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An agency of Industry Canada

CA 2801004 C 2015/06/23

(11)(21) 2 801 004

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(22) Date de dépôt/Filing Date: 2010/04/15

(41) Mise à la disp. pub./Open to Public Insp.: 2010/12/09

(45) Date de délivrance/Issue Date: 2015/06/23

(62) Demande originale/Original Application: 2 739 690

(30) Priorités/Priorities: 2009/06/03 (GB0909584.5);
2009/12/29 (GB PCT/GB2009/051777)

(51) Cl.Int./Int.Cl. *F24F 13/18* (2006.01),
E04H 5/02 (2006.01), *E06B 5/00* (2006.01),
E06B 7/02 (2006.01), *F24F 13/10* (2006.01),
F24F 7/013 (2006.01), *G06F 1/20* (2006.01),
H05K 7/20 (2006.01)

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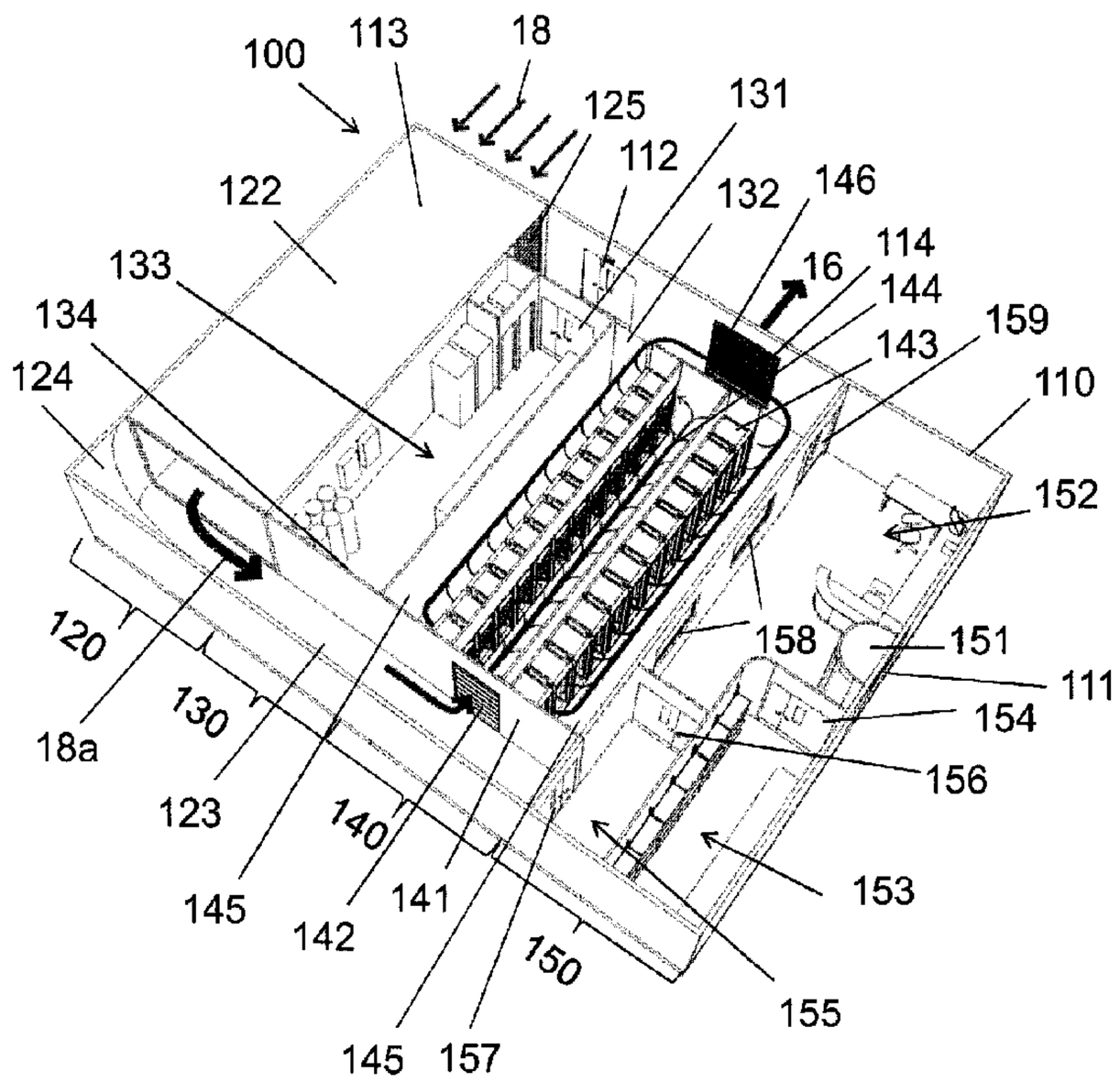
(54) Titre : CENTRE INFORMATIQUE
(54) Title: DATA CENTRE



(57) Abrégé/Abstract:
A data centre (100) includes at least one rack room (in for example module 140)having a floor and a plurality of rack storage areas on the floor, each rack storage area being arranged to accommodate a plurality of racks (143) in which a plurality of rack-mountable electronic components may be housed, one or more controllable air circulation systems (in for example module 122), one or more cold aisles (144) in the rack room, each cold aisle being adjacent to a rack storage area, and one or more hot aisles (145) in the rack room, each hot aisle being adjacent to a rack storage area. There may be a large air duct, in the form of a personnel corridor (123), for transporting, under the control of the one or more air circulation systems, cooling air, above the floor, to the one or more cold aisles. The air supply corridor/duct (123) may have a height greater than 1.5m above the floor and a cross-sectional area of at least $2m^2$ and a maximum dimension in the plane of the cross-section of less than 3m.

ABSTRACT

Data Centre

A data centre (100) includes at least one rack room (in for example module 140)having a floor and a plurality of rack storage areas on the floor, each rack storage area being arranged to accommodate a plurality of racks (143) in which a plurality of rack-mountable electronic components may be housed, one or more controllable air circulation systems (in for example module 122), one or more cold aisles (144) in the rack room, each cold aisle being adjacent to a rack storage area, and one or more hot aisles (145) in the rack room, each hot aisle being adjacent to a rack storage area. There may be a large air duct, in the form of a personnel corridor (123), for transporting, under the control of the one or more air circulation systems, cooling air, above the floor, to the one or more cold aisles. The air supply corridor/duct (123) may have a height greater than 1.5m above the floor and a cross-sectional area of at least $2m^2$ and a maximum dimension in the plane of the cross-section of less than 3m.

Data Centre

Background of the Invention

The present invention concerns data centres, a method of cooling equipment in a data centre and also subject matter ancillary thereto. More particularly, but not exclusively, this invention concerns data centre buildings, for example provided in modular form. The invention also concerns a data centre building, a method of cooling electronic equipment in a data centre building, a method of constructing a data centre building, a method of extending an existing modular data centre building, a rack room building module for building a data centre, and a door arrangement for use within a building, for example a data centre. The invention also concerns a method of constructing a data centre in a space within a building.

A data centre is a late 20th Century development that has grown as a response to the increasing demand for computer processing capability and a recognition of the importance of IT in the place of every business and organisation today. Whereas smaller organisations have sufficient processing power with laptops, PCs and occasionally servers, larger organisations require higher capacity centralised processing to serve a wide range of needs and applications. A few years ago this capacity was supplied by large mainframe computers, but more recently the method used has been to provide data centres comprising many networked computer servers known as blades installed in racks enabling controlled and modular expansion of capacity. The racks also typically house telecommunications equipment such as routers to handle data flow between the computer servers and data flow between the data centre and the outside world.

Data centres can mirror the growth and business activities of successful companies. The growth of a data centre within in an expanding company may typically work as follows:

1. Initially the data centre may start as single rack of servers in an air conditioned room – sometimes referred to as a ‘data closet’.
2. As the organisation expands and along with it the number of IT racks employed, the closets become ‘Server Rooms’ or ‘IT Rooms’.

3. Eventually the number of racks and size of room expands, often to the point where a dedicated building or part of a building houses the IT. Whilst there is no strict definition of when the size of an IT facility becomes large, or sophisticated, enough to be termed a "data centre", data centres are typically relatively large IT facilities providing robust and resilient IT facilities. Typically, there will be more than 50 servers (often many more) and at least some redundancy in the power supply powering the servers to ensure continuity of service.
4. As the company grows and/or becomes a multi-national organisation additional data centres will be built and sometimes numbers of these will be consolidated into 'Super Data Centres'.

Data centre facilities can require a floor space ranging from a few hundred square feet to a million square feet. The most prevalent size for a small data centre is five to ten thousand square feet with fifty to a hundred thousand square feet being the most common floor area requirement for a large data centre.

Data centres will typically have the ability to deliver applications spread across an organisation and/or supply chain and/or customers in differing geographical locations. There will typically be a dedicated mechanical and electrical (M&E) plant to deliver power, cooling and fire suppression with built-in redundancy with the aim of providing near continuous operation. The M&E plant may be located separately from the IT equipment to enable appropriately qualified engineers to work on either the M&E plant or the IT equipment independently of the other (thus improving security).

The IT industry has long recognised the criticality of central computing facilities and the need for energy efficient operations to control cost effectiveness. Current data centre technology is the summation of 30 years of innovation and engineering design thought and has come a long way in recent times. One key problem faced is how to cool a data centre effectively and efficiently. As explained above, a data centre can grow over time according to demand. As a result the following can happen:

1. A building is created, or a room within a building is allocated to IT. An electrical sub-system of conditioned ('Clean') power is run out to the IT room and the building's air conditioning system is adjusted to cool that room.

2. As the data room grows in scale, IT racks are laid out in rows. More IT products lead to more heat produced and so increased ventilation and air conditioning is required. Typically CRAC (Computer Room Air Conditioning) units are added to the end of the rows to provide the cooling. Air produced by these units is entrained through a raised floor and exits through floor grilles at the front of the IT rack rows. The IT products installed in the racks contain integral fans which draw the cooled air from the front across the circuitry and heat is exhausted via vents in the products to the rear. The separation created by these IT racks creates a 'hot aisle' into which air is expelled by the IT products in the racks and a 'cold aisle' from which cooler air is drawn into and through the IT products by their integral fans.

3. Dedicated M&E plant may be required. The M&E plant is sized based on an assessment of the future business requirements (over the next decade for example). Direct expansion (DX) or chilled water cooling plant is used to chill the air distributed within the data centre. Typically a 'set-point' is created to maintain the room at 21 Celsius, allowing for IT heat output and/or external ambient conditions.

The way in which cooling is effected in purpose built data centres often results in a similar arrangement. Thus, the equipment in the data centre is prevented from over-heating by means of introducing cool air into the room. A typical arrangement of the prior art is shown schematically in Figure 1 of the attached drawings. Thus, the data centre includes a rack room 1 defined by walls 2 in which two sets of racks 4 for IT equipment are accommodated. The IT equipment in the racks 4 generate heat, represented by dark arrows 6. The cooling of the IT equipment is achieved by introducing cold air into the room by means of air conditioning units, the cold air being represented by light arrows 8. It will be seen that such an arrangement is not particularly thermally efficient.

The drive for more efficient use of power has given rise to a need to make the cooling used in data centres more efficient, as cooling of equipment typically contributes significantly to the power used by a data centre. For example, the power usage in certain data centres may require between 2 and 3kW of power for every 1kW of power used to

power the IT equipment, at least 1kW of which would be related to cooling. The efficiency of a data centre may be measured by means of a quantity known as the Power Usage Effectiveness (PUE), which is the ratio of the total energy used by a data centre, including IT equipment, and the energy consumed by the IT equipment only. If the power consumed by a data centre were 2.5MW of which only 1.0MW powers the IT equipment, then the PUE would be 2.5 (which represent an average PUE for a typical data centre). The closer to unity the PUE is, the more efficient the data centre is. It is currently estimated that the more efficient data centres currently installed operate at a PUE of about 1.6.

In recent years, approaches such as adding baffles across the top of the hot and/or cold aisles, with doors or further panels across the end of the aisle to contain entrainment of the air have been made, leading to debate about whether it is more effective to 'contain' the cold aisle or the hot aisle. A baffle arrangement is for example proposed in WO 2006/124240 (American Power Conversion Corporation).

Some recent configurations have utilised a new generation of 'in-row' cooling units in-between the racks, or, attached to the rear rack door. These bring the advantage of concentrated cooling but carry a high risk of refrigerant leakage. A slightly different arrangement, potentially suffering from similar problems is described in EP1488305. EP1488305 discloses a plurality of cabinets forming a data centre, each cabinet housing a rack of IT equipment and each cabinet comprising an equipment cooling unit within the cabinet to provide cooling.

The data centre industry is also suffering from being unable to meet demand sufficiently quickly and from reacting to the need to make such data centres energy and space efficient. IT capacity has grown at an exponential rate, doubling about every 18 – 24 months, in the last 30 years. Cooling capacity and space limits are frequently and repeatedly reached creating significant bottlenecks in IT businesses. Building a new data centre to alleviate such bottlenecks and meet demand is time consuming. Traditional methods of constructing data centres can take up to 2 years to completion. Also, data centres are physically becoming larger year on year because current design and engineering practice seeks to deal with heat issues by assuming low rack density and spreading IT thinly across large numbers of racks or large volumes of space.

The present invention seeks to provide an improved data centre and/or an improved method of, or means for, cooling a data centre. Additionally or alternatively, the invention seeks to provide a data centre and/or a method of, or means for, cooling a data centre that mitigates one or more of the above mentioned disadvantages.

Summary of the Invention

The present disclosure provides a data centre building including:

at least one rack room,

one or more controllable air circulation systems,

one or more cold aisles in the rack room,

one or more hot aisles in the rack room, and

an air supply corridor for transporting cooling air, above the floor, to the one or more cold aisles.

The air supply corridor may function also as a personnel access corridor. The air supply corridor may have a height greater than 1.5m above the floor. The air supply corridor may extend from a location outside the rack room.

The data centre building may be a building in which all the interior space is taken up by the data centre. Of course, alternatively, the data centre building may be a building in which only part of the interior space is taken up by the data centre, with the rest of the interior space being available for other uses.

Each rack room may have a floor and a plurality of rack storage areas on the floor, each rack storage area being arranged to accommodate a plurality of racks (for example arranged in a single row) in which a plurality of rack-mountable electronic components may be housed. The racks may be already installed in the data centre building or the data centre building may be provided without racks. The rack storage areas may include fixings or other means on the floor for facilitating correct positioning of the racks when installed. Each cold aisle may be positioned adjacent to a rack storage area. Each hot aisle may be positioned adjacent to a rack storage area. Cooling air is preferably transported to the one or more cold aisles under the control of the one or more air circulation systems.

Thus, in an embodiment, an over-floor corridor may act as a cooling air duct. By using an over-floor corridor as a cooling duct, high rates of supply of air may be achieved whilst making efficient use of the space within the volume of the building.

The one or more air circulation systems may comprise one or more fans. Each fan may be sufficiently large to generate an air flow of at least $0.5m^3s^{-1}$. Each fan is preferably sufficiently large to generate an air flow of at least $1m^3s^{-1}$, and more preferably at least $5m^3s^{-1}$. Together the one or more air circulation systems may have sufficient capacity to generate an air flow of at least $5m^3s^{-1}$, and more preferably at least $10m^3s^{-1}$. There may be five or more fans. For example, ten or more fans may be provided, such fans collectively being able to generate an airflow of at least $50m^3s^{-1}$.

The hot or cold aisles may each be positioned between two adjacent rack storage areas. The hot or cold aisles may extend parallel to a rack storage area. The present disclosure also provides certain beneficial aspects which may have advantages in embodiments where there are no readily discernable hot and/or cold aisles. It will of course be appreciated that the skilled person may also be able, when considering a particular data centre building without racks installed therein, to discern which regions of the building would be deemed as the rack storage areas, as the hot aisles and as the cold aisles. The air supply corridor may be located wholly outside the rack room. More than one air supply corridor may be provided.

The air supply corridor may have a height greater than 1.5m above the floor, for at least 90% of its length. The air supply corridor may have a large cross-sectional area, namely an area greater than $2m^2$, and preferably greater than $3m^2$. The air supply corridor may have such a large cross- sectional area for at least 90% of its length. The hot and cold aisles may each have cross-sectional area greater than $2m^2$, and possibly greater than $3m^2$.

In data centres of the prior art it is common to provide under-floor air ducts. Certain embodiments of the present invention remove the need for such under floor ducts. There is therefore no need to have a high raised floor in embodiments of the present invention. The upper surface of the floor may be less than 500mm above the base of the building, for example. Better use may therefore be made of the vertical space available in

a building of a given height. The height of buildings may for example be limited if the buildings are assembled off-site and transported via road or rail networks in a part-assembled or fully assembled state. Additionally, or alternatively, the under-floor space may be utilised for functions other than air-ducts. For example, cables or other services may be routed under-floor.

Preferably, the data centre building is so arranged that in use air flows along a path from said one or more air circulation systems via said corridor to at least one of the cold aisles, such that the air flow is substantially horizontal for the entire path. The path of air-flow is preferably entirely above floor level. The path of the air-flow may pass along at least part of an access corridor, separate from both (a) the one or more cold aisles and (b) the one or more hot aisles, the access corridor facilitating access from outside the building to one of the rack storage areas. The one or more air ducts and/or corridors via which cooling air (whether or not heated by IT equipment in the racks) flows may extend in a generally horizontal direction for at least 90% of their length and preferably extend only in a generally horizontal direction for substantially their entire length.

At least one rack room may comprise a plurality of racks. A row of racks may be provided at each rack storage area. The racks may stand, preferably directly, on the floor. Each rack may be arranged to house a plurality of rack-mountable electronic components, such as IT components. Each rack may be in the form of a rack having a multiplicity of slots arranged in a single column. There may be more than 20 slots per rack. The slots are preferably arranged such that a single IT component may be mounted in the slot. Such IT components may include server blades. The IT components may each be provided within a casing, for example a metal box. The casing may include one or more vents, for example grilles, at the front and rear of the casing to facilitate the flow of cooling air through the casing to cool the IT component during use. There may be one or more fans inside the casing. Preferably, there are at least 10 racks per rack room, and preferably more than 24 racks per rack room. One or more racks may be housed in a cabinet. There may be one cabinet per rack. One cabinet may alternatively accommodate a plurality racks. The cabinet preferably has a vent or vents provided on its front face. The cabinet may have a vent or vents provided on its rear face.

One of the hot or cold aisles may be arranged to act in use as an air duct. For example, the racks, and the adjacent floor and ceiling, may together define a volume in which air is entrained, causing a pressure difference across the rack, which in use allows air to bleed through the rack (i.e. to cool electric IT components mounted in the racks). The volume defined between adjacent rows of racks may include an inlet, for example at one end of the rows of racks, and outlets (from the perspective of said "volume") defined in the racks, but otherwise sealed so as to force air entering the volume to exit only via the racks. (Of course, from the perspective of IT equipment in the racks, the front of the racks may be considered as acting as *inlets* and the back of the racks as outlets.) The bottom of the racks may meet with the floor. The tops of the racks may meet with the ceiling. The racks may include, or abut, a region of wall that meets with either the floor or ceiling, in the case where the rack is shorter in height than the floor to ceiling height.

Cabling may be held above or below the racks in cable ducts that run the length of the racks. The cable ducts are preferably provided above the racks. Cables may run from such cable ducts to IT equipment in the racks.

The air supply corridor and at least one of (a) the one or more cold aisles and (b) the one or more hot aisles, may conveniently provide access to the plurality of rack storage areas.

There may be a plurality of cold aisles. There may be a plurality of hot aisles. The aisles may be substantially straight along their length. The data centre building may be so arranged that a plurality of cold aisles are interleaved between a multiplicity of hot aisles. It will be appreciated that a "cold aisle" may be "cold" in the sense that it is upstream of the rack storage area in the direction of flow of cooling air, in use. It will also be appreciated that a "hot aisle" may be "hot" in the sense that it is downstream of the rack storage area in the direction of flow of air from the racks that has, in use, been heated by IT components in the racks. The hot aisle may be hot in the sense that the temperature in the hot aisle is, once a steady state has been achieved during operation, typically higher then the temperature in the cold aisle.

The data centre building may include an air supply duct for transporting cooling air to the plurality of racks. The air supply duct may optionally replace the function of the air supply corridor mentioned above. At least part of the air supply duct may be

defined by means of the space between two adjacent racks. For at least 90% of the length of the air supply duct, the air supply duct may have a closed cross-section having an area of at least $2m^2$. Thus, in an embodiment of the invention, the racks entrain air-flow and the air duct has a large cross-section. The duct is preferably elongate in geometry. The maximum dimension of the duct (for at least 90% of its length) within the plane of the cross-section of the duct is preferably less than 4m and more preferably less than 3m. Whilst the duct preferably has a large cross-section it is also preferred that the duct is not excessively wide or tall, for example to assist with the entraining of the air flow. The air supply duct may extend from a source of cooling air, for example one or more fans, to a plurality of racks. Thus, the air supply duct may extend from the air circulation systems to the plurality of racks. At least part of the air supply duct may be defined by an access corridor. The air supply duct may include a vent controllable to vary the air flow along the duct. The air supply duct is preferably in fluid communication with the space between two different adjacent racks. There may be a plurality of vents, preferably controllable vents. In the case where there are two or more cold aisles, there may be a vent provided that is associated with each cold aisle. The air supply duct (and/or the air supply corridor) is preferably entirely located above floor-level. It will however be appreciated that certain benefits of certain aspects may be retained in an embodiment in which part or all of the air duct is below floor level. For example, below a method of "hot-adding" a rack room to a data centre building is described, wherein such a method may be carried out whether or not the air supply duct is below floor level.

Above reference is made to the "length" of the air duct or the "length" of the air supply corridor. It will be understood that the length in question may be the length between the air circulation system(s) and the racks, when installed, or alternatively simply the length upstream of the racks.

The data centre building may be so arranged that there is at least one aisle in the rack room, the aisle being adjacent to a rack storage area, said at least one aisle including a doorway to the aisle, and an access door arrangement. The door arrangement may include a door movable between a closed position, closing the doorway, and an open position, allowing personnel access to the aisle. The access door arrangement may have a

controllable air intake. The air intake may for example comprise a vent. The air intake and/or door may be arranged to move so as to scoop more or less air from an airflow. The air intake may be arranged to move so as to enlarge or reduce the effective cross-sectional area of one or more apertures. The controllable air intake may be controllable by moving the door. The door may be moved, whilst still closed, when varying the airflow. The door arrangement may include a door and a separate air-intake. The door may comprise the air intake. The building may be so arranged that, in use, cooling air flows via said doorway into or from the aisle, for example when the door is closed. The flow of air through the door, when in its closed position, is advantageously controllable by means of a controllable vent. Thus, in an embodiment, the access door into the data room has a controllable vent, so that the door has a dual function. It will be appreciated that the air flow regime of the building is arranged to function with all such doors normally being closed. Thus, the doors are arranged to be normally closed, for example only being opened when personnel access is required. In another embodiment, the door arrangement includes a door that is movable relative to the wall when the door is in its closed position to allow an air intake to scoop varying amounts of air from an air supply corridor. In this embodiment, the controllable air intake controls air flow via a different part of the door arrangement than the part through which personnel can gain access. The door arrangement may be located on the end of a cold aisle. The door arrangement may be located on the end of a hot aisle, in which case it will be appreciated that the "cooling air" that passes via the door will typically have been heated by the rack-mountable electronic components.

