



(51) International Patent Classification:
H05K 7/20 (2006.01)

(21) International Application Number:
PCT/US2019/017026

(22) International Filing Date:
07 February 2019 (07.02.2019)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **HEWLETT PACKARD ENTERPRISE DEVELOPMENT LP** [US/US]; 11445 Compaq Center Drive W., Houston, Texas 77070 (US).

(72) Inventors: **FRANZ, John**; 11445 Compaq Center Dr W, Houston, Texas 77070 (US). **LUNSMAN, Harvey J.**; 1168 Technology Way, Bldg. 2, Chippewa Falls, Wisconsin 54729 (US).

(74) Agent: **MAUGHAN, Eric Lee** et al.; 3404 E. Harmony Road, Mail Stop 79, Fort Collins, Colorado 80528 (US).

(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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, 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,

(54) Title: PHOTO-ETCHED CHASSIS COOLING WALLS

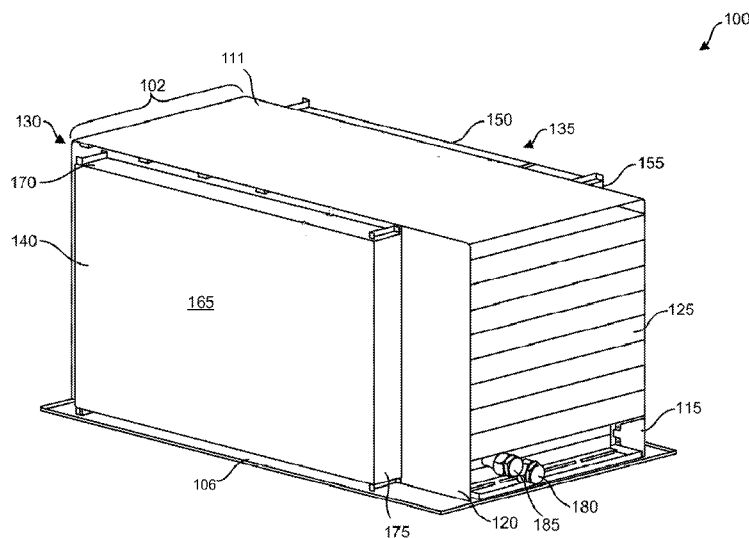


FIG. 1

(57) Abstract: An electronic component enclosure includes a plurality of wall structures defining outer walls of the enclosure. Each wall structure has an internal fluid channel for circulation of cooling fluid. The enclosure further includes at least one partition structure disposed within the outer walls and having an internal fluid channel in sealed fluid communication with the internal fluid channel of at least one of the plurality of wall structures. The internal fluid channel of at least one of the plurality of wall structures and the internal fluid channel of the at least one partition structure defines a continuous fluid circulation path between a fluid inflow port and a fluid outflow port.



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).

Published:

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

PHOTO-ETCHED CHASSIS COOLING WALLS

BACKGROUND

[0001] Electronic equipment such as computers and related components typically generate thermal energy (i.e., heat) during operation. The amount of heat generated may vary based on many factors, including the number and type(s) of electronic components, the operational state of those components (and hence the power they are consuming), and so on. Excessive temperature, in turn, may have an adverse effect on the performance of electronic components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] For a detailed description of various examples, reference will now be made to the accompanying drawings, in which:

[0003] FIG. 1 is a perspective view of an electronic component enclosure assembly in accordance with one or more examples of the present disclosure;

[0004] FIG. 2 is another perspective view of the electronic component enclosure assembly from FIG. 2;

[0005] FIG. 3 is a side perspective view of a portion of the electronic component enclosure assembly from FIG. 1;

[0006] FIG. 4 depicts a cooling fluid circulation path defined within a partition structure of an electronic component enclosure assembly in accordance with one or more examples of the present disclosure;

[0007] FIG. 5 is a block diagram illustrating deployment of a plurality of electronic component enclosure assemblies in accordance with one example; and

[0008] FIG. 6 is a flow diagram depicting a method for enclosing an electronic component in accordance with one example or more examples of the present disclosure.

DETAILED DESCRIPTION

[0009] As noted above, the amount of heat generated by electronic components may vary based on many factors, including the number and type(s) of electronic components, the operational state of those components (and hence the power they are consuming),

and so on. Electronic components, such as semiconductor microprocessors and memory circuits, may generate substantial amounts of heat during operation. Excessive temperature, in turn, may have an adverse effect on the performance of electronic components.

[0010] Often, computers and related electronic components are disposed and arranged within enclosures. Enclosures may provide physical protection for the enclosed components from environmental conditions such as dust and particulate infiltration, moisture, and so on, and may facilitate the efficient mounting and installation of component systems, among other functions. However, because electronic equipment tends to generate heat, provisions must be made to ensure that enclosures do not permit excessive heat to accumulate around the enclosed components, since excessive heating may cause temporary or lasting impairment to the functioning of electronic components. Such provisions include the providing of natural ventilation through enclosures, forced ventilation through the provision of electric fans and the like, and providing other dedicated heat-dissipating components and structures, such as heat sinks, circulating liquid-cooling systems, and even complete immersion of electronic components in dielectric fluids. Different approaches to heat-dissipation of electronic systems may be perceived to have different advantages and disadvantages, in term of their relative costs, complexities, structural limitations, and so on. Dissipation of heat from electronic components and systems such as computers is especially important for high-performance computing (HPC) systems, data and data processing centers, and the like, in which potentially large numbers of electronic systems capable of generating substantial amounts of heat may be located.

[0011] In this description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the examples disclosed herein. It will be apparent, however, to one skilled in the art that the disclosed example implementations may be practiced without these specific details. In other instances, structure and devices are shown in block diagram form in order to avoid obscuring the disclosed examples. Moreover, the language used in this disclosure has been principally selected for readability and instructional purposes and may not have been selected to delineate or circumscribe the inventive subject matter, resorting to the claims being necessary to determine such

inventive subject matter. Reference in the specification to “one example” or to “an example” means that a particular feature, structure, or characteristic described in connection with the examples is included in at least one implementation.

[0012] The terms “electronic component” and “electronic device” as used herein are intended to refer broadly and generally to any electrically-powered device or system, including but not limited to computing devices such as microprocessors, memory modules, and any and all related components, which may be disposed and arranged on one or more printed circuit boards (PCBs), electrical power supplies and transformers, and so on, all of which tending to radiate thermal energy (heat) during normal operation.

[0013] Heat generation by electronic components may be especially problematic when such devices or systems are disposed within enclosures, as either single devices or systems within dedicated housings, or with equipment possibly comprising multiple components designed to be arranged in racks or cabinets commonly used for such purposes.

[0014] Excessive temperatures may diminish the performance of electronic components, and in extreme cases may cause component failure. Heat generation becomes of increasing concern in the context of high performance computing (HPC) and other large-scale data storage or data processing facilities, which may comprise numerous processors and large amounts of electronic memory. In such systems, multiple processor boards, memory units, magnetic and/or solid-state disk drives, power supplies, and/or other electronic components may be deployed and contained within one or more enclosures. It is desirable, therefore, to provide for dissipation of heat away from the immediate surroundings of enclosed electronic components, especially the interiors of enclosures housing such components.

[0015] As noted above, various heat dissipation approaches have been implemented, including, for example, heat sinks, air circulation fans (with appropriate ventilation), and liquid-cooled systems in which a cooling fluid, such as water, circulates between a heat source and a heat sink. Some heat dissipation systems involve complete immersion of components in dielectric fluids, such as mineral oil for example. Such approaches may be effective to varying degrees in capturing and conducting or otherwise dissipating some

fraction of heat away from the immediate surroundings of the electronic components, such as to the outside of the enclosure containing the electronic components.

