



(51) International Patent Classification:

H05K 7/20 (2006.01) *F25D 23/12* (2006.01)
F24H 3/02 (2006.01) *G05D 7/00* (2006.01)

(21) International Application Number:

PCT/US2016/043077

(22) International Filing Date:

20 July 2016 (20.07.2016)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

15/016,234 4 February 2016 (04.02.2016) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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(54) Title: INFORMATION HANDLING SYSTEM HAVING FLUID MANIFOLD WITH EMBEDDED HEAT EXCHANGER SYSTEM

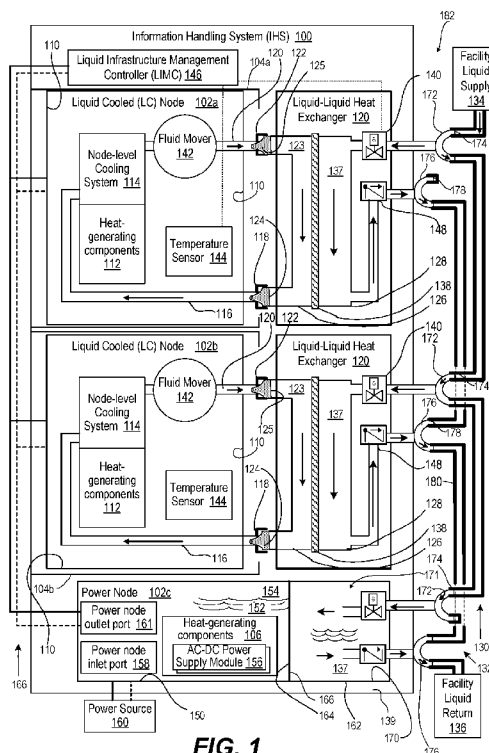


FIG. 1

(57) Abstract: A Rack Information Handling System (RIHS) has a liquid-to-liquid heat exchanger (LTLHE) that is received in a rear section of a rack and includes node-receiving supply port/s and return port/s. LTLHE includes a first liquid manifold extending between the node-receiving supply port/s and the node-receiving return port/s. LTLHE includes a second liquid manifold capable of being in sealed fluid connection to a supply conduit and a return conduit of a liquid cooling supply for fluid transfer of a second cooling liquid. LTLHE includes a transfer plate formed of thermally conductive material separating the first and second liquid manifolds for transferring heat from the first cooling liquid to the second cooling liquid. RIHS includes a node-receiving chassis configured to receive inserted liquid cooled nodes that sealingly engage for fluid transfer of the first liquid to LTLHE embedded in the rack for heat absorption and transfer by the second liquid.



Published:

— *with international search report (Art. 21(3))*

INFORMATION HANDLING SYSTEM HAVING FLUID MANIFOLD WITH EMBEDDED HEAT EXCHANGER SYSTEM

PRIORITY

[0001] The present invention claims priority from U.S. Patent Application Ser. No. 15/016,234, filed February 4, 2016 which is fully incorporated herein by reference.

BACKGROUND

1. Technical Field

[0002] The present disclosure generally relates to information handling systems (IHS), and more particular to removing heat from a direct-interface liquid cooled (DL) rack-configured IHS (RIHS) using a liquid-to-liquid heat exchanger.

2. Description of the Related Art

[0003] As the value and use of information continue to increase, individuals and businesses seek additional ways to process and store information. One option available to users is an Information Handling System (IHS). An IHS generally processes, compiles, stores, and/or communicates information or data for business, personal, or other purposes, thereby allowing users to take advantage of the value of the information. Technology and information handling needs and requirements vary between different users or applications. IHSs may vary regarding what information is handled, how the information is handled, how much information is processed, stored, or communicated, as well as how quickly and efficiently the information is processed, stored, or communicated. The variations in IHSs allow for IHSs to be general or configured for a specific user or specific use such as financial transaction processing, airline reservations, enterprise data storage, or global communications. In addition, IHSs may include a variety of hardware and software components that may be configured to process, store, and communicate information and may include one or more computer systems, data storage systems, and networking systems.

[0004] For implementations requiring a large amount of processing capability, a rack-configured (or rack) IHS (RIHS) can be provided. The RIHS includes a physical rack, within which is inserted a plurality of functional nodes, such as server (or processing) nodes/modules, storage nodes, and power supply nodes. These nodes, and particularly the

server nodes, typically include processors and other functional components that dissipate heat when operating and/or when connected to a power supply. Efficient removal of the heat being generated by these components is required to maintain the operational integrity of the RIHS. Traditional heat removal systems include use of air movers, such as fans, to convectionally transfer the heat from inside of the RIHS to outside the RIHS. More recently, some RIHS have been designed to enable submersion of the server modules and/or the heat generating components in a tank of cooling liquid to effect cooling via absorption of the heat by the surrounding immersion liquid.

[0005] The amount of processing capacity and storage capacity per node and/or per rack continues to increase, providing greater heat dissipation per node and requiring more directed cooling solutions. Extreme variations can exist in server/power/network topology configurations within an IT rack. In addition to dimension variations, the thermal requirements for heat-generating functional components for power, control, storage and server nodes can be very different between types or vary according to usage. These variations drive corresponding extreme diversity in port placement, fitting size requirements, mounting locations, and manifold capacity for a liquid cooling subsystem. Further, a chassis of each node is typically densely provisioned. Lack of space thus exists to mount a discrete water distribution manifold in high-power IT racks.

BRIEF SUMMARY

[0006] The illustrative embodiments of the present disclosure provides an Information Handling System (IHS) including a node-receiving chassis having a front access side and an opposing rear side. At least one liquid cooled (LC) node inserted into a bay of the node-receiving chassis. The LC node includes a node enclosure provisioned with at least one heat-generating component. The node enclosure is provisioned with an internal node-level liquid cooling system of conduits. The system includes at least one node supply conduit connected for fluid transfer to at least one supply conduit intake port. The system includes at least one node return conduit connected for fluid transfer to at least one return conduit output port. The at least one supply conduit intake and return conduit output ports are located at an inserted end of the node enclosure. The at least one supply conduit intake and

return conduit output ports are oriented toward the opposing rear side of the node-receiving chassis respectively enabling receipt of a first cooling liquid at a first temperature and return of the first cooling liquid at an increased temperature due to heat absorption within the node enclosure. A liquid-to-liquid heat exchanger (LTLHE) is positioned towards the rear side of the node-receiving chassis. LTLHE includes at least one node-receiving supply port and at least one node-receiving return port oriented facing the opposing rear side of the chassis. The node-receiving supply and return ports enable sealed engagement, for first cooling liquid transfer, to the at least one supply conduit intake port and from the at least one return conduit output port of the at least one LC node. LTLHE includes a first liquid manifold extending between the at least one node-receiving supply port and the at least one node-receiving return port. The first liquid manifold is in sealed fluid connection to the intake and output ports of the node-level liquid cooling system of conduits. The first liquid manifold provides a first liquid cooling loop for continuous flow of the first liquid through the at least one LC node and through the first liquid manifold. A second liquid manifold is capable of being in sealed fluid connection to a supply conduit and a return conduit of a liquid cooling supply for fluid transfer of a second cooling liquid. A transfer plate formed of thermally conductive material separates the first and second liquid manifolds for transferring heat from the first cooling liquid to the second cooling liquid.

[0007] According to one aspect, the present disclosure provides a Rack Information Handling System (RIHS) that includes a rack having one or node-receiving bays. An LTLHE is received in a rear section of the rack. The LTLHE includes at least one node-receiving supply port and at least one node-receiving return port. The LTLHE includes a first liquid manifold extending between the at least one node-receiving supply port and the at least one node-receiving return port. The LTLHE includes a second liquid manifold capable of being in sealed fluid connection to a supply conduit and a return conduit of a liquid cooling supply for fluid transfer of a second cooling liquid. The LTLHE includes a transfer plate formed of thermally conductive material and separating the first and second liquid manifolds for transferring heat from the first cooling liquid to the second cooling liquid. A node-receiving chassis has a front access side and an opposing rear side and having a bay configured to receive an inserted at least one LC node. LC node includes a node enclosure provisioned with at least one heat-generating component. An internal node-

level liquid cooling system of conduits includes at least one node supply conduit connected for fluid transfer to at least one supply conduit intake port and at least one node return conduit connected for fluid transfer to at least one return conduit output port. The at least one supply conduit intake and return conduit output ports are located at an inserted end of the node enclosure and oriented toward the opposing rear side of the node-receiving chassis. The supply conduit intake and return conduit output ports sealingly engage for fluid transfer respectively at least one node-receiving supply port and at least one node-receiving return port. The supply conduit intake and return conduit output ports enable receipt of a first cooling liquid at a first temperature and return of the first cooling liquid at an increased temperature due to heat absorption within the first liquid manifold.

[0008] According to one aspect, the present disclosure provides a power node including a power node enclosure receivable in a power node-receiving bay of a rack. The power node enclosure is sealed to contain immersion cooling liquid. The power node enclosure is provisioned with at least one heat generating component that receives, converts, and/or distributes electrical power for use by other nodes within the RIHS. A power node inlet port and at least one power distribution outlet port respectively receives facility power and distributes power to the internal RIHS components. At least one liquid to liquid heat transfer mechanism has a first surface that is impinged upon by a volume of at least one of the immersion cooling liquid and immersion cooling liquid vapor. The at least one liquid to liquid heat transfer mechanism has a second surface that receives a flow of a second cooling liquid via a liquid manifold providing a system of conduits. The system of conduits is sealably engaged to the supply and return conduits of the liquid cooling supply to enable a flow of the second cooling liquid manifold to absorb heat from the power node enclosure.

[0009] According to one aspect, the present disclosure provides a method of assembling an RIHS. In one or more embodiments, the method includes mounting in a rack a node-receiving chassis having a front access side and an opposing rear side. The method includes attaching in a rear section of the rack the LTLHE. The method includes inserting the at least one LC node into a bay of the node-receiving chassis.

[0010] According to one aspect, the present disclosure provides a method of assembling an RIHS. The method includes inserting one or more nodes containing electrical power consuming components into one or node-receiving bays of a rack. The method includes

inserting into the rack a power node having a power node enclosure sealed to contain immersion cooling liquid and provisioned with at least one heat generating component. The method includes electrically connecting a power node inlet port and at least one power distribution outlet port of the power node to rack electrical power distribution components. The power node inlet port and at least one power distribution outlet port respectively receives facility power and distributes power to the internal IHS components. The method includes sealingly engaging for fluid transfer at least one liquid to liquid heat transfer mechanism. The liquid to liquid heat transfer mechanism has a first surface that is impinged upon by a volume of at least one of the immersion cooling liquid and immersion cooling liquid vapor. The liquid to liquid heat transfer mechanism has a second surface that receives a flow of a second cooling liquid via a liquid manifold. The liquid manifold provides a system of conduits that is sealably engaged to the supply and return conduits of the liquid cooling supply. The sealing engagement enables a flow of the second cooling liquid manifold to absorb heat from the power node enclosure.

[0011] The above presents a general summary of several aspects of the disclosure in order to provide a basic understanding of at least some aspects of the disclosure. The above summary contains simplifications, generalizations and omissions of detail and is not intended as a comprehensive description of the claimed subject matter but, rather, is intended to provide a brief overview of some of the functionality associated therewith. The summary is not intended to delineate the scope of the claims, and the summary merely presents some concepts of the disclosure in a general form as a prelude to the more detailed description that follows. Other systems, methods, functionality, features and advantages of the claimed subject matter will be or will become apparent to one with skill in the art upon examination of the following figures and detailed written description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The description of the illustrative embodiments can be read in conjunction with the accompanying figures. It will be appreciated that for simplicity and clarity of illustration, elements illustrated in the figures have not necessarily been drawn to scale. For example, the dimensions of some of the elements are exaggerated relative to other elements.

Embodiments incorporating teachings of the present disclosure are shown and described with respect to the figures presented herein, in which:

[0013] FIG. 1 illustrates a side perspective view of an internal layout/configuration of an example Liquid-Cooled (LC) Information Handling System (IHS) that utilizes an embedded Liquid-to-Liquid Heat Exchanger (LTLHE), according to one or more embodiments;

[0014] FIG. 2 illustrates a side perspective view of an internal layout/configuration of another example LC IHS that utilizes an embedded LTLHE, according to one or more embodiments;

[0015] FIG. 3 illustrates a detailed block diagram of a Direct-Interface Liquid-Cooled (DL) Rack Information Handling System (RIHS) configured with LC nodes arranged in blocks and which are cooled in part by a liquid cooling system having a liquid rail comprised of Modular Liquid Distribution (MLD) conduits, and in part by block liquid manifolds for some LC nodes and in part by liquid-to-liquid heat exchangers (LTLHEs), according to multiple embodiments;

[0016] FIG. 4 illustrates a front perspective view of an example DL RIHS, according to one or more embodiments;

[0017] FIG. 5 illustrates a rear perspective view of the example DL RIHS of **FIG. 4** with a louvered rear door in an open position to expose an example liquid rail, according to one or more embodiments;

[0018] FIG. 6 illustrates a right side perspective view of the example block of LC nodes and a corresponding LTLHE configured for open-loop cooling liquid distribution, according to one or more embodiments;

[0019] FIG. 7 illustrates a perspective detail view of the LTLHE of **FIG. 6**, according to one or more embodiments;

[0020] FIG. 8 illustrates a right side perspective view of the assembled LTLHE of **FIG. 6**, according to one or more embodiments;

[0021] FIG. 9 illustrates a right side perspective view of a disassembled LTLHE of **FIG. 6**, according to one or more embodiments;

[0022] FIG. 10 illustrates a right side view of the disassembled LTLHE of **FIG. 9**, according to one or more embodiments;

[0023] FIG. 11 illustrates a flow diagram of a method of assembling a DL RIHS that utilizes LTLHEs for cooling LC nodes, according to one or more embodiments;

[0024] FIG. 12 illustrates a flow diagram of a method of assembling a DL RIHS that utilizes an immersion-cooled power node, according to one or more embodiments;

[0025] FIG. 13 illustrates a front-angled perspective view of an immersion Power Distribution Unit (PDU), according to one or more embodiments;

[0026] FIG. 14 illustrates a rear perspective view of the immersion PDU of **FIG. 13**, according to one or more embodiments;

[0027] FIG. 15 illustrates a rear perspective view of the immersion PDU of **FIG. 13** with a top panel removed to expose a liquid-to-liquid heat exchanger and supply piping, according to one or more embodiments;

[0028] FIG. 16 illustrates a top perspective view of the immersion PDU of **FIG. 15**, with a top panel and heat exchanger removed to expose the internal power devices, according to one or more embodiments;

[0029] FIG. 17 provides a second internal view of the power devices and supply piping of the immersion PDU of **FIG. 16**, with a rear panel having a main power supply connector and power distribution outlets, and supply and return connectors embedded therein, according to one or more embodiments; and

[0030] FIG. 18 is a side cross-sectional view of the immersion PDU of **FIG. 13**, with cooling fluid convection loops illustrated by arrows, according to one or more embodiments.

DETAILED DESCRIPTION

[0031] A Rack Information Handling System (RIHS) has a liquid-to-liquid heat exchanger (LTLHE) that is received in a rear section of a rack and includes node-receiving supply port/s and return port/s. LTLHE includes a first liquid manifold extending between the node-receiving supply port/s and the node-receiving return port/s. LTLHE includes a second liquid manifold capable of being in sealed fluid connection to a supply conduit and a return conduit of a liquid cooling supply for fluid transfer of a second cooling liquid. LTLHE includes a transfer plate formed of thermally conductive material separating the

first and second liquid manifolds for transferring heat from the first cooling liquid to the second cooling liquid. RIHS includes a node-receiving chassis configured to receive inserted liquid cooled nodes that sealingly engage for fluid transfer of the first liquid to LTLHE embedded in the rack for heat absorption and transfer by the second liquid.