As mentioned above, the door may comprise a controllable vent. The vent may be moveable between an open position thus allowing air to pass via the vent and a closed position. When in the closed position, airflow via the vent (controllable air intake) may be restricted (preferably substantially prevented). The vent may comprise a row of vertical blades arranged for rotation about a vertical axis, such that the vent may be moved between closed and open positions by means of rotation of the blades. The blades may comprise at least one pair of adjacent blades that are arranged to rotate simultaneously in opposite directions. The blades are preferably arranged to rotate together to effect control of the flow of air through the vent. There may be two or more

motors to move the blades. There are preferably six or more blades. The blades preferably extend across more than 50% of the width of the door. The blades preferably extend across more than 50% of the height of the door. The effective open area when the vent is open may be greater than $1m^2$. The vent is preferably arranged such that in the event of a failure the vent would fail "open".

The door arrangement preferably further comprises at least one motor for moving the controllable air intake between an open position thus allowing air to pass via the air intake and a closed position. The at least one motor is preferably arranged so that the amount of airflow through the door may be adjusted between three or more levels. The level of adjustment possible may be substantially continuous as between the fully closed and fully open positions. The door arrangement may be arranged to receive a control signal for controlling the operation of the at least one motor. The control signal is preferably set in dependence on measured characteristics of the air in or immediately outside the building.

The door arrangement described above may have independent application for use within a building, not necessarily a data centre. Also, it will be appreciated that the door arrangement could be provided separately from the data centre building. The present disclosure thus further provides a door arrangement that is arranged to be fitted within a wall space, the door arrangement including a door allowing human access therethrough and a controllable air intake arranged such that the flow of air through the door, when in its closed position, is controllable by means of the controllable air intake. The door arrangement is preferably arranged to receive a control signal for controlling the operation of a motor provided to move the controllable air intake. Other features mentioned above may be incorporated into this aspect.

The one or more controllable air circulation systems may be arranged to cause circulation of cooling air to rack storage areas under a controlled pressure regime. An air circulation control unit may be provided to control such a process. Pressure sensors may for example be provided to provide a measure of pressure in different regions of the data centre. The control unit may be arranged to receive signals representative of the pressure so measured, such signals being used to control the cooling of the data centre. The cooling and/or the pressure regime may of course be adjusted by means of controlling

(automatically) the controllable air intake of the access door arrangement mentioned above. The data centre building may include an airlock room to facilitate control of the pressure regime. For example, the airlock room may allow access to a rack room, whilst maintaining the controlled pressure regime. The pressure regime may comprise maintaining differential pressures as between the pressure in a cold aisle and the pressure in a hot aisle, so that air flow is encouraged from the cold aisle to the hot aisle. The pressure regime may comprise maintaining differential pressures as between the pressure in a hot aisle and a downstream pressure, for example outside the building, to encourage extraction of air away from the hot aisle. The pressure regime may comprise maintaining differential pressures as between the pressure in a cold aisle and an upstream air duct or corridor. The differential pressure may be required upstream of a cold aisle simply to enable differential pressures downstream. The pressure differential between two successive points on the airflow route (for example either side of the racks or either side of an air intake dividing a rack room from an airflow) is preferably greater than 10 Pa, and preferably less than 100Pa.

The airlock room preferably comprises two doors, one door allowing entry into the airlock room from a location outside of the area of controlled pressure regime and another door allowing entry into the area of controlled pressure regime. Preferably, an electronic control unit prevents the two doors from both being open at the same time during normal operation of the data centre. The control unit may for example allow the two doors to be open at the same time in the event of an emergency. The building may include a corridor that allows access between the airlock room and another room, for example a rack room. Such a corridor may also be arranged to allow passage of cooling air, for example to a rack room.

As mentioned above there may be a cold region, for example a cold aisle and a hot region, for example a hot aisle, the cold region being separated from the hot region by a rack. The rack may be a predominantly metal rack. Preferably, the metal rack includes insulation to reduce conduction and/or convection of heat from the hot region to the cold region. It has been found that adding a thermal insulating layer to shield the metal framework of the racks can significantly improve the thermal efficiency of the building. This is thought to be as a result of the surprisingly high effects of conduction of heat from

the hot region, for example a hot aisle to the cold region, for example a cold aisle by means of conduction through the metal frame. Thus, in an embodiment, the racks are thermally insulated to prevent, or at least significantly reduce, (reverse) conduction of heat from the hot aisle to the cold aisle. The metal rack may include uprights, which extend along the lateral edges of the rack. The insulation preferably extends to cover the uprights. The rack will of course, in use, include one or more rack-mountable electronic components. In such a case, the insulation preferably covers substantially the whole of the front of the rack, apart from those regions occupied by the one or more rack-mountable electronic components. The insulation is preferably arranged so that slots in the rack for mounting of rack-mountable electronic components may be selectively covered (by insulating material) or exposed to allow insertion of an IT component (server blade for example). For example, the insulation may comprise a facing that extends across the front of the rack, wherein the facing includes a plurality of removable strips. Thus, each strip may be removably mounted to allow (on removal of the strip) for insertion of a rack-mountable electronic component into the rack. The insulation may comprise a portion that extends across at least one of the two sides of the rack. The rear of the rack may be open. The rack may additionally or alternatively include one or more blanking plates. For example, a blanking plate may be associated with each slot and a removable strip may also be associated with each slot. Such blanking plates may assist in reducing conduction of heat from the hot aisle to the cold aisle, but may also additionally or alternatively provide a better physical seal between the hot and cold aisles and thereby restrict convection of heat from the hot aisle to the cold aisle. Sealing the gaps that might otherwise exist in the area of the racks is important because otherwise cooling air may pass from one side of the racks to the other via such gaps thereby bypassing the rack-mountable electronic components which require cooling. Convection of heat from the hot aisle to the cold aisle may also be reduced by means of removably mounted vertical blanking strips filling the gap that might otherwise exist between adjacent racks. Such means may also assist in entraining air-flow through and/or directly over and around the rack-mountable electronic components. One or more cables may pass via the boundary between adjacent racks. As such the racks may advantageously include an aperture on each side to allow for passage of such cables. The

aperture may be defined simply be means of the space between the front and rear vertical supports on one side of a rack, and the structure on the side of the rack may for example be substantially open.

The one or more controllable air circulation systems may form part of a single air cooling system with built in redundancy for ensuring continued operation of the data centre building in the event of failure of one of the parts of the air cooling system. The single air cooling system may be in the form of a separate module, as described in more detail below. The single air cooling system may for example comprise a multiplicity of fans including at least one fan more than necessary (at least N+1 redundancy). The air cooling system may include an active refrigerant-based cooling unit (possibly one only or possibly two for the sake of redundancy). The air cooling system may include a mechanical cooling unit for cooling air before it is used to cool equipment in the rack rooms. The mechanical cooling unit may comprise an air conditioning unit, for example having DX refrigeration coils. The mechanical cooling unit may comprise a non-refrigerant based cooling apparatus, for example a humidification unit, an evaporative cooling unit and/or an adiabatic cooling unit. Redundancy may be provided in the air circulation system by means of being designed for primary operation without refrigerant-based cooling. For example, the use of ambient air from outside the building can be used to cool the racks, provided that the temperature is below a maximum threshold temperature (for example 37 degrees Celsius). Use of ambient air, as the cooling air, can be sufficient (for example when utilising embodiments in which ambient air is treated via a humidity-based cooling unit) for at least 97% of the duration of the operation of the data centre in certain climates. Thus, the 3% or less of the time where active refrigerant-based cooling is additionally required may be considered as an exceptional case, such that provision of a doubly redundant refrigerant-based active cooling system is rendered unnecessary. Thus, the data centre building may offer sufficiently robust and continuous operation without requiring two independent active refrigerant-based cooling systems (of the type requiring mechanical DX cooling, condensers, compressors, and the like).

The data centre building is preferably formed from a plurality of separate modules. One of the modules may be in the form of a rack room module accommodating a rack room. The rack room may include a plurality of racks in which a plurality of rack-

mountable electronic components are housed. One of the modules may be in the form of an air circulation module. The air circulation module may accommodate one or more air circulation systems for transporting cooling air to a rack room. The air circulation module may include a multiplicity (for example four or more) of fans. The air circulation module may include an active refrigerant-based cooling unit (preferably one only) for cooling air before it is used to cool equipment in the rack rooms. The air circulation module may comprise one or more mechanical cooling units. Each rack room module may include a cooling air duct for transporting cooling air transported from an air circulation module to the rack room. Such a cooling air duct may extend from one side of the rack room module to an opposite side. One of the modules may be in the form of a services plant module. The services plant module may comprise power plant equipment. The services plant module may comprise fire suppression equipment. The services plant module may comprise control equipment for controlling cooling and powering of IT equipment in one or more rack rooms. The power plant equipment (in the services plant module) may include an uninterruptible power supply (UPS), for example including a battery back-up unit. The power plant equipment may include switchgear equipment. The power plant equipment may include electrical distribution equipment. One of the modules may be in the form of a personnel module. The personnel module may be arranged to provide secure access to the data centre building. The personnel module may include office space. The personnel module may include an airlock room. The personnel module may include a door providing access to one or more data rooms. One module, not itself being a rack room, may define a cold aisle, or more preferably a hot aisle, adjacent to a rack storage area in a rack room. In an embodiment described below, the services plant module (comprising the power plant equipment) includes a hot aisle, such that a corridor of the services plant module acts, in use, as an exhaust duct.

The data centre building preferably comprises at least one rack room module, at least one air circulation module, and at least one services plant module. According to certain embodiments, one air circulation module serves many rack room modules. Providing a data centre building in which a single air circulation module is able to serve more than one rack room modules enables a data centre building to be

constructed having one or relatively few rack room modules and then adding further rack room modules as demand for IT capacity grows, without requiring the addition of an extra air circulation module. It will therefore be appreciated that there may be advantages to providing a data centre building having one or more rack room modules, and one or more air circulation modules, wherein all of the one or more air circulation modules have the capacity to cool more than all of the one or more rack room modules. For example, the one or more air circulation modules may have the capacity to cool at least twice as many rack room modules as are provided. The one or more air circulation modules may have more than three times the required capacity. For example, each single rack room may have a cooling requirement of at least 10kW, or at least 50kW. Some data centre designs may have rack rooms each having a cooling requirement of greater than 150kW. A single air circulation module may have a cooling capacity of more than 200kW, and possibly more than 300kW, thus allowing for future expansion.

Each module may have a similar construction. Each module may comprise a frame structure having a rigid base from which there extends a multiplicity of vertical structural support columns. The frame structure may include two or more beams at the top of the frame each extending between a pair of the vertical support columns. The base may comprise a steel frame. The steel frame may be formed by means of a plurality of I-beams. The base may be formed from concrete supported on a steel framework or sheeting. The module may comprise a roof section. The base may comprise a timber floor fixed onto a frame. The base may be formed from board material supported on joists. The joists may be metal. Each module preferably has a length greater than 10 metres. Each module preferably has a length less than 20 metres. Each module preferably has a height greater than 2 metres. Each module preferably has a height less than 4.2 metres. Each module preferably has a width greater than 2.5 metres. Each module preferably has a width less than 5 metres. A module may include a wall extending upwards from at least one edge of the base. A module may have a base having an edge extending between two corners of the base, such that the edge (or at least a part of it) is not associated with a wall, thus defining a substantially open face of the module. The module may have an open face to cooperate with a corresponding open face of an adjacent module in a building, so that an open space (for example as part of a room or

corridor of the building) is defined partly by one module and partly by an adjacent module. It will be appreciated that the open face may extend only part of the way along the edge of the base, there being a wall along the remaining part(s) of the edge. Each module is preferably shaped so as to be suitable for transportation by road. Each module preferably includes structure configured to allow the module to be lifted by, for example, a fork-lift.

When the modules are assembled to form the data centre building, there may be a gap between adjacent modules. The gap is preferably between 2.5mm and 50mm, preferably between 5mm and 20mm. The gap between adjacent modules is preferably filled with one or more sealing strips. The sealing strip may be metal.

The present disclosure also provides a method of cooling electronic equipment in a data centre building. The method may comprise a step of providing and then operating a data centre building according to the present invention as described or claimed herein. The method may include a step of cooling racks of items of electronic equipment by operating one or more air circulation devices to transport air above the floor via at least one access corridor, providing access to the racks. The method may include a step of removing air from the racks. The method may cause the removed air to be exhausted directly to the exterior of the building. The method may cause the removed air to pass via an access corridor. The access corridor preferably extends from a location outside of the rack room to a location inside the rack room. The access corridor may comprise a door. The access corridor need not be straight.

The air circulation devices may use one or more fans to push air through the building. The one or more exhausts may therefore be passive exhausts, in that the exhausts do not themselves assist extraction of air from the building. The passive exhausts may include one or more controllable vents.

The method may include a step of cooling racks of items of electronic equipment by operating one or more air circulation devices to transport air from outside the building at ambient air temperature to the racks, preferably without utilising refrigerant-based active cooling. The air may then be removed from the racks and exhausted to outside the building via at least one air exhaust. The one or more air circulation devices may be provided upstream of the racks. The one or more air circulation devices preferably

provide a sufficient pressure differential, as compared to the air pressure immediately outside the building, to be able independently to cause air to be exhausted out of said at least one exhaust at a rate of at least $10m^3s^{-1}$ per rack room (or optionally at least 8 m^3s^{-1} per rack room, or optionally at least $5m^3s^{-1}$ per rack room). Such rates might represent the higher end of the likely range of operational air exhaust rates. The data centre building may be arranged to operate at low IT demand levels with exhaust rates of the order of only $0.3m^3s^{-1}$ per rack room. In the case where there are for example, three or more (or optionally five or more) rack rooms in a building, or a floor thereof, air may be exhausted at a rate of at least $50m^3s^{-1}$ from the building (or floor of the building, as the case may be), when operating at high demand for example. Alternatively or additionally, air may be exhausted out of said at least one exhaust at a rate of at least $0.4m^3s^{-1}$ per rack. If there are 24 racks in a rack room, such a rate would be equivalent to about $10m^3s^{-1}$ per rack room. Alternatively or additionally, air may be exhausted out of said at least one exhaust at a rate of at least $0.002m^3s^{-1}$ per slot in the racks in the room. If there are 40 racks in a rack room and 40 slots per rack, such a rate would be equivalent to about $3.2m^3s^{-1}$ per rack room. Alternatively or additionally, air may be exhausted out of said at least one exhaust at a rate of at least $0.005m^3s^{-1}$ per rack slot, preferably at a rate of at least $0.008m^3s^{-1}$ per rack slot. At low demand, the air may be exhausted out of said at least one exhaust at a rate of as little as $0.00024m^3s^{-1}$ per rack slot. If there are 24 racks in a rack room and 40 slots per rack (of which at any given time 10 or more are each closed over by a blanking strip thereby restricting or preventing the flow of air therethrough), such a rate may be equivalent to less than $0.2m^3s^{-1}$ per rack room. Air may be exhausted out of said at least one exhaust at a rate of at least $0.01m^3s^{-1}$ per rack slot, or possibly at least $0.15m^3s^{-1}$ per rack slot (such rates again representing the higher end of the range of likely operational exhaust rates). Thus, in an embodiment, a sufficiently large volume of air per second is used to effect "ambient air" cooling of the IT equipment in the data room. There may therefore be less of a need for use of refrigerant-based active cooling. In certain embodiments, there is for example no need for CRAC units to be provided. This means of cooling may be used even when the ambient air temperature outside is higher than 20 degrees Celsius. Preferably, the method includes a step of operating the data centre and cooling it by

means of airflows where the rate of exhaust is greater than $5m^3s^{-1}$ per rack room and also a step, performed at a different time, of operating the data centre and cooling it by means of airflows where the rate of exhaust is less than $1m^3s^{-1}$ per rack room.

There may be fewer exhausts than there are rack rooms. There may be at least 10 racks per room, preferably more than 20 racks per room. Each building may include more than two rack rooms. Preferably, however, there are fewer than ten data rooms/rack rooms per floor of the building. Each rack may have more than 10 slots for insertion of separate IT equipment units. Each rack may have more than twenty such slots. Thus, each rack room may, when operating at full capacity, accommodate over 500 separate equipment units, and possibly more than 1,000.

The method may extract heat at a rate of at least 5kw per rack room module, or optionally at a rate of at least 10kw per rack room module. When IT demand is high, there may be a need for higher heat extraction rates. The method may extract heat at a rate of at least 50kw per rack room module, and possibly at a rate of at least 80kw per rack room module. Such heat extraction rates may be achieved solely with ambient air cooling.

The method may additionally include a step of detecting fire or smoke. In the event that fire or smoke is detected, the method may include a step of ceasing transport of air from outside the building. Such a step may be conducted under the control of a fire suppression control unit. The method may also include a step of closing the one or more air exhausts. The method may include a step, in the event that fire or smoke is detected, of causing cooling air to be re-circulated. For example, the items of electronic equipment may be cooled by operating the one or more air circulation devices to transport air from within the building, to the racks and then from the racks back to the air circulation devices, with an optional step of cooling the air (for example by means of mechanical cooling equipment). Once air is being re-circulated within the building, a fire suppression control unit may then be able to discern whether the fire/smoke previously detected was from outside the building or inside the building. If fire or smoke continues to be detected, then appropriate action may be taken. For example, fire suppression gas may be released into the data centre building. Embodiments of the present invention

enable rapid deployment of fire suppression gas throughout the data centre building as a result of the large volume of air/gas that is able to flow through the building per second.

The present disclosure yet further provides a method of building a data centre building. The data centre building so built may be in the form of a data centre building according to the present invention as described or claimed herein. The method of building the data centre building may comprise a step of extending an existing modular data centre building, in which there is provided at least one rack room module accommodating a rack room having a plurality of racks in which a plurality of rack-mountable electronic components are housed. There may be an air circulation module accommodating one or more air circulation systems for transporting cooling air to said at least one rack room in each rack room module. Each rack room module may include a cooling air duct for transporting such cooling air from the air circulation module to the rack room, the cooling air duct extending from one side of the rack room module to an opposite side. The step of extending an existing modular data centre building is advantageously conducted whilst the plurality of rack-mountable electronic components in each rack room of the existing building are operated and cooled by means of air from said at least one air circulation module. The method may include a step of adding a further (new) rack room module accommodating a rack room and having a cooling air duct extending from one side of the rack room module to an opposite side, such that an end of the cooling air duct on one side of the further (new) rack room module is aligned with an end of the cooling air duct on one side of a rack room module of the existing modular data centre building. The method may then include a step of connecting the cooling air duct of the further (new) rack room module with the cooling air duct of the rack room module of the existing modular data centre building. The method may include a step of removing an end portion of the building (for example a further module, optionally in the form of a personnel module) from the end of the existing data centre building to expose the side of the rack room module at the end of the existing building to which the extension is to be added. The method may include a step of blocking off an end of the cooling air duct of the rack room module of the existing modular data centre building before such an end portion of the building is removed. By utilising a modular building technique a “hot add” (i.e. allowing continuity of operation of the IT equipment in the data centre building) of an extra rack

room may be achieved in a matter of days (for example less than 48 hours), as compared to previous timescales of the order of weeks.

The disclosure also provides a rack room building module for building a data centre installation, wherein the module comprises:

a base for supporting a floor,

a plurality of racks for housing a plurality of rack-mountable electronic components, and

an above-floor cooling air duct extending from one side of the rack room module to an opposite side.

In an embodiment, the rack room building module comprises a steel frame having the dimensions of an ISO shipping container. It may be constructed so as to be suitable for transporting as a shipping container. Advantageously, this embodiment may be used both in easily accessible areas such as city centres and in remote areas.

It will of course be appreciated that features described in relation to one aspect may be incorporated into other aspects . For example, the method described may incorporate any of the features described with reference to the apparatus and *vice versa*.

The present disclosure further provides a method of constructing a data centre in a building. The method may include the steps of:

(a) providing a space within the building;

(b) providing at least one hole in an external wall of the building through which outside air may enter the space or inside air may leave the space;

(c) providing at least one partition to be installed in the space;

(d) installing the at least one partition in the space such that the partition(s) define:

at least one rack room having a floor and a plurality of rack storage areas on the floor, each rack storage area being arranged to accomodate a plurality of racks in which a plurality of rack-mountable electronic components may be housed;

one or more cold aisles in the rack room, each cold aisle being adjacent to a rack storage area,

one or more hot aisles in the rack room, each hot aisle being adjacent to a rack storage area, and;

an air supply corridor for transporting, under the control of the one or more air circulation systems, cooling air, above the floor, to the one or more cold aisles, the air supply corridor having a height greater than 1.5m above the floor;

(e) installing in the space one or more controllable air circulation systems.

Advantageously, the method provides a data centre that can be used in locations where the construction of a new building may not be possible or desirable, such as in city centres. The method may also be used by an organisation with an existing data centre or data room to easily upgrade the existing data centre or data room to use the present invention, thereby improving its efficiency. Alternatively, it may be used in a building that has been purpose-built to accommodate a data centre constructed according to the method.

The present disclosure also provides a kit of parts for constructing a data centre in a space within a building, wherein the kit includes at least one partition arranged for installation in the space such that the partition(s) and the space cooperate so as to define:

at least one rack room having a floor and a plurality of rack storage areas on the floor, each rack storage area being arranged to accomodate a plurality of racks in which a plurality of rack-mountable electronic components may be housed;

one or more cold aisles in the rack room, each cold aisle being adjacent to a rack storage area,

one or more hot aisles in the rack room, each hot aisle being adjacent to a rack storage area, and;

an air supply corridor for transporting, under the control of the one or more air circulation systems, cooling air, above the floor, to the one or more cold aisles, the air supply corridor having a height greater than 1.5m above the floor.

Description of the Drawings

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying schematic drawings, of which:

Figure 1 shows a prior art rack room;

Figure 2 is a very schematic drawing showing a data centre building according to an embodiment of the invention;

Figure 3 shows a data centre building according to another embodiment of the present invention;

Figure 4 is a partial plan view of a data centre building according to yet another embodiment, including schematic shading of hot and cold areas;

Figure 5 shows the air optimisation module of the data centre building of Figure 3;

Figure 6 shows the plant room module of the data centre building of Figure 3;

Figure 7 shows the rack room module of the data centre building of Figure 3;

Figure 8 shows the entry module of the data centre building of Figure 3;

Figures 9-12 show how the data centre building of Figure 3 can be enlarged by adding further rack room modules;

Figure 13 shows a multi-storey data centre building;

Figure 14 is a plan view of the data centre building of Figure 4, operating when the ambient air is at a temperature of less than 18°C;

Figure 15 is a partial plan view of the data centre building of Figure 4, operating when the ambient air is between 18°C and 24°C;

Figure 16 is a partial plan view of the data centre building of Figure 4, operating when the ambient air is between 24°C and 37°C;

Figure 17 is a partial plan view of the data centre building of Figure 4, operating when the ambient air is at a temperature greater than 37°C;

Figure 18 is a perspective view of a rack row for use in embodiments of the present invention;

Figures 19a to 19d show a rack room door with variable air flow intake according to a yet further embodiment of the invention;

Figure 20 shows a rack room door with variable air flow intake according to another embodiment of the invention.

Figure 21 shows a perspective view of a data centre building according to yet another embodiment of the invention;

Figure 22 shows an exploded perspective view of the data centre building of Figure 21;

Figure 23 shows a plan view of a floor of a building including three data centres according to a further embodiment of the invention; and

Figure 24 shows a partial perspective view of a partially constructed data centre according to the embodiment of Figure 23.

Detailed Description

Figure 2 shows a data centre building 10. The building 10 is rectangular with external walls 12. The building is divided into front and rear sections by an internal dividing wall 12a, located approximately one third of the length of the building from the rear external wall.