[0016] There may be trade-offs in the advantages and disadvantages of different approaches to heat capture/dissipation for electronic components. For example, with approaches requiring electronic component enclosures to be ventilated, such as with cooling fans and/or via convection, the existence of ventilation openings may undesirably decrease the ability of the enclosure to protect the electrical components from external mechanical/physical conditions. Ventilated openings in an enclosure may permit infiltration of dust and other particulates, and may not protect internal components from high humidity or other undesirable environmental conditions besides temperature. Electric fans employed to promote heat-dissipating air circulation themselves consume power (thus potentially contributing to the generating of heat), and constitute an additional system component consuming power, requiring maintenance, and being subject to potential mechanical failure. Noise generation may also be of concern.

[0017] Liquid-cooled systems employing dedicated heat-capturing structures such as cold plates, coupled to heat-exchanging cooling fluid loops, may be effective in capturing heat from electronic components and conducting the heat to a heat exchanger or the like outside of the immediate environment of the components and their enclosures. These dedicated heat-capturing structures must be designed and configured to be disposed either in direct contact with specific heat-generating electronic components, or in sufficiently close proximity to such components that they are capable of capturing an appreciable amount of the heat generated from the areas that surround the high powered devices such as CPU, DIMM or HCA (host card adapter). Such dedicated structures occupy valuable space within the enclosures, add undesirable weight to the enclosures, and must each be incorporated into a cooling fluid circulation loop with dedicated plumbing and fluid connections. Moreover, the presence of liquids, such as water, circulating in close proximity to electronic components may be considered undesirable due to the risk of fluid leakage.

[0018] A problem may also arise in large-scale data storage and/or data processing centers, which may include HPC systems comprising large numbers of enclosures in a single space, such as a room or a building, which in turn may also be enclosed. Although

heat may be effectively transferred to the outside of individual enclosures using techniques such as described above, the combined heat of a number of enclosures in a common enclosed space may lead to undesirable ambient thermal conditions within the common space itself. This, in turn, may necessitate further accommodations to be made, such as providing powerful and costly HVAC air conditioning and/or air exchange systems to maintain desired temperature and humidity conditions in the larger surrounding environment.

[0019] Thus, it may be desirable to provide an enclosure for electronic components or systems which is capable of capturing all or substantially all of the heat generated by the enclosed electronic components and conducting the heat to an exterior location, for example, to a heat exchanger. It may also be desirable to not add weight or increase system size due to accomplish the heat capture, It may also be desirable to provide a completely sealed enclosure so as to eliminate the infiltration of dust, humidity, and the like into the enclosure. A fully sealed system allows for a wider customer adoption by enabling a more flexible deployment choice agnostic of many environmental restrictions.

[0020] Referring to FIG. 1, there is shown a perspective view of an electronic component enclosure assembly 100 according to one example. Enclosure assembly 100 in FIG. 1 includes an exterior casing having a top portion 111 a rear portion 113, first and second side portions 115 and 120, and first and second end portions 125 and 130. As described herein, the exterior casing encloses and protects a substantially sealed enclosure 102. As used herein, the descriptor “substantially sealed” refers to an enclosure which does not allow for the exchange of air between the exterior of the enclosure and the interior of the enclosure. In this illustrative example, main enclosure 102 may have dimensions of approximately 24 inches in width, 20 inches in height, and 40 inches in length.

[0021] In the example of FIG. 1, enclosure assembly 100 further consists of first and second auxiliary enclosures 135 and 140. Auxiliary enclosure 135 includes an auxiliary side casing 145 (not visible in the view of FIG. 1), an auxiliary top casing 150, an auxiliary end casing 155 and an opposing auxiliary end casings (not visible in the view of FIG. 1). Auxiliary enclosure 140 includes an auxiliary side casing 160, an auxiliary top casing 165, an auxiliary end casing 170 (and an opposing auxiliary end casing not visible in the view of FIG. 1).

[0022] With continued reference to FIG. 1, enclosure assembly 100 is provided with a cooling fluid inflow port 180 and a cooling fluid outflow port 185. These ports 180, 185 enable enclosure assembly 100 to be coupled a fluid-cooling circulation loop as hereinafter described. In the example of FIG. 1, ports 180 and 185 are both shown situated generally near the bottom of enclosure assembly 100. In an alternative examples, inflow port 180 may be situated as shown while outflow port 185 is situated at or near the top of enclosure assembly. In still other examples, more than one inflow port 180 and/or outflow port 185 may be provided to facilitate fluid flow.

[0023] FIG. 2 is another perspective view of enclosure assembly 100 from FIG. 1. In FIG. 2, enclosure assembly 100 is rotated 180° with respect to the orientation of FIG. 1; also, in the view of FIG. 2, an end wall opposite end casing 155 for auxiliary enclosure 135 is not shown, in order to expose to view internal structure of auxiliary enclosure, and end casing 130 of main enclosure 102 is not shown, in order to expose to view internal elements of enclosure assembly 100.

[0024] As shown in FIG. 2, a plurality of internal partition structures 205 extend within main enclosure 102. In this example, partition structures 205 have dimensions substantially conforming to the volume defined within the wall structures. Partition structures 205 may define one or more internal compartments 212 within main enclosure 102, as hereinafter described. As also shown in FIG. 2, a plurality of partition structures 210 are provided within the space defined by auxiliary enclosure 135, with partition structures 210 defining a plurality of internal compartments within auxiliary enclosure 135. (It is to be understood that a similar plurality of partition structures, not shown, may be provided within the space defined by auxiliary enclosures 135 and 140.)

[0025] Turning to FIG. 3, there is shown a perspective end view of a portion of enclosure assembly 100 including a portion of main enclosure 102. It is to be noted that FIG. 3 is not to scale, and neither top casing 111 nor pan 106 is shown, for the purposes of clarity. As shown in FIG. 3, each partition structure 205 comprises a substantially planar portion 302 extending between bottom wall structure 105 and top wall structure 110 of main enclosure 102, collectively defining the plurality of compartments 212 within main enclosure 102. In addition, each partition structure 205 integrally includes a bottom attachment portion 304

for attachment of partition structure 205 to bottom wall structure 105 and a top attachment portion 306 for attachment of partition structure 205 to top wall structure 110.

[0026] FIG. 3 shows that bottom wall structure 105 is a laminar structure comprising a lamination of an upper layer 308 and a lower layer 310. In this example, upper and lower layers 308 and 310 are both made of steel, although other metals and materials having suitable thermal conductivity, corrosion resistance, and mechanical strength may be employed. As shown in FIG. 3, lower layer 310 of bottom wall structure 105 is formed so as to define a plurality of inflow channels 312 between lower layer 310 and substantially planar upper layer 308. Inflow channels 312 are configured to be in sealed, fluid communication with fluid inflow port 180, shown in FIG. 1, such that cooling fluid 314 (e.g., water) may be directed into and circulated through enclosure assembly 100. In one example, inflow channels are formed in lower layer 310 by means of mechanical deformation of the material.

[0027] In order to maintain a sealed fluid circulation path through enclosure assembly 100, welding, brazing, diffusion bonding, adhesives, or other suitable connection methods may also be used to seal upper layer 308 to lower layer 310 of bottom wall structure 105. This is represented by welding joints 316 in FIG. 3.

