling unit, and the cooling unit fan.
- 152** The air conditioning apparatus according to claim 151 wherein said stored energy is also sufficient to generate electricity to power parts of said control system in a reduced power mode for the interim period.
- 153** The air conditioning system according to claim 146 wherein said one or more of said exhaust fan and said cooling unit fan are driven by a motor operated with a variable frequency drive.
- 154** The air conditioning apparatus according to claim 153 wherein said stored energy is sufficient to generate electricity to power said variable frequency drive for the interim period.
- 155** The air conditioning apparatus according to claim 146 wherein both said exhaust fan and said cooling unit fan are configured with the weighted rotor assembly.
- 156** The air conditioning apparatus according to claim 146 wherein the weighted rotor assembly weighs several pounds.

FLOATING T-SCIF – SWC-050 – (FIGURES 14-16)

- 157 Patent Pending
- 158 Patent Pending
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- 166 Patent Pending
- 167 Patent Pending

DUAL REDUNDANT ROOF – SWC-060 – (FIGURES 17-25)

- 168 A data center comprising:
 - i a rainfly roof configured to protect the data center from adverse weather events disposed upon a rainfly structure having vertical support columns and a first set of framing members;
 - ii a secondary roof structure disposed near the rainfly roof structure and coupled thereto by the vertical support columns;

iii a lower roof structure disposed below the secondary roof structure and coupled thereto by the vertical support columns; and

iv a second set of framing members disposed between the secondary and lower roof structures.

169 The data center of claim 168, wherein the first and second sets of framing members each include main support beams and purlins coupled perpendicularly thereto.

170 The data center of claim 169, wherein the members are offset to mitigate damage to the data center when an airborne objects striking the data center during severe weather becomes lodged in one or more of the sets of framing members.

171 The data center of claim 168, further comprising a data hall within the data center having a ceiling disposed, wherein the data hall is adapted to store a plurality of cabinets to hold electronic equipment therein.

172 The data center of claim 171, further comprising one or more heat chimneys to conduct heated air out of the data hall through the ceiling into a hot air return region above such that the heated air escapes the data center through one or more hot air exhaust openings.

173 The data center of claim 172, wherein the cabinets of electronic equipment are positioned in a plurality of rows such that heated air conducts from the electronic equipment in each row through the chimneys into a hot air return region above the data hall ceiling.

174 The data center of claim 172, further comprising:

- i** one or more air supply openings located adjacent to a air supply region around the ceiling of the data hall; and
 - ii** one or more air exhaust openings located adjacent to the air return region near the ceiling of the data hall.
- 175** The data center of claim 174, wherein the data center is coupled with an apparatus to control a plurality of air conditioning units located alongside the outside of the data center adapted to be coupled with the cold air supply openings to deliver cool air into the data hall.
- 176** The data center of claim 175, wherein the hot air exhaust openings feed the heated air into the plurality of air conditioning units.
- 177** The data center of claim 171, wherein the secondary and the lower roof structures are coupled together using an airtight sealed joint allowing the data hall to facilitate air flow through the electronic equipment.
- 178** The data center of claim 168, wherein the secondary and lower roof structures are adapted to remain intact.
- 179** The data center of claim 168, wherein the lower roof structure is adapted to remain intact in the event of failure in both the rainfly and secondary roof structures.
- 180** The data center of claim 168, further comprising an insulation layer coupled between the secondary and lower roof structures.
- 181** The data center of claim 168, further comprising an exterior drainage system coupled with the rainfly roof to drain rainwater away from the data center.

182 The data center of claim 168, wherein the secondary roof structure includes a second redundant drainage system disposed thereon adapted to drain rainwater away from the data center in case of leaks in the rainfly roof structure.

183 A method for protecting electronic equipment in a data center comprising:

iii shielding the data center from adverse weather events using a rainfly roof structure having vertical support columns and a first set of framing members;

iv providing a secondary roof structure disposed below the rainfly roof structure and coupled thereto by the support beams;

v providing a lower roof structure disposed below the secondary roof structure and coupled thereto by the vertical support beams; and

vi providing a second set of framing members disposed between the secondary and lower roof structures; and

vii offsetting the first set of framing members from the second set of framing members.

184 The method of claim 183, wherein the first and second sets of framing members each include main support structures coupled perpendicularly thereto.

185 The method of claim 184, further comprising offsetting the purlins of the first and second sets of framing members to mitigate damage to the data center from airborne objects.