[0032] In the following detailed description of exemplary embodiments of the disclosure, specific exemplary embodiments in which the disclosure may be practiced are described in sufficient detail to enable those skilled in the art to practice the disclosed embodiments. For example, specific details such as specific method orders, structures, elements, and connections have been presented herein. However, it is to be understood that the specific details presented need not be utilized to practice embodiments of the present disclosure. It is also to be understood that other embodiments may be utilized and that logical, architectural, programmatic, mechanical, electrical and other changes may be made without departing from general scope of the disclosure. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present disclosure is defined by the appended claims and equivalents thereof.

[0033] References within the specification to “one embodiment,” “an embodiment,” “embodiments”, or “one or more embodiments” are intended to indicate that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. The appearance of such phrases in various places within the specification are not necessarily all referring to the same embodiment, nor are separate or alternative embodiments mutually exclusive of other embodiments. Further, various features are described which may be exhibited by some embodiments and not by others. Similarly, various requirements are described which may be requirements for some embodiments but not other embodiments.

[0034] It is understood that the use of specific component, device and/or parameter names and/or corresponding acronyms thereof, such as those of the executing utility, logic, and/or firmware described herein, are for example only and not meant to imply any limitations on the described embodiments. The embodiments may thus be described with different nomenclature and/or terminology utilized to describe the components, devices, parameters, methods and/or functions herein, without limitation. References to any specific protocol or proprietary name in describing one or more elements, features or concepts of the

embodiments are provided solely as examples of one implementation, and such references do not limit the extension of the claimed embodiments to embodiments in which different element, feature, protocol, or concept names are utilized. Thus, each term utilized herein is to be given its broadest interpretation given the context in which that terms is utilized.

[0035] As utilized herein, the term “rack-configured” (as in RIHS) generally refers to the configuration of a large scale sever system within a physical rack having multiple chassis receiving rails for receiving specific sizes of information technology (IT) nodes, such as server modules, storage modules, and power modules. The term node generally refers to each separate unit inserted into a 1U or other height rack space within the rack. In one embodiment, operational characteristics of the various IT nodes can be collectively controlled by a single rack-level controller. However, in the illustrated embodiments, multiple nodes can be arranged into blocks, with each block having a separate block-level controller that is communicatively connected to the rack-level controller.

[0036] For purposes of this disclosure, an information handling system (defined at the individual server level) may include any instrumentality or aggregate of instrumentalities operable to compute, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, an information handling system may be a personal computer, a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price. The information handling system may include random access memory (RAM), one or more processing resources such as a central processing unit (CPU) or hardware or software control logic, ROM, and/or other types of nonvolatile memory. Additional components of the information handling system may include one or more disk drives, one or more network ports for communication with external devices as well as various input and output (I/O) devices, such as a keyboard, a mouse, and a video display. The information handling system may also include one or more buses operable to transmit communications between the various hardware components.

[0037] As illustrated by the figures and described herein, multiple processing servers or server IHSs (referred to herein as server nodes) can be included within the single RIHS. Certain aspects of the disclosure then relate to the specific LC (sever or other) nodes and

the functionality associated with these individual nodes or block-level groupings of nodes, while other aspects more generally relate to the overall DL RIHS containing all of the LC nodes.

[0038] As one design detail/aspect for the present innovation, consideration is given to the fact that extreme variations can exist in server/power/network topology configurations within an IT rack. In addition to dimension variations, the thermal requirements for heat-generating functional components for power, control, storage and server nodes can be very different between types or vary according to usage. The present disclosure addresses and overcomes the challenges with distributing liquid cooling fluids throughout an IT rack having nodes with a large number of variations in distribution components.

[0039] In addition to direct-interfacing of liquid cooling to the primary heat generating components of the rack such as the processor, the present disclosure also includes additional consideration for cooling of secondary equipment and auxiliary components within the rack utilizing fluid-to-fluid heat exchanger methodology. Additionally, the present disclosure provides a modular approach to utilizing an air-to-liquid heat exchanger with quick connection and scalability to allow the solution to be scalable in both 1U and 2U increments.

[0040] **FIG. 1** illustrates an Information Handling System (IHS) **100** that includes liquid cooled (LC) nodes **102a – 102b** and an immersion-cooled power node **102c** (collectively “nodes” **102**). The LC nodes **102a – 102b** are respectively received in node-receiving chasses **104a – 104b** each having a front access side and an opposing rear side. A node enclosure **110** of each LC node **102a – 102b** is provisioned with heat-generating component/s **112** and an internal node-level LC system **114** of conduits. The LC system **114** includes node supply conduit/s **116** connected for fluid transfer to supply conduit intake port/s **118**. The LC system **114** includes node return conduit/s **120** connected for fluid transfer to return conduit output port/s **122**. The supply conduit intake and return conduit output ports **118, 122** are located at an inserted end of the node enclosure **110** and are oriented toward the opposing rear side of the node-receiving chassis **104a – 104b** respectively. The supply conduit intake and return conduit output ports **118, 122** respectively enable receipt of a first cooling liquid **123** at a first temperature and return of the first cooling liquid **123** at an increased temperature due to heat absorption within the

node enclosure **110**. A liquid-to-liquid heat exchanger (LTLHE) **120** is positioned towards the rear side of each node-receiving chassis **104a – 104b**.

[0041] Each LTLHE **120** includes node-receiving supply port/s **124** and node-receiving return port/s **125** that are oriented facing the opposing rear side of the chassis **104a – 104b** to enable sealed engagement, for first cooling liquid transfer, to the supply conduit intake port/s **116** and from the return conduit output port/s **118** of the respective LC node **102a – 102b**. A first liquid manifold **126** extends between the node-receiving supply port/s **124** and the node-receiving return port/s **118**. The first liquid manifold **126** is engageably in sealed fluid connection to the intake and output ports **118, 122** of the node-level LC system **114** of conduits to provide a first liquid cooling loop for continuous flow of the first liquid through the at least one LC node **102a – 102b** and through the first liquid manifold **126**. A second liquid manifold **128** is capable of being in sealed fluid connection to a supply conduit **130** and a return conduit **132** of a liquid cooling supply, such as a facility liquid supply **134** and a facility liquid return **136**, for fluid transfer of a second cooling liquid **137**. A transfer plate **138** is formed of thermally conductive material. The transfer plate **138** separates the first and second liquid manifolds **126, 128** for transferring heat from the first cooling liquid to the second cooling liquid **137**.

[0042] In one or more embodiments, nodes **102** are received in a block chassis **104a – 104b** that are mounted to, or that is integral to, a rack **139**. A dynamic control valve **140** can dynamically regulate liquid flow through the second liquid manifold **128** of the LTLHE **120**. A fluid mover **142**, such as a pump on a cold plate, can dynamically regulate liquid flow through the first liquid manifold **126**. Sensor/s **144** that detect intake, internal or exhausted temperatures, moisture levels, or liquid pressure are positioned to detect a temperature within the nodes **102**. A liquid infrastructure management controller (LIMC) **146** is in communication with the sensor/s **144** and the dynamic control valve **140** to control an amount of liquid flow in response to the temperature detected by the sensor/s **144**. A check valve **148** can prevent backflow into the second liquid manifold **128**.

[0043] The power node **102c** has a power node enclosure **150** sealed to contain immersion cooling liquid/s **152**, such as a dielectric liquid, and immersion cooling liquid vapor **154**. The power node enclosure **150** is provisioned with heat generating component/s **112** that include redundant AC-to-DC power supply modules **156**. The redundant AC-to-DC power

supply modules **156** has a power node inlet port **158** that receives AC electrical power from a power source **160**, such as a facility electrical circuit. The redundant AC-to-DC power supply modules **156** has power distribution outlet port/s **161** that distributes DC electrical power for use by other nodes **102 a – 102b** within the IHS **100**. The power node **102c** includes a liquid-to-liquid heat transfer mechanism **162** that has a first surface **164** that is impinged upon by a volume of the immersion cooling liquid/s **152** and immersion cooling liquid vapor **154** and a second surface **166** that receives a flow of a second cooling liquid **137**, such as facility water, via a liquid manifold **170**. The liquid manifold **170** provides a system **171** of conduits that is sealably engaged to the supply and return conduits **130, 132** of the liquid cooling supply provided by facility liquid supply and return **134, 136**. The liquid manifold **170** enables a flow of the second cooling liquid **137** to absorb heat from the power node enclosure **150**.

[0044] In one or more embodiments, the second liquid manifold **128** of the LTLHE **120** and the liquid manifold **170** of the liquid-to-liquid heat transfer mechanism **162** of the power node **102c** each include a supply bypass tube **172** terminating in the two supply connections **174** and a return bypass tube **176** terminating in two return connections **178**. The dynamic control valve **140** directs a portion of the second cooling liquid **137** from the supply bypass tube **172** to the node-receiving input port/s **125**. The check valve **148** allows forward flow only of the cooling liquid that has absorbed heat from the heat-generating component/s **112** from the node **102** back to return bypass tube **176**. In one or more embodiments, the supply and return conduits **130, 132** can be Modular Liquid Distribution (MLD) conduits **180** to connect in succession respectively the supply bypass tubes **172, 176** to form a liquid rail **182**.

[0045] In one or more embodiments, a liquid rail can include a series of secondary conduits, such as supply divert conduit and return divert conduit that provides a by-pass fluid path for each of MLD conduits **180**. In operation, divert conduit/s allow for the removal of corresponding MLD conduit **180**, thus removing the flow of cooling liquid to the particular block of nodes, without interrupting the flow of cooling liquid to the other surrounding blocks of computer gear. For example, a particular MLD conduit **180** can be replaced due to a leak. For another example, a block liquid manifold **128** can be replaced. The inclusion of divert conduits thus enables rapid servicing and maintenance of block

liquid manifold **128** and/or nodes within block chassis without having to reconfigure the MLD conduits **180**. In addition, the IHS **100** can continue operating as cooling liquid continues to be provided to the remainder of the blocks that are plugged into the liquid rail. Re-insertion of the MLD conduit **180** then reconnects the flow of cooling liquid to the block for normal cooling operations, and shuts off the diverted flow of cooling liquid. In an exemplary embodiment, the MLD conduits **180** provide a quick disconnect feature that interrupts flow when not fully engaged to a respective ports. Disconnection of an MLD conduit **180** interrupts flow in a primary portion of the liquid rail for either supply or return, shifting flow through one or more divert conduits to provide cooling liquid to the other block liquid manifolds **120**. In one or more embodiments, a manual or active shutoff valve can interrupt flow on either or both of the primary or divert portions of the liquid rail.

[0046] FIG. 2 depicts an example IHS **200** having components an LC power node **202b** inserted into the node-receiving chassis **104b**. Liquid cooling is provided by an LTLHE **120** rather than being integral to a power node enclosure **250**.

[0047] FIG. 3 depicts an example RIHS **300** having illustrative example of LC nodes **302a** – **302j** (collectively refer to as nodes **302**), with each nodes **302a** – **302i** having a node enclosure **304** provisioned with heat-generating components **306**. RIHS **300** includes a power node **302i** that is also liquid cooled. Additionally, RIHS **300** also includes an infrastructure node **302j** and liquid filtration node **302k**, which do not necessarily include heat-generating components **306** that require liquid cooling, as the other LC nodes **302a** – **302i**. A Direct-Interface Liquid Cooling (DL) subsystem (generally shown as being within the RIHS **300** and labelled herein as **308**) can be utilized for cooling the nodes **302** via an internal node-level system **309** of conduits. In the illustrative embodiments, nodes **302a** – **302d** receive cooling liquid from a DL subsystem **308** via block liquid manifolds (BLM) **310** that are received in a rear section of a rack **312**. Additional structural features associated with the allocation of liquid flow to a BLM **310** are provided in related patent applications Docket No. *106280.01*, whose content has been incorporated herein by reference.

[0048] LC nodes **302a** – **302d** include other components **314** that are not necessarily heat generating, but which are exposed to the same ambient heat conditions as the heat-generating components **306** by virtue of their location within the node enclosure **304**. In

one embodiment, these other components **314** can be sufficiently cooled by the direct-interface liquid cooling methodology applied to the node **302a – 302d** and/or using forced or convective air movement, as described later herein. Each node **302** is supported and protected by a respective node enclosure **304**. Nodes **302a – 302d** are further received in node receiving bays **316** of a first block chassis **319a** of a first block **320a**. Nodes **302e – 302h** are received in a second block chassis **319b** of a second block **320b**. (Blocks **320a–320b** are collectively referred to as blocks **320**.) In the illustrative embodiments, the nodes **302** are vertically arranged. In one or more alternate embodiments, at least portions of the nodes **302** (and potentially all of the nodes) may also be arranged horizontally while benefitting from aspects of the present innovation.

[0049] LC nodes **302e – 302i** receive secondary cooling liquid from the DL subsystem **308** via a corresponding LTLHE **318** according to aspects of the present disclosure. LC nodes **302e – 302h** are connected to a liquid rail **324** of the RIHS **300** by MLD conduits **328**. LC nodes **302e – 302i** include a fluid mover **330** to recirculate the first cooling liquid through the respective LTLHE **318**.

[0050] The power node **302i** has heat-generating components such as redundant AC-DC power supply modules **306a** that are immersed for cooling in a dielectric liquid. The AC-DC power supply modules **306a** receive AC power via a power node inlet port **334** from a power source **336**. The AC-DC power supply modules **306a** distributes DC power via a power node outlet port **338** over rack electrical distribution components **340** to other nodes **302a – 302i, 302j– 302k**. The dielectric liquid is liquid cooled by cooling liquid from the DL subsystem **308** via a liquid-to-liquid heat exchanger (LTLHE) **342**.

[0051] The present innovation is not limited to any specific number or configuration of nodes **302** or blocks **320a, 320b** in a rack **312**. According to one aspect, nodes **302** can be of different physical heights of form factors (e.g., 3U, 3.5U, 2U), and the described features can also be applied to nodes **302** having different widths and depths (into the rack), with some extensions made and/or lateral modifications to the placement of cooling subsystem conduits, as needed to accommodate the different physical dimensions. As a specific example, power node **302i** is depicted as having a larger node enclosure **304a** (with corresponding different dimensions of AC-DC power supply modules **306a**) of a different number of rack units in physical height (e.g., 2U) that differs from the heights (e.g., 3U) of

the other nodes **302a – 102h** and **302j – 302k**. RIHS **300** can include blocks **320** or nodes **302** selectably of a range of discrete rack units. Also, different types of Information Technology (IT) components can be provided within each node **302**, with each node possibly performing different functions within RIHS **300**. Thus, for example, a given node **302** may include one of a server module, a power module, a control module, or a storage module. In a simplest configuration, the nodes **302** can be individual nodes operating independent of each other, with the RIHS **300** including at least one rack-level controller (RC) **342** for controlling operational conditions within the RIHS **300**, such as temperature, power consumption, communication, and the like. Each node **302** is then equipped with a node-level controller (NC) **344** that communicates with the rack-level controller **342** to provide localized control of the operational conditions of the node **302**. In the more standard configuration of a DL RIHS **300**, and in line with the described embodiments, RIHS **300** also includes block-level controllers (BCs) **346**, communicatively coupled to the rack-level controller **342** and performing block-level control functions for the LC nodes **302** within the specific block **320**. In this configuration, the nodes **302** are arranged into blocks **320**, with each block **320** having one or more nodes **302** and a corresponding block-level controller **346**. Note the blocks **320** do not necessarily include the same number of nodes **302**, and a block **320** can include a single node **302**, in some implementations.