[0028] Each partition structure 205, including each substantially planar portion 302, lower attachment portion 304, and upper attachment portion 306, includes at least one internal fluid channel providing a path for circulation of cooling fluid through the structure 205. In this example, each partition structure 205 is a laminar structure comprising at least an outer layer 318 and an inner layer 320. Both layers 318, 320 may be made of steel, although other metals or materials of sufficient thermal conductivity, corrosion resistance, and mechanical strength may be employed. Outer layers 318 and inner layers 320 are joined together via welding, diffusion bonding or other suitable connection methods to form a laminated, substantially uniform sealed structure. Outer layers 318 and inner layers 320 are present in each portion 302, 304, and 306 of each partition structure 205. Continuous, permanent, connections, such as by welding, diffusion bonding, etc.) between outer layer 318 and inner layer 320 are designated with reference numerals 322 in FIG. 3.

[0029] In this example, one (or both) of layer 318 and inner layer 320 of each laminar partition structure 205 is fabricated so as to define sealed fluid circulation paths between

outer layer 318 and inner layer 320. In one example, a layer such as layer 320 is photo-etched to remove material in a pattern defining at least one fluid circulation channel providing for fluid circulation between layers 318 and 320. Fluid circulation channels are designated with reference numerals 324 in FIG. 3. As with the two layers 308 and 310 of bottom wall structure 105, outer layer 318 and inner layer 320 of each partition structure may be fused together by any suitable means, such as welding, diffusion bonding, etc., such that circulation channels 324 are sealed to ensure no escape of cooling fluid circulating through partition structures 205.

[0030] Photo-etching is a proven technique for photochemically forming features in metal (or other materials) in a highly precise and repeatable manner. In this example, each section 302 of partition structures 205 may be on the order of 0.027 inches thick, with each outer layer and inner layer comprising approximately one-half of the total thickness. These dimensions are exemplary only, and the dimensions of particular implementations may be different. (And again, it is noted that FIG. 3 is not to scale.) The example shows however that heat-capturing partition structures 205 may be incorporated without occupying more volume within main enclosure 102 than would be occupied by conventional structures found in such enclosures, and without substantially increasing the weight of main enclosure 102 as compared with heat-dissipating structures not having fluid circulation channels defined therein.

[0031] Using photo etching techniques, circulation channels 324 may be formed by etching a portion of the thickness of one or both of the outer layers 318 and inner layers 320 of partition structures 205. Outer layers 318 and inner layers 320 may then be diffusion bonded, vacuum brazed, or otherwise joined together by suitable means to ensure that circulation channels 324 are fluid-tight.

[0032] In this example, for each partition structure 205, cooling fluid 314 is conveyed from inflow channels 312 defined in bottom wall 105 through an inflow port 326 formed in upper layer 308 of bottom wall 105 which are in turn aligned with ports 328 defined in outer layer 318 of partition structure 205. In one example, pattern 402 is formed in one or more layers of laminar structures, such as wall structures 105, 110, 115, 120, 125, and 130 and one or more partition structures 205 by a photo-etching process capable of partially removing material from the desired layers in a precise and repeatable manner.

[0033] An example of a pattern 402 for establishing cooling fluid circulation channels 324 within a partition structure 205, and in particular, in a substantially planar portion 302 of a partition structure, is shown in FIG. 4.

[0034] In FIG. 3, dashed lines 330 show circulation paths for fluid 314 from inflow channel 314, through ports 326 and 328, and through partition structures 205. At upper attachment portion 306 of each partition structure 205, fluid 314 passes through an outflow port 332 in outer layer 318 of partition structure 205 and a corresponding outflow port 334 in a lower layer 336 of enclosure top wall structure 110.

[0035] Fluid 314 passing through ports 332 and 334 as just described is collected in outflow channels 340 defined between upper layer 338 and lower layer 336 of top wall structure 110.

[0036] Top wall structure 110 is configured in substantially the same way as bottom wall structure 105, with a lower layer 336 and an upper layer 338 defining at least one sealed fluid outflow channels 340. For example, fluid outflow channels 340 may be formed by mechanical deformation of upper layer 338. Upper and lower layers 336 and 338 of top wall structure 110 may be bonded in the same manner as upper and lower layers 308 and 310 of bottom wall structure 105. This bonding may be accomplished through diffusion bonding techniques, for example, and further may involve additional welding joints 316, as shown in FIG. 3. Outflow channels 340 defined within top wall structure 110 are in fluid communication with cooling fluid outflow port 185, previously described with reference to FIG. 1, to allow circulation of fluid through at least one continuous cooling fluid flow path defined by one or more wall structures 105, 110, 115, 120, 125, and 130 and one or more partition structures 205 of enclosure assembly 100, between inflow port 180 and outflow port 185.

[0037] As shown in FIG. 3, the plurality of partition structures 205 may be provided within main enclosure 102. In the present example, the combined heat-capturing surface area of the various components having fluid circulation paths defined therein, including wall structures 105, 110, 115, 120, 125, and 130 as well as partition structures 205, promotes the thermal capturing performance of the enclosure assembly as a whole, making it possible to implement an enclosure assembly 100 as a substantially sealed enclosure. It is contemplated that although enclosure 102 is substantially sealed, in one example, one or

more internal fans may nonetheless be provided to improve internal air circulation and thereby enhance the heat-capturing capability within enclosure 102.

[0038] Partition structures 205 may be attached to bottom wall structure 105 with fasteners of any suitable type (e.g., threaded fasteners, rivets, etc.). In the example of FIG. 3, a plurality of rivets 342 are shown, at locations where no circulation path 324 is present between upper layer 308 and lower layer 310 of bottom wall structure 105, to ensure the integrity of the sealed cooling fluid circulation loop. Rivets 342 secure each partition structure 205 to bottom wall structure 105 to ensure a fluid-tight connection therebetween. To further ensure the integrity of the cooling fluid circulation loop, O-rings 344 may be provided as shown in FIG. 3. Similar connections with rivets 342 and O-rings 344 may be made between the upper attachment portions 306 of partition structures 205 and top wall structure 110.

[0039] Referring again to FIGS. 1 and 2, in one example, enclosure assembly 100 includes auxiliary enclosures 135 and 140, each having a plurality of partition structures 210 therein. In this example, auxiliary enclosures 135 and 140 may serve to house a plurality of power supply units (PSUs) providing operating power to electronic components such as processing units and memory units, housed within main enclosure 102.

[0040] In this example, auxiliary enclosures 135 and 140 may be constructed substantially in accordance with main enclosure 102 as herein disclosed. This may include providing auxiliary enclosure side wall structures 145 and 165, auxiliary enclosure top wall structures 150 and 170, and the respective auxiliary enclosure end wall structures in the form of laminated heat-capturing laminar panels substantially similar to side wall structures 110 and 115 and partition structures 205 described herein with reference to FIGS. 1-4. Fluid-circulating paths formed in these structures may be introduced into the cooling fluid circulation loop entering and exiting enclosure assembly 100 through cooling fluid inflow port 180 and outflow port 185.

[0041] In one example, operation of enclosure assembly 100 proceeds as follows: Lower-temperature (i.e., cooled or chilled) cooling fluid 314, such as water, is provided at cooling fluid inflow port 180. The incoming cooling fluid may be supplied, for example, from a heat exchange unit. Fluid inflow port 180 is in fluid communication with inflow channels 312 formed in bottom wall 105 of assembly 100. The cooled fluid 314 follows a circulation path

extending within one or more partition structures 205 between bottom wall structure 105 and top wall structure 110. As cooling fluid traverses this circulation path, it captures heat within enclosure assembly 100. Part of the circulation path involves an attachment portion 304 of the one or more partition structures 205 for establishing a fluid-tight seal between partition structures 205 and bottom wall structure 105. Another part of the circulation path involves an attachment portion 306 of the one or more partition structures 205 for establishing a fluid-tight seal between partition structures 205 and top wall structure 110. Cooling fluid 314 flows into outflow channels 340 defined in top wall structure 110. Outflow channels 340, in turn, are in fluid communication with cooling fluid outflow port 185, from which cooling fluid that captures heat within enclosure assembly 100 is re-circulated to a heat exchange unit, where the heat captured along the fluid circulation path may be extracted.

