US Patent & Trademark Office
Patent Public Search | Text View

United States Patent	12396140
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Chen; Chao-Jung et al.

System and method for hybrid direct-to-chip liquid and immersion cooling

Abstract

A hybrid cooling system is configured to receive heat-generating components of an information technology (IT) device. The system includes a chassis having a peripheral wall that extends between a chassis base and an open top surface, the peripheral wall forming an enclosure between an upstream side and a downstream side. An immersion conduit delivers an immersion coolant and fills the enclosure to fully immerse the heat-generating components. An outlet duct drain overflow of the immersion coolant accumulated in the enclosure. A cold plate within the enclosure is configured for direct contact with at least one heat-generating component. A supply conduit delivers a direct coolant in cooled form within the cold plate, and is in flow communication with a cold plate inlet connector. A return conduit removes the direct coolant in heated form from the cold plate, and is in flow communication with a cold plate outlet connector.

Inventors: **Chen; Chao-Jung (Taoyuan, TW), Huang; Yu-Nien (Taoyuan, TW), Tan; Herman (Taoyuan, TW)**

Applicant: **Quanta Computer Inc.** (Taoyuan, TW)

Family ID: **1000008765376**

Assignee: **QUANTA COMPUTER INC. (Taoyuan, TW)**

Appl. No.: **18/473199**

Filed: **September 22, 2023**

Prior Publication Data

Document Identifier	Publication Date
US 20250040101 A1	Jan. 30, 2025

Related U.S. Application Data

us-provisional-application US 63515537 20230725

Publication Classification

Int. Cl.: **H05K7/20** (20060101)

U.S. Cl.:

CPC **H05K7/2079** (20130101); **H05K7/20236** (20130101); **H05K7/20254** (20130101);

Field of Classification Search

CPC: H05K (7/2079); H05K (7/20236); H05K (7/20254); H05K (7/20772); H05K (7/206)

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
9622379	12/2016	Campbell	N/A	H05K 7/20318
2011/0315353	12/2010	Campbell	165/104.31	H05K 7/20809
2014/0133099	12/2013	Campbell	361/698	H05K 7/20818
2022/0210949	12/2021	Edmunds et al.	N/A	N/A
2023/0046075	12/2022	Chen	N/A	H05K 7/20272

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
2751096	12/2015	CA	G01P 13/0026
108304054	12/2017	CN	N/A
115707206	12/2022	CN	N/A

OTHER PUBLICATIONS

TW Office Action for Application No. 113102029 mailed Aug. 9, 2024, w/ First Office Action Summary, 9 pp. cited by applicant

TW Search Report for Application No. 113102029 mailed Aug. 9, 2024, w/ First Office Action, 1 p. cited by applicant

Primary Examiner: Rathod; Abhishek M

Attorney, Agent or Firm: NIXON PEABODY LLP

Background/Summary

RELATED APPLICATIONS (1) This application claims priority to and the benefit of U.S. Provisional Application No. 63/515,537, filed on Jul. 25, 2023, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

(1) The present invention relates generally to cooling of an information technology ("IT") system, and more specifically, to hybrid cooling that combines immersion cooling and direct-contact cooling.

BACKGROUND OF THE INVENTION

(2) IT systems, including server systems, require cooling to prevent overheating. Cooling demands have increased, as the power and speed of server systems have increased. Immersion cooling for the IT system is one preferred method of cooling, which requires immersing components of the IT system (e.g., mainboard, storage devices, add-on-card, power supply unit) into a tank that is filled with a cooling liquid. The cooling liquid acts as a medium for dissipating heat generated from the components of the IT system. However, physical space (e.g., existing industrial rack or cabinet footprint) and budgets associated with present immersion cooling of IT systems are severely limited, resulting in drastic cooling problems. Moreover, immersion cooling has limited cooling capacity when highly-localized power components, such as main computing chips, such as central processing units (CPUs) or graphic processing units (GPUs), are included in the IT system. The present disclosure provides a solution for these and other problems.

SUMMARY OF THE INVENTION

(3) The term embodiment and like terms, e.g., implementation, configuration, aspect, example, and option, are intended to refer broadly to all of the subject matter of this disclosure and the claims below. Statements containing these terms should be understood not to limit the subject matter described herein or to limit the meaning or scope of the claims below. Embodiments of the present disclosure covered herein are defined by the claims below, not this summary. This summary is a high-level overview of various aspects of the disclosure and introduces some of the concepts that are further described in the Detailed Description section below. This summary is not intended to identify key or essential features of the claimed subject matter. This summary is also not intended to be used in isolation to determine the scope of the claimed subject matter. The subject matter should be understood by reference to appropriate portions of the entire specification of this disclosure, any or all drawings, and each claim.