[0052] DL subsystem **308** provides direct-interface liquid cooling to heat-generating components **306** via a liquid rail **324** under the control of the rack-level controller **342**, block-level controllers **346**, and/or node-level controllers **344**, in some embodiments. Rack-level controller **342** controls a supply valve **350**, such as a solenoid valve, to allow cooling liquid, such as water, to be received from a facility liquid supply **352**. The cooling liquid is received from facility liquid supply **352** and is passed through liquid filtration node **302k** before being passed through supply conduit **354** of liquid rail **324**. Each block **320a**, **320b** receives a dynamically controlled amount of the cooling liquid via block-level dynamic control valve **356**, such as a proportional valve. Return flow from each block **320a**, **320b** can be protected from backflow by block-level check valve **333**. The individual needs of the respective nodes **302a – 302d** of block **320a** can be dynamically provided by respective node-level dynamic control valves **358**, controlled by the block-level controller **346**, which control can, in some embodiments, be facilitated by the node-level controllers **344**. In

addition to allocating cooling liquid in accordance with cooling requirements (which can be optimized for considerations such as performance and economy), each of the supply valve **350** and/or dynamic control valves **356**, **358** can be individually closed to mitigate a leak. A check valve **360** is provided between each node **302a – 302h** and **302j** and a return conduit **362** of the liquid rail **324** to prevent a backflow into the nodes **302a – 302h** and **302j**. The return conduit **362** returns the cooling liquid to a facility liquid return **364**.

[0053] To support the temperature control aspects of the overall system, RIHS **300** includes temperature sensors **366** that are each located within or proximate to each node **302a-302k**, with each temperature sensor **366** connected to the node-level controller **344** and/or the corresponding block-level controller **346**. Temperature sensors **366** operate in a feedback control loop of the DL subsystem **308** to control the amount of liquid flow required to cool the nodes **302a – 302h** and **302j**. In one or more embodiments, the rack-level controller **342** can coordinate performance constraints to block-level controllers **346** and/or node-level controllers **344** that limit an amount of heat generated by the heat-generating components **306** to match a heat capacity of the flow of cooling liquid in DL subsystem **308**. Alternatively or in addition, the rack-level controller **342** can coordinate cooling levels to block-level controllers **346** and/or node-level controllers **344** that in turn control the dynamic control valves **356**, **358** for absorption and transfer of the heat generated by the heat-generating components **306** by the DL subsystem **308**. In one or more embodiments, support controllers such as an LIMC **368** can perform management and operational testing of DL subsystem **308**. LIMC **368** can monitor pressure sensors **370** and liquid sensors **373** to detect a leak, to validate operation of a dynamic control valves **356**, **358** or shut-off valves such as supply valve **350**. LIMC **368** can perform close-loop control of specific flow rates within the RIHS **300**.

[0054] Temperature monitoring controls are provided to ensure that sufficient volume and flow rate of cooling liquid are provided to properly cool any exhaust air and maintain node **302** at a desired operating temperature (or within a desired operating temperature range). In one embodiment, the temperature and volume of cooling liquid from the facility liquid supply **350** is determined based on measurements and testing and/or empirical calculations to provide adequate cooling for the operational requirements of the RIHS **300**. In one or more embodiments, at least the volume of the cooling liquid is dynamically controlled to

more closely approximate the cooling requirements of RIHS **300** and/or at least any air-cooled node **302j** at a given time. In the illustrative embodiment, a first temperature sensor **366a** is positioned to detect an air temperature of a selected one of an air intake and air exhaust of a node **302**. Second temperature sensor **366b** is positioned to detect an air temperature within the node **302**. LIMC **368** is in communication with first and second temperature sensors **366a**, **366b** and with dynamic control valve **356** and LIMC **368** can dynamically adjust a volume of cooling liquid based at least in part on a difference between the detected air temperatures.

[0055] In at least one alternate embodiment, LIMC **368** is coupled to and receives the detected temperature readings from a node controller and/or a block controller that in turn is coupled to first temperature sensor **366a** and second temperature sensor **366b**. LIMC **368** and/or one of the other controllers generates a control signal that is sent to a pulse width modulation (PWM) circuit (not shown), which is coupled to dynamic control valve **356**. In response to receipt of the control signal, PWM circuit in turn generates a PWM signal that can control the open position of dynamic control valve **356**. The PWM signal adjusts the open position of dynamic control valve **356**, and the open position of the valve determines (and can be used to regulate) the amount (or rate) of cooling liquid that flows through dynamic control valve **356**. For rack-level valve control, LIMC **368** triggers a specific value of the PWM signal based on a rack level determination that can include consideration of available (un-allocated or reclaimed) volume of liquid flow across the RIHS **300** and other factors. LTLHE **318** can be configured as a single node LTLHE or a block level LTLHE supporting multiple adjacent nodes within a block chassis **319** of RIHS **300**, and the flow control aspects described as being provided by LIMC **368** can also be provided by a block level controller, in one or more embodiments. Additional control features associated with the allocation of liquid flow to LTLHE **318** are provided in related patent applications *Docket Nos. 106460.01* and *106284.01*, whose content are incorporated herein by reference.

[0056] FIGs. 4 – 5 illustrate a DL RIHS **400** that receives LC nodes **402** (FIG. 4) from a front side **404** of a rack **406** having a rack enclosure **408** formed in part by a top panel **410** (FIG. 5), side panels **412**, and a bottom panel (not shown). FIG. 5 illustrates a rear section **414** of the rack enclosure **408** that is accessible via a louvered door **416**. LTLHE **418** and

block liquid manifolds **420** support respective node-receiving bays **422**. Modular Liquid Distribution (MLD) conduits **424** form a supply conduit **426** and a return conduit **428** of a liquid rail **430**.

[0057] **FIGs. 6 – 7** illustrate an example block **600** of LC nodes **602** that are sealingly engaged to a LTLHE **604**. **FIGs. 6 – 10** illustrate that the LTLHE **604** includes a first liquid manifold **606**, a transfer plate **608**, and a second liquid manifold **610**. In one or more embodiments, a liquid rail **612** include supply and return conduits **614**, **616** that linearly attach to each other. Centerline supply and return hose connections **618**, **620** of the supply and return conduits **614**, **616** attach to supply and return connections **622**, **624** of the LTLHE **604**.

[0058] **FIG. 11** illustrates a method **1100** of assembling an RIHS that utilizes LTLHEs to cool LC nodes. In one or more embodiments, the method **1100** includes assembling the LTLHE that includes at least one node-receiving supply port and at least one node-receiving return port. The LTLHE includes a first liquid manifold extending between the at least one node-receiving supply port and the at least one node-receiving return port. The LTLHE includes a second liquid manifold capable of being in sealed fluid connection to a supply conduit and a return conduit of a liquid cooling supply for fluid transfer of a second cooling liquid. The LTLHE includes a transfer plate formed of thermally conductive material separating the first and second liquid manifolds for transferring heat from the first cooling liquid to the second cooling liquid (block **1102**). The method a flow diagram of a method of assembling a DL RIHS, according to one or more embodiments **1100** includes mounting in a rack a node-receiving chassis having a front access side and an opposing rear side (block **1104**). The method **1100** includes attaching in a rear section of the rack the LTLHE (block **1106**). The method **1100** includes provisioning a node enclosure of at least one LC node with at least one heat-generating component (block **1108**). The method **1100** includes attaching an internal node-level liquid cooling system of conduits to the node enclosure. The system includes at least one node supply conduit connected for fluid transfer to at least one supply conduit intake port and at least one node return conduit connected for fluid transfer to at least one return conduit output port (block **1110**). The method **1100** includes inserting the at least one LC node into a bay of the node-receiving chassis (block **1112**). The method **1100** includes sealingly engaging at least one supply

conduit intake and return conduit output ports located at an inserted end of the node enclosure and oriented toward the opposing rear side of the node-receiving chassis to the LTLHE (block **1114**). The sealing engagement enables receipt of a first cooling liquid at a first temperature and return of the first cooling liquid at an increased temperature due to heat absorption within the node enclosure. Then method **1100** ends.

[0059] **FIG. 12** illustrates method **1200** of assembling an RIHS that utilized an immersion-cooled power node. In one or more embodiments, the method **1200** includes inserting one or more nodes containing electrical power consuming components into one or node-receiving bays of a rack (block **1202**). The method **1200** includes inserting into the rack a power node having a power node enclosure sealed to contain immersion cooling liquid and provisioned with at least one heat generating component (block **1204**). The method **1200** includes electrically connecting to rack electrical power distribution components a power node inlet port and at least one power distribution outlet port of the power node that respectively receives facility power and distributes power to the internal IHS components (block **1206**). The method **1200** includes sealingly engaging for fluid transfer at least one liquid to liquid heat transfer mechanism having a first surface that is impinged upon by a volume of at least one of the immersion cooling liquid and immersion cooling liquid vapor. The at least one liquid to liquid heat transfer mechanism having a second surface that receives a flow of a second cooling liquid via a liquid manifold. The liquid manifold provides a system of conduits that is sealably engaged to the supply and return conduits of the liquid cooling supply to enable a flow of the second cooling liquid manifold to absorb heat from the power node enclosure (block **1208**). Then method **1200** ends.

[0060] In the above described flow chart of **FIGs. 11 – 12**, the methods may be embodied in an automated manufacturing system that performs a series of functional processes. In some implementations, certain steps of the method are combined, performed simultaneously or in a different order, or perhaps omitted, without deviating from the scope of the disclosure. Thus, while the method blocks are described and illustrated in a particular sequence, use of a specific sequence of functional processes represented by the blocks is not meant to imply any limitations on the disclosure. Changes may be made with regards to the sequence of processes without departing from the scope of the present disclosure. Use

of a particular sequence is therefore, not to be taken in a limiting sense, and the scope of the present disclosure is defined only by the appended claims.

[0061] RIHS receives high voltage AC (VAC) that is power converted down to a 12 volt DC (VDC) power by Power Supply Units (PSUs) within a Power Distribution Unit (PDU). The PSUs bridges the data center supply power to the type of power required by IT equipment within the RIHS. This power conversion creates a tremendous amount of heat. The amount of power that can be supplied by a Power Supply Unit (PSU) is limited by its ability to be cooled. Today, Direct Current Supply (DCS) is limited to 2000W maximum power from each PSU. Generally-known RIHSes include PSUs that are mounted to a rack in a server bay. For example, a generally-known RIHS can include 400V/240VAC 3-phase data center input power strip. A particular outlet of the power strip provides 240VAC 1-phase Power Distribution Unit (PDU) power output via electrical power cables to one server PSU of three server PSUs inserted in PSU bays of a server-sized PSU chassis.

[0062] **FIG. 13** illustrates an immersion PDU **1300** having a PDU chassis **1302** that is rack-unit dimensioned to be received in a server slot or bay of the RIHS **400** (**FIG. 4**). **FIG. 14** illustrates immersion PDU **1300** having liquid cooling and electrical interfaces on a back side **1304** of PDU chassis **1302**. Liquid cooling interfaces include left and right liquid supply connections **1306**, **1308** with a bypass feature. Liquid cooling interfaces include left and right liquid return connections **1310**, **1312** with a bypass feature. Electrical interfaces include three-phase (x, y, z) circuit breakers **1314**, an electrical cable **1316** that provides data center input power (e.g., 480VAC), and positive and negative direct current (DC) bus bars **1318**, **1320** that provide server output power (e.g., 12VDC) that can be distributed to multiple servers (i.e., functional nodes requiring power) of the RIHS **400** (**FIG. 4**). **FIG. 15** illustrates that the PDU chassis **1302** forms a sealed enclosure that contains a dielectric liquid **1322**. The dielectric liquid can be water and/or can be oil or some other liquid that is able to absorb a large amount of heat and quickly release that heat to a cooling source, such as a condenser or radiator. The cooling liquid received from the liquid supply connections **1306**, **1308** is kept separate from the dielectric liquid. The cooling liquid is directed through supply conduits **1323** to pass through a radiator **1324** that absorbs and removes heat from the dielectric liquid **1322**. The warmed cooling liquid is

directed from the radiator **1324** through return conduits **1326** to the liquid return connections **1310**, **1312**.

[0063] FIGs. **16 – 18** illustrate examples in which immersion PDU **1300** supports eighteen (18) server PSUs **1328** that are immersed in the dielectric liquid **1322** within the PDU chassis **1302**. The dielectric liquid **1322** is electrically non-conductive and can have roughly one thousand times the cooling capacity per unit of volume than air. In one embodiment, each server PSU **1328** converts 240VAC to 12 VDC used by functional computing components in the RIHS. With the cooling benefit of the immersion PDU **1300**, each server PSU **1328** can operate at 3000W for a total of 54,000 Watts maximum DC power output in the same volumetric footprint as generally-known PSUs without immersion cooling. FIG. **18** illustrates thermal flow within the immersive PDU **1300**. As heat is dissipated from the immersed PSUs **1328**, heat causes the local fluid (dielectric liquid **1322**) to expand, decrease density, and rise to the top of the enclosure (PDU chassis **1302**) due to free convection flow. The radiator **1324** at the top of the enclosure can use water from a facility cooling loop as a cooling liquid to absorb the heat from the dielectric liquid **1322**. According to one aspect, the process of heat removal can involve single phase heat transfer (i.e., dielectric liquid to cooling liquid) or dual phase heat transfer (i.e., liquid to gas and back to liquid). The nature of the heat transfer (e.g., single phase versus dual phase) can depend on the amount of heat being absorbed by the dielectric liquid from the heat generating power components. As the dielectric liquid **1322** cools, from being in contact with the embedded radiator **1324** providing the flow of cooling liquid flow and the exterior surface to facilitate heat transfer, the density of the cooled fluid (liquid or gas) increases, and the cooler liquid sinks to the bottom of the enclosure via free convection cooling. According to one aspect, the enclosure is passive, requiring no pumps or fans.

[0064] One or more of the embodiments of the disclosure described can be implementable, at least in part, using a software-controlled programmable processing device, such as a microprocessor, digital signal processor or other processing device, data processing apparatus or system. Thus, it is appreciated that a computer program for configuring a programmable device, apparatus or system to implement the foregoing described methods is envisaged as an aspect of the present disclosure. The computer program may be embodied as source code or undergo compilation for implementation on a processing

device, apparatus, or system. Suitably, the computer program is stored on a carrier device in machine or device readable form, for example in solid-state memory, magnetic memory such as disk or tape, optically or magneto-optically readable memory such as compact disk or digital versatile disk, flash memory, etc. The processing device, apparatus or system utilizes the program or a part thereof to configure the processing device, apparatus, or system for operation.

[0065] While the disclosure has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the disclosure. In addition, many modifications may be made to adapt a particular system, device or component thereof to the teachings of the disclosure without departing from the essential scope thereof. Therefore, it is intended that the disclosure not be limited to the particular embodiments disclosed for carrying out this disclosure, but that the disclosure will include all embodiments falling within the scope of the appended claims. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another.