The rear section (on the left in Figure 2) defines an air optimisation room 11, which provides a system of circulating cooling air in the building 10. Ambient air (represented by the light arrow 18) can enter the air optimisation room 11 through an ambient air intake 13 in the rear external wall. Ambient air 18 can be treated/cooled in the air optimiser room and this air 18a is then used for cooling. If the ambient air outside the building 10 is sufficiently cool, the ambient air may be used as cooling air, without requiring any active refrigerant-based cooling by the air optimisation room 11. Cooling air 18a passes into the front section of the building 10 through a controllable vent 17 in the internal dividing wall 12a.

The front section (on the right in Figure 2) of the building 10 defines a rack room 19. The rack room 19 houses two rows of racks 14. The racks 14 extend away from the internal dividing wall 12a, towards the front of the building. Each rack row extends approximately out to two thirds of the length of the front section of the building. Although only shown schematically in Figure 2, there are 20 racks in each row, each rack housing up to 40 items of IT equipment (typically server blades). There may therefore be as many as 1,600 items of IT equipment in the racks. A blanking panel 14a extends

between the front ends of the two rows of racks, thereby defining a cold region 19a between the internal dividing wall 12a, the two racks 14 and the blanking panel 14a.

A hot region 19b is defined on the other side of the racks 14 and the blanking panel 14a. Air can escape from the hot region 19b though a hot air exit 15 in the front external wall of the building.

In use, ambient air 18 enters the air optimisation room 11 through the ambient air intake 13. The ambient air 18 is cooled/treated as necessary in the air optimisation room 11 resulting in cooling air 18a, which enters the rack room 19, into the cold region 19a, via the vent 17. The cooling air 18a moves over the racks 14 in the rack room 19 to reach the hot region 19b and in the process cools the racks 14. The resulting hot air (indicated by dark arrows 16) coming off the racks 14 then leaves the rack room through the hot air exit 15. It will of course be appreciated that the hot air 16 is simply the result of the cooling air 18a having been heated by the equipment in the racks 14 and is otherwise essentially the same air. As such the operation may be considered as involving the flow of cooling air into the rack room 19, the flow of cooling air via the racks 14 and then the flow of cooling air (then heated by the racks such that the "cooling air" may then have less, if any, ability to cool) out of the rack room. As such "hot air" or "exhaust air" can be considered as heated or used "cooling air". In the Figures air upstream of the racks is indicated by light arrows and downstream or exhaust air is indicated by dark arrows.

The volume of air flow through the building may, during certain conditions for example when outside temperature is relatively high and/or IT loads are relatively high, be at least $12m^3s^{-1}$. The air optimiser module has the capacity to generate air flow through the building at a rate as high as at least $40m^3s^{-1}$ (i.e. more than about $1m^3s^{-1}$ per rack and about $0.025m^3s^{-1}$ per rack slot, assuming that substantially all air flowing through the building passes via a rack slot). The volume of air flow through the building may during other occasions be about $0.3m^3s^{-1}$, during certain conditions. Such a rate of supply of air may still be sufficient to cool the IT equipment in the single rack room of the building by means of ambient air cooling alone for ambient air temperatures of up to 24 degrees Celsius.

Figure 3 shows a rectangular data centre building 100 with external walls 110 and a flat roof of a further embodiment.

At the front of the building 100 is a hole in the external wall defining an entrance 111. On a right side of the building, towards the rear is a second hole in the external wall defining a fire exit 112. Also on the right side of the building, behind the fire exit 112 is a hole defining an ambient air intake hole 113 (not visible). In front of the fire exit 112 but also on the right side of the building is a hole defining a hot air outlet hole 114.

The data centre building 100 is made up of four rectangular modules that are placed side to side so that the long sides of the rectangular modules are adjacent each other. The ends of the rectangular modules form the external side walls of the building. The external walls of the modules are formed from steel frames that are welded and bolted.

The floor of the modules is formed from steel frames and joists. The floor panels additionally have timber floorboards. The roof is constructed from a suitable weatherproof panel system and watertight membrane, including falls to one side of the roof and external drainage collection. The wall panels of the modules are formed from highly insulated steel panels, with a fire resistance of at least one hour. In addition, the wall and roof panels may also be constructed with magnetic shielding, RF or X-ray protection. The internal finish of the walls and ceiling is a plastic coated galvanised steel finish.

The modules are connected to each other by using modular wiring systems or quick disconnects on mechanical pipework. Hence, the modules can be easily connected and disconnected from each other.

In the embodiment shown in Figure 3, there is an air optimisation module 120 located at the rear of the building 100, a plant room module 130 located in front of the air optimisation module 120, a rack room module 140 located in front of the plant room module 130 and a personnel module, here in the form of an entry module 150, located in front of the rack room module 140, at the front of the building 100.

The air optimisation module 120, shown most clearly in Figure 5, includes the rear external wall of the building 100 and the rearmost parts of the left and right side walls of the building.

The air optimisation module 120 contains an air optimisation unit 122 located at the rear, right corner of the building. The air optimisation unit 122 is located adjacent the

external right side wall of the building 100 so that an ambient air intake grille (not visible) on one end of the unit 122 lines up with the ambient air intake hole 113. The ambient air intake grille includes vents that are controllable so that the amount of air entering the air optimisation unit 122 through grille can be controlled.

The air optimisation unit 122 also has a second air intake in the form of a return air grille 125. The return air grille 125 is located at the right, front end of the optimisation unit 122, near the end wall including the ambient air intake grille. The return air grille 125 includes vents that are controllable so that the amount of air entering the air optimisation unit 122 through grille 125 can be controlled.

The air optimisation unit 122 contains various air treatment apparatus, including banks of fans, air filters, humidification apparatus and an active DX cooling system. The DX cooling system includes soft copper refrigeration pipework. The humidification apparatus is used to provide adiabatic cooling during use. The air optimisation unit 122 also contains an air mixing box (not shown) for mixing the air from return air grille 125 and ambient air intake grille. The unit 122 also contains sound attenuation apparatus.

To the left side of the air optimisation unit 122 is an air supply corridor 123. The air supply corridor 123 runs from the rear external wall, and along and in between the left side of the air optimisation unit 122 and the left external side wall. A curved wall 124 is located in the rear, left corner of the building to help direct air from the air optimisation unit 122 along the corridor 123.

The floor of the air optimisation unit 122 is a non-slip safety floor.

The plant room module 130, shown most clearly in Figure 6, includes two parts of the two external side walls of the building.

The plant room module 130 contains a rectangular plant room 133 defined by plant room walls 134. The plant room 133 is located centrally along a rear side of the plant room module 130. When the air optimisation module 120 and the plant room module 130 are joined, the plant room 133 sits against the front side of the air optimisation module 120 and the left end of the plant room 133 lines up with the left end of the air optimisation unit 122.

At the left, front end of the plant room 133, plant room wall 134 is extended to the front side of the plant room module 130. Hence, a passageway running along and in

between the left external side wall of the building and the plant room wall 134 is defined. This passageway runs along the width of the plant room module 130 and is closed off from the plant room 133 and the rest of the plant room module 130 by the plant room walls 134. The passageway joins up with and forms part of the air supply corridor 123.

To the right side of the plant room module 130 is a hot air corridor 132 running along the width of the plant room module 130 and along the external side wall of the building containing the fire exit 112. The plant room module 130 contains a fire exit door 135 over the fire exit 112. When the air optimisation module 120 and plant room module 130 are joined together, the hot air corridor lines up with the return air grille 125.

The hot air corridor 132 also extends around the front of the plant room 133, in between the front plant room wall 134 and the front of the plant room module 130. This corridor extends up to the right side of the extended plant room wall 134. This allows air from the rack room module 140 (located in front of the plant room module 130) to enter the hot air corridor 132.

On the left end wall of the plant room 133 is a plant room access door 131. The door 131 allows access to the plant room 133 from the hot air corridor 132.

The plant room 133 contains various apparatus, including fire suppression gas discharge canisters 136 and associated manifold and valves, a power metering panel 137a for monitoring the power consumed by each rack in the rack room module 140, a dual electrical distribution panel 138, an uninterruptable power supply 139a and back-up batteries 139b. These apparatus are mounted on the internal sides of the plant room walls 134.

The plant room 133 also contains a process control panel 137b, including a VESDA (Very Early Warning Smoke Detection Apparatus) fire detection monitoring panel, mounted on an internal side of the plant room walls 134. The process control panel 137b receives data from various sensors including sensors in the rack room module 140 and an outside ambient air temperature sensor. This outside ambient air temperature sensor may be placed outside the building 100 or just inside the building 100, near the ambient air intake grille. It uses this information to control the fans, humidification apparatus, cooling system and controllable vents in the building in order to achieve effective cooling of the racks in the rack room module 140.

The fire suppression gas discharge canisters 136 are connected to the air optimisation unit 122 so that in the event of a fire (when the VESDA monitoring panel is triggered), gas from the canisters 136 can be discharged through the air optimisation unit 122 into air supply corridor 123.

The uninterruptable power supply 139a and back-up batteries 139b are designed to provide 10 minutes of power in the event of failure of an external power supply. The batteries are provided with their own dedicated cooling system.

The floor of the plant room 133 is a non-slip safety floor.

The rack room module 140, shown most clearly in Figure 7, includes parts of the external side walls of the building.

The rack room module 140 contains two elongate rectangular rack storage areas, the areas being parallel to each other. The areas are together positioned centrally along a rear side of the rack room module 140. At the left end of the rack storage areas is an internal wall 141 running along the width of the rack room module 140. When the plant room module 130 and the rack room module 140 are joined, the rack storage areas sit against the plant room module 130 and the internal wall 141 lines up with the left end of the air optimisation unit 122 and left wall 134 of the plant room 133.

Hence, a passageway running along and in between the left external side wall of the building and the internal wall 141 is defined. This passageway runs along the width of the rack room module 140 and is closed off from the rack room area and the rest of the rack room module 140 by the internal wall 141. The passageway joins up with and forms part of the air supply corridor 123.

Each rack storage area is effectively defined by a single row of racks 143 running lengthways along the rack room module 140, i.e. widthways across the building, from the internal wall 141 to the right end of the rack room area. The two rows of racks 143 are separated by a cold aisle 144.

At the right end of the rack room area, spanning across the ends of both rack rows, is a cold aisle blanking panel 147 designed to close off the cold aisle 144 at the right end. At the top of both rows of racks 143 are over-rack blanking plates 148 designed to stop cold air travelling over the racks 143 between the top of the racks and the ceiling of the rack room module 140. Hence, air can only leave the cold aisle 144 through the racks

143. There is no personnel access possible from the cold aisle 144 directly to the other side of the racks 143.

Air from the supply air corridor 123 can enter the cold aisle 144 through cooling air intake grille 142, located on the internal wall 141 in between the rows of racks 143. The grille 142 includes vents that are controllable by the process control panel 137b so that a desired air pressure regime can be achieved. The cooling air intake grille 142 is part of a securable door that can be opened and closed to allow personnel access from the air supply corridor 123 to the cold aisle 144 of the rack room module 140. The cooling air intake grille door 142 is made from aluminium and/or steel.

The rearmost row of racks 143 is located adjacent the passageway in the plant room module 130 that joins up with the hot air corridor 132. Hence, hot air coming from the rearmost rack 143 is directed to the hot air corridor 132 via this passageway. Hence, the passageway is defined as a hot aisle 145.

Around the right end and along the front side of the front rack is a passageway that joins up with and forms part of the hot air corridor 132 running along the right side of the building 100. Hence, hot air coming from the other (foremost) rack 143 is directed to the hot air corridor 132 via this passageway. Hence, the passageway is also defined as a hot aisle 145.

On the right end wall of the rack room module 140 is a hot air outlet grille 146 corresponding to the hot air outlet hole 114. The grille 146 has vents that are controllable by the process control panel 137b so that the amount of hot air 16 that is exhausted from the building 100 through hot air outlet grill 146 can be controlled.

Figure 18 shows a row of racks 143 in more detail. The rack frames 143a are made of metal. Each rack is an open fronted 42u standard universally compatible server rack. The racks are joined together in rows by filler pieces 143c. The filler pieces can be a plain infill panel, a vented infill panel (including a mesh panel on the filler piece), a power distribution support infill panel or a cable management infill panel. It is preferred for the filler pieces 143c to be in the form of vertically extending blanking strips that seal the racks and thereby restrict undesirable heat convection. Cables are run vertically to the top of the racks through the cable management panels and guided through cable trays (not shown) at the top of the racks. Cables can then be run down one side of the row of racks

143 in cable trough 143d. Hence, the cable is kept out of the air flow and this improves efficiency. A gasket seal 143e is provided around the top of the racks 143 to provide a seal against air flow.

Each rack is fitted with a "42u" insulation strip. The insulation strip is made up of individual blanking strips 143b that can be removed from the racks. Each individual blanking strip 143b corresponds in height to the height of each unit space on the rack. Hence, individual blanking strips 143b can be placed on the racks to cover any area not occupied by electronic components in the racks. The strips 143b can be removed to allow additional electrical components to be inserted in the racks 143. The strips 143b reduce the conduction of heat from the hot aisles 145 to the cold aisle 144. Insulation material is also placed on the over-rack blanking plates 148 and cold aisle blanking panel 147 (not shown in Figure 18). Thus, the metal rack includes a thermally insulating barrier that reduces flow of heat from the hot aisle to the cold aisle via heat conduction across the metal rack.

A floor 149 of the rack room module 140 has an anti-static vinyl covering.

The rack room module 140 also contains sensors for measuring the air temperature, humidity level, pressure and air flow. These sensors are connected to the process control panel 137b in the plant room 133.

The entry module 150, shown most clearly in Figure 8, includes the front external wall and the foremost parts of the external side walls of the building.

The entry module 150 has an entry portal 151 located adjacent the entrance 111 to the building 100. The entry portal 151 is a semi-circular door surrounding the entrance 111 to the building. Hence, upon entering the building, personnel pass through the entrance door 111 into a semi-circular space defined by the entry portal 151 and then through the semi-circular entry portal 151 itself. The entry module 150 also has a security/reception area 152, located to the left and to the rear of the entry portal 151.

On the right side of the entry module, in the front right corner of the building 100, is a storage and IT staging room 153, accessed through a door 154. To the rear of the storage and IT staging room 153, located in the right, rear corner of the entry module 150, is an air lock room 155. The air lock room 155 is accessed from the security/reception area 152 through an air lock access door 156. An air supply corridor access door 157,

adjacent the right side wall of the building, provides access from the air lock room 155 to the air supply corridor 123 of the rack room module 140.

The air supply corridor access door 157 can only be opened when the air lock access door 156 is closed. Similarly, the air lock access door 156 can only be opened when the air supply corridor access door 157 is closed. Hence, loss of air pressure of the air supply corridor can be reduced, while still allowing personnel access to the air supply corridor 123 and cold aisle 144, through the door of the cooling air intake grille 142.

On the rear side of the entry module 150 are two central windows 158 allowing personnel in the entry module 150 to see into the rack room module 140.

In the right, rear corner of the entry module 150 is a hot air corridor access door 159. This door 159 links up to the hot air corridor 132 of the rack room module 140 and hence allows personnel access to the hot air corridor 132, the rear of the racks 143 facing the hot aisles 145 and the plant room 133, through plant room access door 131.

The floor of the entry module 150 is a non-slip safety floor.

The plant room 133 and the entry module 150 contain their own heating and ventilation system that is not connected to the supply of air from the air optimisation unit 122. The heating system includes an electric panel heater with an integral thermostat.

All external doors of the building 100 (i.e. entrance 111 and fire exit door 135) are made from aluminium or steel. The doors can contain double glazed window panels.

Figure 4 shows a data centre building 100, similar to that shown in Figure 3. However, the building of Figure 4 has three rack room modules 140. Each rack room module 140 is identical. Hence, a building 100 is provided that can accommodate more racks 143.

Cooling air 18a from the air supply corridor 123 can enter the cold aisle 144 of each rack room module 140 through the controlled vents of the cooling air intake grilles 142. The hot air 16 from the racks 143 can leave the rack room modules 140 through hot aisles 145 in between the racks 143. The hot air 16 then reaches the hot air corridor 132, as before.

Figure 9 shows a data centre building with an air optimisation module 120, a plant room module 130, an entry module 150 and two rack room modules 140.

Figure 10 shows that the entry module 150 of the building 100 of Figure 9 can be removed to leave the front of the second rack room module 140 exposed. A blocking panel 141a is placed over then front end of the air supply corridor 123 to reduce loss of air supply pressure.

Figure 11 shows that three (or any number) of additional rack room modules 140 can be placed next to the existing rack room modules 140 such that the internal walls 141 line up to create a lengthened air supply corridor 123. Hence, the building of Figure 11 contains an air optimisation module 120, a plant room module 130 and five connected rack room modules 140.

Figure 12 shows that the entry module 150 removed from the building 100 of Figure 9 can be replaced next to the foremost rack room module 140 of Figure 11. Hence, the building of Figure 9 can be expanded from having two rack room modules 140 to having five rack room modules 140.

As many rack room modules 140 as desired can be added, as long as the capacity of the air optimisation unit 122 is sufficient to cope with the cooling requirements of all the rack room modules 140.

The expansion of data centre buildings 100 can be conducted whilst the electronic components in each rack 143 of the existing rack room modules 140 are operated and cooled by cooling air 18a from the air supply corridor 123. Such a process is referred to elsewhere in this document as a “hot add” process.

Figure 13 shows a multi-storey data centre building 100. The building 100 has three storeys stacked on top of each other. Each storey is made up of an air optimisation module 120, a plant room module 130, three rack room modules 140 and an entry module 150. The particular type of modular construction employed by this embodiment lends itself to a fully scalable, and very flexible, data centre construction method.

In addition, each storey includes a stair module 160 placed in front of the entry module 150, on the right hand side. Each stair module 160 is rectangular with a height identical to the entry module 150 and the rest of the modules, a width similar to the entry module 150 and a length of about half that of the entry module 150.

Each stair module 160 has an exit door 163 (visible for third storey only) on the left rear corner of the module 160 such that the exit door 163 lines up with and allows

access to the entry portal 151 of the entry module 150. Hence, the exit door 163 of each stair module 160 allows access to the entry module 150 on the respective level.

Each stair module 160 also contains a set of stairs 162 extending from the bottom of the stair module 160 to the top of the stair module 160. Hence the stairs 162 allow personnel to move up to the entry module 150 above.

Of course, for the uppermost (third) storey, there is no level above and so the stairs 162 do not lead up to a next level.

The lowermost (first) storey stair module 160 also has an entry door 161 located on the left side of the front wall of the stair module 160 to allow personnel access to the building 100.

Alternatively, any or all of the above described embodiments, may not include an entry module 150. Instead, the front side of the foremost rack room module 140 is enclosed by an external front wall. The external front wall should include an air supply corridor access door on the left hand side to allow access to the air supply corridor 123 and a hot air corridor access door on the right hand side to allow access to the hot air corridor 132.

In use, the data centre building 100 of any of Figures 3, 4, 9, 12 or 13 operates to cool the racks 143 in the rack room module(s) 140 by generating a sufficient quantity, velocity and pressure of cooling air 18a in the air optimisation unit 122. The air optimisation unit 122 also filters the air using air filters and performs humidification / de-humidification on the air, as necessary.

The cooling air 18a is pushed out of the air optimisation unit 122, directed by the curved wall 124 and moves along the air supply corridor 123. The vents in the cooling air intake grille(s) 142 are controlled so as to ensure appropriate distribution of the cooling air 18a in the cold aisle(s) 144 of the rack room module(s) 140 in dependence on the cooling requirements of the IT equipment in the racks associated with each cold aisle (which may for example be measured by temperature sensors at the rear of the racks). The cooling air 18a is drawn across the racks in the rack room module(s) 140 by the integral fans in the electrical components in the racks and cools the electrical components.

The resulting hot air 16 moves through the hot aisles 145 in the rack room module(s) 140 and plant room module 130 to the hot air corridor 132. The pressure differential between the cooling air 18a and the hot air 16 is maintained at a sufficient level to ensure there is no return of hot air 16 through the racks. This is done by monitoring the amount of air flow in the rack room module 140 using the air flow sensor. The amount of air flow is fed to the process control panel 137b in the plant room 133. The process control panel 137b then controls the fans in the air optimisation unit 122 and the various controllable vents in the building (apart from the vents 142 in the data room doors, which are used to control the amount of cooling air fed to each cold aisle) so that satisfactory air pressure is delivered to the air supply corridor 123 to give a satisfactory air pressure differential and air flow in the rack room module 140. The humidity of the air in the rack room module 140 is monitored by the humidity level sensor and fed to the process control panel 137b. The process control panel 137b then controls the humidification apparatus in the air optimisation unit 122 so that satisfactory air humidity is delivered.

The building 100 operates differently depending on the temperature of the outside ambient air. This is done in order to allow the cooling air 18a to be between 18°C and 24°C, whilst minimising the amount of refrigerant-based mechanical cooling that needs to be performed on the air by the cooling system in the air optimisation unit 122.

When the outside temperature is below 18°C, as shown in Figure 14, the process control panel 137b controls the cooling system in the air optimisation unit 122 so that the cooling system is turned off. The process control panel 137b also controls the vents in the return air grille 125 so that the vents on the grille 125 are open. This allows some of the hot air 16 in the hot air corridor 132 to re-enter the air optimisation unit 122. The rest of the hot air 16 escapes out of the building 100 through hot air outlet grille(s) 146. I.e. there is partial extraction of ambient air 18 and partial re-circulation of hot air 16. The hot air 16 that re-enters the air optimisation unit 122 goes through the air mixing box (not shown) in the unit 122 and mixes with the ambient air 18 being drawn into the air optimisation unit 122 through the ambient air intake grille. This results in warmer than ambient air passing from the air optimisation unit 122 into the air supply corridor 123 and reaching the cold aisle(s) 144 of the rack room module(s) 140.

The temperature of the air at the rear of each row of racks in the rack room module(s) 140 is monitored by the air temperature sensors and fed to the process control panel 137b. Pressure measurements are also taken. The process control panel 137b controls the vents 142 in the cold aisle doors in dependence on cooling demand and controls the fans in the air optimisation unit 122 and other vents so that a sufficient air flow is delivered from the air supply corridor 123 to the cold aisles in the rack room module(s) 140.

When the outside temperature is between 18 and 24°C, as shown in Figure 15, the process control panel 137b controls the cooling system in the air optimisation unit 122 so that the cooling system is turned off. The process control panel 137b also controls the vents in the return air grille 125 so that the vents on the grille 125 are closed. This means that no hot air 16 can re-enter the air optimisation unit 122. I.e. there is no re-circulation of hot air 16 and there is total ambient air 18 extraction. All of the hot air 16 escapes out of the building 100 through hot air outlet grille(s) 146.

The temperature of the air at the rear of each row of racks in the rack room module(s) 140 is monitored by the air temperature sensors and fed to the process control panel 137b. Pressure measurements are also taken. The process control panel 137b controls the vents 142 in the cold aisle doors in dependence on cooling demand and controls the fans in the air optimisation unit 122 so that a sufficient air flow is delivered from the air supply corridor 123 to the cold aisles in the rack room module(s) 140 to a satisfactory temperature.