- 186** The method of claim 183, further comprising storing a plurality of cabinets holding electronic equipment in a data hall having a ceiling disposed below the lower roof structure.
- 187** The method of claim 186, further comprising conducting heated air out of the data hall through the ceiling into a air return region near using one or more ducts such that the air escapes the data center out through the air exhaust openings.
- 188** The method of claim 186, further comprising positioning the cabinets of electronic equipment in a plurality of rows such that air is emitted from the electronic equipment in each row into the air return region above the data hall ceiling.
- 189** The method of claim 186, further comprising supplying cool air to the data hall through one or more air supply openings located adjacent to a air supply region below the ceiling of the data hall.
- 190** The method of claim 189, further comprising controlling a plurality of air conditioning units to be located alongside the air supply openings on the outside of the data center to deliver the air into the data hall.
- 191** The method of claim 190, further comprising feeding the heated air into the plurality of air conditioning units from the hot air exhaust openings further.
- 192** The method of claim 183, further comprising providing an insulating layer between the secondary and lower roof structures.
- 193** The method of claim 183, further comprising:

viii coupling the secondary and the lower roof structures together using an airtight sealed joint; and

ix pressurizing the data hall to facilitate air flow through the electronic equipment.

194 The method of claim 183, further comprising designing the secondary and lower roof structures to remain intact in the event of a rainfly roof structure failure.

195 The method of claim 183, further comprising designing the lower roof structure to remain intact in the event of failure in both the rainfly and secondary roof structures.

196 The data center of claim 183, further comprising coupling an exterior drainage system with the rainfly roof structure to drain rainwater away from the data center.

197 The data center of claim 168, draining excess rainwater away from the data center using a secondary roof structure below the rainfly roof structure in case of leaks in the rainfly roof structure, the secondary roof structure having a second drainage system.

MANUAL CART FOR TRANSPORTATION OF DATA CENTER ELECTRONIC EQUIPMENT – SWC-070 – (FIGURES 26-28)

198 A cart for transportation of electronic equipment through a data center, said cart being manually propelled and guided, comprising:

i a rectangular bed with a horizontal base and vertical walls on three sides, wherein the open side is a short side;

ii two rectangular wheel plates attached one on either side of the bed to the top edges of the longer two of said vertical walls, said rectangular wheel plates being in a horizontal plane, two wheels being attached to the underside of each of said rectangular wheel plates, said rectangular wheel plates having the same length as said rectangular bed;

iii a vertical skirt attached to said rectangular wheel plates around the outer edges of said rectangular wheel plates, said vertical skirt having a height equal to the height of said vertical walls of said rectangular bed;

iv a frame attached to said rectangular bed, wherein said frame includes four vertical struts attached one to each corner of said rectangular bed and three horizontal struts attached between said vertical struts at the top of said vertical struts, said three horizontal struts being positioned above said vertical walls of said rectangular bed; and

v a gate attached to said horizontal base at the open end of said rectangular bed by one or more hinges, said gate being securable in a vertical plane.

199 The cart of claim 198, further comprising restraints attached one to each of the two vertical struts of said frame at the opposite end of said rectangular bed to the open side of said rectangular bed and the position of attachment of said restraints on the vertical struts is distal to said rectangular bed.

200 The cart of claim 198, wherein each of said wheels is attached to the corresponding rectangular wheel plate by a swivel mount to allow for the wheel to rotate about a vertical axis passing through said swivel mount.

- 201** The cart of claim 198, wherein said cart is configured to provide a clearance of less than or equal to one inch between said horizontal base and the horizontal plane defined by the bottom of the wheels attached to said wheel plates.
- 202** The cart of claim 198, wherein said cart is configured to provide a clearance of less than or equal to half an inch between said horizontal base and the horizontal plane defined by the bottom of the wheels attached to said wheel plates.
- 203** The cart of claim 198, wherein said vertical skirt has one aperture adjacent to each of said wheels, each of said apertures being configured to allow for manual access to the corresponding wheel.
- 204** The cart of claim 198, wherein the four wheels are configured on said cart with one of the four wheels in close proximity to each of the four outer corners of said cart.
- 205** The cart of claim 198, wherein the height of the horizontal struts of said frame above the horizontal base of said rectangular bed is between 40 and 50 inches.
- 206** The cart of claim 198, wherein the horizontal base of said rectangular bed has a length of between 45 inches and 65 inches and a corresponding width of between 29 inches and 41 inches.
- 207** The cart of claim 198, further comprising two triangular brackets each attached between a different one of the two vertical struts adjacent to the open end of said rectangular bed and the top surface of the corresponding adjacent rectangular wheel plate.

208 The cart of claim 198, wherein said gate is securable in a vertical plane by gate restraints attached to the vertical struts of said frame at the open end of said rectangular bed and a gate bar which slides into the gap behind both gate restraints and in front of said gate.

209 The cart of claim 208, wherein said gate bar is configured to fit between said horizontal base of said rectangular bed and said gate when said gate is in a lowered position, said gate bar covering said hinges and being flush with said gate and said horizontal base.

210 The cart of claim 198, further comprising a winch bracket attached to the outer side of the short vertical wall of said rectangular bed and a winch securable in said bracket.