[0066] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

[0067] The description of the present disclosure has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the disclosure in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope of the disclosure. The described embodiments were chosen and described in order to best explain the principles of the disclosure and the practical application, and to enable others of ordinary skill in the art to

understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS

What is claimed is:

1. An Information Handling System (IHS) comprising:
 - a node-receiving chassis having a front access side and an opposing rear side;
 - at least one liquid cooled (LC) node inserted into a bay of the node-receiving chassis, the LC node including a node enclosure provisioned with at least one heat-generating component and an internal node-level liquid cooling system of conduits comprising at least one node supply conduit connected for fluid transfer to at least one supply conduit intake port and at least one node return conduit connected for fluid transfer to at least one return conduit output port, the at least one supply conduit intake and return conduit output ports located at an inserted end of the node enclosure and oriented toward the opposing rear side of the node-receiving chassis respectively enabling receipt of a first cooling liquid at a first temperature and return of the first cooling liquid at an increased temperature due to heat absorption within the node enclosure; and
 - a liquid-to-liquid heat exchanger (LTLHE) positioned towards the rear side of the node-receiving chassis and comprising:
 - at least one node-receiving supply port and at least one node-receiving return port oriented facing the opposing rear side of the chassis to enable sealed engagement, for first cooling liquid transfer, to the at least one supply conduit intake port and from the at least one return conduit output port of the at least one LC node;
 - a first liquid manifold extending between the at least one node-receiving supply port and the at least one node-receiving return port, the first liquid manifold being in sealed fluid connection to the intake and output ports of the node-level liquid cooling system of conduits to provide a first liquid cooling loop for continuous flow of the first liquid through the at least one LC node and through the first liquid manifold;
 - a second liquid manifold capable of being in sealed fluid connection to a supply conduit and a return conduit of a liquid cooling supply for fluid transfer of a second cooling liquid; and

a transfer plate formed of thermally conductive material separating the first and second liquid manifolds for transferring heat from the first cooling liquid to the second cooling liquid.

2. The IHS of claim 1, wherein the node intake and output ports comprise multiple conduit connection affordances located at a rear of the node enclosure to enable sealed connection to the node-receiving supply and return ports of the first liquid manifold
3. The IHS of claim 1, wherein the node intake and output ports comprise a selected one of a male and a female quick connect couplings and the node-receiving supply and the return ports comprise corresponding one of a female and a male quick connect couplings, wherein the male and female quick connect couplings engageably mate and seal when brought together to allow for fluid transfer and are configured to automatically shutoff fluid passage in response to disengagement.
4. The IHS of claim 1, wherein the node enclosure further comprises a pump attached to the liquid cooling system of conduits and which pushes the first cooling liquid through the first cooling loop.
5. The IHS of claim 4, the LC node further comprising a cold plate placed in conductive contact with at least one heat generating component and over which liquid flow is directed via the system of conduits to enable absorption of heat from the cold plate.
6. The IHS of claim 1, further comprising a rack having one or more chasses for receiving nodes, wherein the LTLHE is received in a rear section of the rack and the supply conduit and the return conduit of the liquid cooling supply are provided at the rear section of the rack.
7. The IHS of claim 6, wherein the supply conduit and the return conduit of the liquid cooling supply respectively routes a directional flow of a second cooling liquid when the supply conduit is connected to a liquid supply, wherein the rack-level liquid cooling supply is a part of a rack-level cooling system having a cooling rail comprised of Modular Liquid Distribution

(MLD) conduits, where the supply conduit and the return conduit are respectively provided via respective supply and return MLD conduits, which sealably attach to corresponding supply and return ports of the second liquid manifold.

8. The IHS of claim 7, wherein the LTLHE comprises:

a supply bypass tube and a return bypass tube; and

a dynamic control valve that directs a portion of cooling liquid from the supply bypass tube through the LTLHE and to the return bypass tube;

the IHS further comprising one or more liquid cooling manifolds correspond to one or more LC nodes arranged in the rack where each liquid cooling manifolds includes a supply bypass tube and a return bypass tube connected to another adjacent node by MLD conduits, wherein a plurality of MLD conduits connected across a plurality of nodes form a liquid rail.

9. The IHS of claim 8, wherein the one or more or more liquid cooling manifolds comprises a selected one or more of: an LTLHE; a block liquid manifold that supplies direct-interface liquid cooling to the corresponding one or more LC nodes; and an ATLHE that cools exhaust air from corresponding air cooled one or more nodes.

10. The IHS of claim 7, wherein the supply and return ports of the second liquid manifold of the LTLHE each comprise a selected one of a male and a female quick connect couplings and the MLD conduits comprise corresponding one of a female and a male quick connect couplings, wherein the male and female quick connect couplings engageably mate and seal when brought together to allow for fluid transfer and are configured to automatically shutoff fluid passage in response to disengagement.

11. The IHS of claim 7, wherein the second liquid manifold comprises heat exchanger intake connection and output ports comprise a selected one of a male and a female quick connect couplings and the node-receiving supply and the return ports comprise corresponding one of a female and a male quick connect couplings, wherein the male and female quick connect couplings engageably mate and seal when brought together to allow for fluid transfer and are configured to automatically shutoff fluid passage in response to disengagement.

12. The IHS of claim 6, further comprising a power node received in a power node-receiving bay of the rack, the power node comprising:

a power node enclosure sealed to contain immersion cooling liquid and provisioned with at least one heat generating component that receives and distributes electrical power for use by other nodes within the IHS;

a power node inlet port and at least one power distribution outlet port that respectively receives facility power and distributes power to internal IHS components; and

at least one liquid to liquid heat transfer mechanism having a first surface that is impinged upon by a volume of at least one of the immersion cooling liquid and immersion cooling liquid vapor and a second surface that receives a flow of a second cooling liquid via a liquid manifold providing a system of conduits that is sealably engage to the supply and return conduits of the liquid cooling supply to enable a flow of the second cooling liquid manifold to absorb heat from the power node enclosure.

13. The IHS of claim 12, wherein:

the power node further comprises redundant AC-to-DC power supply modules;

the immersion cooling liquid comprises a liquid dielectric coolant;

the power node inlet port comprises an AC input; and

at least one power distribution outlet port comprises a DC output.

14. The IHS of claim 1, wherein the at least one LC node comprises a power node received in a node-receiving bay of the rack, the power node comprising:

a power node enclosure sealed to contain immersion cooling liquid and provisioned with at least one heat generating component that receives and distributes electrical power for use by other nodes within the IHS; and

a power node inlet port and at least one power distribution outlet port that respectively receives facility power and distributes power to the internal IHS components.

15. A Rack Information Handling System (RIHS) comprising:

a rack having one or node-receiving bays;

a liquid-to-liquid heat exchanger (LTLHE) received in a rear section of the rack, the LTLHE comprising:

at least one node-receiving supply port and at least one node-receiving return port;

a first liquid manifold extending between the at least one node-receiving supply port and the at least one node-receiving return port;

a second liquid manifold capable of being in sealed fluid connection to a supply conduit and a return conduit of a liquid cooling supply for fluid transfer of a second cooling liquid; and

a transfer plate formed of thermally conductive material separating the first and second liquid manifolds for transferring heat from the first cooling liquid to the second cooling liquid; and

a node-receiving chassis having a front access side and an opposing rear side and having a bay configured to receive an inserted at least one liquid cooled (LC) node including a node enclosure provisioned with at least one heat-generating component and an internal node-level liquid cooling system of conduits comprising at least one node supply conduit connected for fluid transfer to at least one supply conduit intake port and at least one node return conduit connected for fluid transfer to at least one return conduit output port, the at least one supply conduit intake and return conduit output ports located at an inserted end of the node enclosure and oriented toward the opposing rear side of the node-receiving chassis to sealingly engage for fluid transfer respectively at least one node-receiving supply port and at least one node-receiving return port enabling receipt of a first cooling liquid at a first temperature and return of the first cooling liquid at an increased temperature due to heat absorption within the first liquid manifold.

16. The RIHS of claim 15, wherein:

the power node further comprises redundant AC-to-DC power supply modules;

the immersion cooling liquid comprises a liquid dielectric coolant;

the power node inlet port comprises an AC input; and

at least one power distribution outlet port comprises a DC output.

17. A method of assembling a Rack Information Handling System (RIHS), the method comprising:

mounting in a rack a node-receiving chassis having a front access side and an opposing rear side;

attaching in a rear section of the rack a liquid-to-liquid heat exchanger (LTLHE) comprising:

at least one node-receiving supply port and at least one node-receiving return port;

a first liquid manifold extending between the at least one node-receiving supply port and the at least one node-receiving return port;

a second liquid manifold capable of being in sealed fluid connection to a supply conduit and a return conduit of a liquid cooling supply for fluid transfer of a second cooling liquid; and

a transfer plate formed of thermally conductive material separating the first and second liquid manifolds for transferring heat from the first cooling liquid to the second cooling liquid;

inserting at least one liquid cooled (LC) node into a bay of the node-receiving chassis, the LC node including a node enclosure provisioned with at least one heat-generating component and an internal node-level liquid cooling system of conduits comprising at least one node supply conduit connected for fluid transfer to at least one supply conduit intake port and at least one node return conduit connected for fluid transfer to at least one return conduit output port, the at least one supply conduit intake and return conduit output ports located at an inserted end of the node enclosure and oriented toward the opposing rear side of the node-receiving chassis respectively enabling receipt of a first cooling liquid at a first temperature and return of the first cooling liquid at an increased temperature due to heat absorption within the node enclosure.

18. A method of assembling a Rack Information Handling System (RIHS), the method comprising:

inserting one or more nodes containing electrical power consuming components into one or more node-receiving bays of a rack;

inserting into the rack a power node having a power node enclosure sealed to contain immersion cooling liquid and provisioned with at least one heat generating component;

electrically connecting to rack electrical power distribution components a power node inlet port and at least one power distribution outlet port of the power node that respectively

receives facility power and distributes power to the internal Information Handling System (IHS) components; and

sealingly engaging for fluid transfer at least one liquid to liquid heat transfer mechanism having a first surface that is impinged upon by a volume of at least one of the immersion cooling liquid and immersion cooling liquid vapor and a second surface that receives a flow of a second cooling liquid via a liquid manifold providing a system of conduits that is sealably engage to the supply and return conduits of the liquid cooling supply to enable a flow of the second cooling liquid manifold to absorb heat from the power node enclosure.

19. A power node comprising:

a power node enclosure receivable in a power node-receiving bay of a rack, sealed to contain immersion cooling liquid, and provisioned with at least one heat generating component that receives and distributes electrical power for use by other nodes within the IHS;

a power node inlet port and at least one power distribution outlet port that respectively receives facility power and distributes power to the internal IHS components; and

at least one liquid to liquid heat transfer mechanism having a first surface that is impinged upon by a volume of at least one of the immersion cooling liquid and immersion cooling liquid vapor and a second surface that receives a flow of a second cooling liquid via a liquid manifold providing a system of conduits that is sealably engage to the supply and return conduits of the liquid cooling supply to enable a flow of the second cooling liquid manifold to absorb heat from the power node enclosure.

20. The power node of claim 19, wherein:

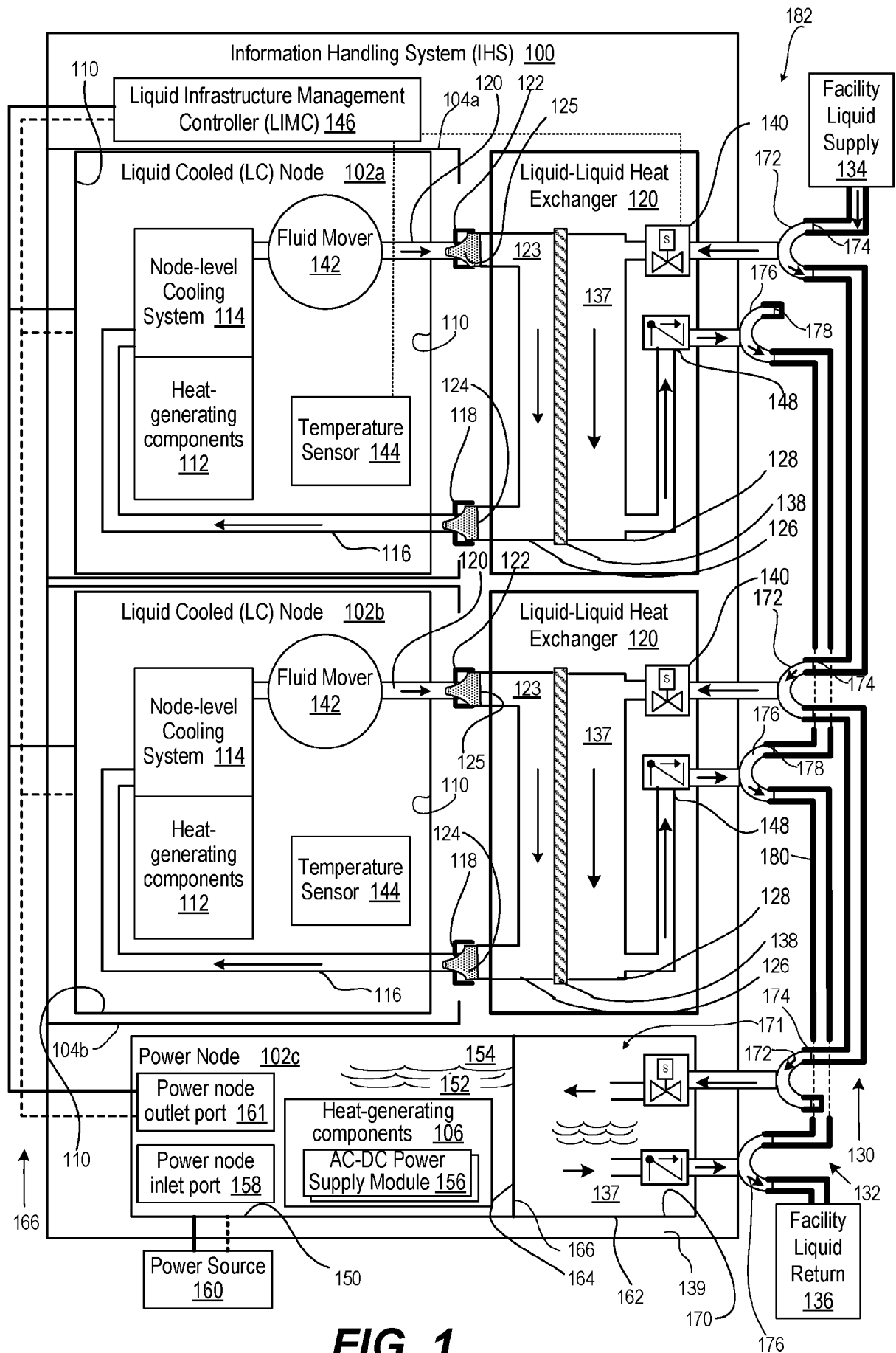
the at least one heat generating component comprises redundant AC-to-DC power supply modules;