When the outside temperature is between 24 and 37°C, as shown in Figure 16, the process control panel 137b controls the cooling system in the air optimisation unit 122 so that the cooling system is turned on and set to cool the cooling air 18a leaving the air optimisation unit 122 down to a maximum of 24°C. This is achieved by using the humidification unit to cause adiabatic cooling of the air. At this stage no refrigerant-based active cooling is required. The process control panel 137b also controls the vents in the return air grille 125 so that the vents on the grille 125 are closed. This means that no hot air 16 can re-enter the air optimisation unit 122. I.e. there is no re-circulation of hot air 16 and there is total ambient air 18 extraction. All of the hot air 16 escapes out of the building 100 through hot air outlet grille(s) 146.

The temperature of the air at the rear of each row of racks in the rack room module(s) 140 is monitored by the air temperature sensors and fed to the process control panel 137b. The process control panel 137b then controls the cooling air flow regime so that a sufficient air flow is delivered from the air supply corridor 123 to the cold aisles.

When the outside temperature is above 37°C, as shown in Figure 17, the process control panel 137b controls the cooling system in the air optimisation unit 122 so that the cooling system is turned on and set to cool the cooling air 18a leaving the air optimisation unit 122 down to a maximum of 24°C. This is achieved by means of additionally using DX-mechanical (refrigerant-based) cooling. The process control panel 137b also controls the vents in the return air grille 125 and hot air outlet grille 146 so that the vents on the grille 125 are open and the vents on hot air outlet grille(s) 146 are closed. This ensures all the hot air 16 re-enters the air optimisation unit 122. I.e. there is total re-circulation of hot air 16 and no ambient air 18 extraction. The process control panel 137b also controls the vents of ambient air intake grille so they are closed. The hot air 16 goes through the air mixing box (not shown) in the air optimisation unit 122 and is re-cooled by the cooling system in the air optimisation unit 122.

The temperature of the air at the rear of the racks in the rack room module(s) 140 is monitored by the air temperature sensors and fed to the process control panel 137b. The process control panel 137b then controls the cooling air flow regime so that a sufficient air flow is delivered from the air supply corridor 123 to the cold aisles.

In the event of the VESDA (Very Early Warning Smoke Detection Apparatus) system detecting a fire, the process control panel 137b activates the fire suppression gas discharge canisters 136. Hence, gas is discharged through the air optimisation unit 122 into air supply corridor 123. At the same time, the process control panel 137b closes vents in the hot air outlet grille(s) 146 and opens vents in the return air grille 125 to ensure the air inside the building 100 is re-circulated. The VESDA system may as an initial step cause air flow into and/or out of the building to be ceased and to operate the building in an air re-circulation mode. On the one hand, if smoke is no longer detected then there may be no need to release the fire suppression gas. On the other hand, if smoke continues to be detected then it may be deduced that the cause of the smoke is

within the building and not an external fire. Fire suppression is then released only as necessary.

As the fire suppression gas rapidly expands, release vents (not shown) in the building 100 are activated to maintain the building integrity.

In the event of a power cut to the external power supply of the building 100, the uninterruptable power supply 139a and back-up batteries 139b are turned on and can provide clean power to allow continuous operation of the racks 143 and other essential services for 10 minutes.

When a data centre building 100 is required, the different modules can be individually delivered on trucks, such as 40 foot articulated or flat bed trucks. The buildings are typically less than 4.2m high and therefore are readily transported via road or rail. The modules can then be craned into place using integral lifting eyes (not shown) on the modules or using slings. The building 100 can be sited on a flat area of concrete. Alternatively, the building 100 can be placed on concrete blockwork if the site is not level or if the level of the building 100 is to match an existing building level.

The building 100 is then connected to the existing site drainage system, telecommunications supply, water supply and electrical power supply. Alternatively, a supplementary power generation unit can be added. The building 100 can also be connected to the existing building management systems, security systems or fire alarm systems of the site.

When it is required to relocate the data centre building, this can be done by disconnecting the external power supply etc. and individually craning modules onto trucks to be delivered and re-set up elsewhere.

In an alternative embodiment, shown in Figures 21 and 22, each module has the dimensions of an ISO shipping container and is constructed so that it may be transported as a shipping container. ISO shipping containers come in a range of lengths and heights but are all 2259 mm wide between the corner fittings (measured from the centre of the hole in the fitting). Common lengths are approximately 6 m, approximately 12 m and approximately 14 m.

Each module comprises a steel framework, with the vertical parts of this framework including an integrated drainage system (not shown). The walls, roof and

floor of each module are made of corrugated steel. Although in this embodiment the dimensions of the modules are different to those in the embodiments described above, the way the modules are fitted out and connected together is substantially the same. The layout of a data centre built using this type of module can therefore take any of the same forms as a data centre built using the modules shown in Figs 3-17.

Figure 21 shows a data centre 200 constructed from container-sized modules. It comprises an air optimisation module 220, a plant room module 230, eight rack room modules 240, and a hot aisle unit 250. An end wall of the air optimisation module 220 and an end wall of one of the rack room modules 240 have been replaced with an air intake 260 and an exhaust air outlet 270 respectively. One or more of the panels forming an external wall of the data centre 200 may include a door (not shown). Figure 22 is an exploded view of the data centre of Figure 21.

A further embodiment of the invention is illustrated by Figures 23 and 24. Figure 23 shows the layout of a storey of a building into which three data centres 300a, 300b and 300c according to the invention have been installed. Part 380 of the storey is not taken up by a data centre and this may be used for another purpose such as office space or storage. Data centres 300a and 300b each comprise two air optimisation rooms 320, two plant rooms 330, a rack room 340 and an air supply corridor 350. Data centre 300c comprises an air optimisation room 320, a plant room 330, a rack room 340 and an air supply corridor 350. Holes (not shown) have been made in the walls of the building to serve as intakes for outside air and outlets for exhaust air.

Data centres 300a, 300b and 300c have been constructed by installing partitions into a space in the existing building. The partitions are formed using a kit of parts consisting of metal girders and insulated steel panels. Figure 24 shows a partially constructed data centre 300 according to this embodiment of the invention. A framework 400 built from the metal girders has been constructed in a space within a building. The space has a concrete floor. Wall panels 410 and ceiling panels 420 are attached to this framework. Panels including dampers (not shown) are positioned so as to line up with the intake and outlet holes in the exterior walls of the building. Ladder racks 430 are suspended above the ceiling panels 420 to support the cabling and other mechanical and electrical services that are provided to the racks. The panels are arranged to form a data

centre having an air optimisation room, a plant room, a rack room, and an air supply corridor. The layout of the data centre is the same as in other embodiments of the invention. The rack room includes separate hot aisles and cold aisles in the same arrangement as in the other embodiments of the invention.

For countries in the Northern Hemisphere, it is anticipated that the ambient air temperature will be below 37°C 97% of the time. Hence, for these countries, the building 100 can operate in either of the first three modes of operation described for 97% of the time. Hence, for 97% of the time, the building 100 only uses ambient airflow and humidity-controlled cooling and does not need to rely on refrigerant-based cooling. This dramatically reduces the energy consumption of the data centre building 100.

Even in the hottest, driest or most humid locations on the planet, the building can still operate in the first or second mode a significant proportion of the time and therefore can use only air flow cooling. Even at temperatures of up to 37°C, the building 100 will operate in the third mode of operation and therefore can still utilise efficient means of cooling.

The most common benchmark of energy efficiency for data centres is power usage efficiency (PUE). In this embodiment, this may conveniently be defined as the total energy used by the data centre divided by the energy deployed to the racks 143. Typical prior art data centres have a PUE of greater than 1.5. A data centre building 100 of the present invention could have a PUE of less than 1.2 for most parts of the world. This figure would increase for hotter parts of the world where refrigerant-based mechanical cooling has to be used more often.

In the above-described embodiments, the securable door allowing personnel access from the air supply corridor 123 to the cold aisle 144 of the rack room module 140 includes an adjustable air intake means in the form of an air intake grille 142 including vents. The door can be configured differently to provide cooling air 18a into the cold aisle 144 via the doorway. Figures 19a, b, c and d show such a door 170. The door is mounted in a door frame 170a. The door frame is hinged to the internal wall 141 of the room module 140, adjacent a door hole in the internal wall, along a first side 171 of the door frame. The first side 171 of the door frame is the side furthest from the air optimisation unit 122. The door frame 170a is hinged to a first side of an air intake grille

172 along a second opposite side of the door frame. The grille is attached to the internal wall 141 by a hinge along a second opposite side of the grille. The hinge is also slidable along the internal wall 141. When the door frame 170a is in a closed position, as shown in Figures 19a and 19b, the door frame and grille 172 lie in line with each other and parallel to the internal wall 141, such that the door and door frame covers the hole in the internal wall 141 and the grille lies flush behind the wall 141. The door 170 can be opened from the door frame 170a when the frame is in the closed position. When the door frame is in an open position, as shown in Figure 19d, the door frame is hinged away from the hole in the wall 141. The grille pivots with respect to the door frame and by the hinge on the internal wall 141 and the internal wall hinge slides along the internal wall 141 such that the second side of the grille remains in contact with the internal wall 141 and the first side of the grille remains connected to the second side of the door frame. Hence, an angled path against the door and door frame and through the grille is provided for air in the air supply corridor 123. The door arrangement therefore acts as a variable air inlet scoop. The air thus flows from bottom to top as shown in Figures 19c and d (the air supply corridor being below the doorway in the Figures). The door can also be opened from the door frame in the open position, as shown in Figure 19c. The door frame and grille can also be positioned in a number of intermediate positions between the fully open and fully closed positions described above. The door arrangement could of course also be used in a reverse configuration, so that first side of the door frame is the side nearest the air optimisation unit with air flowing from the top to bottom as shown in Figures 19c and d (the air supply corridor being below the doorway in the Figures).

Figure 20 shows yet another embodiment of a door 180 for allowing personnel access therethrough whilst also providing a means for controlling airflow through the door whilst the door is in its closed position. The door thus includes adjustable air intake means in the form of a vent 181 having a number of vertical blades 182 arranged in a row. The blades are each mounted for rotation about a vertical axis, such that the vent may be moved between closed and open positions by means of rotation of the blades. The blades 182 are arranged such that pairs of adjacent blades are arranged to rotate simultaneously in opposite directions. Having such an arrangement facilitates better control of the air-flow in comparison to the case where all blades rotate in the same

direction. Two motors (not shown) are arranged to move the blades 182, one motor for the odd-numbered blades and one motor for the even-numbered blades (counting from left to right). (It will be appreciated that one motor could be arranged to control all the blades.) The area covered by the blades extends across about 80% of the width of the door. The area covered by the blades 182 extends across about 60% of the height of the door. The effective open area when the vent 181 is fully open is about 1.4m^2. The vent is arranged such that in the event of a failure the vent fails "open".

The door arrangement includes a flexible cable 183 that runs from the motors to the hinge 184 side of the door and then onto the structure of the adjacent wall 185. The cable carries a control signal which controls the operation of the motors. The control signal is preferably set in dependence on measured characteristics of the air in or immediately outside the building.

Whilst the present invention has been described and illustrated with reference to particular embodiments, it will be appreciated by those of ordinary skill in the art that the invention lends itself to many different variations not specifically illustrated herein. By way of example only, certain possible variations will now be described.

The air supply corridor 123 from the air optimisation unit 122 to the rack room module(s) 140 may be independent of the passageway leading to the rack room module(s) 140. The air may be supplied at least partially via an under-floor duct.

The data centre building 100 need not be constructed from separate modules.

Moreover, cooling air may be transported through a wall of the rack room via one or more apertures or passageways in the wall that are not arranged to permit personnel access. There may be an access door to the rack room that is not part of the intended path for cooling air.

The racks and aisles defined by the racks need not be straight and/or rectangular in plan-view.

Where in the foregoing description, integers or elements are mentioned which have known, obvious or foreseeable equivalents, then such equivalents are herein incorporated as if individually set forth. Reference should be made to the claims for determining the true scope of the present invention, which should be construed so as to encompass any such equivalents. It will also be appreciated by the reader that integers or

features of the invention that are described as preferable, advantageous, convenient or the like are optional and do not limit the scope of the independent claims. Moreover, it is to be understood that such optional integers or features, whilst of possible benefit in some embodiments of the invention, may not be desirable, and may therefore be absent, in other embodiments.

Claims

1. A data centre building including

at least one rack room,

one or more cold aisles in the rack room,

one or more hot aisles in the rack room, and

one or more controllable air circulation systems for transporting cooling air to the one or more cold aisles,

wherein the data centre building is formed from a plurality of separate modules, each module comprising a frame structure having a rigid base from which there extends a multiplicity of vertical structural support columns, and a wall extending upwards from at least one edge of the base, the base also having an edge extending between two corners of the base, such that at least a part of the edge is associated with an opening, thus defining a substantially open face of the module, which cooperates with a corresponding open face of an adjacent module in the building, so that an open space is defined partly by one module and partly by an adjacent module.

2. A data centre building according to claim 1, wherein the open space forms part of a corridor of the building.

3. A data centre building according to claim 1 or claim 2, wherein the data centre building includes a cooling air duct for transporting cooling air from the one or more air circulation systems to the at least one rack room.

4. A data centre building according to claim 3, wherein the cooling air duct extends between one side of at least one of the plurality of modules and an opposite side of the at least one of the plurality of modules.

5. A data centre building according to claim 3 or claim 4, wherein the cooling air duct includes a vent controllable to vary the air flow along the duct.

6. A data centre building according to any one of claims 3 to 5, wherein at least part of the cooling air duct is below floor level.

7. A data centre building according to any one of claims 3 to 5, wherein at least part of the cooling air duct is above floor level.

8. A data centre building according to any one of claims 1 to 7, wherein the building comprises at least one air circulation module which accommodates one or more of the air circulation systems.

9. A data centre building according to any one of claims 1 to 8, wherein the building is a multi-storey data centre building.

10. A data centre building according to any one of claims 1 to 9, wherein each module has a length between 10 metres and 20 metres.

11. A data centre building according to any one of claims 1 to 10, wherein each module has a height between 2 metres and 4.2 metres.

12. A data centre building according to any one of claims 1 to 11, wherein each module has a width between 2.5 metres and 5 metres.

13. A data centre building according to any one of claims 1 to 12, wherein there is a gap between adjacent modules, the gap being between 2.5mm and 50mm wide.

14. A data centre building according to any one of claims 1 to 13, wherein the rack room includes a plurality of racks in which a plurality of rack-mountable electronic components may be housed.

15. A rack room building module for building a data centre installation, wherein the module comprises:

a base for supporting a floor,

a plurality of racks for housing a plurality of rack-mountable electronic components,

a cooling air duct extending from one side of the rack room module to an opposite side,

a wall extending upwards from at least one edge of the base, and

an edge extending between two corners of the base such that at least part of the edge is associated with an opening, thus defining a substantially open face of the module.

16. A rack room building module according to claim 15, wherein the cooling air duct includes a vent controllable to vary the air flow along the duct.

17. A rack room building module according to claim 15 or 16, wherein the module comprises a frame structure having a multiplicity of vertical structural support columns extending from the base.

18. A rack room building module according to claim 17, wherein two or more beams at the top of the frame structure extend between a pair of vertical support columns.

19. A rack room building module according to any one of claims 15 to 18, wherein the base comprises a steel frame formed by means of a plurality of I-beams.

20. A rack room building module according to any one of claims 16 to 20, wherein the module comprises a steel frame having the dimensions of an ISO shipping container.

21. A rack room building module according to any one of claims 15 to 20, wherein the module is a module for building a data centre building according to any one of claims 1 to 14.

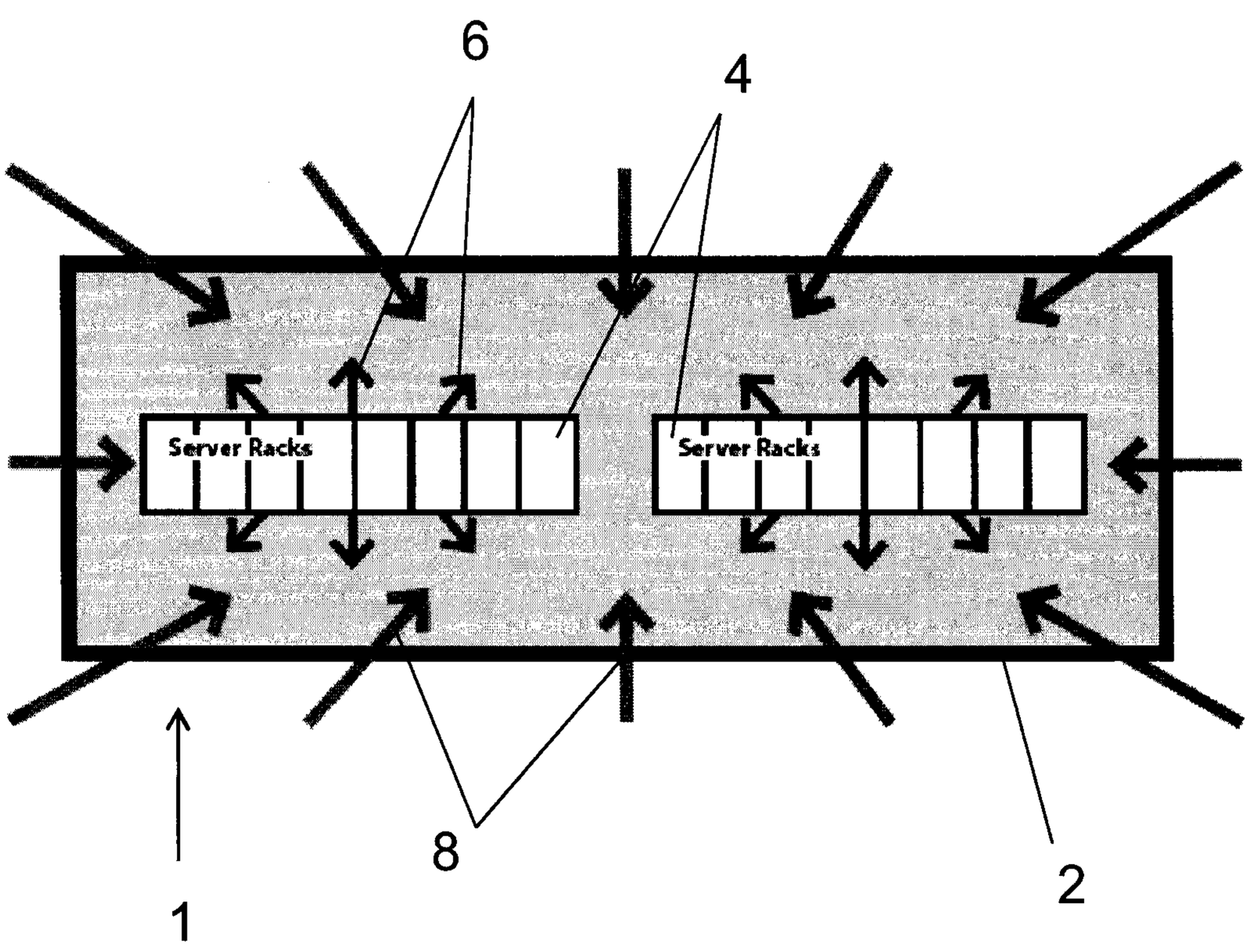
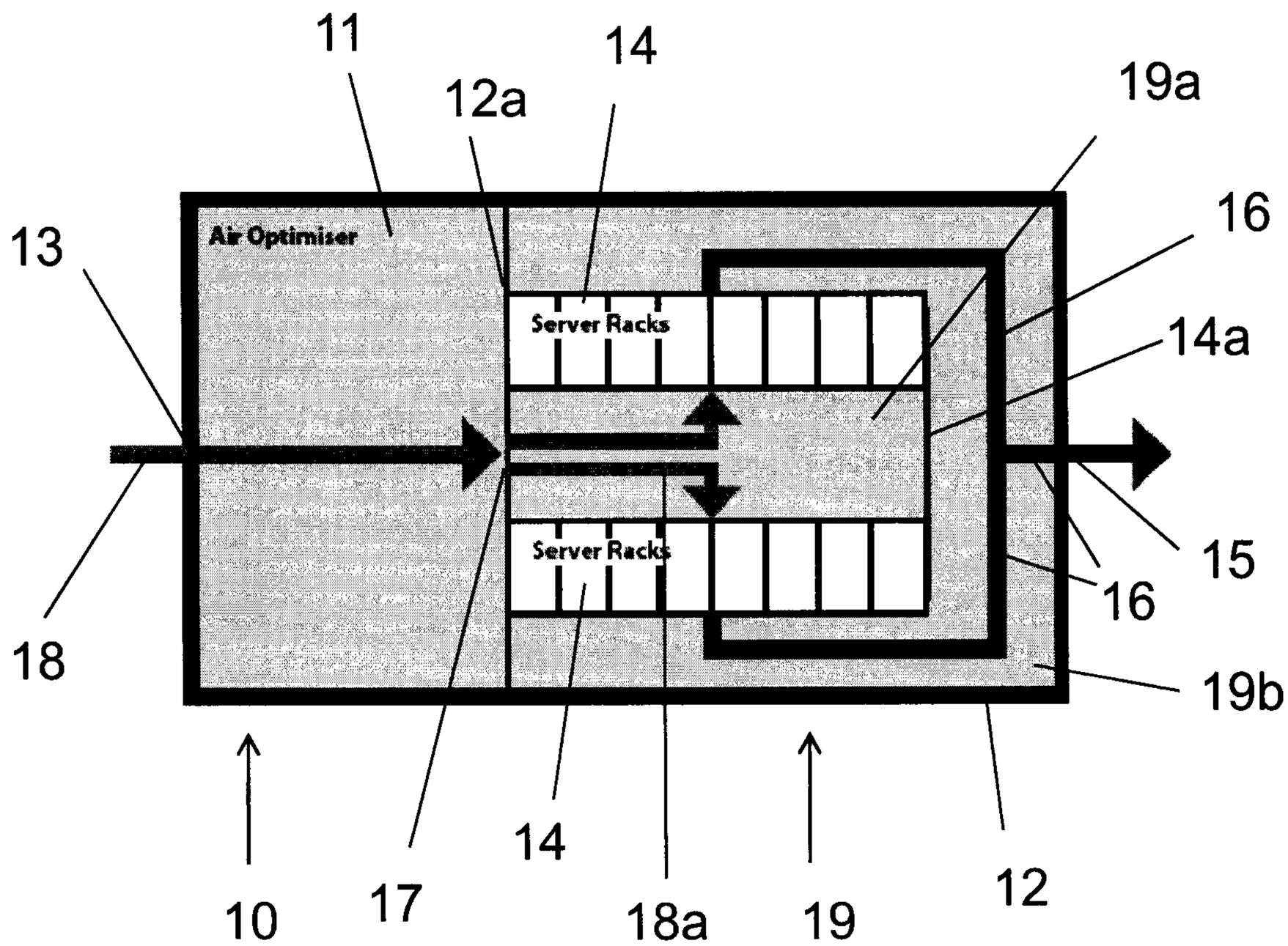


Figure 1

(Prior art)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Server Racks
14a
Server Racks
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19b
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Figure 2