[0042] FIG. 5 is a schematic/block diagram illustrating an example of deploying a plurality of electronic component enclosures such as enclosure assembly 100 from FIG. 1. In the example of FIG. 5, a plurality of heat-capturing enclosure assemblies, 500-1, 500-2, ... 500-N (collectively, enclosure assemblies 500) are deployed in a common environment 502, which may be a data or data processing center or the like. Common environment 502 may be of essentially any size, ranging from a single room to an entire building.

[0043] As shown in FIG. 5, each enclosure assembly 500 each is provided with a cooling fluid inflow port 580 and a cooling fluid outflow port 585, corresponding substantially as described with reference to cooling fluid inflow port 180 and outflow port 185 for the above-described enclosure assembly 100. With ports 580 and 585, enclosure assemblies 500 are incorporated into a cooling fluid circulation loop 503 which also includes a heat exchanger 504.

[0044] Heat exchanger 504 is adapted to receive heated cooling fluid, such as water, at a fluid input 506 and utilize any of many known methods for extracting heat from the fluid, the heated input fluid being directed as indicated by arrow 508 in FIG. 5. After heat exchange, the circulation loop 503 continues with the now-cooled fluid being returned via a fluid output 510, with fluid flow as indicated by arrow 512 in FIG. 5. Cooled fluid returns to environment 502 and is thereafter distributed to cooling fluid inflow ports 585 of enclosure assemblies 500.

[0045] With the objective of attaining room (external to enclosure 100/500) environment thermal neutrality for enclosure assemblies 500 while electronic components are operating therein, the fluid connections comprising any part of the circulation loop 503 which are inside environment 502 may be provided with suitable thermal insulation, thereby preventing or minimizing the transfer of the captured heat into environment 502.

[0046] FIG. 6 is a flow diagram depicting a method 600 for enclosing an electronic component in accordance with one example. As shown in FIG. 6, block 602 represents enclosing an electronic component in a substantially sealed enclosure which includes a plurality of thermally-conductive outer walls and a partition structure. Block 604 in FIG. 6 represents circulating cooling fluid in a continuous loop through an internal fluid channel in at least one of the plurality of outer walls and an internal fluid channel in the partition structure.

[0047] The above discussion is meant to be illustrative of the principles and various implementations of the present disclosure. Numerous variations and modifications will become apparent to those skilled in the art once the above disclosure is fully appreciated. It is intended that the following claims be interpreted to embrace all such variations and modifications.

CLAIMS

What is claimed is:

1. An electronic component enclosure comprising:
 - a plurality of outer walls, each outer wall comprising a thermally conductive material and an internal fluid channel for circulation of cooling fluid;
 - at least one partition structure comprising a thermally conductive material and an internal fluid channel in sealed fluid communication with the internal fluid channel of at least one outer wall of the plurality of outer walls;
 - a fluid inflow port in sealed fluid communication with the internal fluid channel of the at least one outer wall of the plurality of outer walls; and
 - a fluid outflow port in sealed fluid communication with the internal fluid channel of the at least one outer wall of the plurality of walls,wherein the internal fluid channels of the plurality of outer walls and the internal fluid channel of the at least one partition structure define a continuous fluid circulation path between the fluid inflow port and the fluid outflow port.
2. The electronic component enclosure of claim 1, wherein each of the plurality of outer walls comprises a laminar structure including first and second layers defining the internal fluid channel therebetween.
3. The electronic component enclosure of claim 2, wherein the at least one partition structure comprises a laminar structure including first and second layers defining the internal fluid channel therebetween, wherein the internal fluid channel of the at least one partition structure is in sealed fluid communication with the internal fluid channel of the at least one outer wall of the plurality of outer walls.
4. The electronic component enclosure of claim 3, wherein the plurality of outer walls and the at least one partition structure are formed from steel.

5. The electronic component enclosure of claim 4, wherein the internal fluid channel of each of the plurality of outer walls is formed by photo-etching at least one of the first and second layers thereof, and wherein the internal fluid channel of the at least one partition structure is formed by photo-etching at least one of the first and second layers thereof.
6. The electronic component enclosure of claim 1, wherein a combined surface area of the plurality of outer walls and the at least one partition structure establishes a heat-capturing capacity of the enclosure when cooling fluid circulates through the continuous fluid circulation path.
7. The electronic component enclosure of claim 1, wherein the at least one partition structure includes at least one connecting portion for establishing a sealed fluid connection between the internal fluid channel of the at least one partition structure and the internal fluid channel of the at least one outer wall.
8. An enclosure system for electronic components, comprising:
 - a substantially sealed heat-capturing enclosure, the enclosure comprising:
 - a plurality of outer walls, each outer wall comprising a thermally conductive material and an internal fluid channel for circulation of cooling fluid;
 - at least one partition structure defining at least one compartment within the plurality of outer walls, the at least one partition structure comprising a thermally conductive material and having an internal fluid channel in sealed fluid communication with the internal fluid channel of at least one outer wall of the plurality of outer walls;
 - a fluid inflow port in sealed fluid communication with the internal fluid channel of the at least one outer wall of the plurality of outer walls; and
 - a fluid outflow port in sealed fluid communication with the internal fluid channel of at least one outer wall of the plurality of outer walls, wherein the internal fluid channels of the plurality of outer walls and the internal fluid channel of the at least one partition structure define a continuous fluid circulation path between the fluid inflow port and the fluid outflow port; and

a heat exchanger coupled to the fluid inflow port and the fluid outflow port of the enclosure, the heat exchanger to circulate cooling fluid through the continuous fluid circulation path.

9. The enclosure system of claim 8, wherein each outer wall of the plurality of outer walls comprises a laminar structure including first and second layers defining the internal fluid channel therebetween.

10. The enclosure system of claim 9, wherein the at least one partition structure comprises a laminar structure including first and second layers defining the internal fluid channel therebetween, wherein the internal fluid channel of the at least one partition structure is in sealed fluid communication with the internal fluid channel of the at least one outer wall of the plurality of outer walls.

11. The enclosure system of claim 10, wherein the plurality of outer walls and the at least one partition structure are formed from steel.

12. The enclosure system of claim 11, wherein the internal fluid channel of each outer wall of the plurality of outer walls is formed by photo-etching at least one of the first and second layers thereof, and wherein the internal fluid channel of the at least one partition structure is formed by photo-etching at least one of the first and second layers thereof.

13. The enclosure system of claim 8, wherein a combined surface area of the plurality of outer walls and the at least one partition structure establishes a heat-capturing capacity of the enclosure when cooling fluid circulates through the continuous fluid circulation path.

14. The enclosure system of claim 8, wherein the at least one partition structure includes at least one connecting portion for establishing a sealed fluid connection between the internal fluid channel of the at least one partition structure and the internal fluid channel of the at least one outer wall of the plurality of outer walls.