211 A method of manually transporting electronic equipment through a data center on a cart, comprising:

- i** loading electronic equipment onto said cart;
- ii** after said loading, stabilizing said electronic equipment in said cart using a strap secured at restraints attached to said cart;
- iii** after said stabilizing, manually maneuvering said cart across a substantially flat floor; and
- iv** after said manually maneuvering, unloading said cart;
- v** wherein said cart comprises:
- vi** a rectangular bed with a horizontal base and vertical walls on three sides, wherein the open side is a short side;

vii two rectangular wheel plates attached one on either side of the bed to the top edges of the longer two of said vertical walls, said rectangular wheel plates being in a horizontal plane, two wheels being attached to the underside of each of said rectangular wheel plates, said rectangular wheel plates having the same length as said rectangular bed;

viii a vertical skirt attached to said rectangular wheel plates around the edges of said rectangular wheel plates not attached to said vertical walls of said rectangular bed, said vertical skirt having a height equal to the height of said vertical walls of said rectangular bed;

ix a frame attached to said rectangular bed, wherein said frame includes four vertical struts attached one to each corner of said rectangular bed and three horizontal struts attached between said vertical struts at the top of said vertical struts, said three horizontal struts being positioned above said vertical walls of said rectangular bed, and the restraints attached one to each of the two vertical struts of said frame at the opposite end of said rectangular bed to the open side of said rectangular bed and the position of attachment of said restraints on the vertical struts is distal to said rectangular bed; and

x a gate attached to said horizontal base at the open end of said rectangular bed by one or more hinges, said gate being securable in a vertical plane;

xi wherein the height of the horizontal struts of said frame above the horizontal base of said rectangular bed is between 40 and 50 inches.

- 212** The method of claim 211, wherein said electronic equipment is a server rack.
- 213** The method of claim 211, wherein said electronic equipment exceeds 40 inches in height;
- 214** The method of claim 211, further comprising manually maneuvering said cart across a height transition in the floor level, said height transition being less than half an inch.
- 215** The method of claim 211, wherein said loading includes attaching a first strap around said electronic equipment, attaching a winch strap to said first strap and manually winching said equipment into said cart, wherein said cart further comprises a winch bracket attached to the outer side of the short vertical wall of said rectangular bed and a winch secured in said bracket.
- 216** The method of claim 211, further comprising, both before said loading, lowering said gate to the floor and placing a bar between said horizontal base of said rectangular bed and said gate, said gate bar covering said hinges and being flush with said gate and said horizontal base.
- 217** The method of claim 211, further comprising, after said loading, raising said gate into a vertical position and securing said gate by sliding said bar in front of said gate and into the gaps behind gate restraints attached to the vertical struts of said frame at the open end of said rectangular bed.

DATA CENTER FACILITY DESIGN – SWC-080 – (FIGURES 29-31)

218 A data center comprising:

- i** a building having a plurality of rooms and first and second load walls disposed on opposite sides of the building;
- ii** a plurality of air handler and fluid cooler devices disposed to the building along the first load wall;
- iii** a plurality of condenser unit devices disposed to the building along the second load wall;
- iv** a sector disposed inside the building, adjacent to the first load wall;
- v** separate UPS and substation distribution equipment rooms, each containing UPS and substation distribution equipment therein, as well as air conditioning equipment that is connected to certain of the plurality of devices; and
- vi** a power spine room disposed between the separate UPS and substation distribution equipment rooms and the sector, the power spine room including a plurality of PDU devices.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

ELECTRONIC EQUIPMENT DATA CENTER OR CO-LOCATION FACILITY DESIGNS AND METHODS OF MAKING AND USING THE SAME

- 1 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 colocation 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 exist that are also unique.
- 2 (Figure 1A) 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 (Figure 1A) 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. 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 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.

3 (Figure 1B) illustrates floor-based components disposed over the floor design of the co-location facility according to the present invention. (Figure 1B) 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 (Figure 1B), 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.

4 Before describing the components in (Figure 1B), 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, thus saving energy, as described herein.

5 Cabinets 110 shown in (Figure 1B) are placed generally over the sides of the perimeter 54 as described, in rows, which cabinets are formed as cages in order to allow air to flow through them. 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 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 (Figure 1A). 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 from the physical space, which warm air area connects 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.

- 6** (Figure 1C) illustrates a perspective cut-away view along line c-c from (Figure 1A) of the (Figure 1A) 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 warm exhaust channel area 240 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.
- 7** 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.
- 8** (Figures 2A-C) illustrate various cut away perspective views of

the thermal compartmentalization and cable and conduit routing system according to the present invention. In particular, (Figure 2A) illustrates a cut away view of a portion of the warm exhaust channel area 240, 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.

9 Before describing the cabling, (Figure 2B) and (Figure 4) illustrate the shield bracket 500, 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 (Figure 4), which are typically a standard “j” hook or a variant thereof. As also illustrated in (Figure 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 bracket 500 on the cabinets 110.

10 With respect to the cabling and conduit, these are used to provide electrical power and data to the various servers in the facility. Conduit, also typically referred to as wiring, 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.

- 11 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. Each ladder rack can also be used for different purposes and still be within the scope of the present invention.
- 12 (Figures 3A and 3B) 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 comers.
- 13 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 setup of the facility, as well as efficient repairs if needed.

- 14 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.
- 15 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.
- 16 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.

DATA MANAGEMENT CENTER AND INTEGRATED WIRING SYSTEM

17 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.