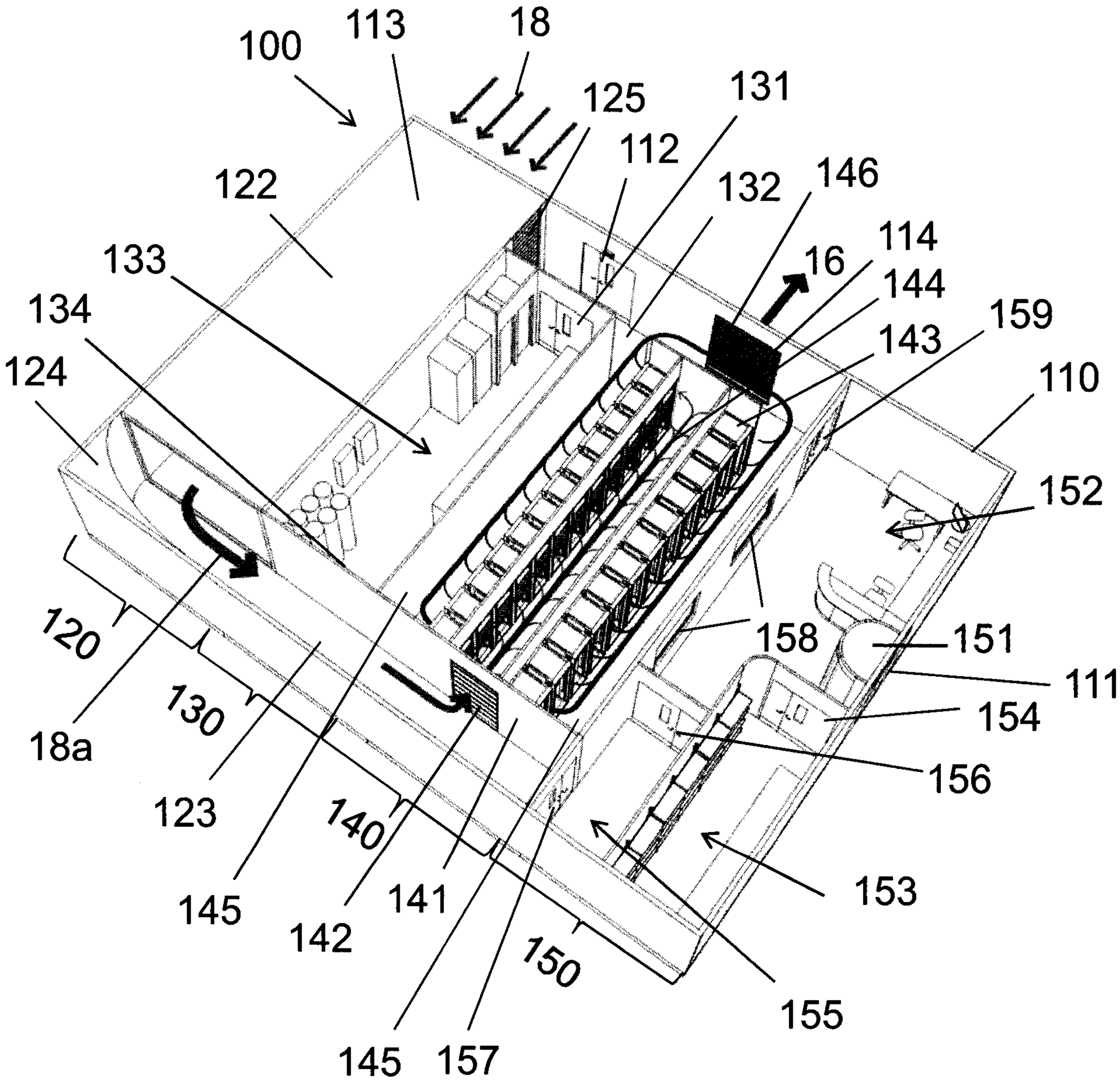
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Figure 3

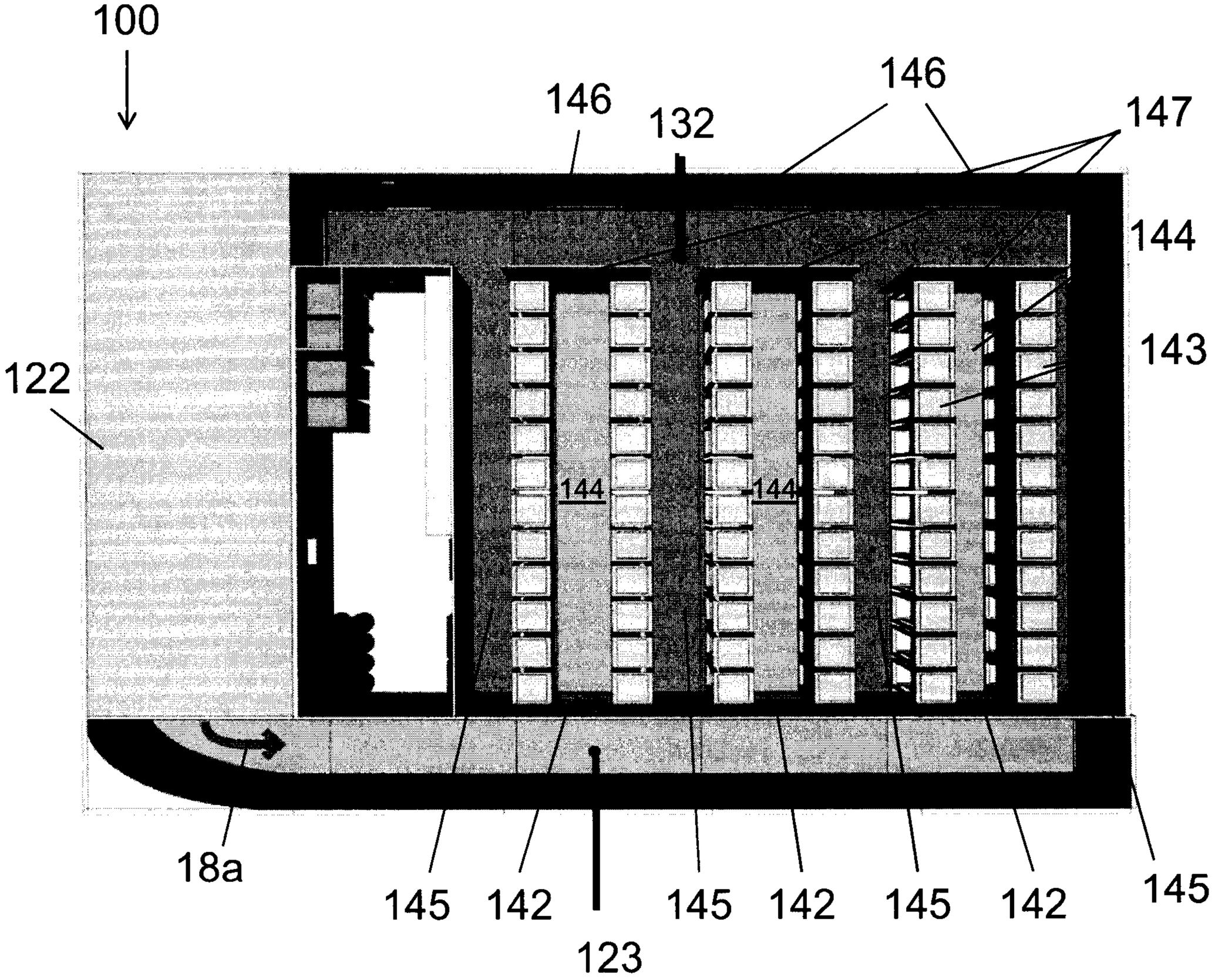
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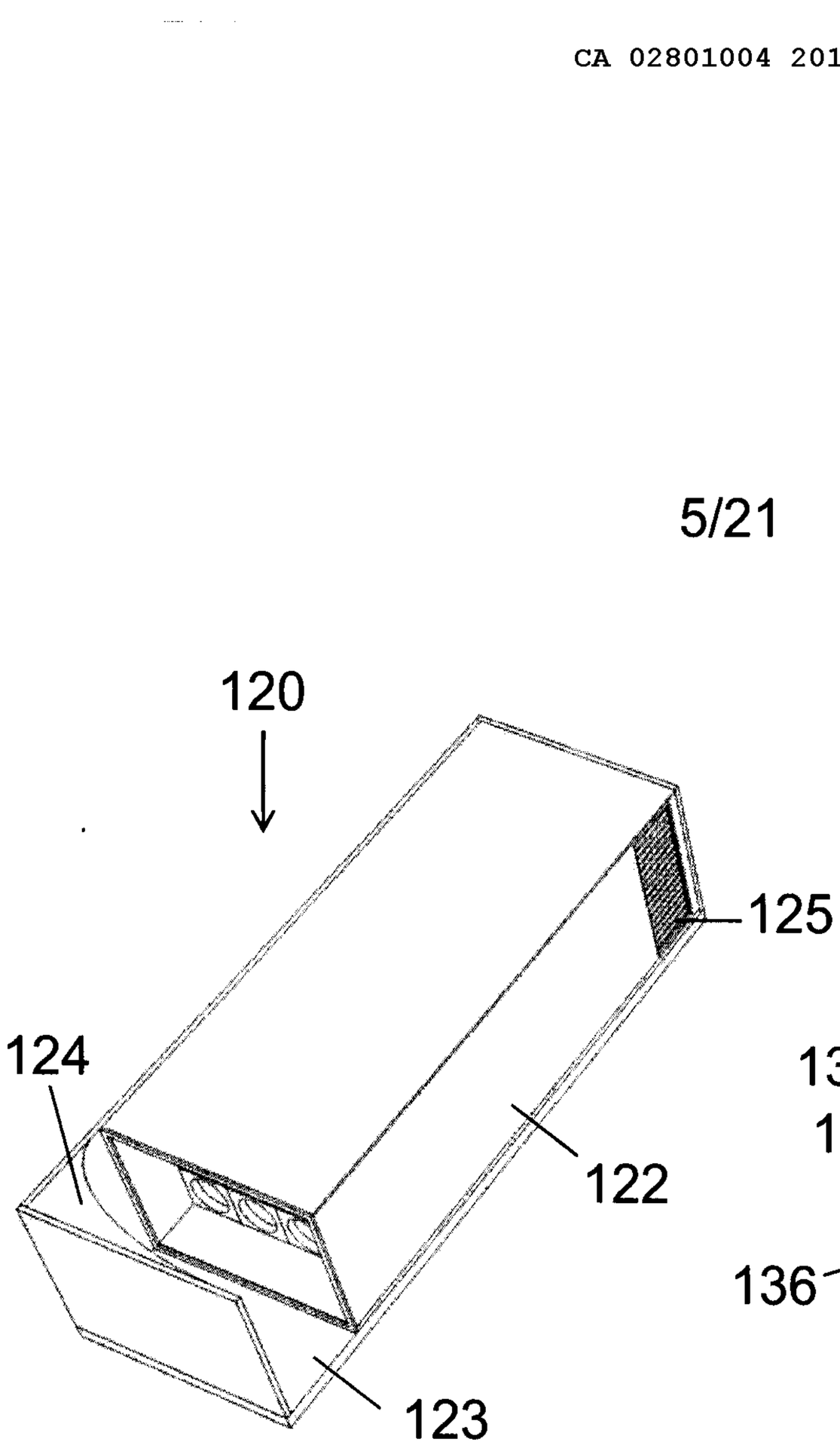
Figure 4



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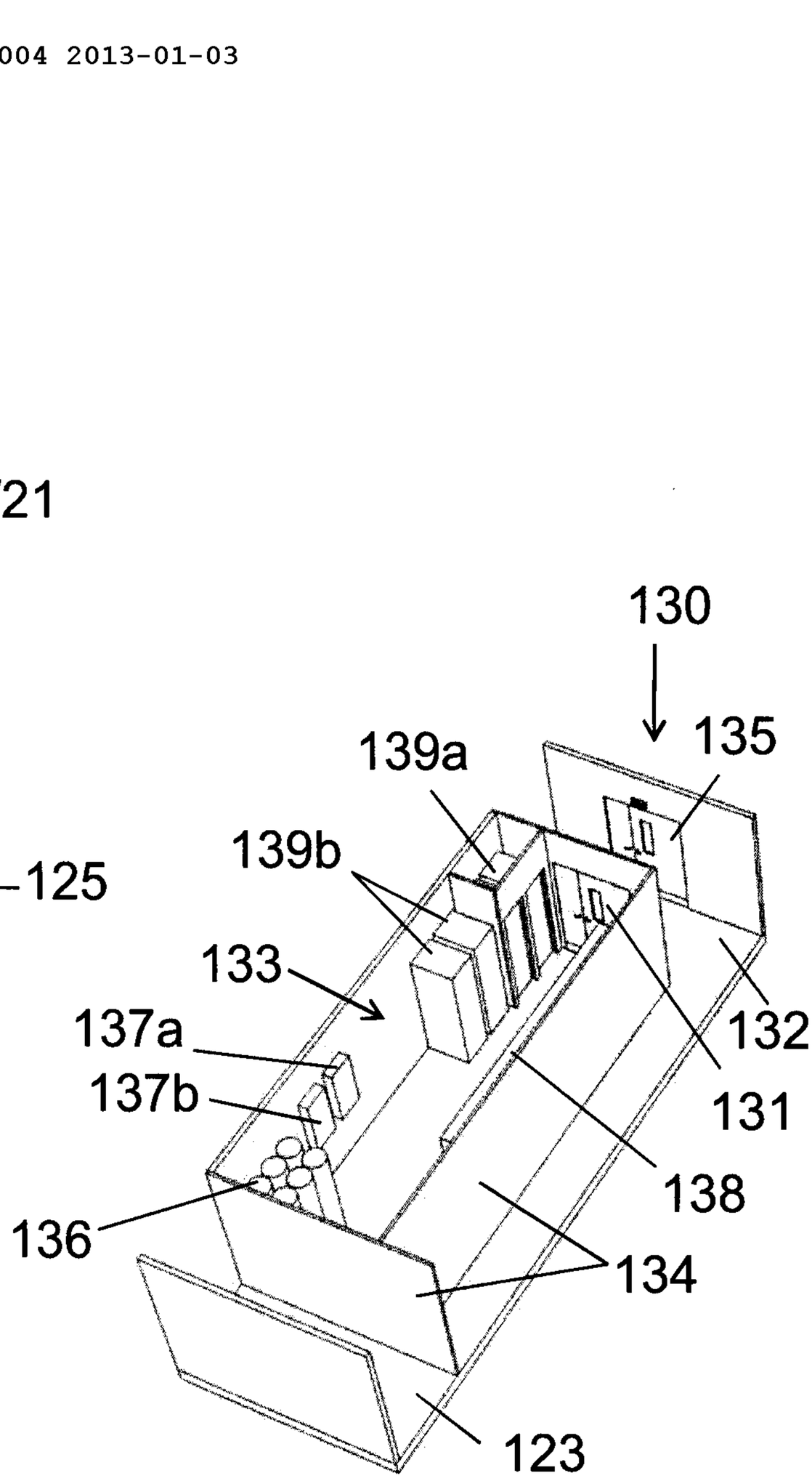

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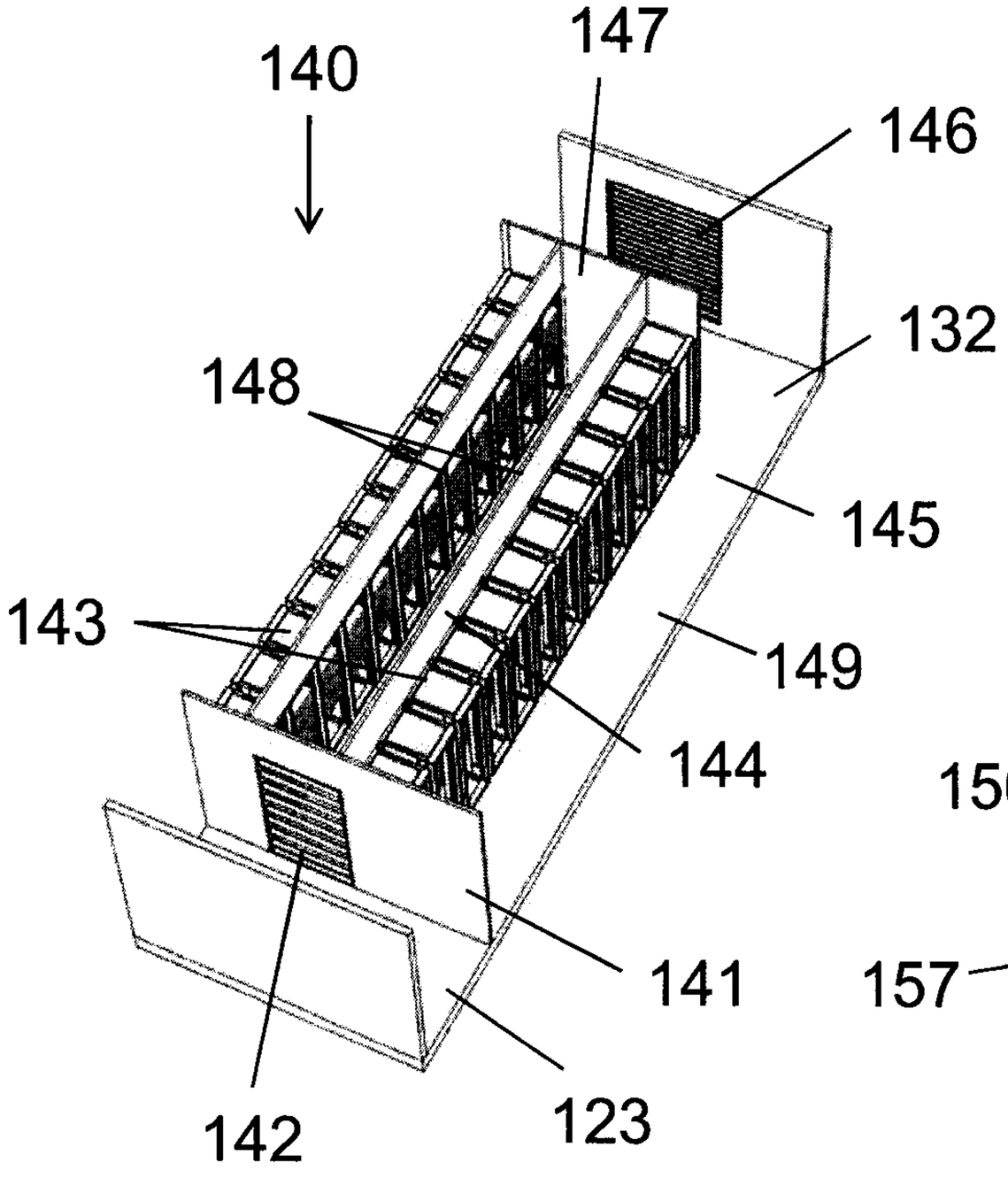

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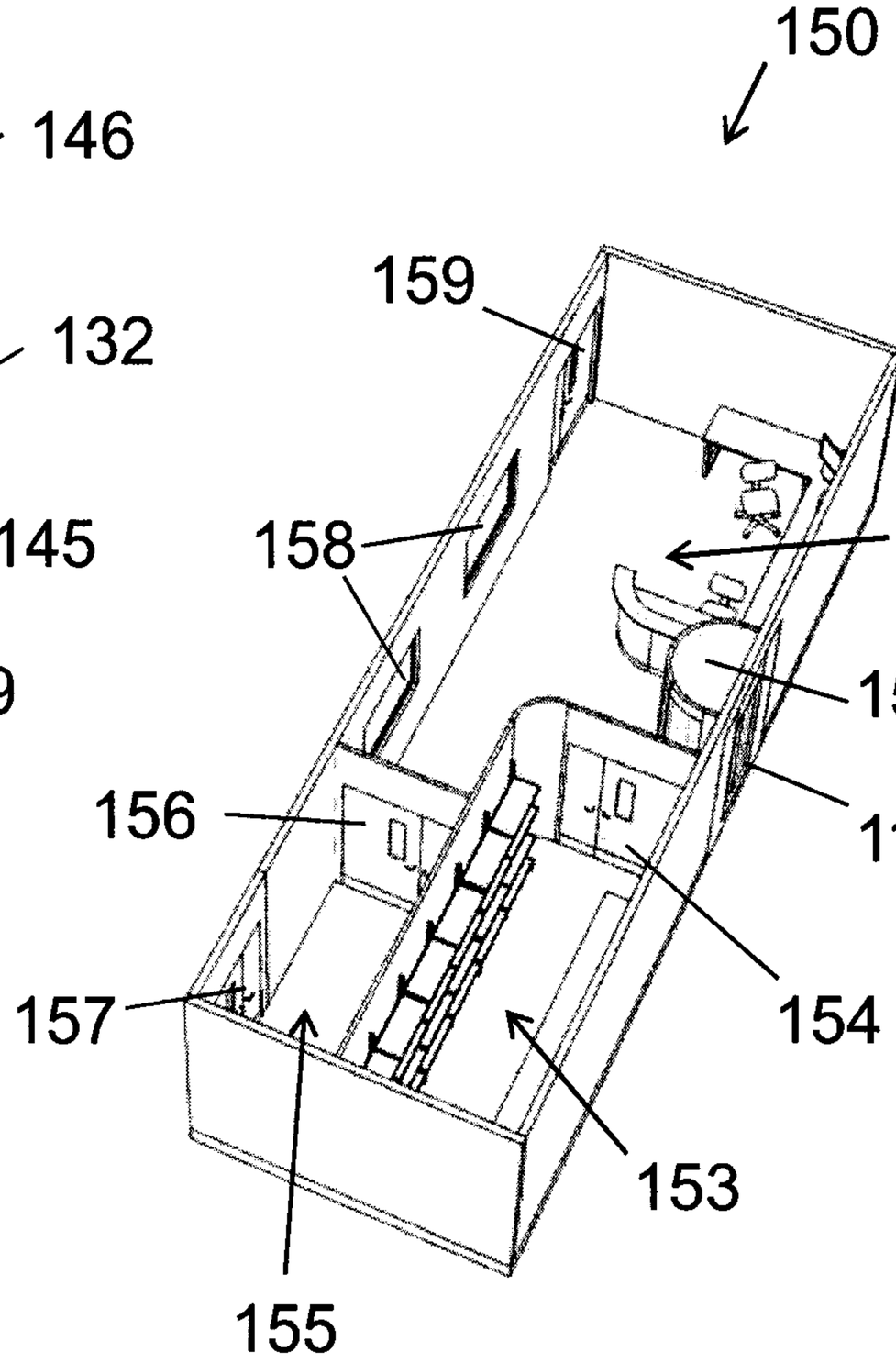