15. A method of capturing heat from an electronic component, comprising:
 - enclosing the electronic component in a substantially sealed enclosure including a plurality of outer walls and a partition structure defining at least one compartment within the enclosure; and
 - circulating cooling fluid in a continuous loop through an internal fluid channel in each of the outer walls and an internal fluid channel in the partition structure, the fluid channel in the partition structure being in sealed fluid communication with the internal fluid channel of at least one outer wall of the plurality of outer walls.
16. The method of claim 15, further comprising:
 - forming each outer wall of the plurality of outer walls as a laminar structure including first and second layers defining the internal fluid channel therebetween.
17. The method of claim 16, further comprising:
 - forming the at least one partition structure as a laminar structure including first and second layers defining the internal fluid channel therebetween.
18. The method of claim 17, further comprising:
 - forming the plurality of outer walls and the at least one partition structure from steel.
19. The method of claim 18, further comprising:
 - photo-etching at least one of the first and second layers of each outer wall of the plurality of outer walls to form the internal fluid channels of the plurality of outer walls; and
 - photo-etching at least one of the first and second layers of the at least one partition structure to form the internal fluid channel of the at least one partition structure.
20. The method of claim 15, further comprising:
 - providing a combined surface area of the plurality of outer walls and the at least one partition structure to establish a heat-capturing capacity of the enclosure when cooling fluid circulates through the continuous fluid circulation path.