18 (Figure 5A) 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 (Figure 1A-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.

19 (Figure 5B1) 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 590-1A and 590-2A, 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.

20 (Figure 5B2) 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.

21 Within the facility there are provided distribution areas 584 and 588, as shown in figure 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 (Figure 1B). 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 (Figures 2A-C) previously.

22 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 (Figures 1A-C) can also define this same space.

23 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 (Figure 5A), 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 (Figure 1B)). 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.

24 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 (Figure 5A) and (Figure 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.

25 While (Figure 1B) 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), (Figure 7A) 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.

26 In another variation of the (Figure 7A) 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 (Figure 7A) 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 (Figure 1C) (Figure 7A) 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.

27 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 (Figure 1B), 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 (Figure 5A) 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 (Figures 6A-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.

28

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.

29 (Figure 6A-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 Figure 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.

30 In (Figure 6A), this additional vertical support 610 includes conduit clamps 620 that allow the clamping of the additional conduits to the additional vertical support 610.

31 In (Figure 6B), the bracket 600A has in addition to the vertical support 610 a support beam 506A (which extends upwards from the support beam 506 shown in (Figure 4), and racks 630, 632, 634, 636, 638, and 640 therebetween. Each of the racks 630, 632, 634, 636, 638, and 640 has 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.

32 In both the brackets 600 of (Figures 6A-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 (Figure 7A)

33 (Figure 7A) 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 598A and 598B to the power equipment unit 180A within the end cabinet cluster 590-1, and distribution power wires and conduit also goes from both the PDUs 598A and 598B to the power equipment unit 180B 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 598A and 598B 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 (Figure 5A) 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.

34 In a preferred configuration of the power equipment 180 shown in (Figure 7A) 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 120c/208v 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.

35 In a preferred configuration for a module of cabinet clusters 590, as schematically shown in (Figure 7B), there are three different PDUs 598 that each receive 480vAC 3-phase power and provide 120vAC 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 (x2) and PDU's 598 (x3), 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.

36 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 to 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.

37 (Figure 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

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

39 As is illustrated in (Figures 5A and 5B1-2), 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.

- 40 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.
- 41 (Figures 9A-9E) 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.
- 42 The heat exchange unit 900 contains an exhaust fan 910, controlled by a VFD fan control and I/O signals block 1330 shown in (Figure 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.
- 43 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.

- 44 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 824A with a MERV 16 bag filter 824B therebehind, which allows replacement of the screen filter 824A without replacement of the bag filter 824B, and vice-versa.
- 45 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.
- 46 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.
- 47 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 (Figure 5A). Optionally, though not shown, another coil that is cooled by a chiller could be included.

48 Also shown in (Figures 9A-9E) 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.

49 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.

50 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.

51 Furthermore, and with reference to (Figure 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

- 52 As referenced previously, and shown explicitly in (Figure 10) the data center 500 includes a control system 1000. The control system includes an 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.
- 53 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.
- 54 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.
- 55 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.

56 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 310-1 in (Figure 5B2) 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 handling 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.

57 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.

58 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.

59 Signals from these sensors 1200, as shown by Temperature, Pressure Differential, Airflow, and Humidity Sensor Control 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.

60 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.

- 61 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.
- 62 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.
- 63 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 (Figure 1C) 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.
- 64 Also shown in (Figure 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.

- 65 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.
- 66 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.

UNINTERRUPTABLE COOLING FAN WITH WEIGHTED ROTOR

- 67 In case of power outage, it is important to be able to continue cooling the data center, and back-up generators are provided for this purpose. However, there is typically a period of time between the power going down and the back-up generators coming on line. To provide continuous power to critical components of the data center, such as the air handling system, during this interim time period uninterruptable power supplies may be provided on-site within distribution area 584 as shown in [Figure 5A](#) and described above. However, due to the high cost of providing uninterruptible power supplies with sufficient energy storage capacity to run the HVAC system, alternative embodiments of the air handling system have been configured which can keep operating during the interim time period with no dependence on the uninterruptible power supplies.

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A cost effective and convenient approach to keeping the air handling system operational during the time interval between loss of grid power and back-up power being on-line may include deploying uninterruptable cooling fans with weighted rotors throughout the air handling system, particularly as noted herein, in order to avoid needing to have as many uninterruptable power supplies for the HVAC system throughout the data center in order to ensure that the fans and other components within the electronics equipment stored in the cabinets is not damaged. A concept of the embodiments is to keep the air moving through the air handling system. This is achieved by adding sufficient weight to fan rotors to store the energy needed for the fans to keep the air flow above the critical level for an interim time period until the back-up generators come on-line and electrical power is once again supplied to the fan motors. All or some of the fans 870 in the air cooling area (see Figures 9D and 9E) may be replaced with the uninterruptable cooling fans described herein in order to provide the back-up cooling described herein. During the interim period between loss of grid power and back-up generators coming on-line, the condenser unit 800 has sufficient cooling capacity for the uninterruptable fans to circulate cool air out to the electronics equipment cabinets, though the condenser unit 800 itself will have lost power and be turned off. Some or all of the exhaust fans 910 (see Figure 9C) may be replaced with the uninterruptable cooling fans as described herein in order to provide the back-up cooling described herein. Furthermore, some or all of both fans 910 and 870 may be replaced with the uninterruptable cooling fans of the present invention. Depending on the number of fans replaced, the specifications of the uninterruptable cooling fans will be set to handle the required air flows.