(4) According to certain aspects of the present disclosure, a hybrid cooling system is directed to an information technology (IT) device, and includes a chassis having a peripheral wall that extends between a chassis base and an open top surface. The peripheral wall forms an enclosure between an upstream side and a downstream side. The chassis is configured to receive heat-generating components of the IT device within the enclosure. The system further includes an immersion conduit for delivering an immersion coolant within the enclosure. The immersion coolant fills the enclosure to immerse the heat-generating components. The system further includes an outlet duct for draining overflow of the immersion coolant accumulated in the enclosure. The system further includes a cold plate positioned within the enclosure and configured for mounting in direct contact with at least one of the heat-generating components. The cold plate has an inlet connector and an outlet connector. The system further includes a supply conduit for delivering a direct coolant in cooled form within the cold plate, the supply conduit being in flow communication with the inlet connector. The system further includes a return conduit for removing the direct coolant in heated form from the cold plate, the return conduit being in flow communication with the outlet connector.

(5) According to some features of the above aspects, the chassis has a rear opening in the downstream side, the rear opening blocked by a movable flap in a closed position. The movable flap has a flap height that is lower than a wall height of the peripheral wall. According to other features of the above aspects, the outlet duct automatically receives the overflow of the immersion

coolant when an accumulation of the immersion coolant reaches the flap height. According to yet other features of the above aspects, the movable flap is rotatable between the closed position, in which at least some of the immersion coolant accumulates in the enclosure, and an open position, in which at least some of the immersion coolant drains from the enclosure.
(6) According to yet other features of the above aspects, the immersion conduit is routed alongside a lateral side the peripheral wall that extends between the upstream side and the downstream side. According to yet other features of the above aspects, the immersion conduit has an inlet end that is fluidly coupled with an immersion quick-disconnect connector, the immersion quick-disconnect connector being mounted in the downstream side near the lateral side. According to yet other features of the above aspects, the immersion conduit has an immersion-delivery side positioned along the upstream side, the immersion conduit delivering the immersion coolant near the upstream side.
(7) According to yet other features of the above aspects, the direct coolant is different than the immersion fluid. According to yet other features of the above aspects, the direct coolant is a dielectric fluid and the immersion fluid is a non-dielectric fluid.
(8) According to yet other features of the above aspects, the system further includes another cold plate positioned within the enclosure and configured for mounting in direct contact with at least one of the heat-generating components, the another cold plate having another inlet connector and another outlet connector. The system further includes another supply conduit for delivering another direct coolant in cooled form within the cold plate, the another supply conduit being in flow communication with the another inlet connector. The system further includes another return conduit for removing the another direct coolant in heated form from the another cold plate, the another return conduit being in flow communication with the another outlet connector.
(9) According to other aspects of the present disclosure, a computing assembly is directed to hybrid immersion cooling and includes a computing rack configured to house a plurality of information technology (IT) devices. The assembly further includes a coolant supply manifold positioned along one end of a downstream side, and a coolant draining manifold positioned along an opposite end of the downstream side. The assembly further includes a plurality of chassis slidably mounted within the computing rack, each chassis of the plurality of chassis being configured to receive a respective IT device of the plurality of IT devices. Each chassis has a peripheral wall that forms an enclosure between an upstream side and a downstream side, the enclosure being configured to receive heat-generating components of the IT device. Each chassis further has an immersion conduit for delivering an immersion coolant within the enclosure, the immersion coolant filling the enclosure to fully immerse the heat-generating components. Each chassis further has a cold plate positioned within the enclosure and configured for mounting in direct contact with at least one of the heat-generating components, the cold plate having an inlet connector and an outlet connector. Each chassis further has a supply conduit for delivering a direct coolant in cooled form within the cold plate, the supply conduit being in flow communication with the inlet connector.
(10) According to some features of the above aspects, the assembly further includes an outlet duct for draining overflow of the immersion coolant accumulated in the enclosure.
(11) According to other features of the above aspects, the assembly further includes a return conduit for removing the direct coolant in heated form from the cold plate, the return conduit being in flow communication with the outlet connector.
(12) According to yet other features of the above aspects, the coolant supply manifold and the coolant draining manifold are mounted generally vertically along the downstream side.
(13) According to yet other features of the above aspects, each chassis is mounted generally horizontally in the computing rack.
(14) According to yet other aspects of the present disclosure, a method is directed to hybrid cooling of an information technology (IT) system. The method includes providing a chassis with a peripheral wall extending between a chassis base and an open top surface, the peripheral wall