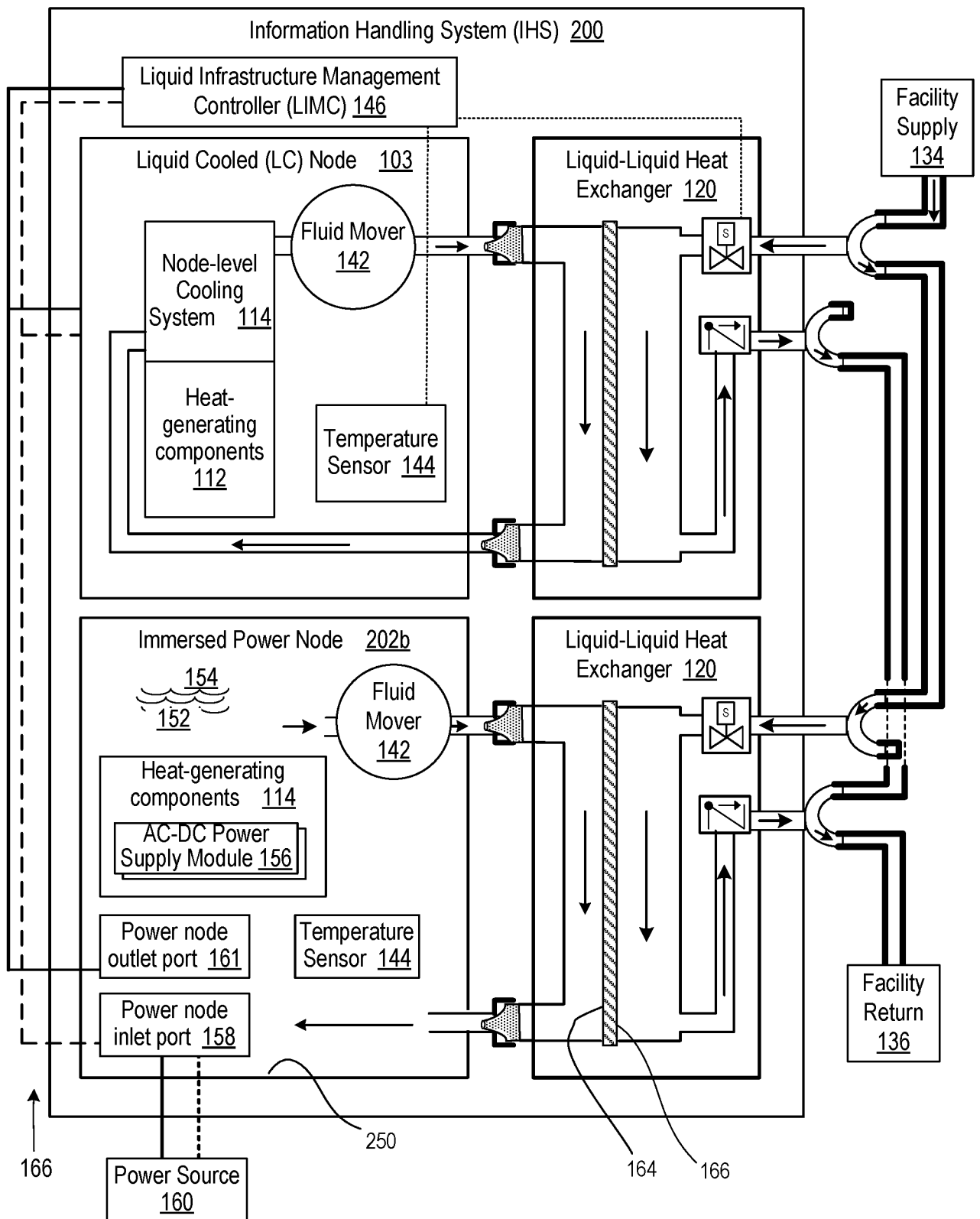
the immersion cooling liquid comprises a liquid dielectric coolant;

the power node inlet port comprises an AC input; and

at least one power distribution outlet port comprises a DC output.

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**FIG. 1**

**FIG. 2**

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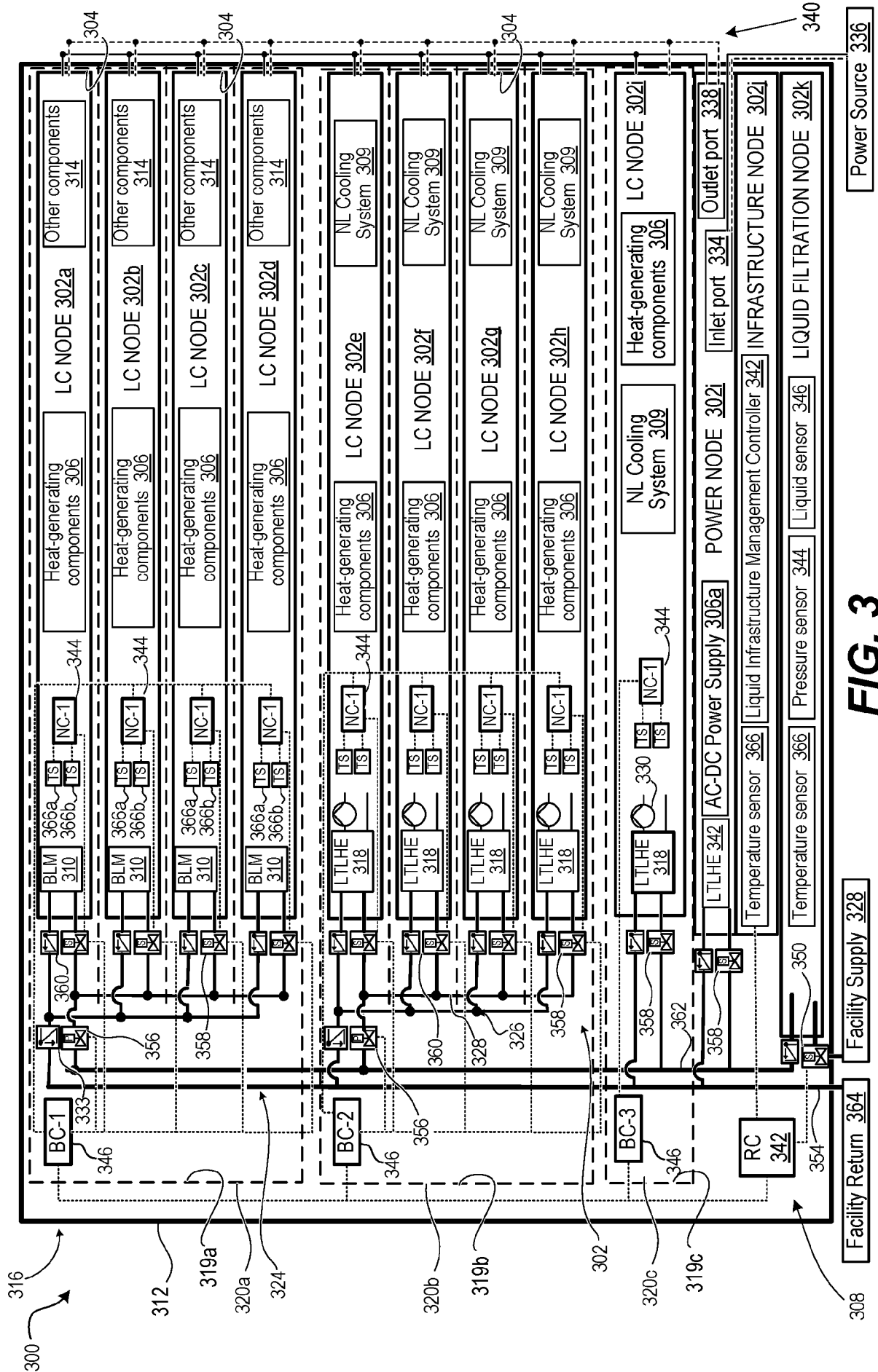