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The uninterruptible cooling fans with weighted rotors are designed to keep spinning, and spinning with enough angular velocity to

provide a good air flow for the entire interim time period. The use of such a fan that keeps spinning and moving the air is contrary to the norm in heating and air conditioning systems in which fans are designed to stop spinning very rapidly, since in a conventional system one wants to maintain the temperature that is set by a thermostat; since the air conditioning coils are still cold, once the action temperature is decreased to a desired temperature, fan blades are turned off and stop spinning quickly so that the actual temperatures is the desired temperature; if the fans were to keep spinning and continuing to blow cold air, the desired temperature would not be achieved, but a temperature lower than that which was desired.

70 **Figures 11A-B** show perspective and side views, respectively, of an example of an uninterruptable cooling fan 1600. However, other fan types may be used, which may or may not use a flywheel, according to the teaching and principles described herein to achieve the desired continuous cooling during a power outage.

Furthermore, some or all of both fans 910 and 870 may be replaced with the uninterruptable cooling fans of the present invention. Depending on the number of fans replaced, the specifications of the uninterruptable cooling fans will be set to handle the required air flows.

71 Energy is stored in the fan rotor assembly (significant weight being preferably placed both in the perimeter of the flywheel as well as the rotor blades) as rotational energy and when grid power is cut the rotors are decelerated by the air resistance of the fan blades which push the air through the air handling system. Energy loss due to friction at the rotor bearings must also be accounted for, but is generally small compared with the air resistance of the moving fan blades. There must be sufficient energy stored in the

fan rotor assembly to keep the air flow above the critical level so as to provide sufficient cooling to the electronics equipment cabinets for the entire interim time period between loss of grid power and back-up generators coming on-line. The rotational energy stored in the fan rotor is given by:

$$E_{\text{rotational}} = \left(\frac{1}{2}\right) I \omega^2 \quad (1)$$

where I is the moment of inertia and ω is the angular speed. The airflow (typically measured in cubic feet per minute, cfm) provided by a fan is proportional to the angular speed of the fan rotor. Thus, knowing the typical operating airflow and the critical airflow required to protect the electronics equipment allows the values for the rotor angular speed at the beginning of the power outage and the minimum at the end of the interim period to be calculated. The energy lost by the rotor during the interim period can be calculated from calibration charts for the fan which include plots of power against airflow. Knowing the beginning and minimum ending angular speeds and the total energy lost by the rotor during the interim period allows for calculation of the minimum moment of inertia that will be required for the fan rotor. The desired inertia of the rotor will typically be the calculated to maintain 100% CFM of the data center space for the duration of outage, which is dependent on (1) the backup generator being used and time it takes from its startup to achieve 100% load; (2) the size of the room (which indicates the amount of standing cold air; and (3) the CFM being consumed – with the first of these factors being most prevalent. Using just the first factor, for example, if a particular backup generator turns on and hits the frequency to accept full load, this requires that the rotor continue to spin at a rated amount for several seconds (without taking into consideration factors (2) and (3), which will always decrease the time needed to spin at the rated amount. Once the desired moment of inertia is known, suitable modifications to the rotor can be made – adding weight in various places to provide the desired moment of

inertia. For example, a disk may be attached to the fan as shown in (Figures 11A-B). The disc may have a uniform weight distribution or may be more heavily weighted at the disk circumference, for example. Alternatively, weight may be added to the outer circumference of the squirrel cage rotor, etc.

- 72 In a particular embodiment, a fanwheel as illustrated in (Figure 11), along with a flywheel, will provide sufficient moment of inertia to maintain the air movement required. (Figures 12A(1-2) and Figure B) illustrate a preferred embodiment of the flywheel 1620 illustrated in (Figures 11A and 11B), usable along with a fanwheel that has a diameter, and a width, and in conjunction in a preferred embodiment with a 7.5HP motor and a 7.5HP ABB ACH VFD, the flywheel being noted as flywheel 1620A. Flywheel 1620A is a flywheel, weighs several pounds, and creates a mass moment of inertia. It is noted that the central mass section 1620A-10 has a reduced width to keep the overall mass of the flywheel to a minimum to preserve motor life, and the outer full width ring portion 1620A-20 contains majority of the mass moment of inertia of the flywheel.
- 73 Figs 13A-B illustrate another preferred embodiment of a flywheel, noted as 1620B, which contains spokes 1620B-10 rather than a central portion 1620A-10 as referred to previously. The weight of this flywheel, is in pounds and provides about the same mass moment of inertia as the (Figure 12A(1-2) and Figure B) flywheel described above.
- 74 In light of the above different flywheel embodiments, a weighted rotor assembly that weighs several pounds and can be configured to provide the sufficient moment of inertia.