1/6

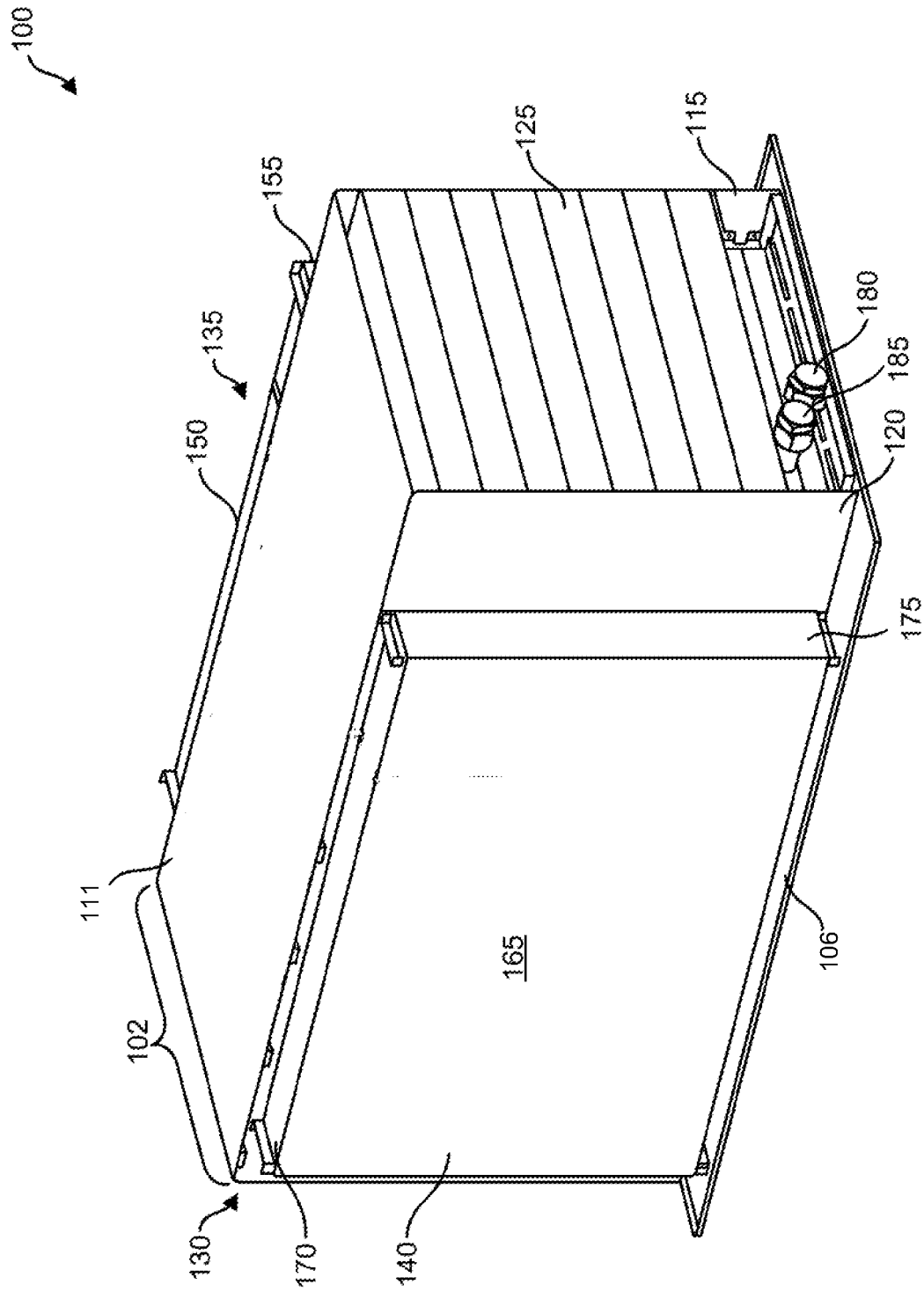


FIG. 1

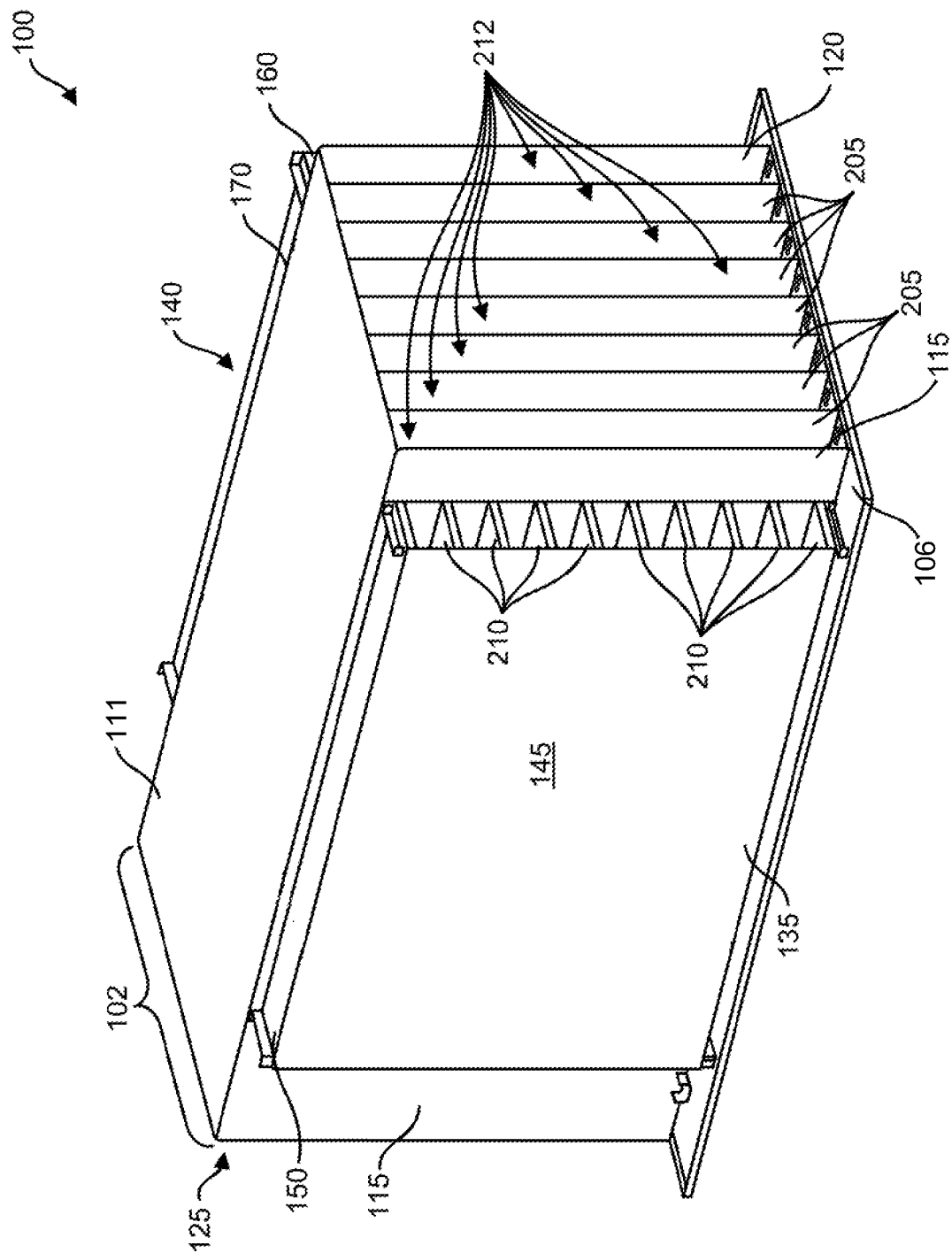
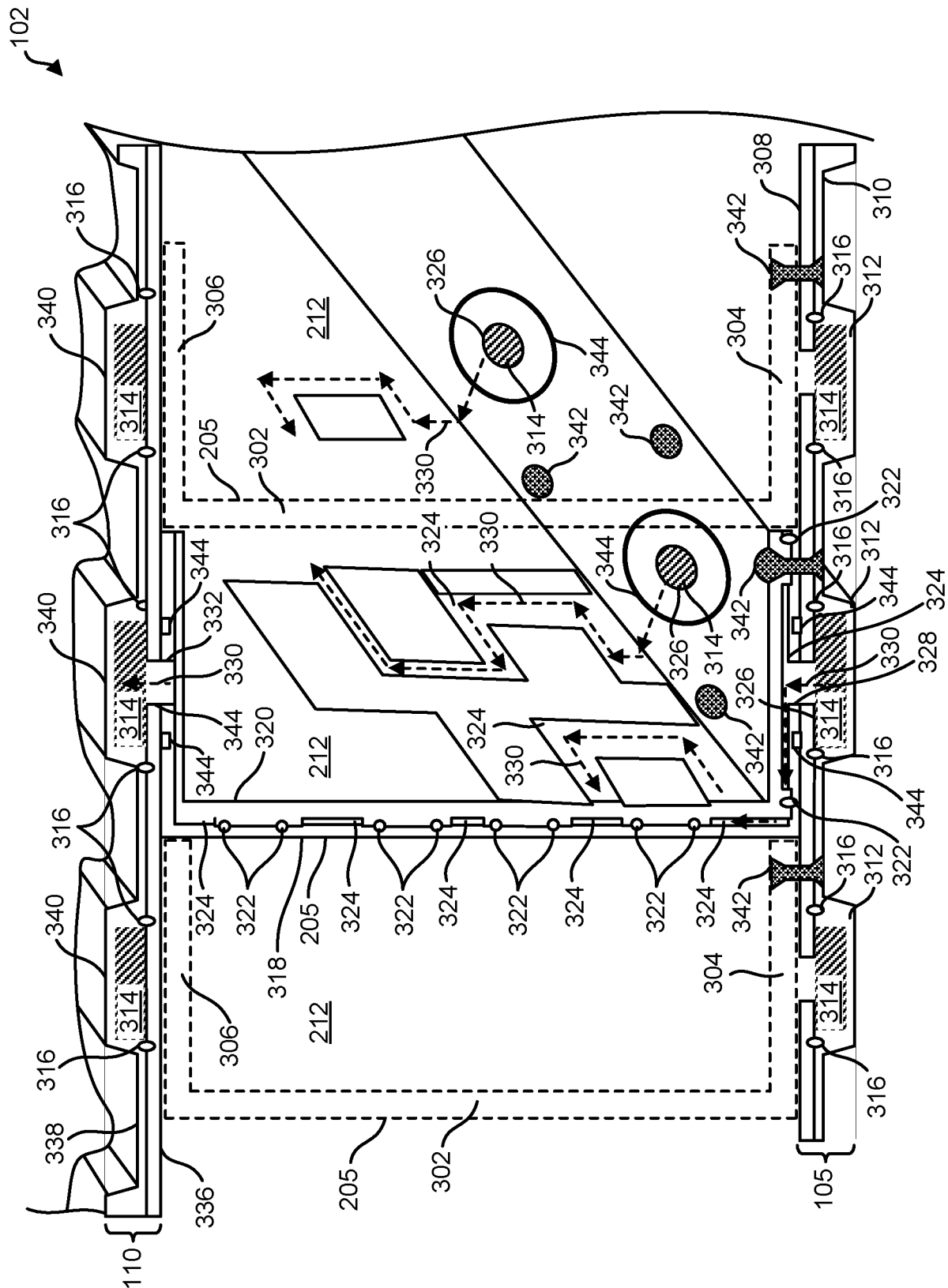