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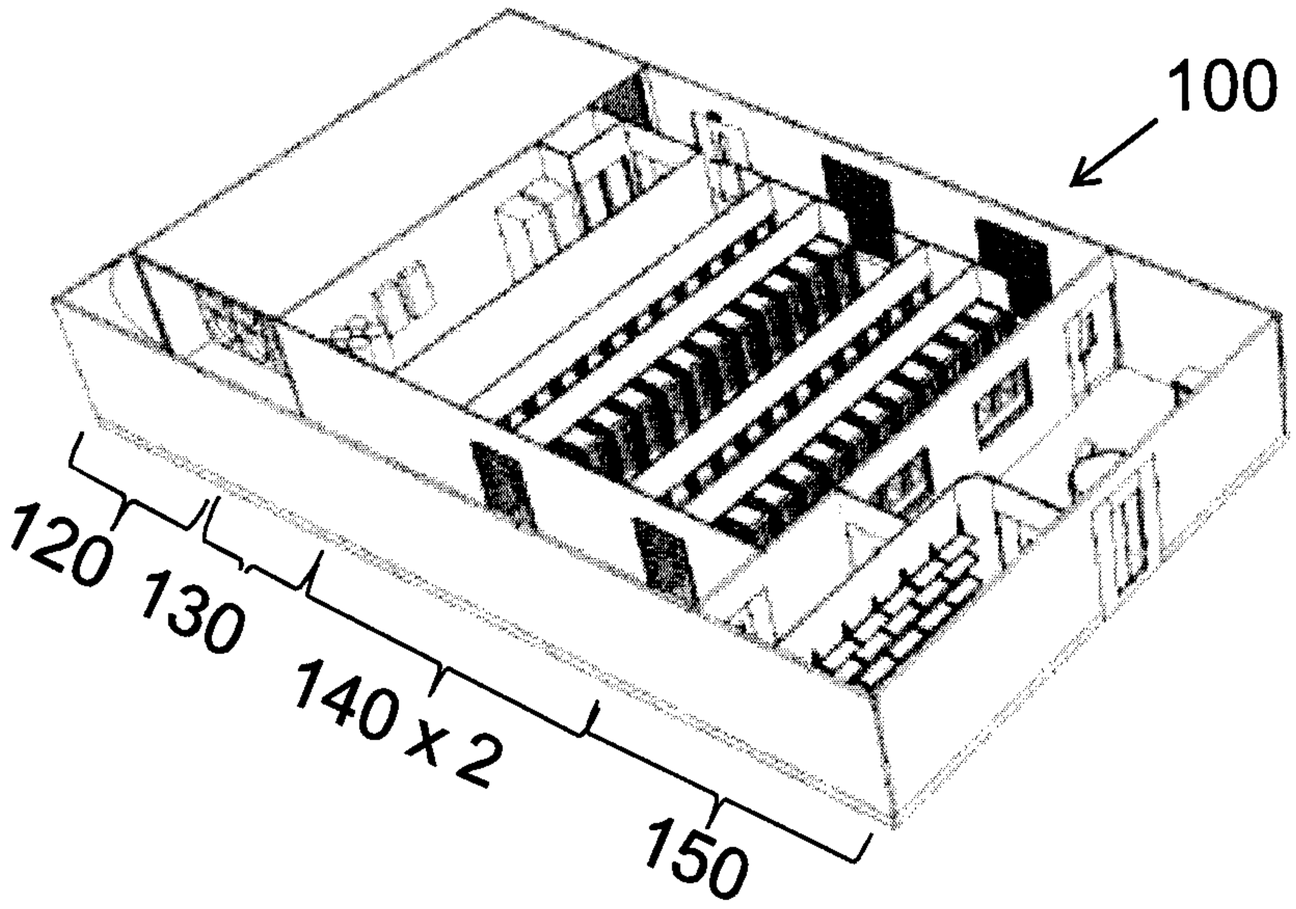

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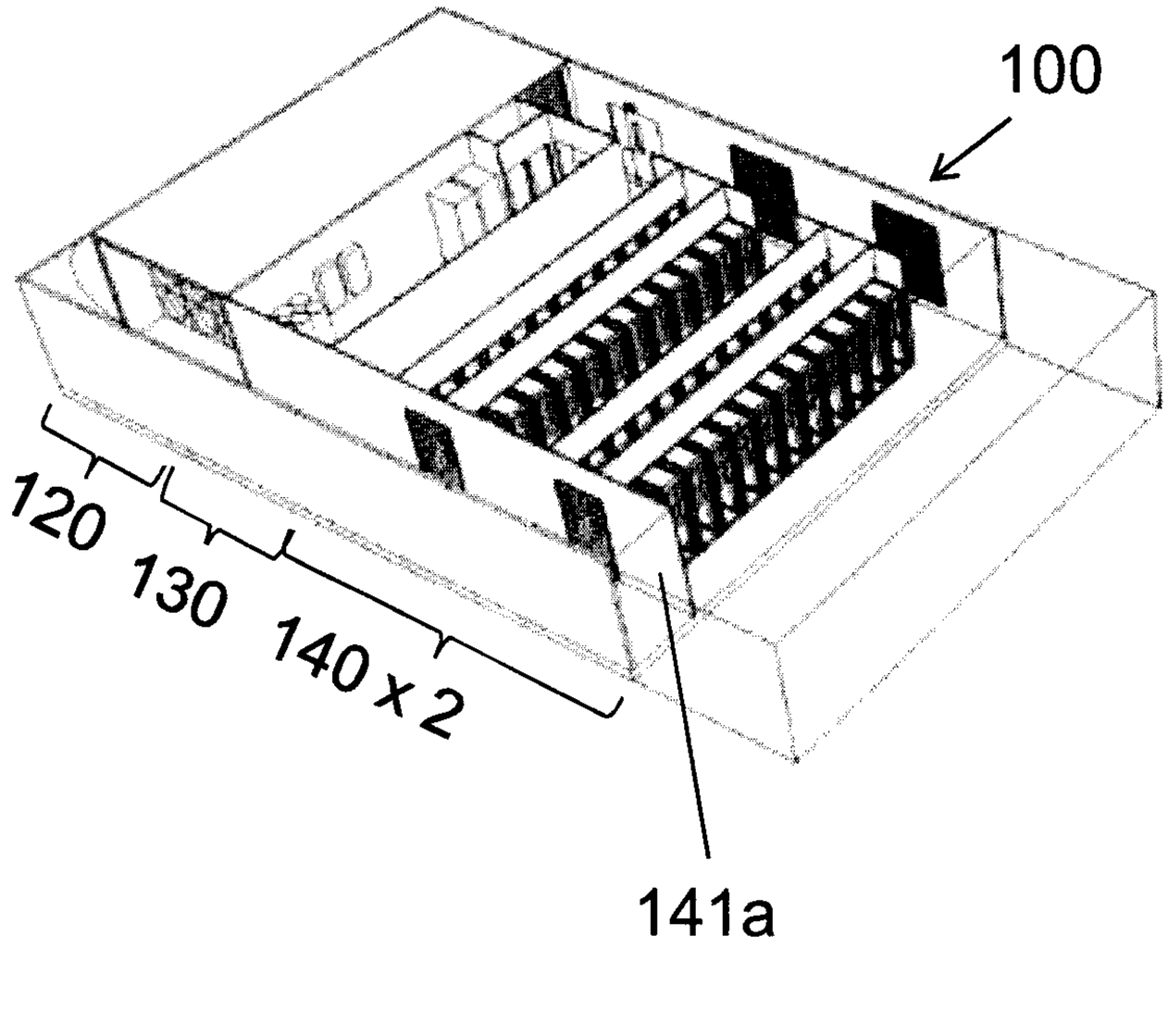

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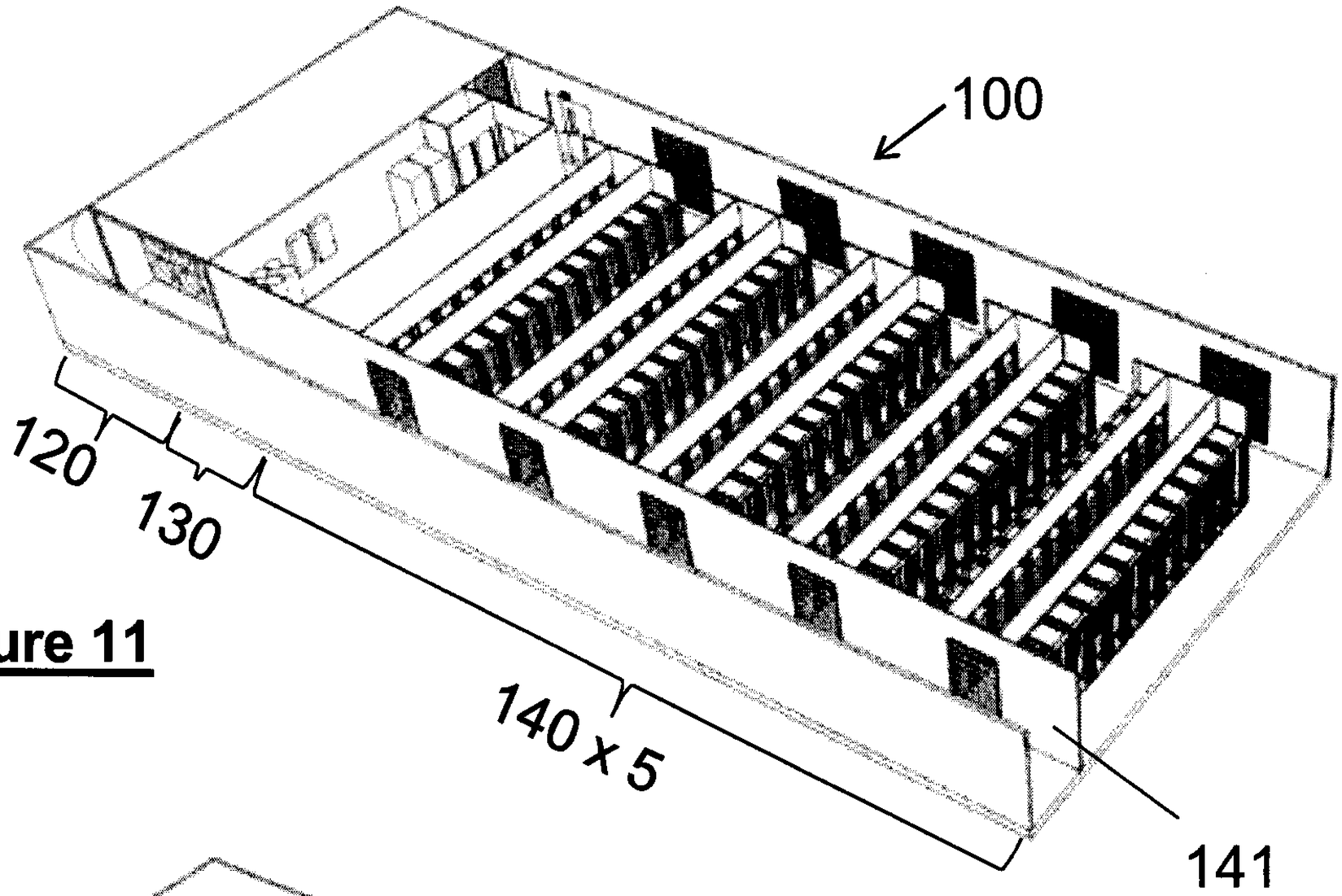

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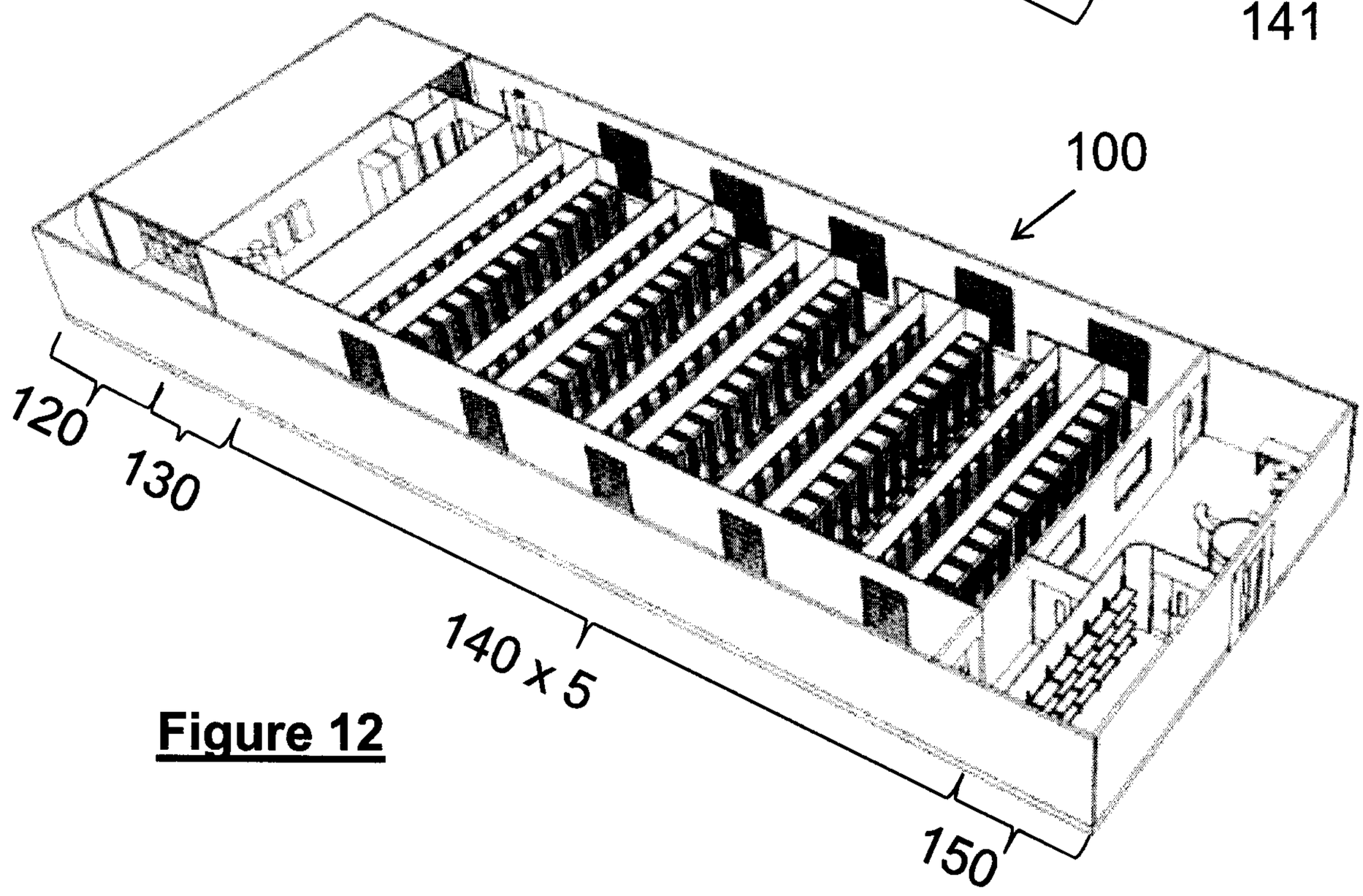

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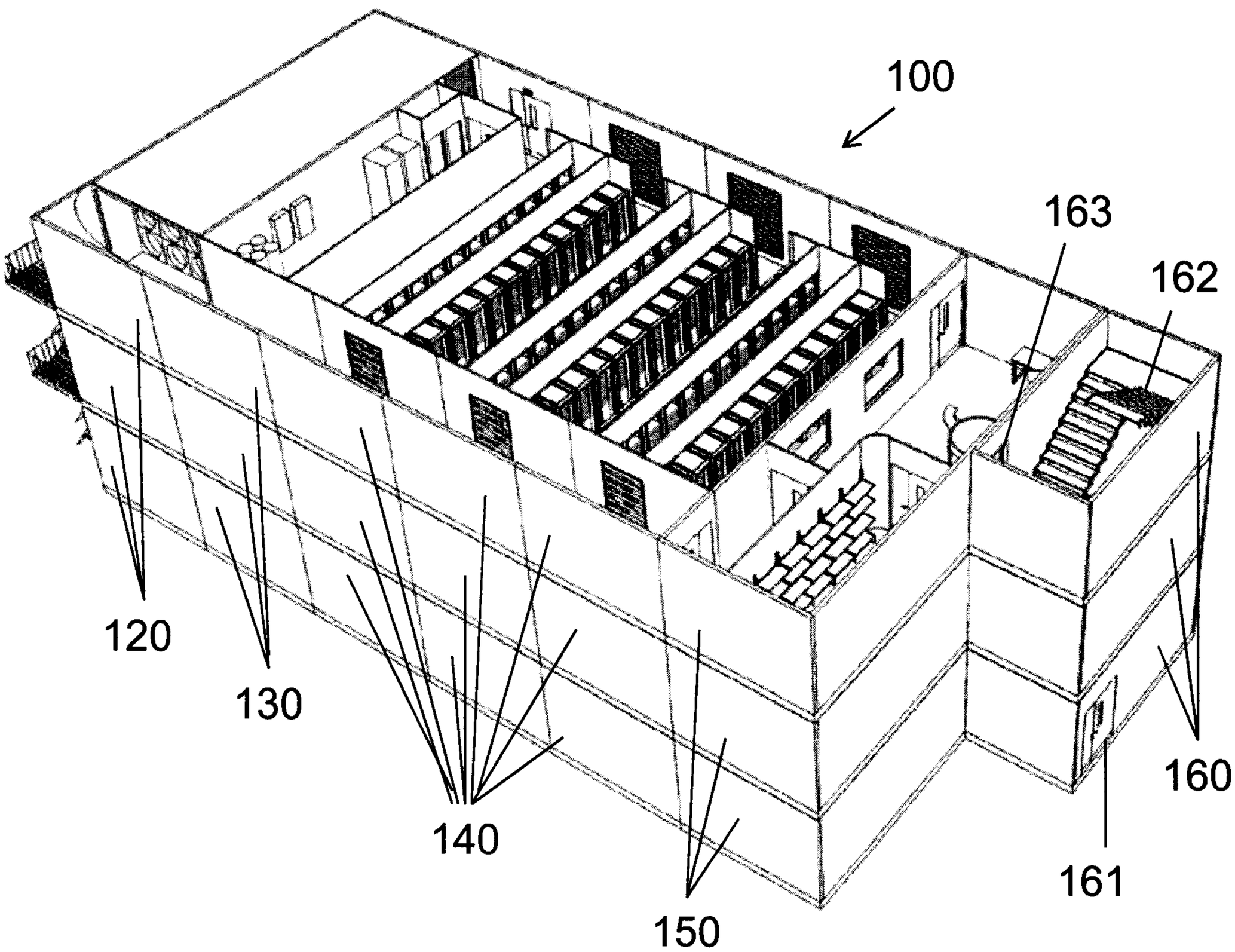

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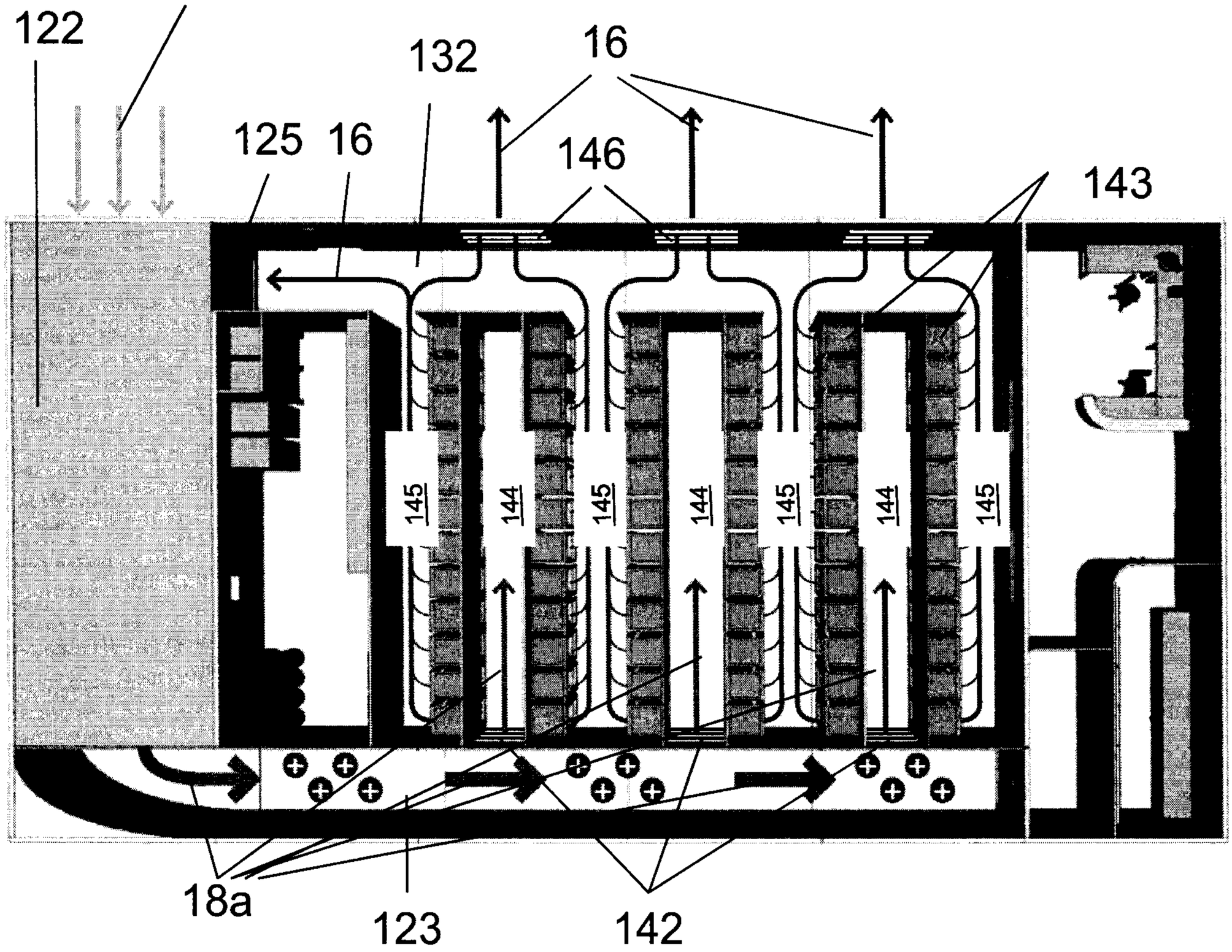

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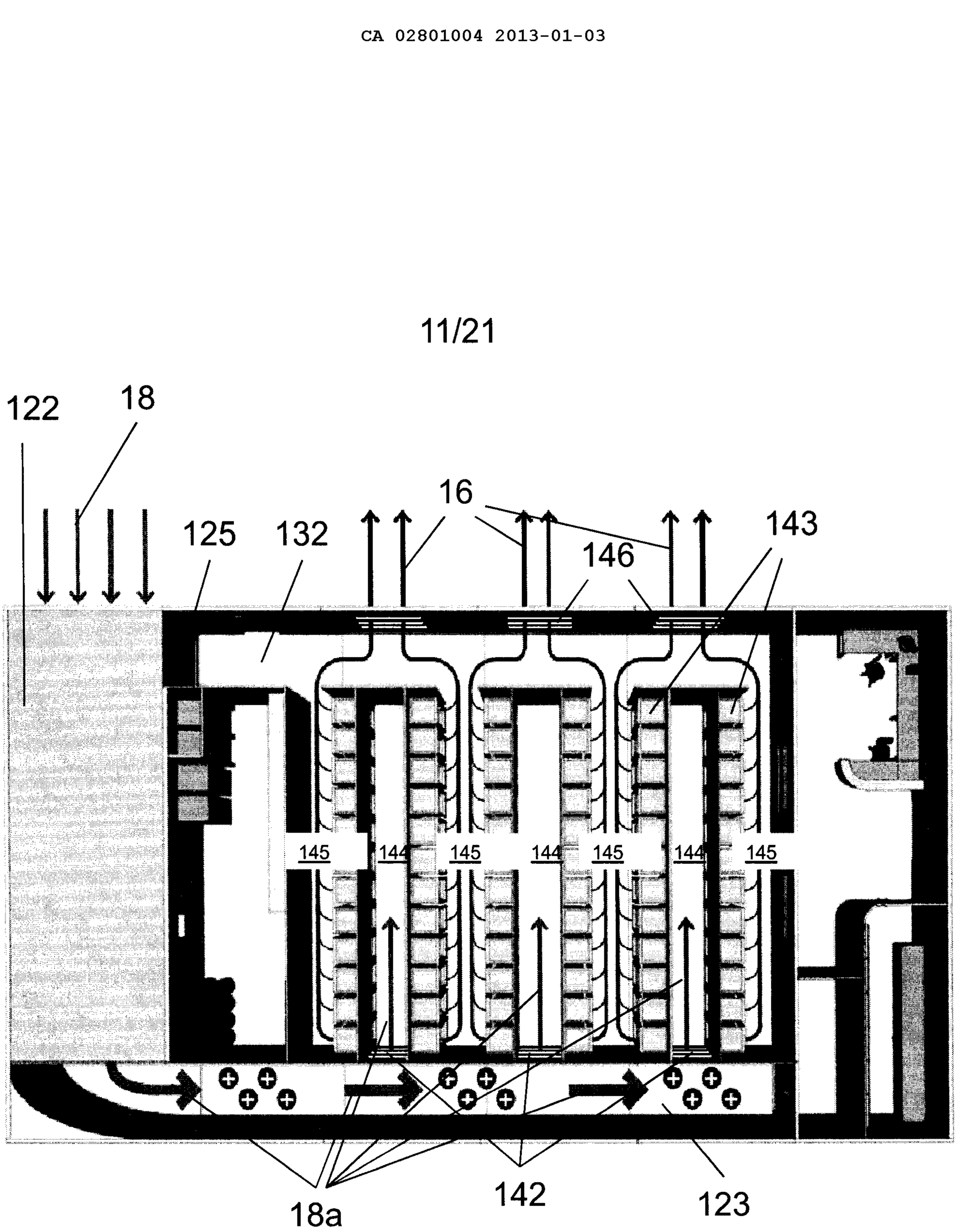