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Furthermore, the uninterruptible cooling fans may be configured for generation of electricity during a power outage in order to keep a control system for the air handling unit powered until back-up generators come on-line. Thus, the power generated by the fans as described herein can be used to power parts of the control system (in particular in a reduced power mode to ensure proper turn off sequencing of various equipment) and/or the VFD circuits. Maintaining the VFD circuits in an always-on state, without turning off due to lack of power being supplied thereto, has a particular advantage in that the VFD circuits then don't need to be reset. As described above energy is stored in the fan rotors which may be used to continue moving air through the air handling system during a power outage. Some of this stored energy may also be used to generate electricity for continuous operation of the air handling control system, including variable frequency drives for the cooling fans themselves, should VFD be used. The necessary voltage may be generated by the fan rotors back-driving the fan motors to which they are coupled. The fan motors must be adapted for this purpose using a solenoid and control module associated therewith. Note that keeping the control circuitry of the VFD powered during the interim time period is required if the fan motors are to go back on-line immediately on the back-up generators coming on-line – if the VFD loses power then it may have to go through a start-up sequence before power is provided to the fan motors, as noted above, which further increases the time that the fans motors are not powered.

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Although the embodiments have been particularly described, 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 their spirit and scope. Accordingly, it will be appreciated that in numerous instances some features 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. as described herein can be used to power parts of the control system (in particular in a reduced power mode to ensure proper turn off sequencing of various equipment) and/or the VFD circuits. Maintaining the VFD circuits in an always-on state, without turning off due to lack of power being supplied thereto, has a particular advantage in that the VFD circuits then don't need to be reset.

FLOATING T-SCIF

- 77** 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.
- 78** (Figures 14A & 14B) show different views of a portion of a data center or co-location facility according to the present invention. In the present invention parallel rows of equipment cabinets 1602 are arranged so as to allow the cabinets to be rolled in and out of place as required and the thermal compartments 1601, cooling ducts 1610 and support frames 1607 and 1608 are configured accordingly. The equipment of (Figures 14A & 14B) may be integrated with the air handling systems described in U.S. Utility Application Serial No. 12/384,109 entitled "Electronic Equipment Data Center or Co-location Facility Designs and Methods of Making and Using the Same" filed on March 30, 2009,

incorporated by reference in full herein, wherein the condenser air conditioning units and heat expulsion chambers are either disposed within or outside the exterior walls of the facility. Furthermore, the equipment of (Figures 15A & 15B) may include aspects of one or more of the cable and conduit routing system configurations as described in U.S. Utility Application Serial No. 12/384,109, and expanded upon in more detail below. The equipment of (Figures 14A & 14B) includes a thermal compartment 1620 configured to provide isolation of the hot air exhaust from the areas that require cooling as much as possible, and to also create air flows in which the cool air moves efficiently through the electronic equipment cabinets 1602 into the hot aisles from where it is exhausted by the air handling system. The air flow through the electronic equipment cabinets is configured and controlled to provide efficient cooling of the electronic equipment while also cooling the facility in an environmentally efficient manner.

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(Figure 14A) illustrates the floor design 1600 used in a data center or co-location facility according to this embodiment of the present invention. Parallel rows of electronic equipment cabinets 1602 are configured back-to-back either side of a hot aisle 1603. The ends of each aisle are closed off; the partitions 1606 include doors for access to the aisles 1603. Each pair of rows either side of a aisle is part of a compartment 1601. Each compartment 1601 has a aisle 1604 on either side. The floor 1605 of the facility may be marked to explicitly show the various areas of the facility. For example, the center area of the aisle 1603 may be marked. The typical dimensions of the central area are typically in the range of several feet 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. The areas where rows of cabinets 1602 are positioned may be marked in another manner, such as using a

grey tile that is different in color from the center area. Furthermore, the floor areas outside of the cabinets and hot aisle may be marked in yet a different manner, such as using a light grey tile. The placement of these markings for the different areas 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 pushing cabinets into place, the cabinets will sit on a grey tile, facing a tiled aisle at the back and a light area that is for the front of the cabinet that will face the aisle, hence the correct position of a cabinet will be readily apparent.

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Furthermore, (Figure 14A) shows support frames 1607 for the thermal compartments 1601, and also support frames 1608 for cold air ducts. The frames 1607 for the thermal compartments are bolted to the floor 1605. In the example shown in (Figure 14A), the frames 1607 divide up the rows into three equal groups of cabinets. (Such a group of cabinets is shown in (Figure 16).) The cold air ducts which are supported by frames 1608 run parallel to the rows of cabinets and are positioned directly above the cold aisles 1604. The frames 1607 and 1608 may be made of structurally sound materials. Further details of the frames 1607 and 1608 are shown in (Figures 14B & 15).