forming an enclosure between an upstream side and a downstream side. The peripheral wall has a rear opening blocked with a flap, the flap being movable between a closed position and an open position. The method further includes receiving heat-generating components of the IT system into the chassis, at least one of the heat-generating components being in direct contact with a cold plate. The method further includes delivering an immersion coolant within and filling, at least in part, the enclosure to fully immerse the heat-generating components. The method further includes automatically draining, in the closed position, overflow of the immersion coolant accumulated in the enclosure. The method further includes delivering a direct coolant in cooled form within the cold plate, and removing the direct coolant in heated form from the cold plate.
(15) According to some features of the above aspects, the method further includes, in response to manually moving the flap from the closed position to the open position, draining the immersion coolant from the enclosure. According to other features of the above aspects, the method further includes rotating the moving the flap between the closed position and the open position.
(16) According to yet other features of the above aspects, the method further includes receiving the immersion coolant from a supply manifold.
(17) According to yet other features of the above aspects, the method further includes draining the immersion coolant into a recycle manifold.
(18) The above summary is not intended to represent each embodiment or every aspect of the present disclosure. Rather, the foregoing summary merely provides an example of some of the novel aspects and features set forth herein. The above features and advantages, and other features and advantages of the present disclosure, will be readily apparent from the following detailed description of representative embodiments and modes for carrying out the present invention, when taken in connection with the accompanying drawings and the appended claims. Additional aspects of the disclosure will be apparent to those of ordinary skill in the art in view of the detailed description of various embodiments, which is made with reference to the drawings, a brief description of which is provided below.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) The disclosure, and its advantages and drawings, will be better understood from the following description of representative embodiments together with reference to the accompanying drawings. These drawings depict only representative embodiments, and are therefore not to be considered as limitations on the scope of the various embodiments or claims.
(2) FIG. **1**A is a perspective view of a rack for an IT system, according to certain aspects of the present disclosure.
(3) FIG. **1**B is a perspective view of the rack of FIG. **1**A illustrating some internal components, according to certain aspects of the present disclosure.
(4) FIG. **2** is a perspective view of a chassis and coolant manifolds for the IT system of FIG. **1**A, according to certain aspects of the present disclosure.
(5) FIG. **3** is a perspective of the chassis of FIG. **2**, according to certain aspects of the present disclosure.
(6) FIG. **4** is an exploded perspective view showing the chassis of FIG. **2** and a supply conduit, according to certain aspects of the present disclosure.
(7) FIG. **5** is a top view of the chassis of FIG. **2** illustrating immersion cooling, according to certain aspects of the present disclosure.
(8) FIG. **6** is a top view of the chassis of FIG. **2** illustrating direct cooling, according to certain aspects of the present disclosure.
(9) FIG. **7**A is a perspective view illustrating a flap mechanism in a closed position, according to

certain aspects of the present disclosure.
(10) FIG. **7**B is a perspective view illustrating the flap mechanism of FIG. **7**A in an open position, according to certain aspects of the present disclosure.
(11) FIG. **8** is an enlarged cross-sectional view along lines "**8**"-"**8**" of FIG. **5**, illustrating a drainage area, according to certain aspects of the present disclosure.
(12) FIG. **9** is a top view illustrating coolant flow in the chassis of FIG. **5**, according to certain aspects of the present disclosure.
DETAILED DESCRIPTION
(13) Various embodiments are described with reference to the attached figures, where like reference numerals are used throughout the figures to designate similar or equivalent elements. The figures are not necessarily drawn to scale and are provided merely to illustrate aspects and features of the present disclosure. Numerous specific details, relationships, and methods are set forth to provide a full understanding of certain aspects and features of the present disclosure, although one having ordinary skill in the relevant art will recognize that these aspects and features can be practiced without one or more of the specific details, with other relationships, or with other methods. In some instances, well-known structures or operations are not shown in detail for illustrative purposes. The various embodiments disclosed herein are not necessarily limited by the illustrated ordering of acts or events, as some acts may occur in different orders and/or concurrently with other acts or events. Furthermore, not all illustrated acts or events are necessarily required to implement certain aspects and features of the present disclosure.
(14) For purposes of the present detailed description, unless specifically disclaimed, and where appropriate, the singular includes the plural and vice versa. The word "including" means "including without limitation." Moreover, words of approximation, such as "about," "almost," "substantially," "approximately," and the like, can be used herein to mean "at," "near," "nearly at," "within 3-5% of," "within acceptable manufacturing tolerances of," or any logical combination thereof. Similarly, terms "vertical" or "horizontal" are intended to additionally include "within 3-5% of" a vertical or horizontal orientation, respectively. Additionally, words of direction, such as "top," "bottom," "left," "right," "above," and "below" are intended to relate to the equivalent direction as depicted in a reference illustration; as understood contextually from the object(s) or element(s) being referenced, such as from a commonly used position for the object(s) or element(s); or as otherwise described herein.
(15) Referring to FIG. **1**A, an IT system **100** includes a equipment rack **102** that generally forms a cabinet enclosure for housing various IT components. The rack **102** has a left side **104**, a right side **105**, a top side **106**, and a bottom side **107**. The enclosed IT components are accessible via one or more of a front opening **108** and a back opening **109**.
(16) Referring to FIG. **1**B, the IT system **100** includes a plurality of chassis **110** within the rack **102**. For ease of understanding, only one chassis **110** will be further described and illustrated in more detail. In this example, the chassis **110** is a 1 U standard height component, but in other examples the chassis **110** is another standard height, such as a 2 U or 4 U height. Each chassis **110** is in fluid communication with a plurality of coolant manifolds **112**. The coolant manifolds **112** are mounted near the back opening **109** of the rack **102**. The chassis **110** may be configured for receiving computer components such as application servers, storage servers, storage devices, switches, routers and the like.
(17) Optionally, the chassis **110** is mounted in the rack **102** in a slidable configuration to facilitate ease of service when needed. For example, the chassis **110** is slidable between an enclosed position **110***a* and a serviceable position **110***b*. Optionally, each chassis **110** is mounted generally horizontally in the rack **102**. In another optional configuration, each chassis **110** is positioned generally parallel to an adjacent chassis **110** in the rack **102**. In another optional configuration, each chassis **110** is slotted in the rack **102**.
(18) Referring to FIG. **2**, the chassis **110** is coupled to an immersion manifold **114**, a cold manifold