FIG. 3

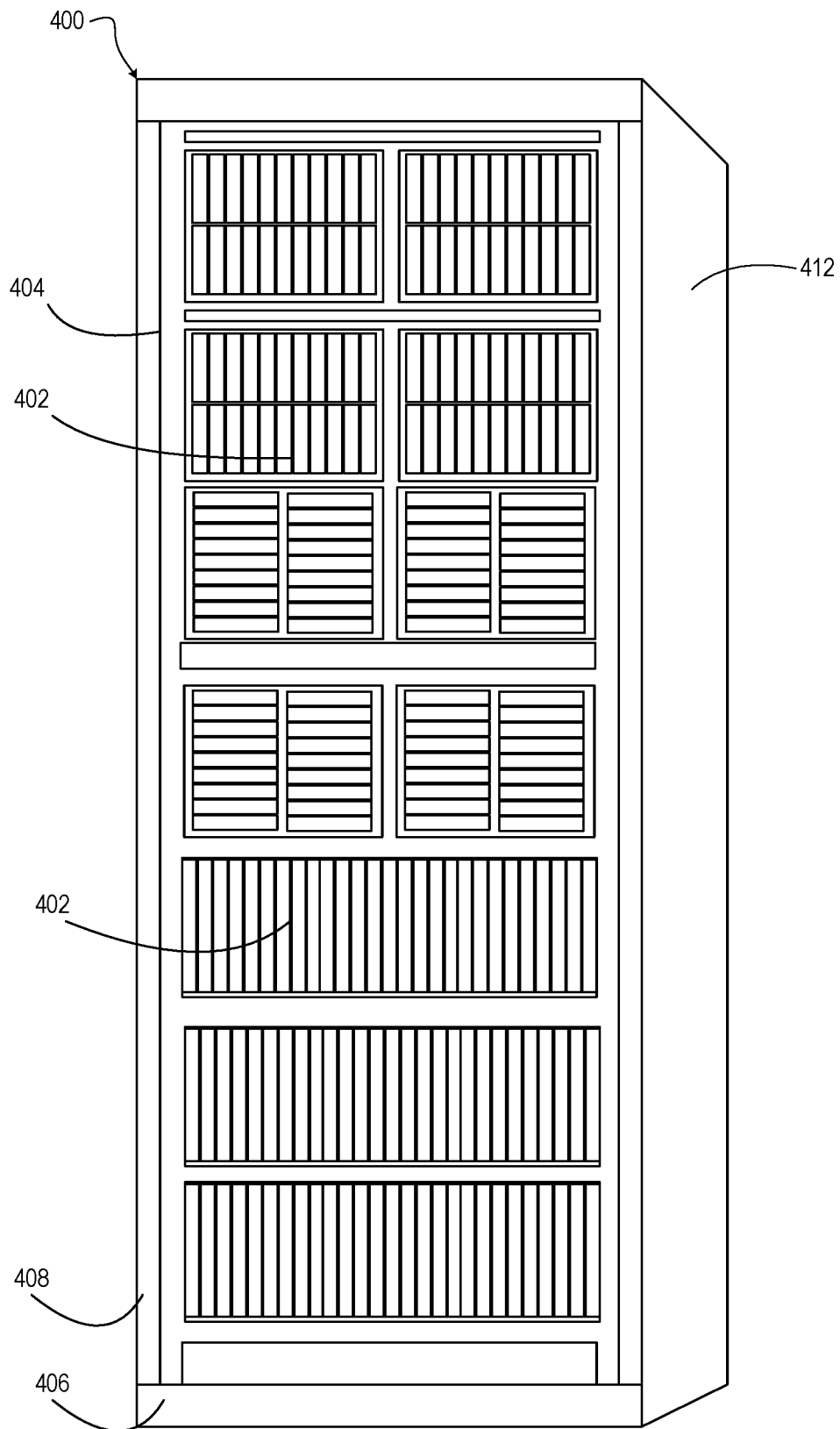


FIG. 4

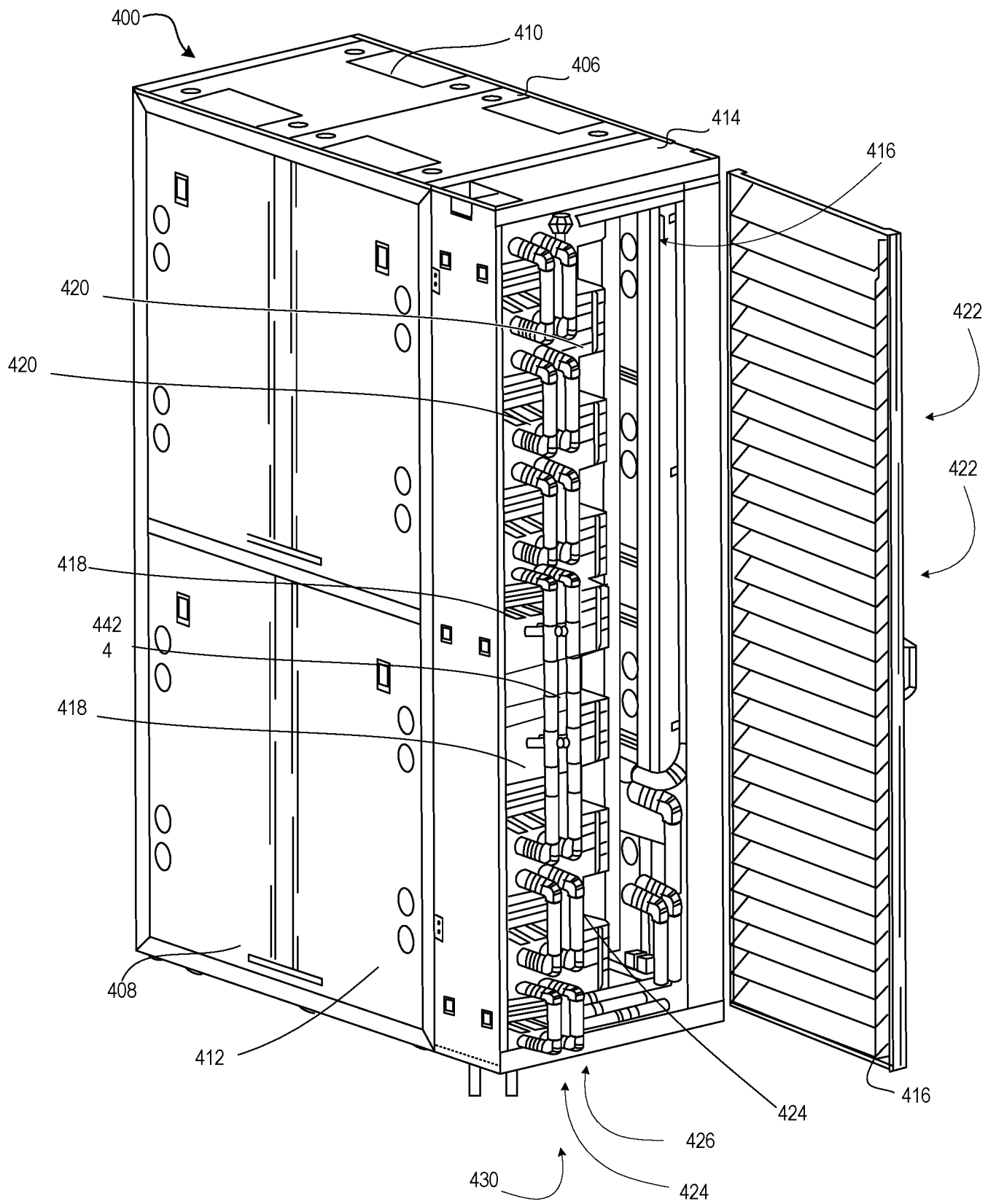


FIG. 5

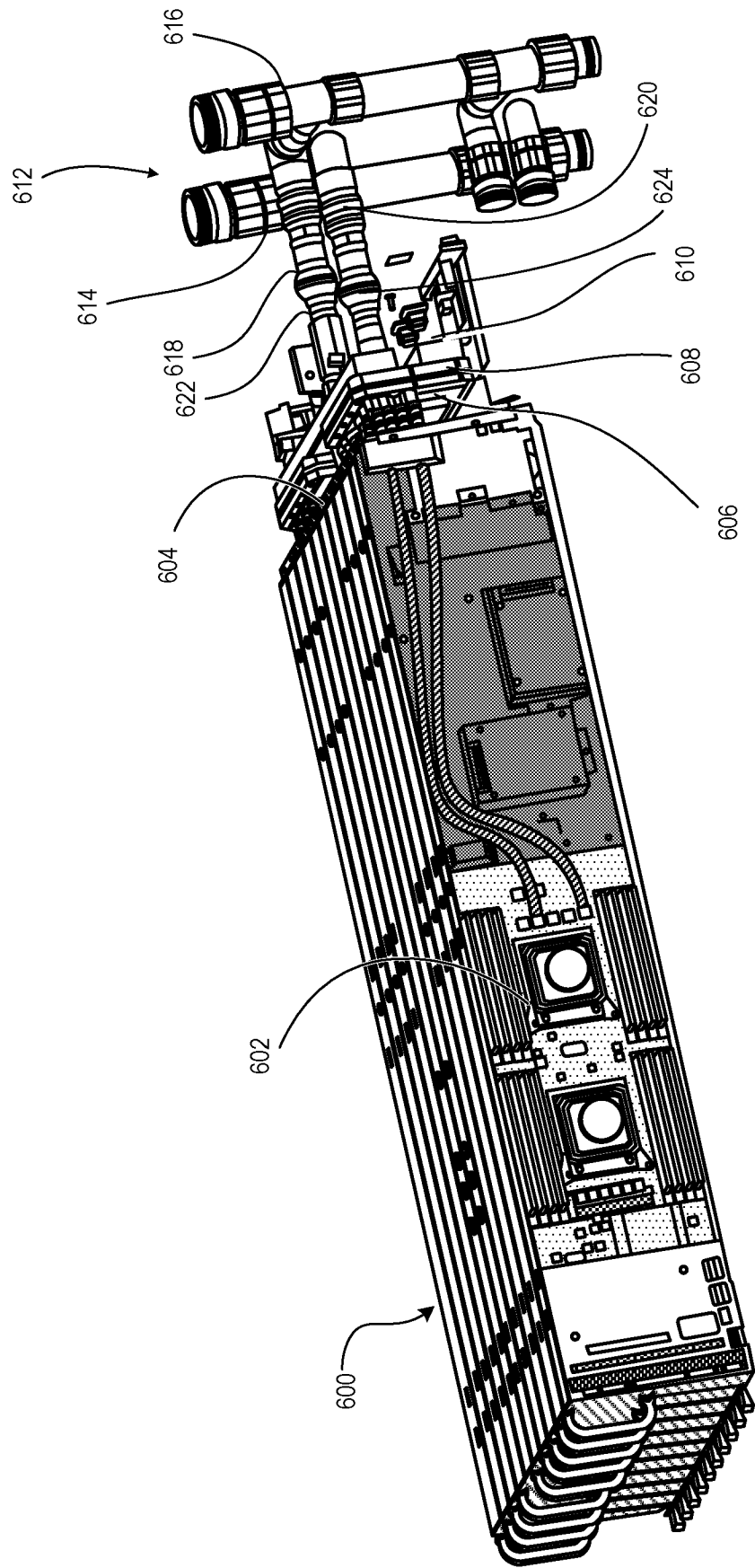


FIG. 6

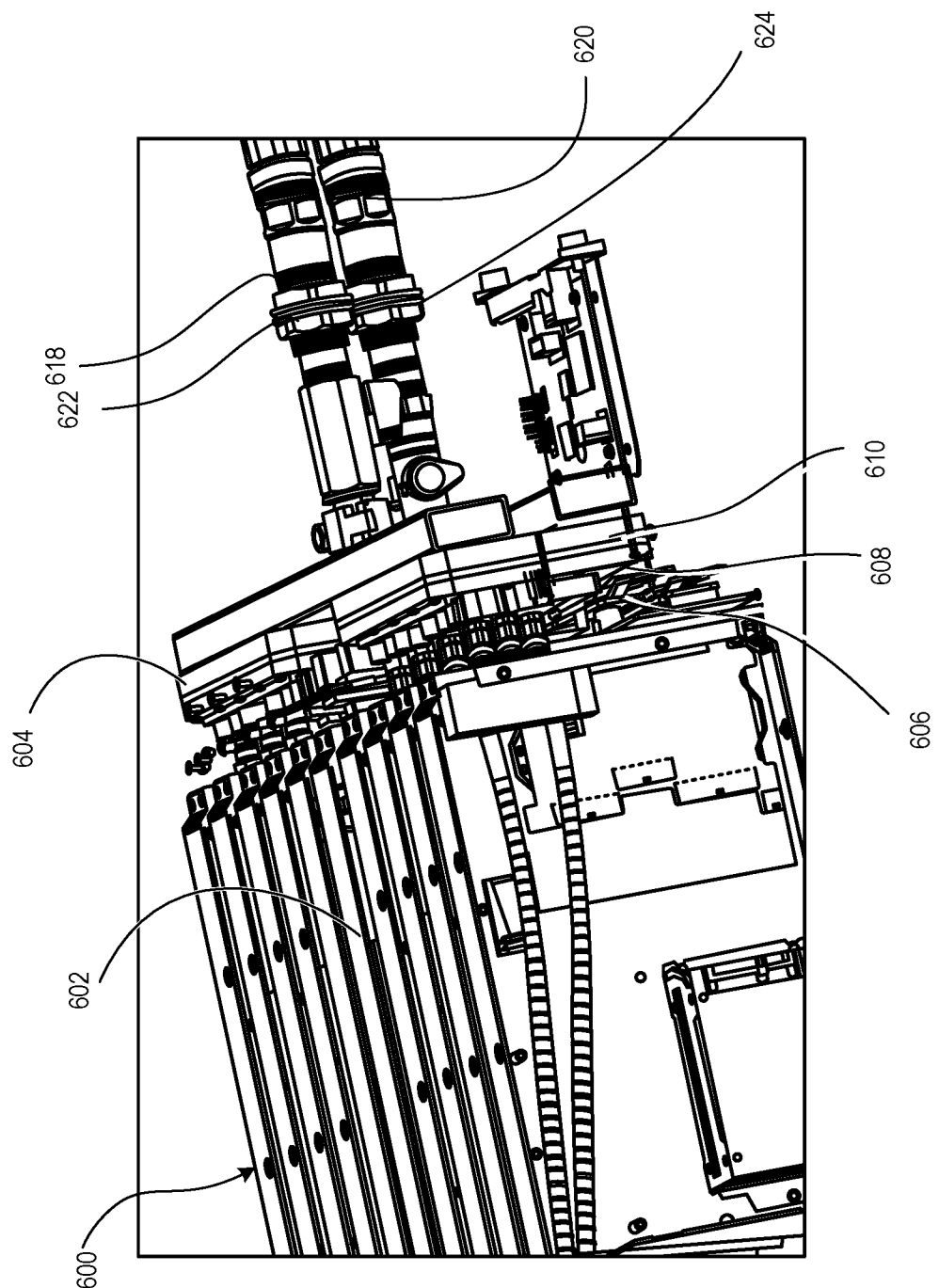


FIG. 7

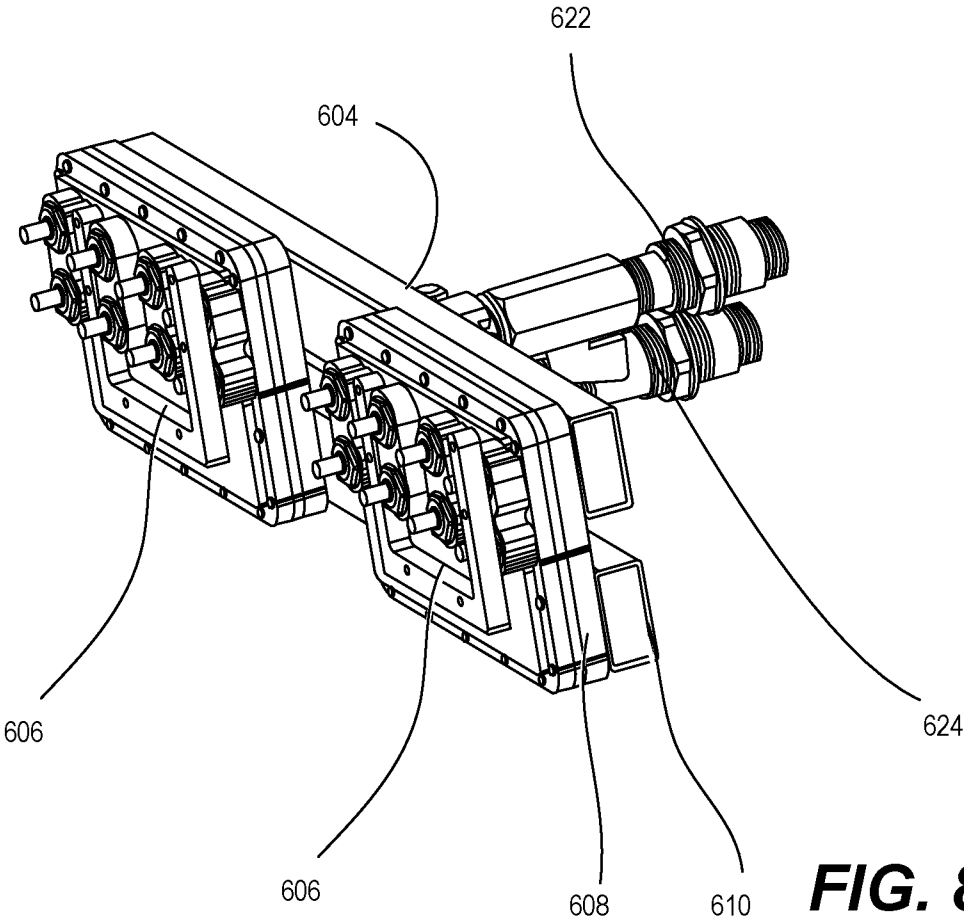