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(Figure 14B) illustrates a cross-sectional view along line X-X from (Figure 14A). (Figure 14B) shows floor 1605, internal wall 1609, false ceiling 1640 and actual ceiling 1650. The false ceiling 1640 and the actual ceiling 1650 are configured to have a gap as the higher the ceiling the more the air rises (and thus also stays further away from the equipment in the cabinets 1602). The false ceiling 1640 is preferably made of tiles that can be inserted into a suspended ceiling as is known, which exhibit a greater mass than many conventional tiles – here it is desired to use tiles that provide effective thermal insulation. The section passes through the frames 1607 which is between cabinets 1602 in the rows

of cabinets associated with each thermal compartment 1601; however, the position of cabinets 1602 immediately adjacent to the plane of the section are indicated by dashed lines. Also shown are single arrows that illustrate the air flow from the air supply ducts 1610, through the electronic equipment cabinets 1602 where the air is heated as it cools the electronic equipment and then the double arrows show the hot air moving upward from the hot air containment chamber 1620 formed by the thermal shields 400 to the region between the false ceiling 1640 and the actual ceiling 1650. Note that the thermal shields 400 bound the hot air containment chamber 1620 and that there is an air-tight seal between the top of the thermal shields and the false ceiling 1640 to ensure all of the hot air flows into the ceiling space from where it is exhausted and that none of the hot air is leaking into the cold aisles and adjacent areas of the facility floor.

82 Though the arrows for cool air in (Figure 14B) are directed straight downward from the cold air supply duct 1610, the vents themselves can be adjusted to allow for directional downward flow at various angles. In a preferred embodiment, each of the vents has 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, this can be detected (using detectors not shown), and then adjusted for by supplying more cold air directed thereto.

83 Furthermore, as described in detail in U.S. Utility Application Serial No. 12/384,109, racks 1660 and 1670 may be attached to the frame 1607 for supporting various cables, wires and conduits. The racks 1670 are shown, as an example to have room for 4 conduits to run wiring or cabling therethrough. As an alternative to the racks 1670, conduit clamps for conduit holding, and holding of the wires or cables within the conduits, may be used, as also described in U.S. Utility Application Serial No. 12/384,109.

84 Also shown in (Figure 14B) are frames 1608 for support of the cold air supply ducts 1610. The frames 1608 are bolted to the floor 1605 at the lower end and to the suspended ceiling 1640 at the upper end. The frames 1608 include a support pillar attached to a square frame within which the cold air supply ducts 1610 are supported, as shown in (Figure 14B).

85 (Figure 15) shows the frame 1607 and thermal shields 400 for one thermal compartment 1601 – this is the same thermal compartment being shown from different perspectives in (Figures 1A & 1B). For ease of illustration the frame on the back side of the thermal compartment, from the perspective of the figure, is not shown. The frame is bolted to the floor 1605 by plates 1681 and provides support for the thermal shields 400 which define the hot air containment chamber 1620 which channels the hot air into the ceiling space for exhausting, as described above. The frame 1607 is comprised of vertical members 1682 and 1683 and horizontal members 1684-1688. The thermal shields are bolted to members 1682, 1687 and 1688. Various racks (not shown) may also be attached to vertical members 1682 and 1683, as described above with reference to (Figure 14B). As described above, the frame 1607 may be made of structurally sound material, such as steel with a welded construction of the various parts as described, molded plastic, or other materials. The configuration of the frame 1607 shown in (Figures 14A, 14B and 15) is only one example of a frame configuration that can support the thermal shields and conduits while allowing the cabinets in the thermal compartment to be moved in and out of place - other configurations of the frame are envisaged which can provide the support desired in this embodiment of the invention.

86 (Figure 16) illustrates a perspective view of part of a group of movable equipment cabinets 1602, with one cabinet rolled out into the cold

aisle, according to embodiments of the present invention. The group of cabinets is configured in a row between support beams of the frame 1607, as described above with reference to (Figures 14A and 15). The arrow shows the direction of movement of the cabinet in and out of the row. The cabinets 1602 are provided with wheels 1702 for ease of movement. Although not shown in Figure 3, the cabinets are typically comprised of a frame supporting electronics within and are covered in wire mesh to allow for air flow through the cabinet.

87 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.

MANUAL CART FOR TRANSPORTATION OF DATA CENTER ELECTRONIC EQUIPMENT

88 The present invention provides a manual cart for safe and efficient transportation of electronic equipment, such as server racks and equipment cabinets, within a data center or co-location facility. Ease of manually maneuvering the cart from a loading dock where customer equipment is received to the cabinet where the equipment is to be installed in the facility is required, and the cart is designed accordingly.