FIG. 2



3
G.
F

4/6

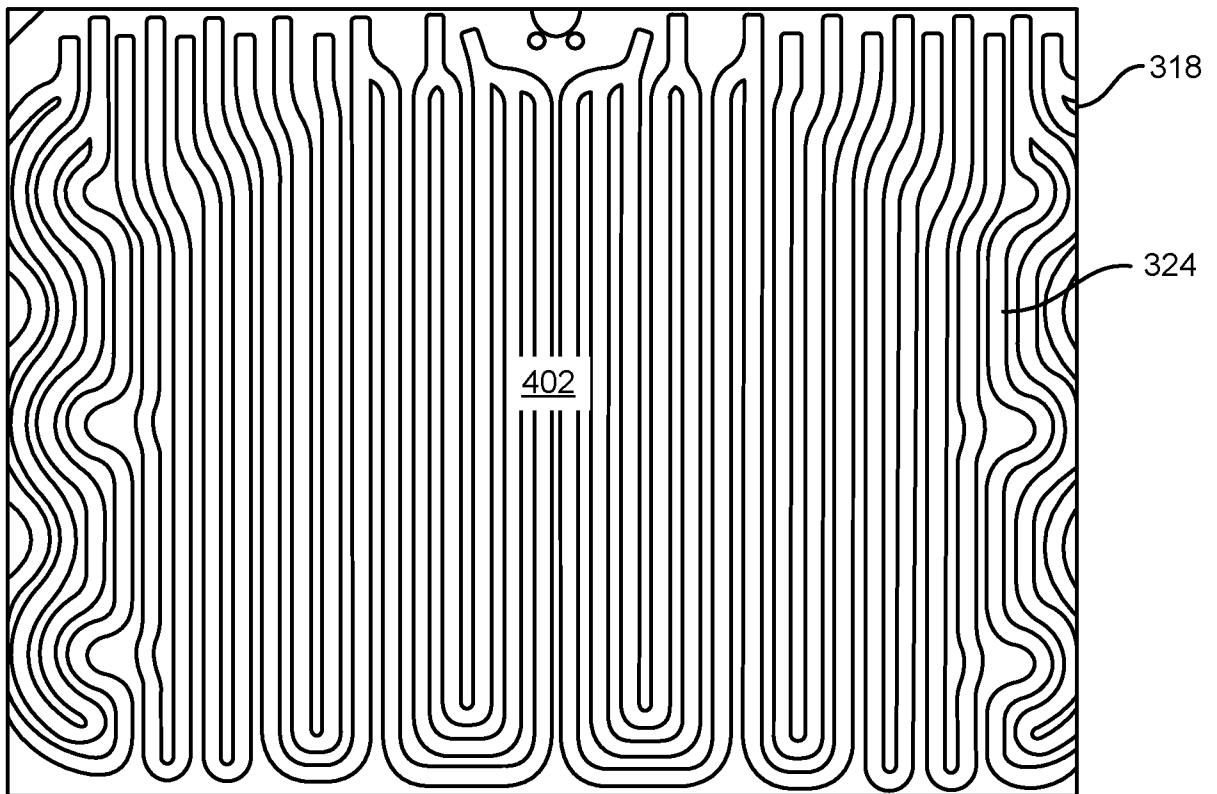


FIG. 4

5/6

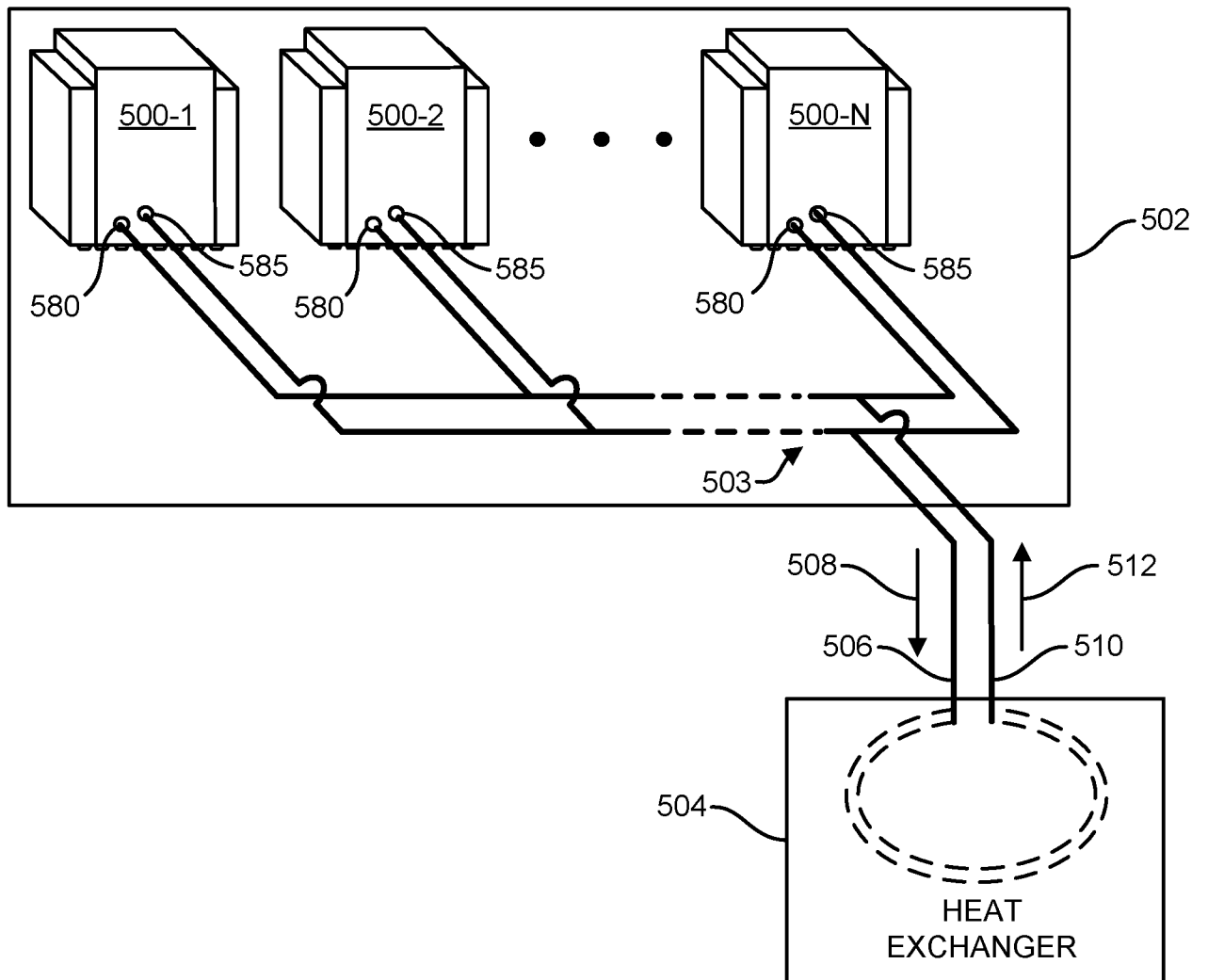


FIG. 5

6/6

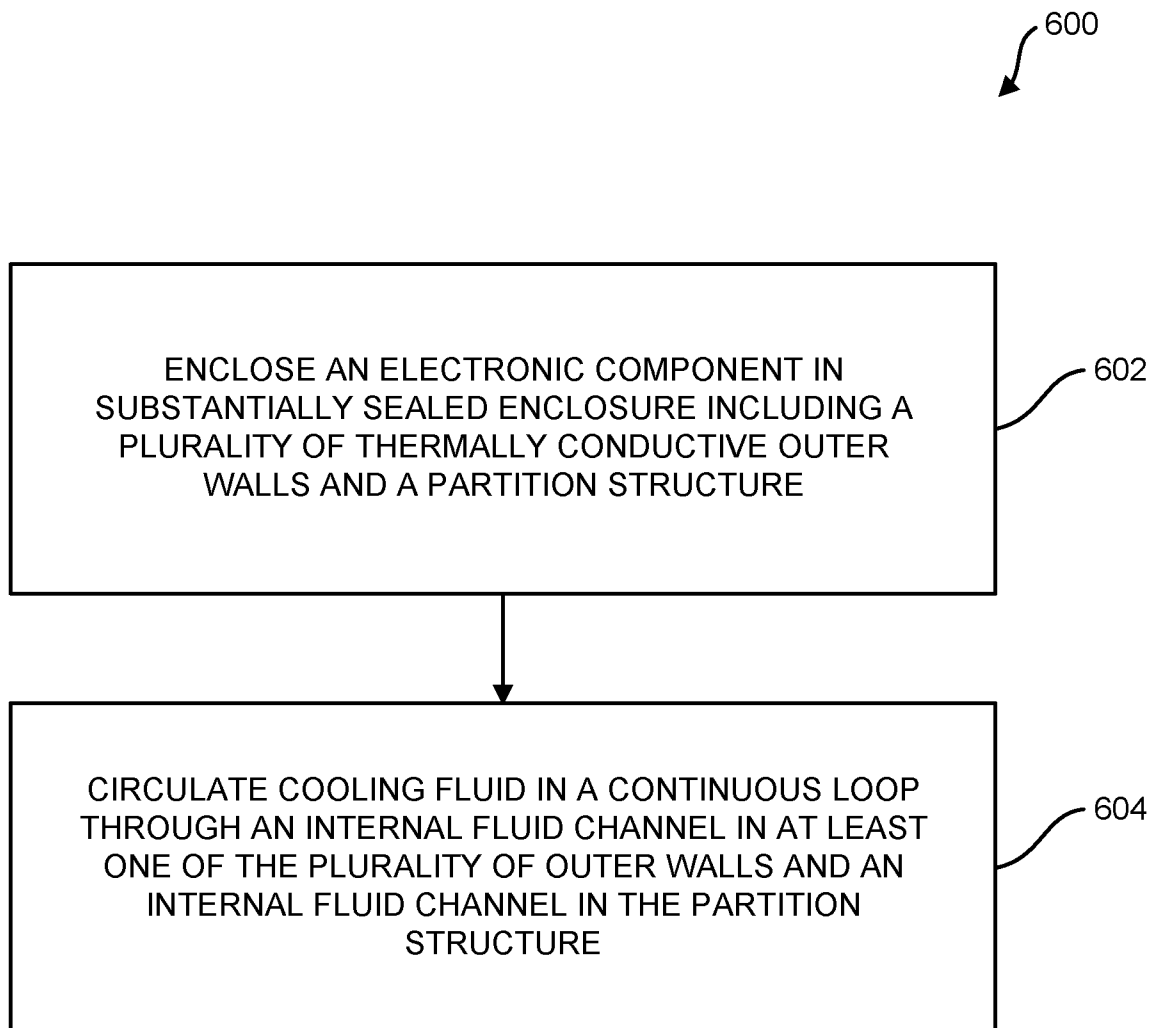


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2019/017026**A. CLASSIFICATION OF SUBJECT MATTER****H05K 7/20(2006.01)i**