FIG. 8

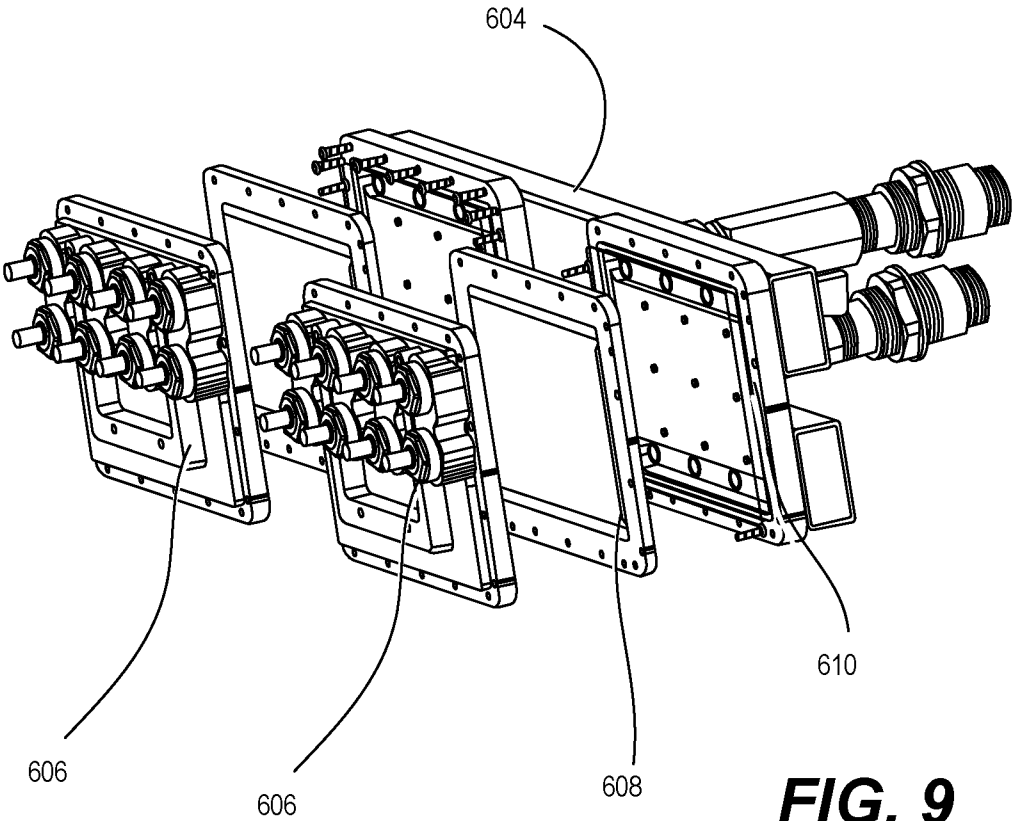


FIG. 9

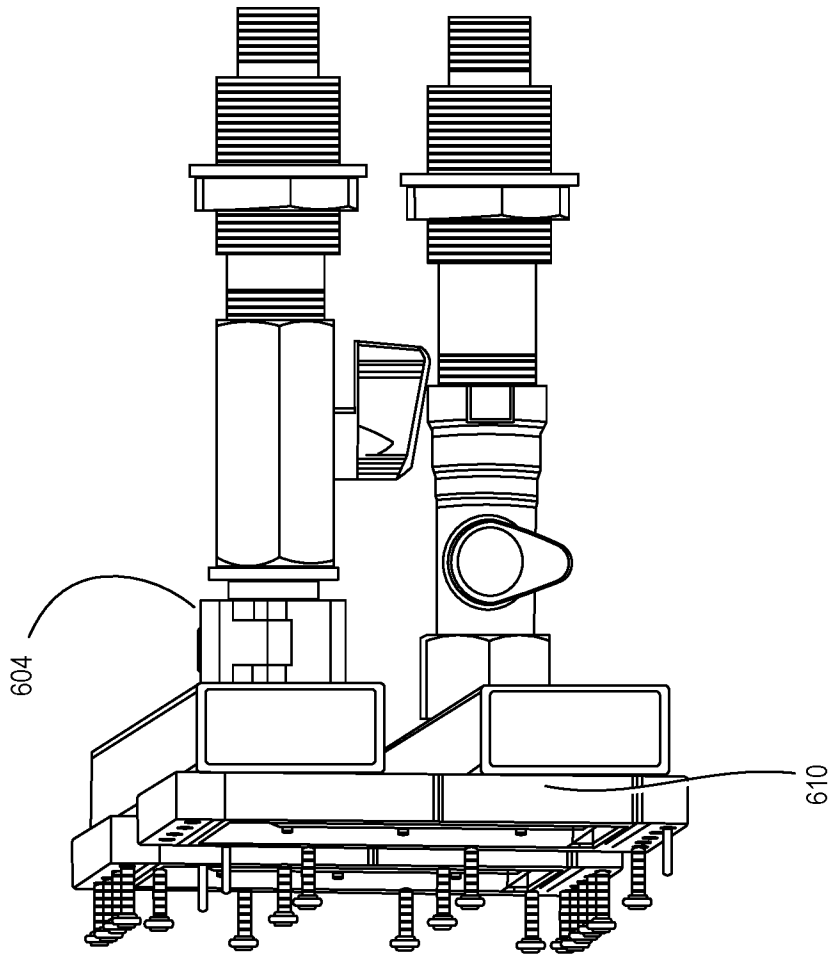
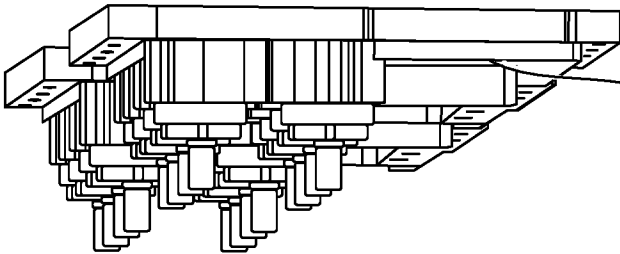
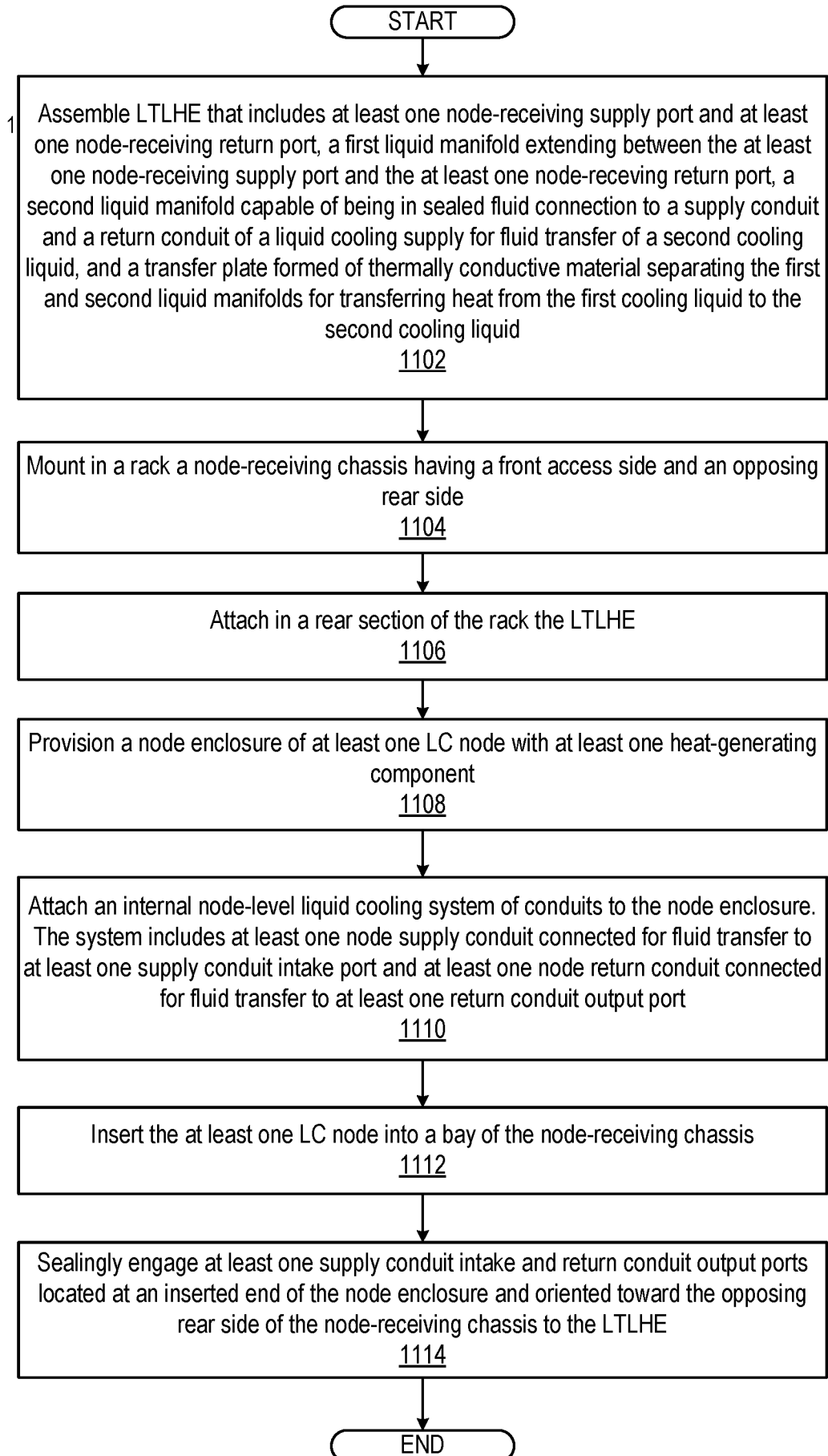
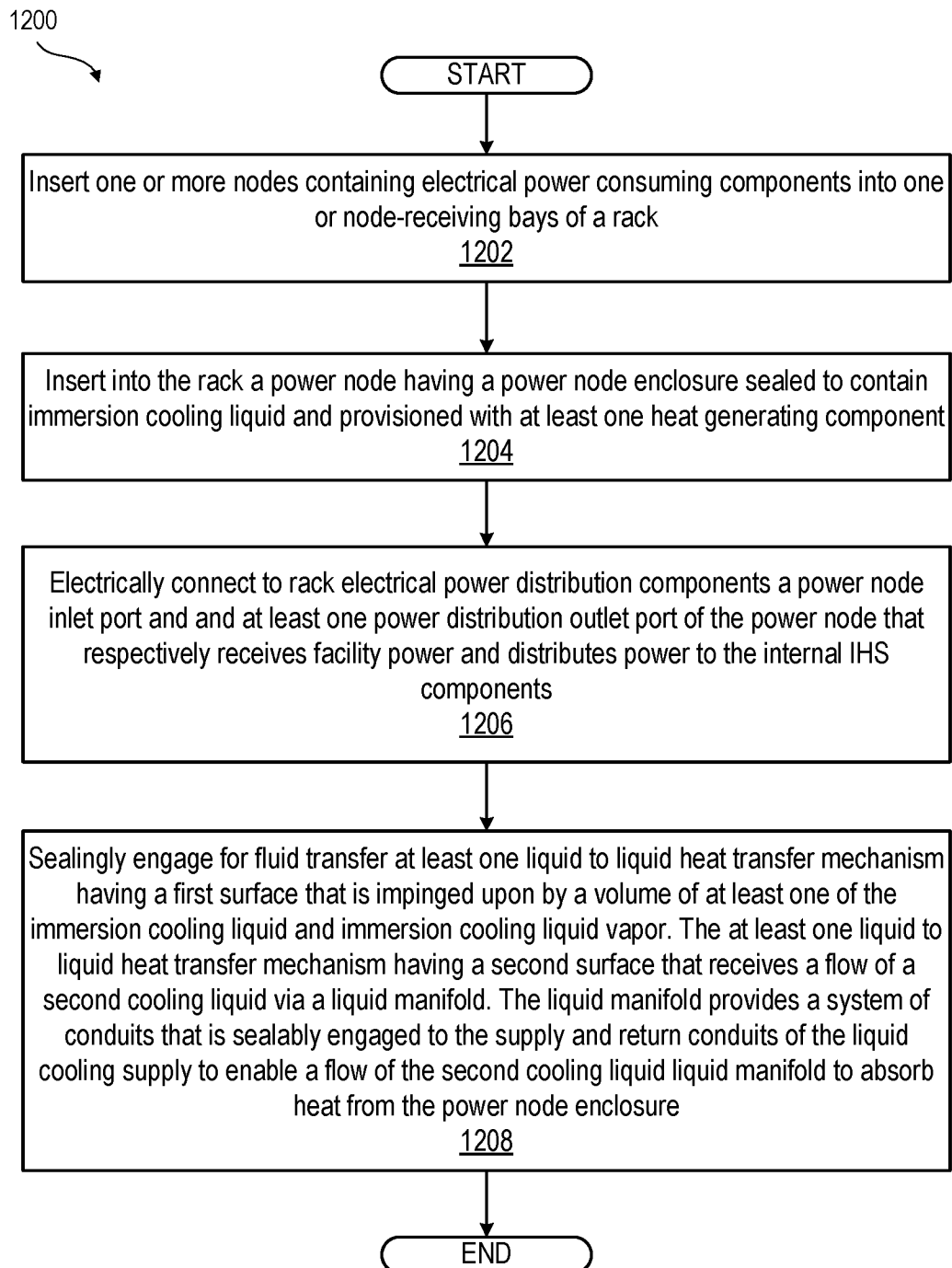