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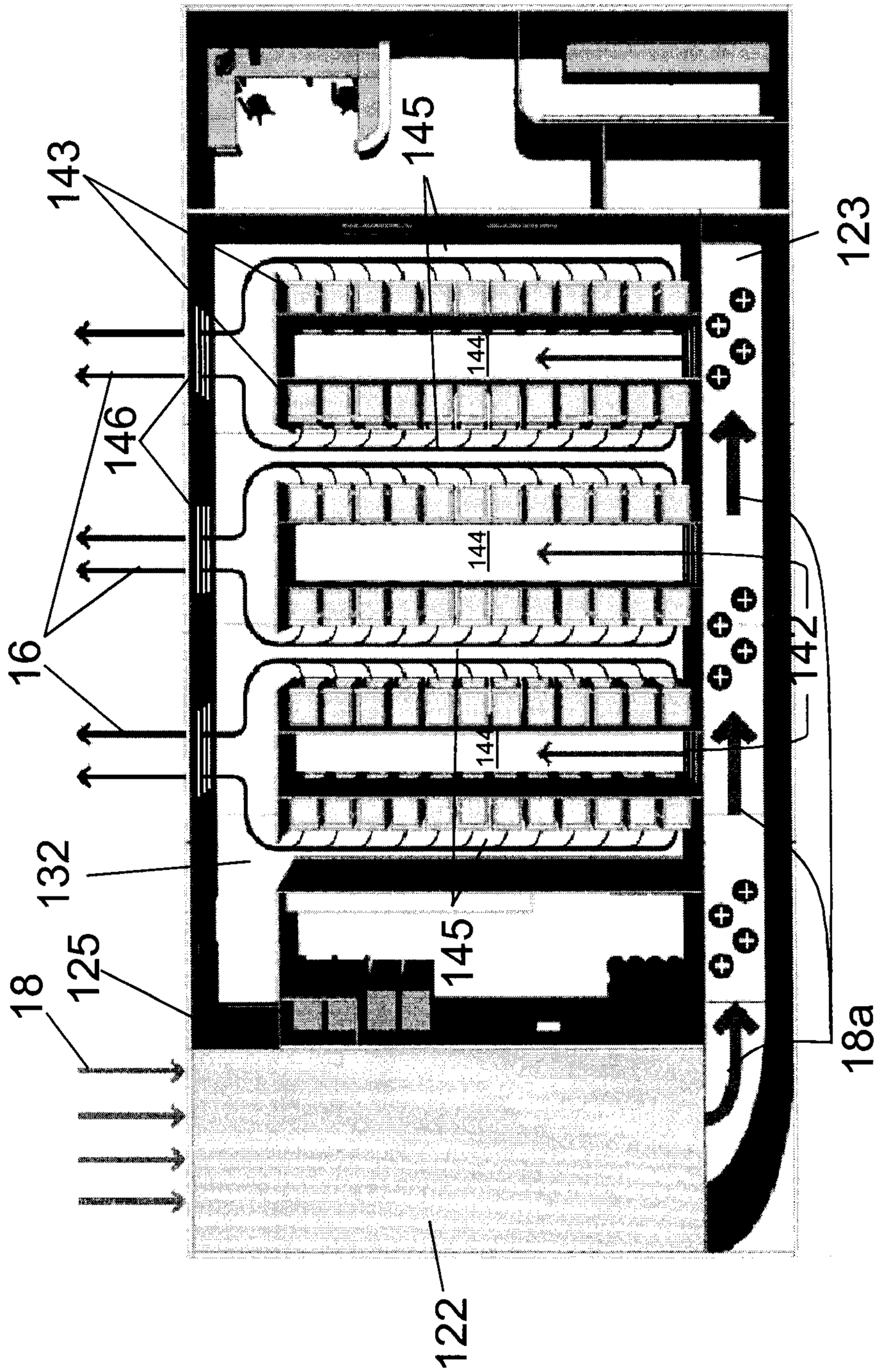

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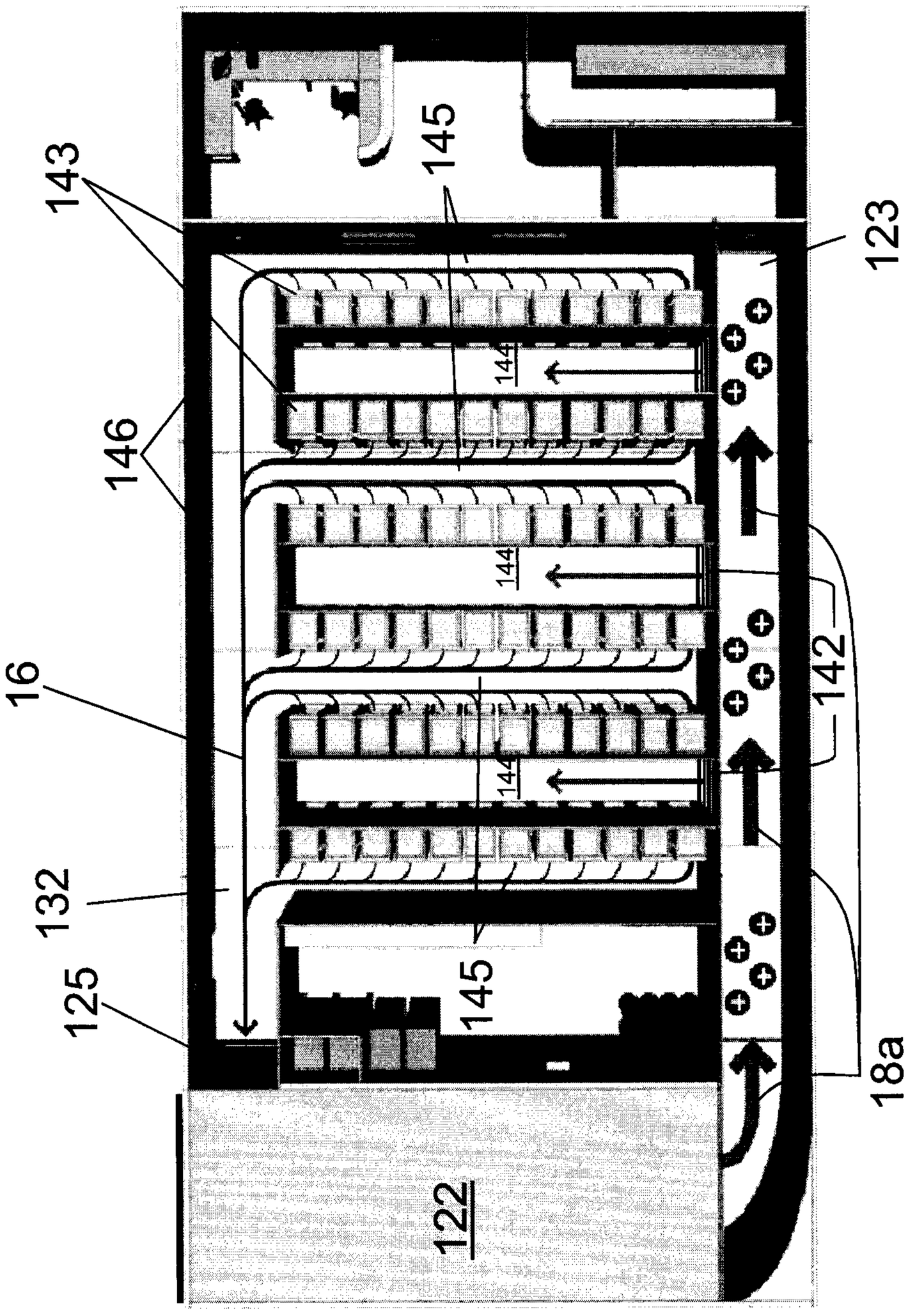

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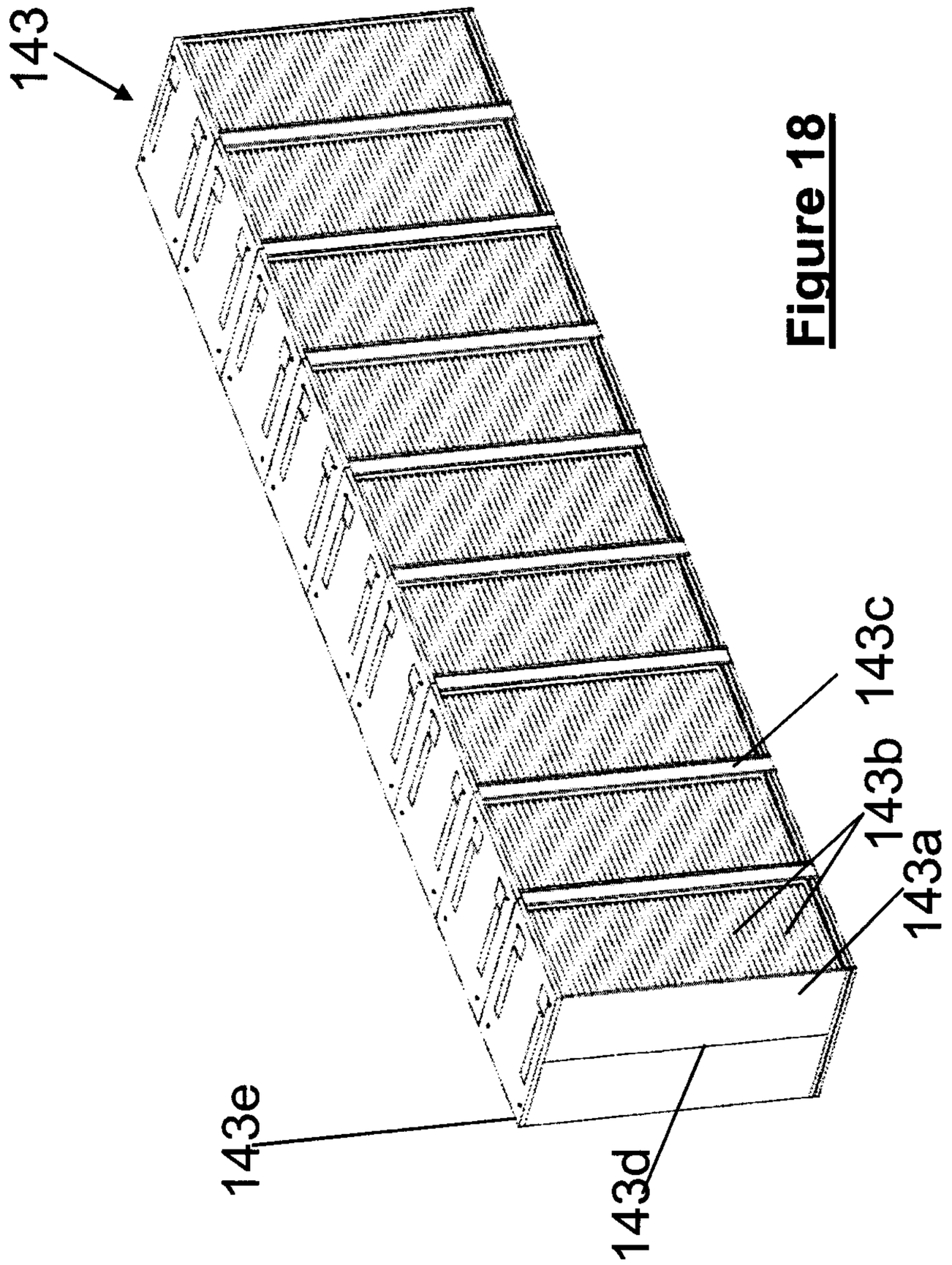

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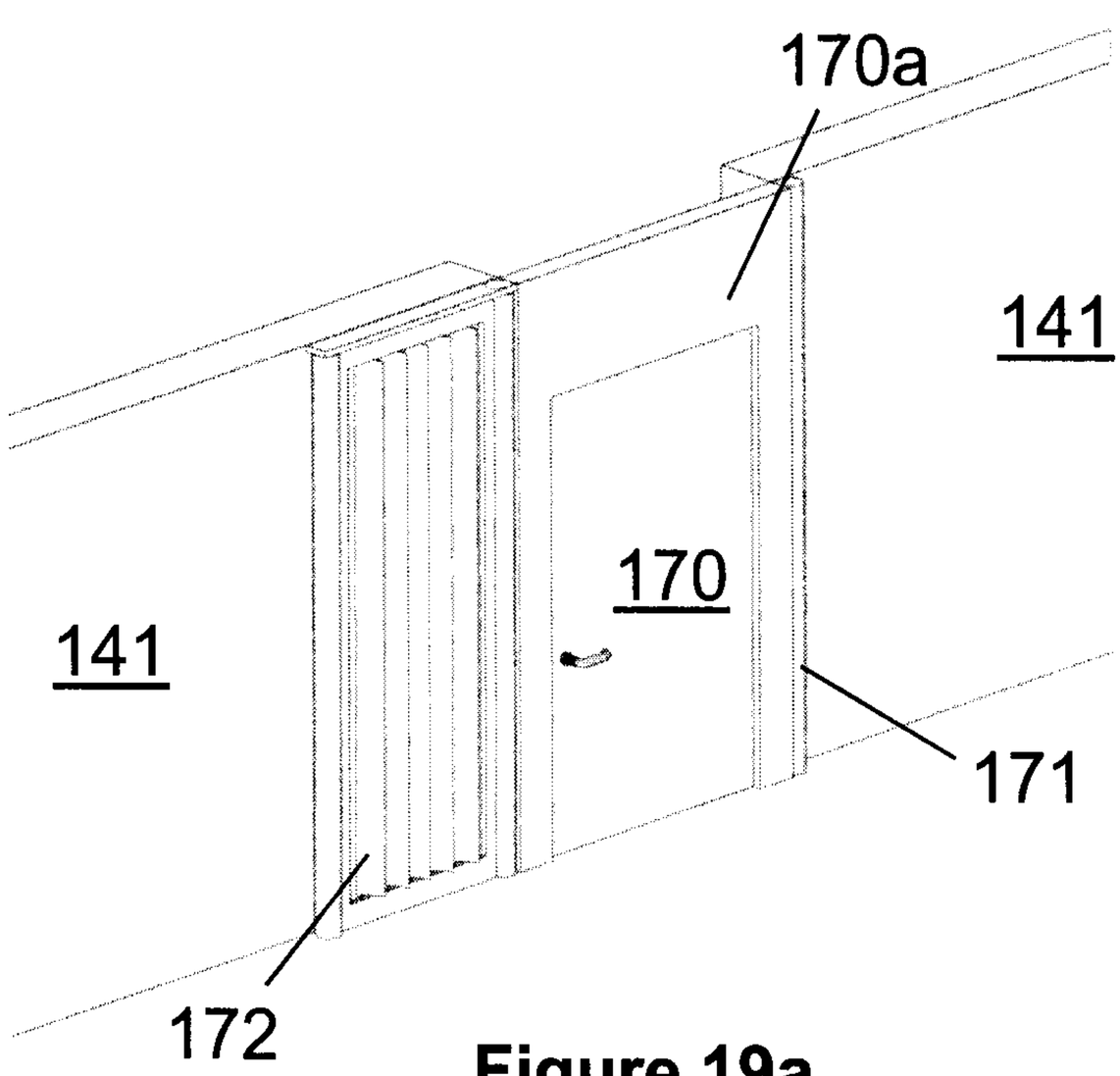

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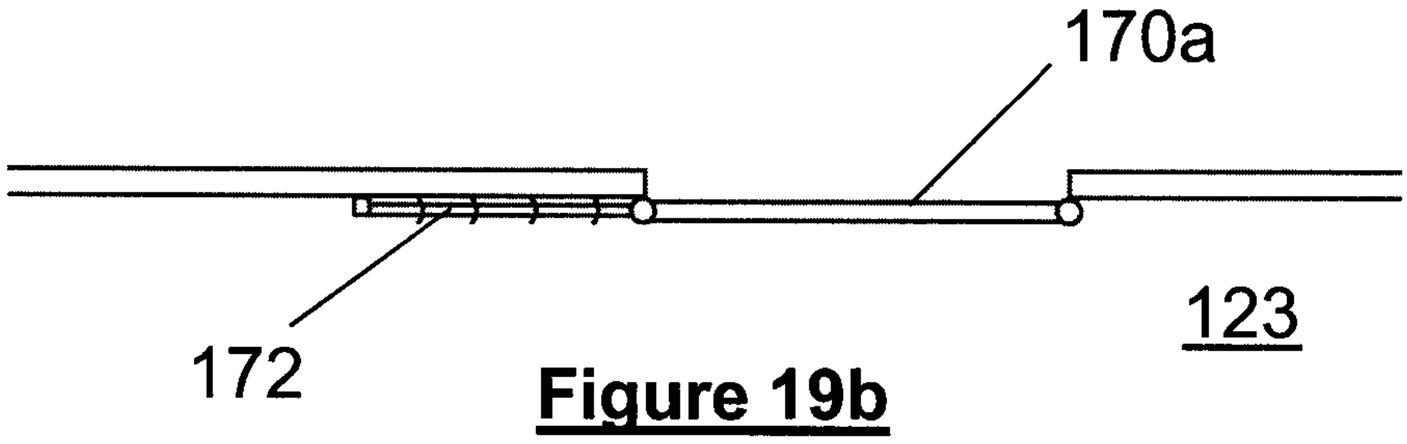
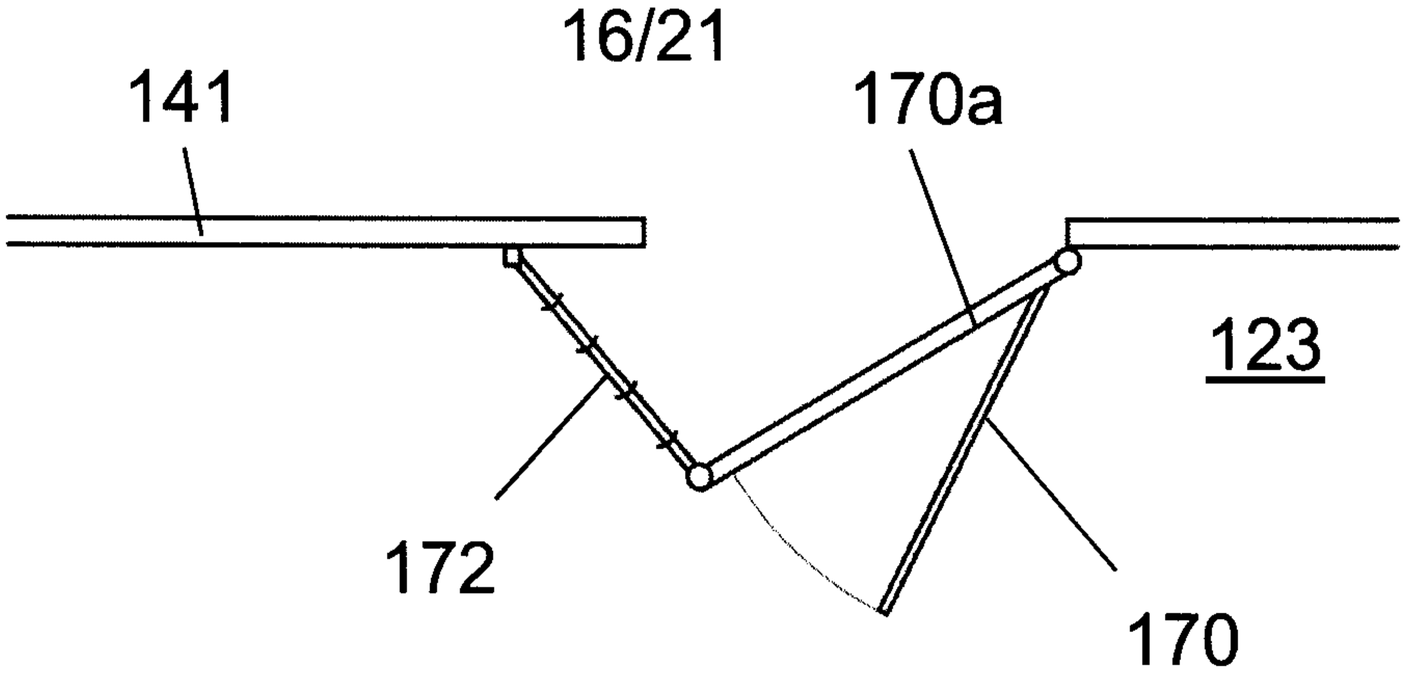


Figure 19b



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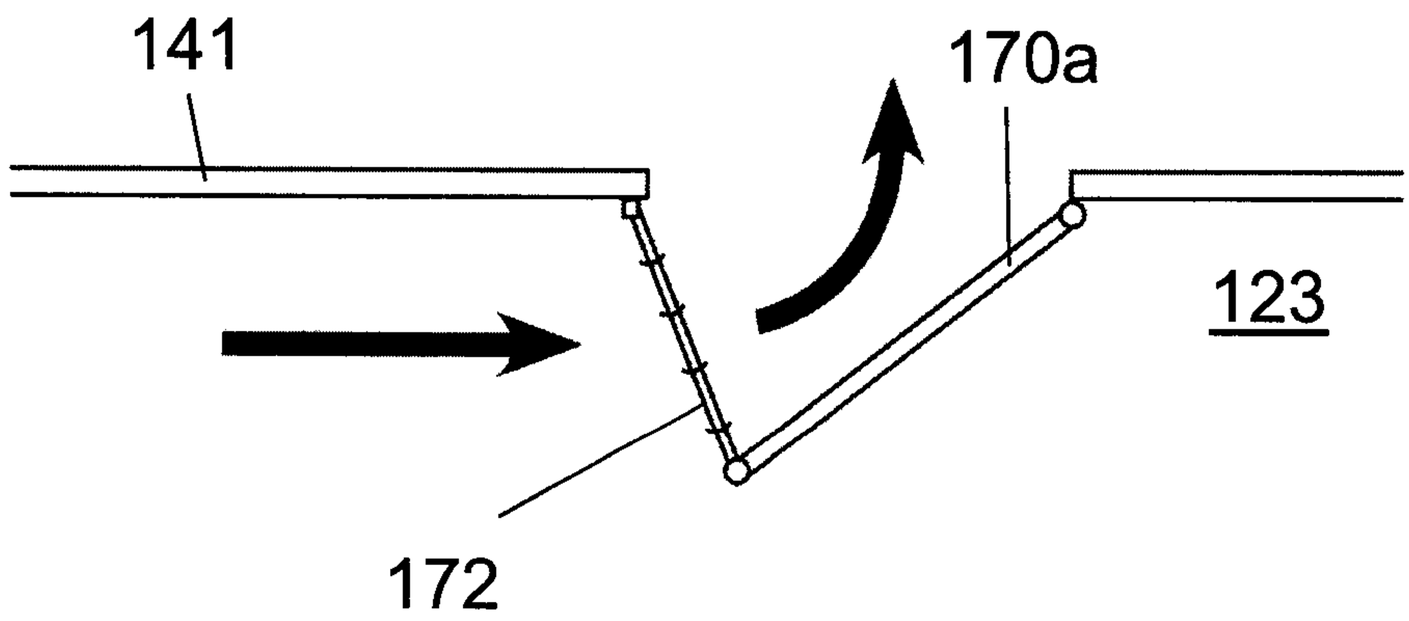