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)

H05K 7/20; B01J 19/00; B23P 6/00; F28D 15/00; F28F 13/00; H05K 13/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: enclosure, wall, partition, cooling, fluid, channel, inflow, outflow

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2014-0216686 A1 (DELL PRODUCTS L.P.) 07 August 2014 See paragraphs 66, 127-132; and figures 4, 8.	1-20
Y	US 2011-0180235 A1 (SRINIVAS GARIMELLA et al.) 28 July 2011 See paragraphs 57, 69, 74, 88; and figures 1, 5.	1-20
A	US 2012-0095268 A1 (ANNA LEE TONKOVICH et al.) 19 April 2012 See the entire document.	1-20
A	AU 2017-202585 A1 (INERTECH IP LLC) 11 May 2017 See the entire document.	1-20
A	KR 10-2016-0145114 A (RAYTHEON CO) 19 December 2016 See the entire document.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent but published on or after the international filing date

"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

02 December 2019 (02.12.2019)

Date of mailing of the international search report

03 December 2019 (03.12.2019)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

PARK, Hye Lyun

Telephone No. +82-42-481-3463



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/017026

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2014-0216686 A1	07/08/2014	US 10143113 B2 US 2016-0234970 A1 US 9328964 B2 WO 2014-120275 A1	27/11/2018 11/08/2016 03/05/2016 07/08/2014
US 2011-0180235 A1	28/07/2011	CN 102112837 A CN 102112837 B EP 2321605 A1 EP 2321605 B1 JP 2011-530059 A JP 5719296 B2 KR 10-1727890 B1 KR 10-2011-0074970 A KR 10-2017-0005164 A WO 2010-014878 A1	29/06/2011 08/05/2013 18/05/2011 12/09/2018 15/12/2011 13/05/2015 18/04/2017 05/07/2011 11/01/2017 04/02/2010
US 2012-0095268 A1	19/04/2012	AU 2011-317159 A1 AU 2011-317159 A8 AU 2011-317159 B2 AU 2011-317245 A1 AU 2011-317245 B2 AU 2016-200508 A1 AU 2016-200508 B2 AU 2016-203247 A1 AU 2016-203247 B2 BR 112013009271 A2 BR 112013009338 A2 CA 2814870 A1 CA 2814870 C CA 2815208 A1 CN 103269786 A CN 103338852 A CN 103338852 B CN 107570091 A DE 112011103503 T5 DE 112011103504 T5 GB 2498294 A GB 2498294 B GB 2502437 A GB 2502437 B JP 2014-505578 A JP 2014-505579 A JP 2016-195993 A JP 2017-100123 A JP 2018-196884 A JP 5922137 B2 JP 6232099 B2 JP 6366937 B2 KR 10-1783794 B1	02/05/2013 26/05/2016 10/03/2016 02/05/2013 05/11/2015 18/02/2016 02/03/2017 18/08/2016 08/03/2018 26/07/2016 26/07/2016 26/04/2012 01/08/2017 26/04/2012 28/08/2013 02/10/2013 09/11/2016 12/01/2018 21/11/2013 14/11/2013 10/07/2013 09/08/2017 27/11/2013 31/05/2017 06/03/2014 06/03/2014 24/11/2016 08/06/2017 13/12/2018 24/05/2016 15/11/2017 01/08/2018 06/11/2017

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/017026

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
AU 2017-202585 A1	11/05/2017	KR 10-1944288 B1	17/04/2019
		KR 10-2014-0030101 A	11/03/2014
		KR 10-2014-0035867 A	24/03/2014
		RU 2013114747 A	27/11/2014
		RU 2013122927 A	27/11/2014
		US 10155213 B2	18/12/2018
		US 2012-0132290 A1	31/05/2012
		US 2017-0014795 A1	19/01/2017
		US 2017-0189885 A1	06/07/2017
		US 2019-0224639 A1	25/07/2019
		US 9527057 B2	27/12/2016
		WO 2012-054455 A2	26/04/2012
		WO 2012-054455 A3	14/06/2012
		WO 2012-054542 A2	26/04/2012
		WO 2012-054542 A3	30/08/2012
		ZA 201302718 B	23/12/2013
		AU 2011-270812 A1	10/01/2013
		AU 2011-270812 B2	19/01/2017
		AU 2011-270812 C1	11/05/2017
		AU 2011-360944 A1	19/09/2013
		AU 2011-360945 A1	05/09/2013
		CA 2803168 A1	29/12/2011
		CA 2803168 C	11/09/2018
		CA 2828694 A1	07/09/2012
		CA 3013470 A1	29/12/2011
		EP 2586281 A2	01/05/2013
		EP 2586281 B1	09/08/2017
		EP 2648496 A2	09/10/2013
		EP 2648496 A3	01/11/2017
		EP 2648496 B1	01/05/2019
		EP 2681637 A2	08/01/2014
		EP 2681978 A1	08/01/2014
		JP 2013-532341 A	15/08/2013
		JP 2014-509726 A	21/04/2014
		JP 2014-513336 A	29/05/2014
		JP 5748849 B2	15/07/2015
		KR 10-1817277 B1	10/01/2018
		KR 10-1911350 B1	25/10/2018
		KR 10-2013-0041124 A	24/04/2013
		KR 10-2014-0015416 A	06/02/2014
		KR 10-2014-0023296 A	26/02/2014
		KR 10-2018-0006485 A	17/01/2018
		KR 10-2018-0116480 A	24/10/2018
		SG 10201507946Q A	29/10/2015
		SG 186785 A1	28/02/2013
		SG 192974 A1	30/09/2013
		SG 193259 A1	30/10/2013
		US 2012-0125028 A1	24/05/2012
		US 2012-0127653 A1	24/05/2012

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/017026

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 10-2016-0145114 A	19/12/2016	US 2012-0127657 A1	24/05/2012
		US 2012-0133256 A1	31/05/2012
		US 2012-0300391 A1	29/11/2012
		US 2012-0318492 A1	20/12/2012
		US 2013-0047653 A1	28/02/2013
		US 2015-0195958 A1	09/07/2015
		US 2017-0079165 A1	16/03/2017
		US 8254124 B2	28/08/2012
		US 8297067 B2	30/10/2012
		US 8305757 B2	06/11/2012
		US 8601827 B2	10/12/2013
		US 9282684 B2	08/03/2016
		US 9763366 B2	12/09/2017
		US 9839163 B2	05/12/2017
		WO 2011-163532 A2	29/12/2011
		WO 2011-163532 A3	16/08/2012
		WO 2012-118553 A2	07/09/2012
		WO 2012-118553 A3	26/10/2012
		WO 2012-118554 A1	07/09/2012
		AU 2015-247709 A1	29/09/2016
		AU 2015-247709 B2	26/07/2018
		CA 2942967 A1	22/10/2015
		CA 2942967 C	05/09/2017
		EP 3132663 A1	22/02/2017
		EP 3132663 B1	29/08/2018
		IL 247962 A	31/05/2018
		JP 2017-517878 A	29/06/2017
		JP 6255514 B2	27/12/2017
		US 2015-0305198 A1	22/10/2015
		US 9468131 B2	11/10/2016
		WO 2015-160910 A1	22/10/2015