FIG. 10



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**FIG. 11**

**FIG. 12**

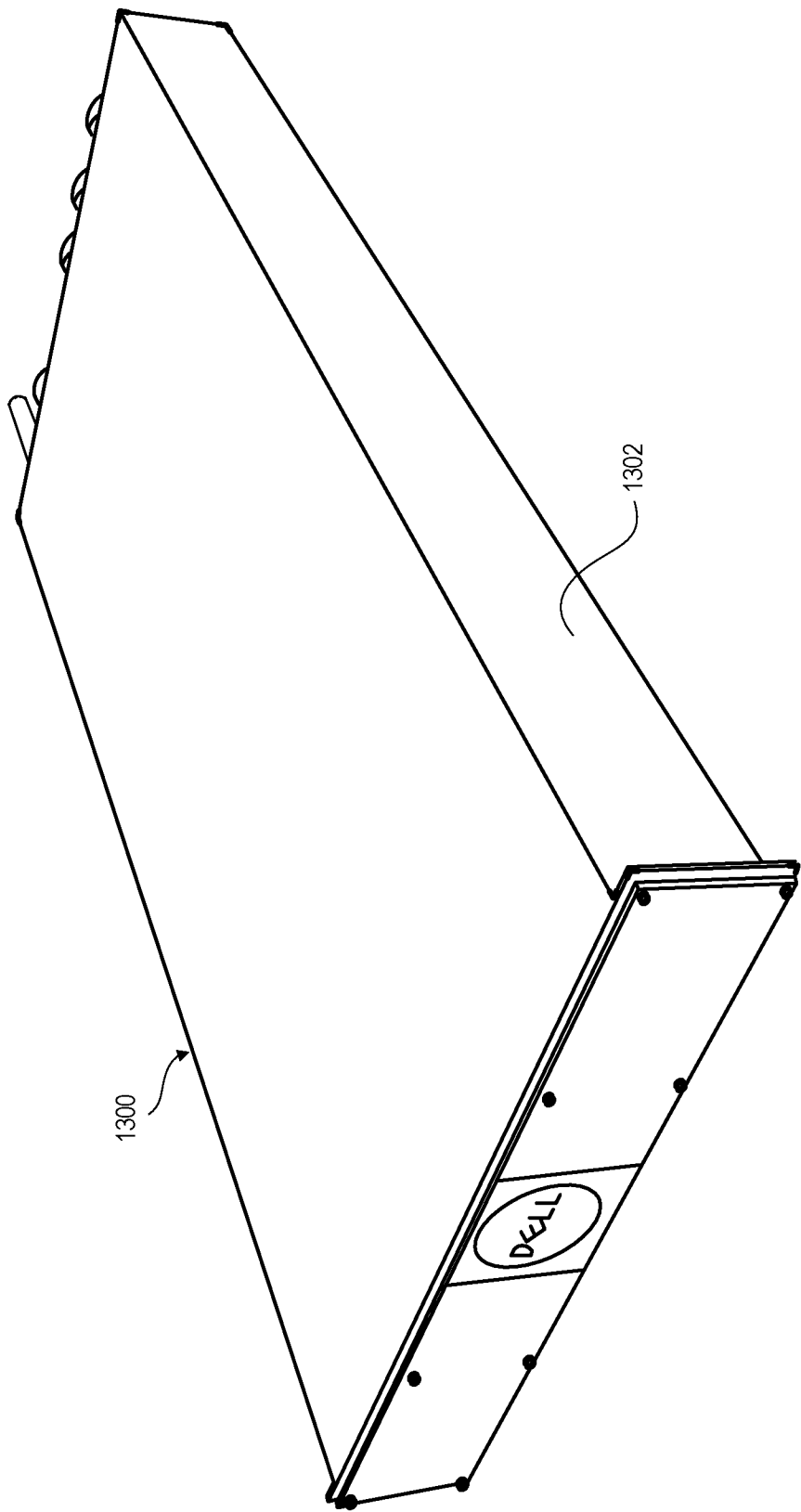


FIG. 13

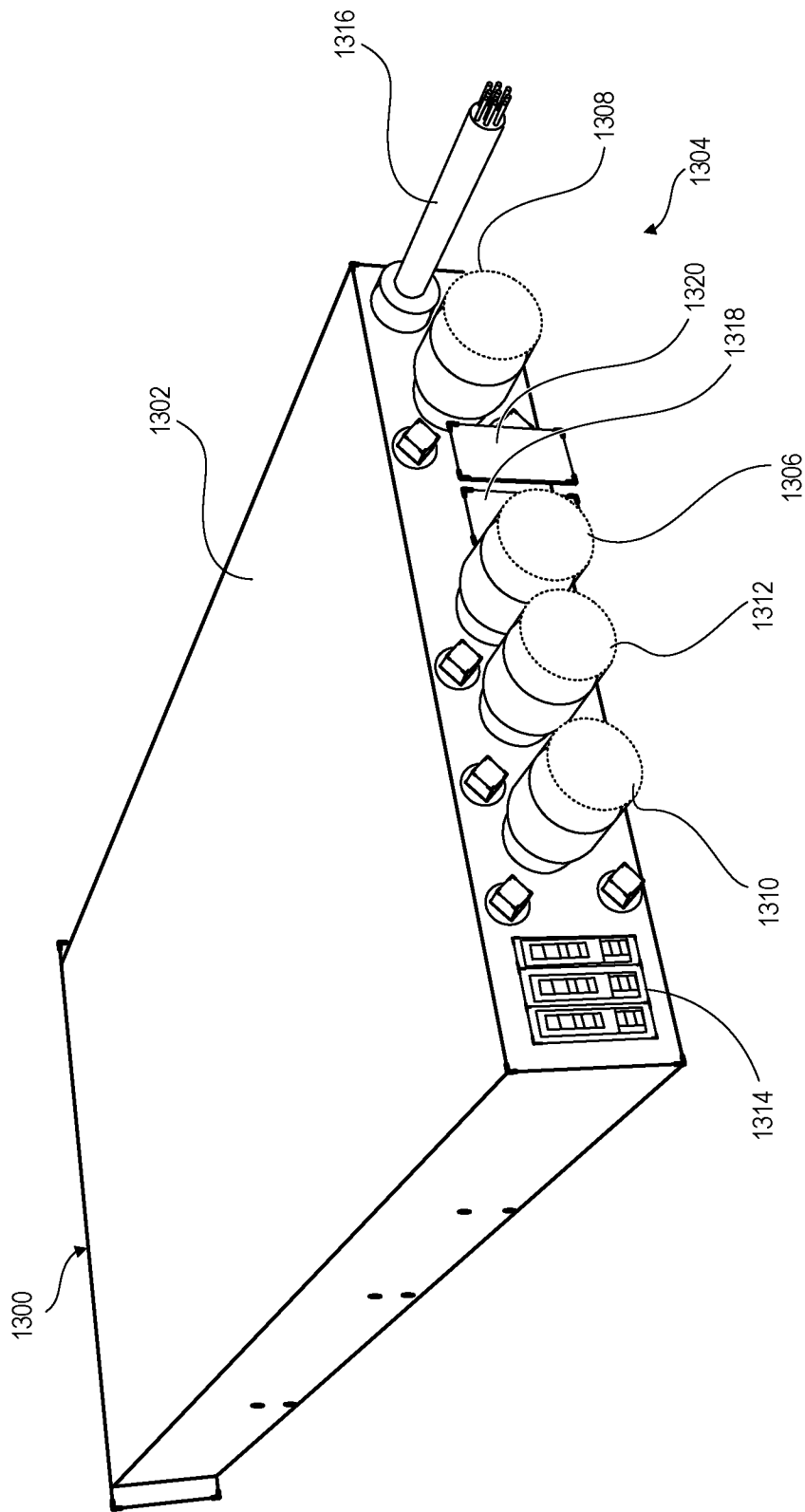


FIG. 14

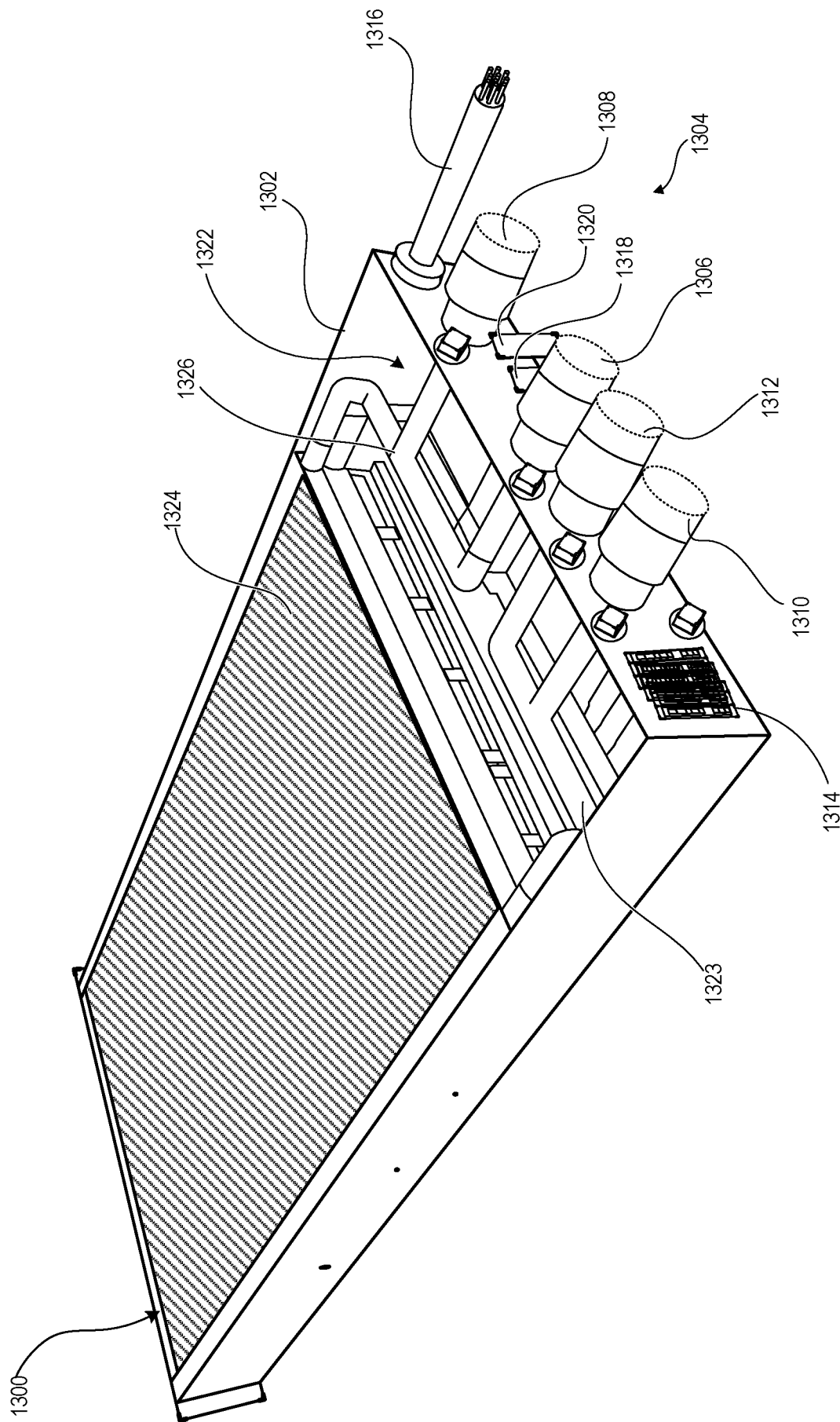


FIG. 15

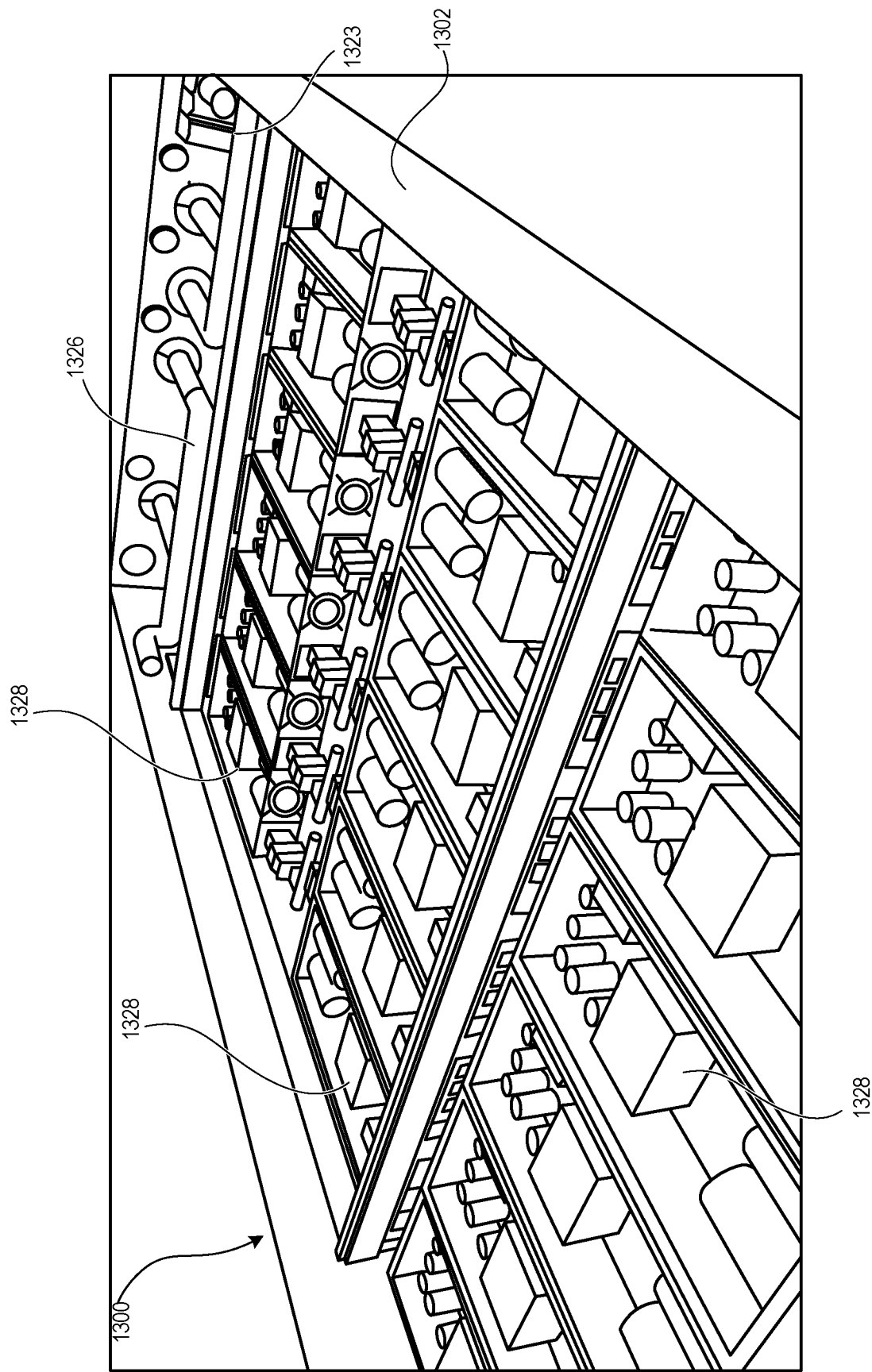


FIG. 16

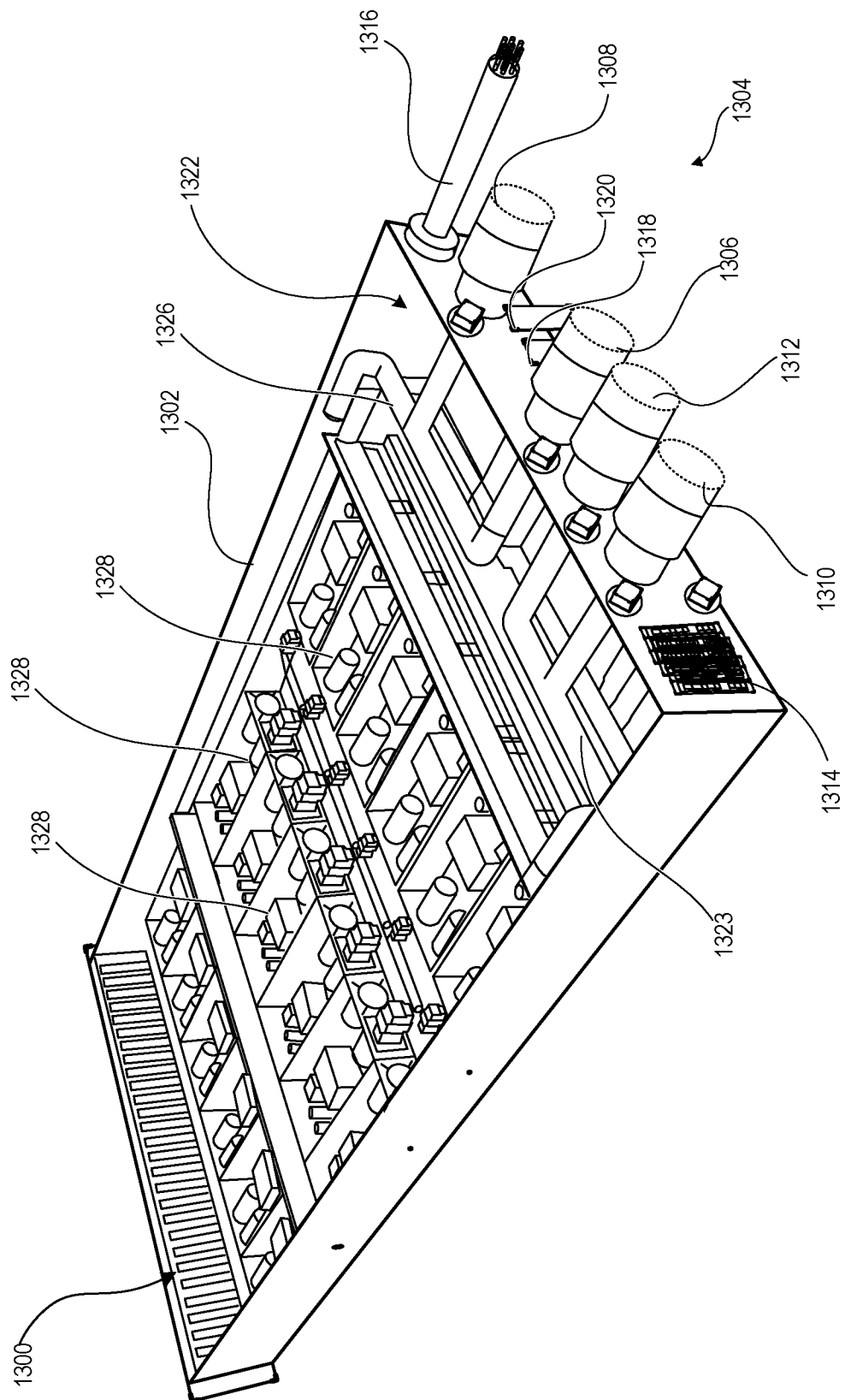


FIG. 17

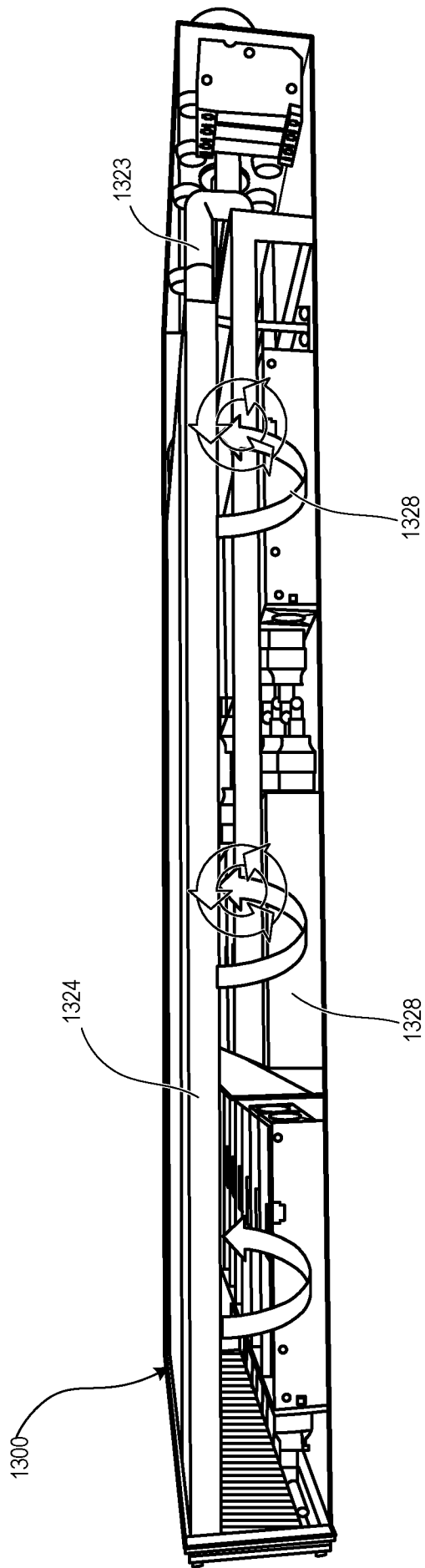


FIG. 18

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2016/043077

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H05K 7/20; F24H 3/02; F25D 23/12; G05D 7/00 (2016.01)

CPC - H05K 7/20745; G05D 7/0635; G06F 1/20; H05K 7/20754 (2016.08)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC - H05K 7/20; F24H 3/02; F25D 23/12; G05D 7/00

CPC - H05K 7/20745; G05D 7/0635; G06F 1/20; H05K 7/20754

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC- 62/259.2; 165/121; 361/698, 698, 699, 704; 700/282, 286 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, Google Scholar

Search terms used: information handling, chassis, liquid cooled node, manifold, power node, distribute, immersion, heat transfer, rack

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2010/0101765 A1 (CAMPBELL et al) 29 April 2010 (29.04.2010) entire document	1-4, 6, 7, 10, 11, 15, 17 --- 5, 8, 9, 12-14, 16, 18-20
Y	US 2014/0123493 A1 (INTERNATIONAL BUSINESS MACHINES CORPORATION) 08 May 2014 (08.05.2014) entire document	5
Y	US 2004/0035132 A1 (PARK et al) 26 February 2004 (26.02.2004) entire document	8, 9
Y	US 2014/0126143 A1 (SILICON GRAPHICS INTERNATIONAL CORP.) 08 May 2014 (08.05.2014) entire document	12-14, 16, 18-20
A	US 2011/0315353 A1 (CAMPBELL et al) 29 December 2011 (29.12.2011) entire document	1-20
A	US 20130138253 A1 (INTERNATIONAL BUSINESS MACHINES CORPORATION et al) 30 May 2013 (30.05.2013) entire document	1-20

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

19 September 2016

Date of mailing of the international search report

04 OCT 2016

Name and mailing address of the ISA/

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