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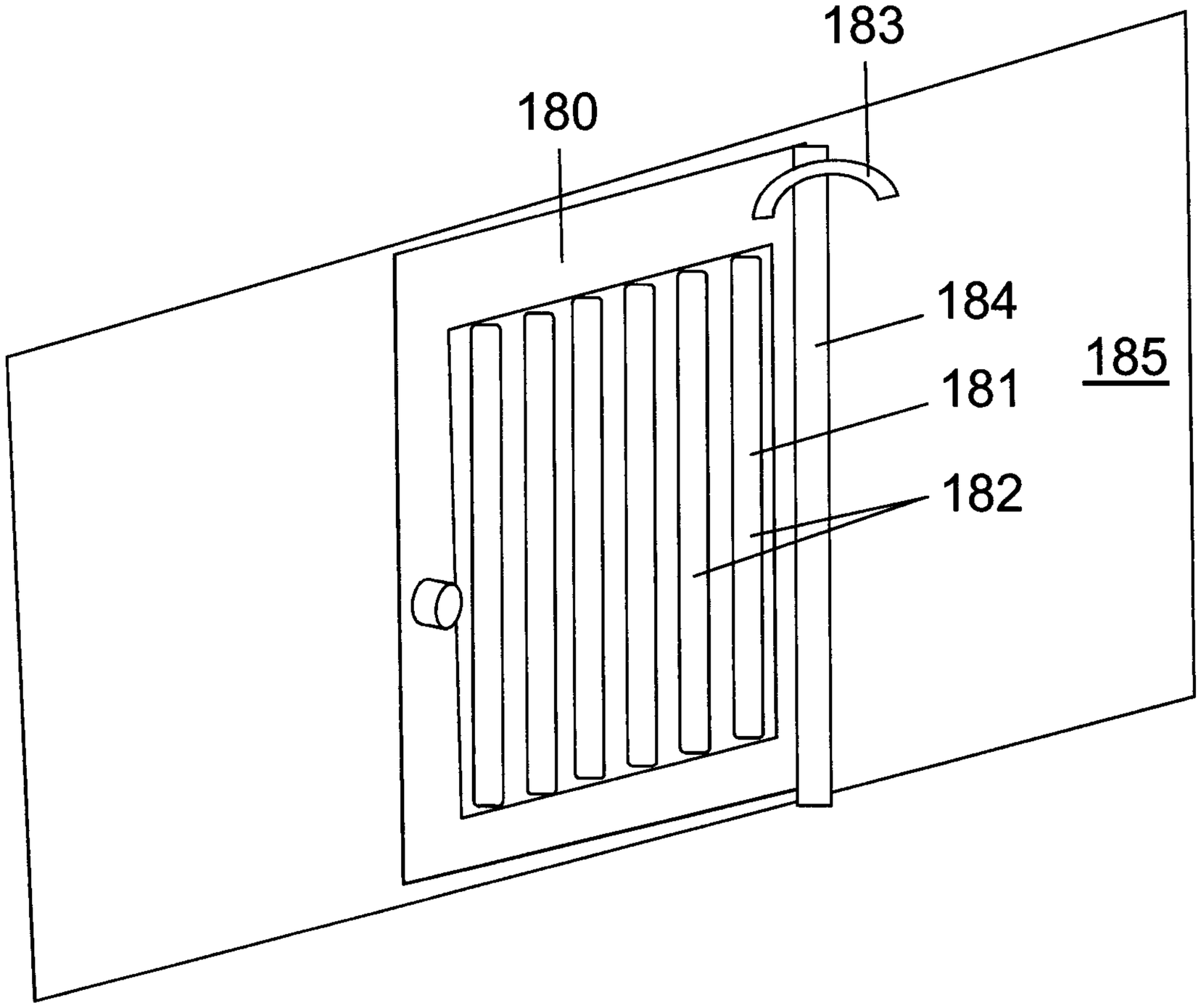

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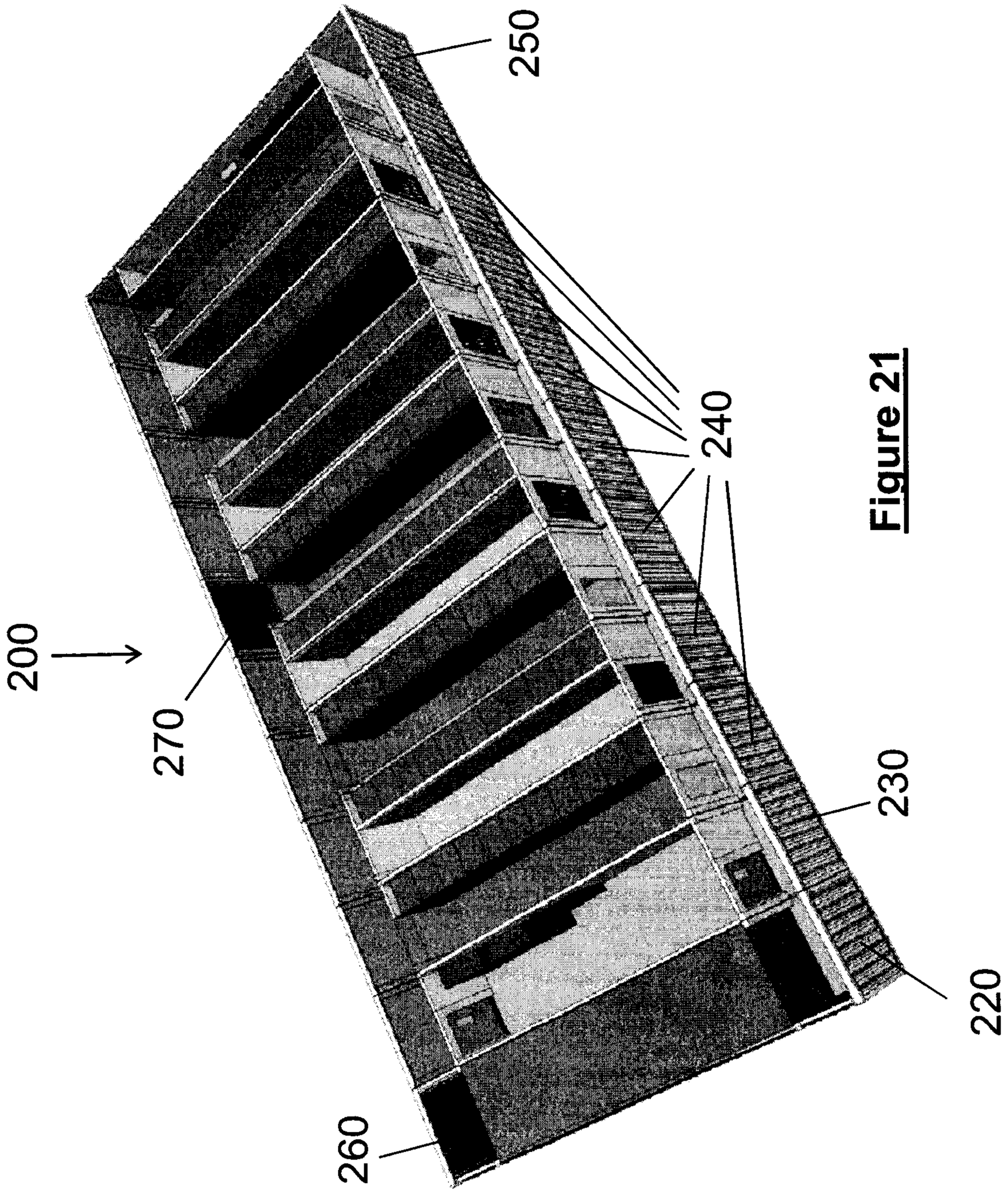

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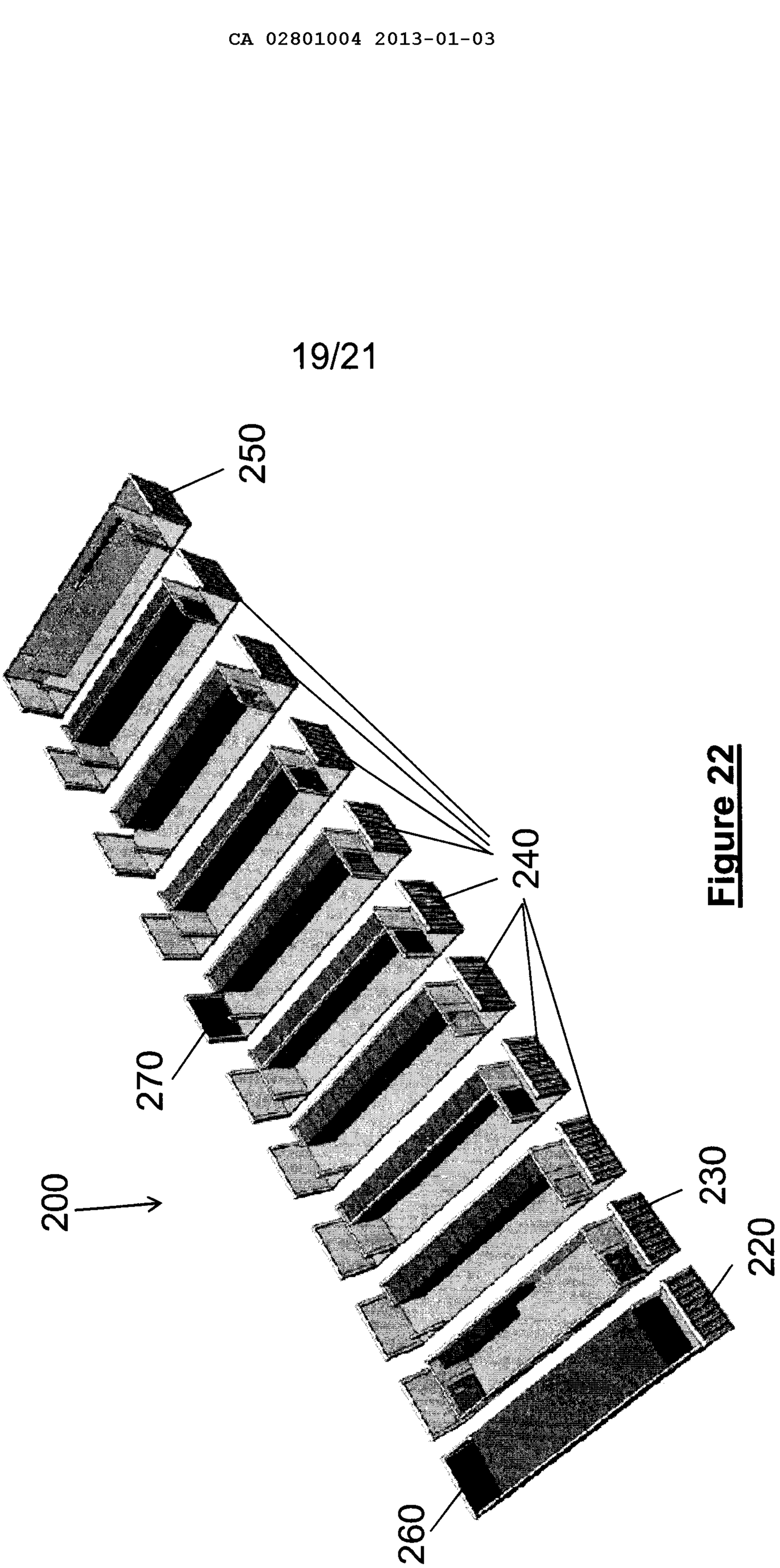

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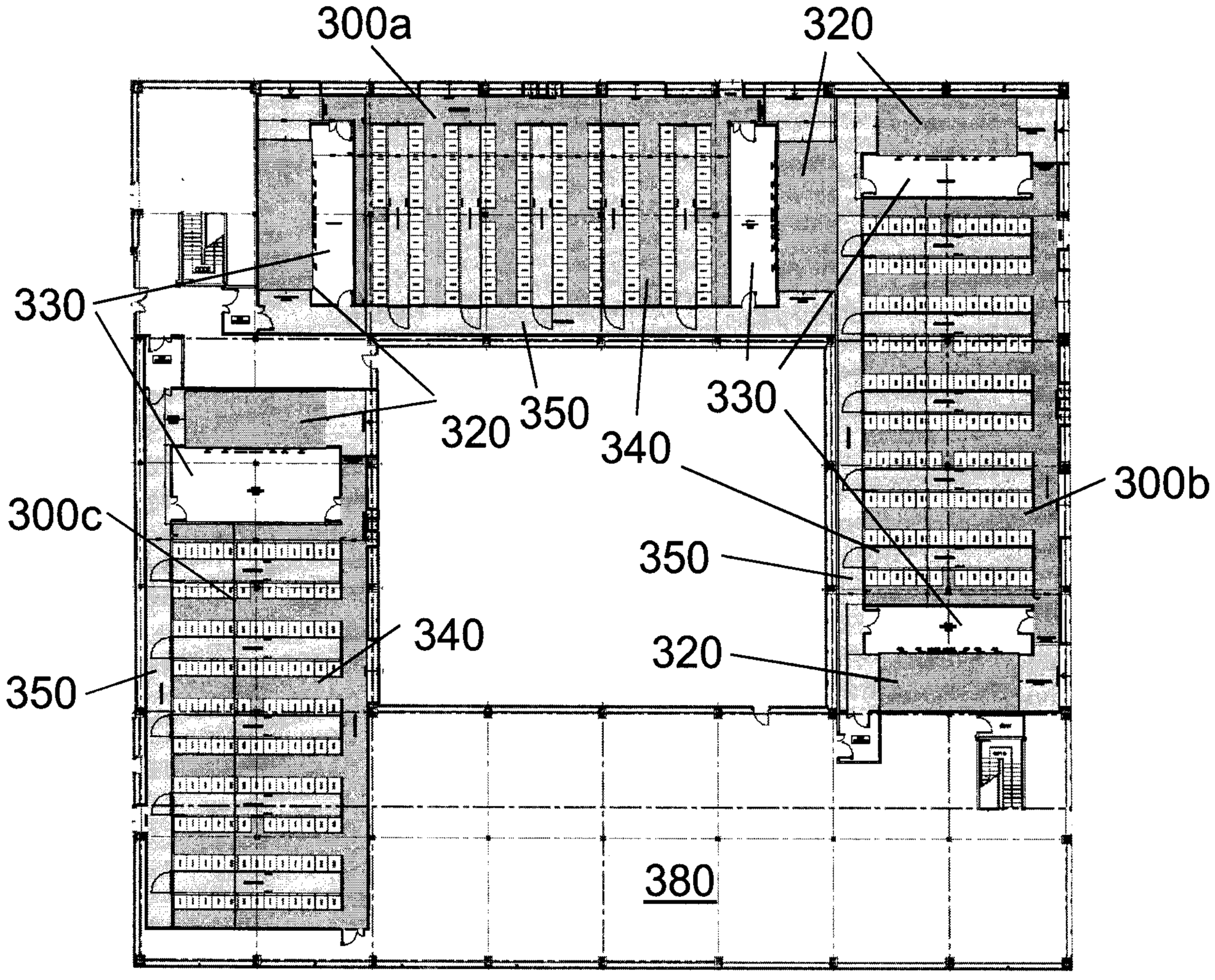

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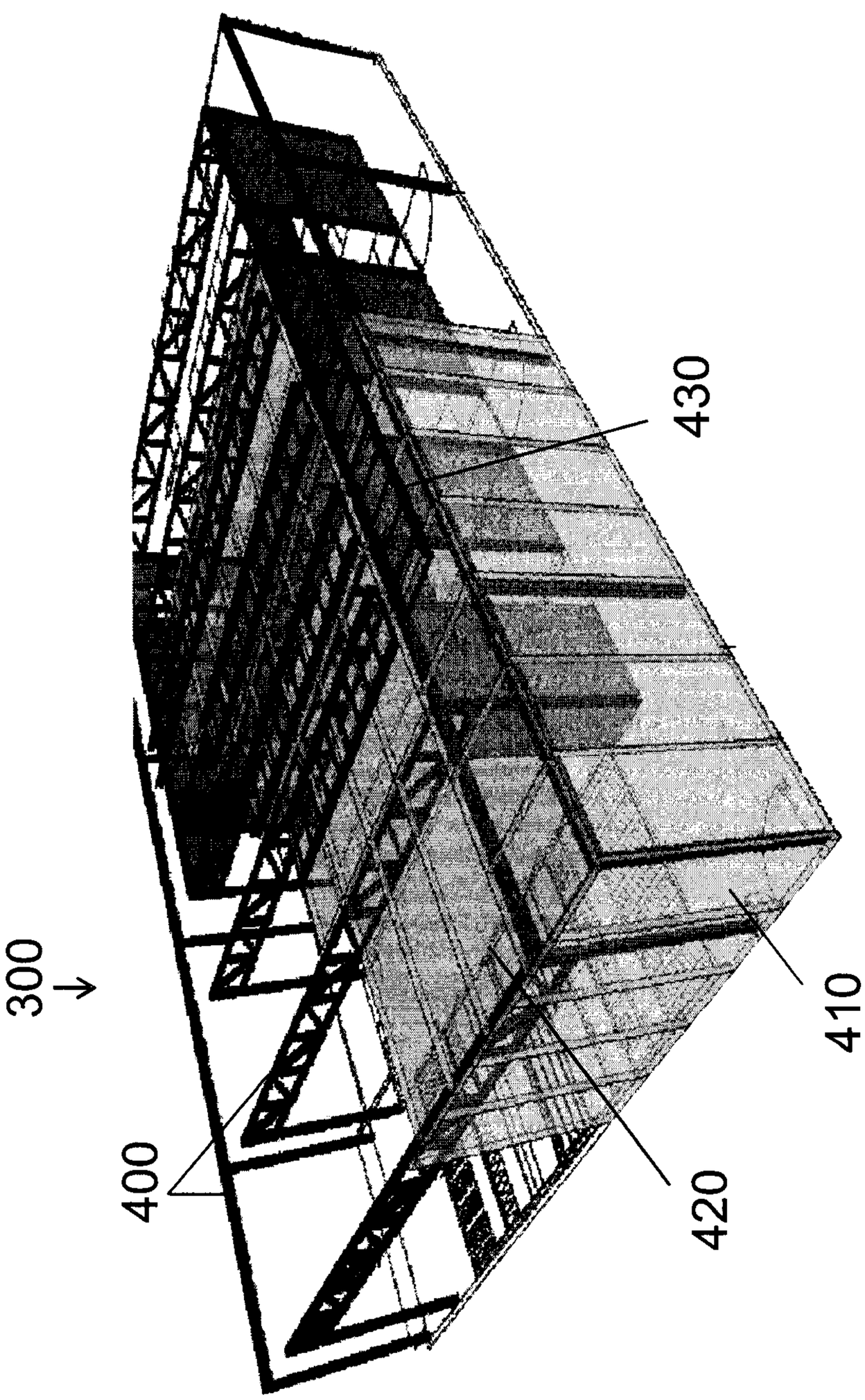

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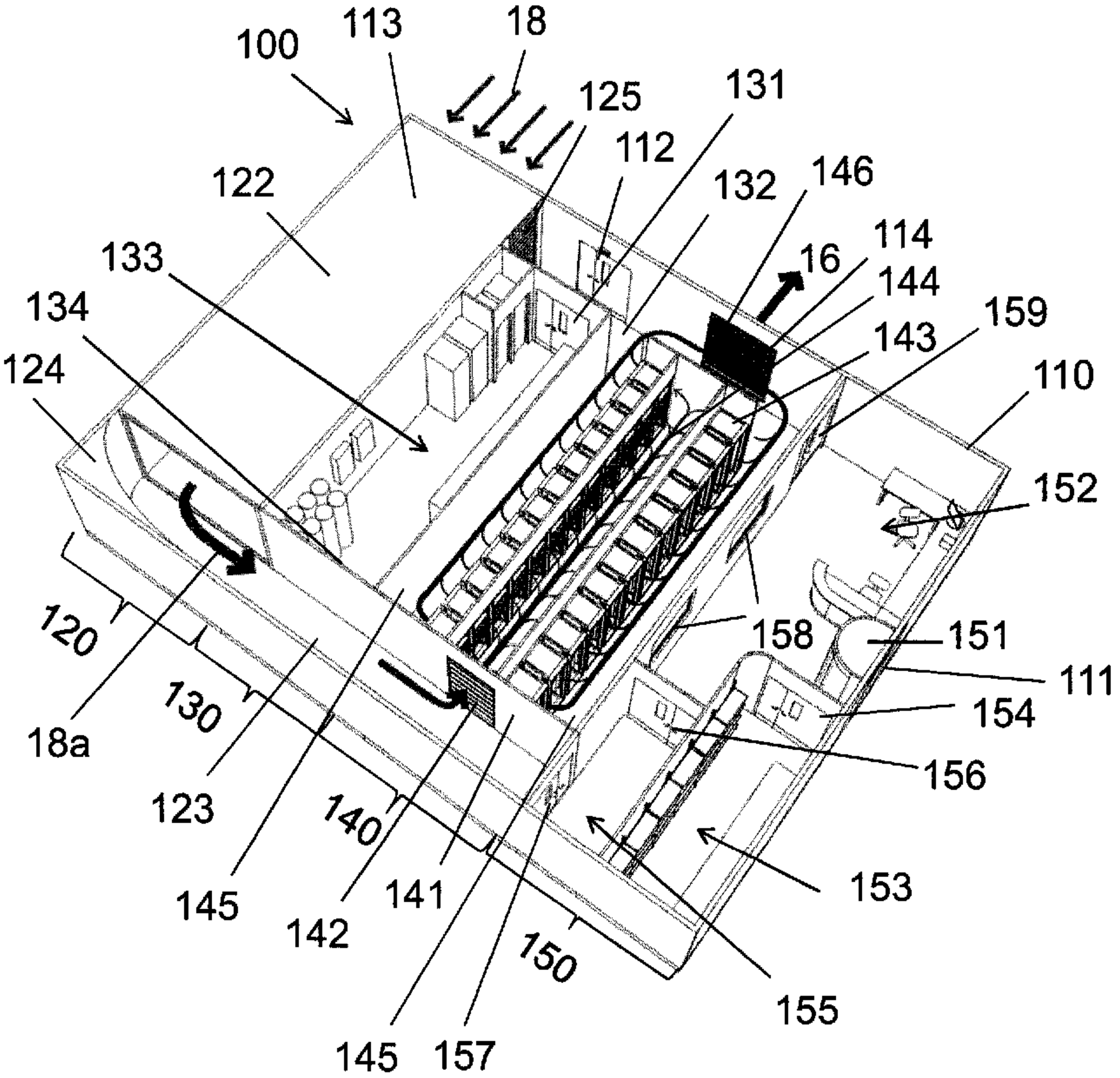
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