89 (Figures 26A-26D) show an equipment cart comprising: a rectangular bed with a horizontal base 102 and vertical walls 104 on three sides,

where the open side is a short side; two rectangular wheel plates 202 attached one on either side of the bed to the top edges of the longer two of the vertical walls, with wheels 204 attached to the undersides of the wheel plates, there being a skirt 206 around the outer edges of the wheel plate and apertures 208 in the skirt adjacent to the wheels; a frame 302 is attached to the bed, where the frame includes four vertical struts attached on each corner of the bed and three horizontal struts attached between the vertical struts at the top of the vertical struts, the three horizontal struts being positioned above the three vertical walls of the bed, two restraints 304 are positioned on the two vertical struts at the opposite end of the bed to the open side of the bed and the position of attachment of the restraints to the vertical struts is distal to the rectangular bed, and two triangular brackets each attached between a different one of the two vertical struts adjacent to the open end of said rectangular bed and the top surface of the corresponding adjacent wheel plate; a gate 402 is attached to the bed base at the open end of the bed by hinges 404 and the gate is secured by gate restraints 406 attached to the vertical struts of the frame in combination with gate bar 408 which slides into the gap behind both gate restraints and in front of the gate; winch bracket 502 is attached to the outer side of the bed wall positioned opposite to the open end of the bed. (Figure 27) shows a manual winch 504 secured in winch bracket 502; use of the manual winch 504 is described below. (Figures 26C-26D) provide representative measurements in inches for the different parts of the cart; these measurements may be changed, although the dimensions of the cart are intended to be compatible with manual movement of the cart by one or more persons.

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The cart is designed to be maneuvered manually by one or more people using the frame to guide the cart; the weight and size of the cart is commensurate with manual maneuvering. The cart may be fabricated from sheet metal, with a gauge and finish suitable for the

intended application of manually moving electronic equipment within a data center or co-location facility. Brakes are included on the cart for immobilizing the cart when required for loading/unloading, etc. – for example, the brakes may be wheel locks accessed through the apertures 208 in the skirt 206.

91 In order to provide rigidity to the various panels of the cart without using heavy gauge sheet metal, a box-type design is utilized. For example, the skirts 206 around the wheel plates 202 and the bed walls 104 provide mechanical stability to the cart, as does the frame 302 and the triangular brackets 306.

92 In order to keep the center of gravity for the cart very close to the floor, and to facilitate in loading and unloading heavy electronic equipment into and from the cart, the bed base 102 is very close to the ground – roughly half an inch above the ground in the example shown in (Figure 26B). In other embodiments the clearance may be less than or equal to one inch. Note that this low clearance is feasible since the cart is being used in a facility with very smooth and flat floors, although transitions in floor level may need to be negotiated, particularly at doorways. half an inch in height.)

Furthermore, the wheels 204 are attached to the wheel plates 202 in positions close to the corners of the cart (see Figure 26D) to provide for stability and maneuverability; the wheels are swivel mounted to the wheel plate 202.

93 The height of the frame 302 – approx. 46 inches above the ground in the example shown in (Figure 26B) - protects taller equipment such as server stacks, etc., from hitting other objects during transport and

also prevents such equipment from toppling out of the cart during maneuvering. More generally, the height of the frame above the base of the rectangular bed is between 40 and 50 inches. Taller loads, such as equipment racks and cabinets and other items over 40 inches in height for example, may be secured to the frame at the restraints 304. For example, once a taller load is loaded into the cart, a ratchet strap may be secured to one of the restraints 304, wrapped around the load, and secured to the second restraint 304; the ratchet strap is properly tightened to secure the load. The lack of a horizontal frame piece over the loading gate of the bed permits items taller than the frame to be loaded into the bed as well as making human access to the bed easier.

94 The gate 402 can be released from a locked upright position (shown in Figure 26A) by removing the bar 408 and the gate is then dropped to the floor for loading and unloading the cart. The hinges 404 attach the gate to the bed base 102 and also define the axis about which the gate hinges. (Figures 28A & 28B) show how the bar 408 may also be used to fill the gap between the horizontal base 102 of the rectangular bed and the gate 402, covering the hinges 404; the bar may be fabricated specifically for these dual purposes and is accordingly flat and machined to conform to the gap between the bed and the gate, as well as being long enough to secure the gate in place in its vertical position using the gate restraints 406.

95 (Figure 27) shows the manual winch 504 secured in place in winch bracket 502. The manual winch may be used to assist in loading heavy equipment into the cart. This loading method may involve the following steps. A strap is placed around the equipment, such as a tall equipment cabinet, at a suitably low position so as to avoid toppling the equipment during the loading – the strap should be attached below the

level of the center of gravity of the equipment. The strap around the cabinet is then attached to the winch strap. When ready, one operator cranks the winch while a number of other operators assist in guiding the cabinet into the cart. The process may be reversed to assist in unloading the equipment from the cart.

96 The width and length of the cart – 63 inches by 55 inches in the example shown in (Figure 26D) – are chosen for ease of maneuvering in a data center or co-location facility where electronic equipment is positioned in cabinets accessed by aisles. The size of the horizontal base of the rectangular bed shown in (Figures 26A-26D) is approximately 54 inches by 34 inches and is suitable for moving server racks and equipment cabinets. More generally, the dimensions of the horizontal base of the rectangular bed may be a length of between 45 inches and 65 inches and a corresponding width of between 29 inches and 41 inches. These dimensions may be varied to suit the environment and equipment being moved.

97 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.

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