115, a hot manifold **116**, and a drainage manifold **17**. The immersion and drainage manifolds **114**, **117** facilitate flow of coolant in and out of the chassis **110** for immersing the chassis **110** with coolant. The hot and cold manifolds **115**, **116** facilitate flow of coolant in and out of the chassis **110** for direct cooling of components within the chassis **110**. The flow of coolant is further described in more detail below in reference to FIG. **9**.

(19) The manifolds **114-117** are part of the coolant manifolds **112** (referred to in FIG. **1**B) and are mounted near a downstream side **118** of the chassis **110**. Optionally, the coolant manifolds **112** are mounted generally vertically along the downstream side **118**. In another optional configuration, the coolant manifolds **112** are mounted generally parallel to each other along the downstream side **118**.

(20) Referring to FIG. **3**, the chassis **110** is generally in the form of a tray that has a plurality of sides, including the downstream side **118**, an upstream side **119**, a left side **120**, and a right side **121**. Optionally, the tray includes a top side **122**, which along with a bottom side **123**, fully encloses the sides **118-121** to form the tray in a generally liquid-tight compartment. The tray further includes an overflow path **134***b* and a drainage path **134***c* discussed below in reference to FIG. **8**.

(21) Each of the four sides **118-121** is continuously connected to form an internal enclosure **124** in which an immersion coolant is delivered. According to the illustrated embodiment, each of the four sides **118-121** forms a respective wall having a height H**1** that may be a standard server unit height U. The downstream side **118** has a rear opening **125**, which (as described below in reference to FIG. **9**) provides an outlet for draining the immersion coolant from the chassis **110**.

(22) Referring to FIG. **4**, the chassis **110** includes an immersion conduit **126** that delivers an immersion coolant to the upstream side **119** within the enclosure **124**. The immersion conduit **126** follows in part an L-shape configuration between the left side **120** and the upstream side **119** of the chassis **110**. The immersion conduit **126** has a general, respective, L-shape with an upstream member **128** that is generally parallel with and adjacent to the upstream side **119**. The upstream member **128** is continuous with and generally perpendicular to a lateral member **130**. The lateral member **130** is generally parallel with and adjacent to the left side **120**.

(23) The upstream member **128** includes a plurality of supply holes **132** for distributing the immersion coolant **134** to fill the enclosure **124**. According to an optional feature, the supply holes **132** are in the form of supply nozzles. According to another optional embodiment, the immersion conduit **126** is in part or in its entirety a tubular conduit with a generally circular cross-sectional profile.

(24) Referring to FIG. **5**, the chassis **110** further includes one or more heat-generating components **136** and a drainage mechanism **138**, within the enclosure **124**. The heat-generating components **136** are mounted adjacent to the upstream side **119**, within the enclosure **124**. The immersion conduit **126** delivers the immersion coolant **134** to the upstream side **119** within the enclosure **124**.

(25) The immersion conduit **126** is fluidly coupled to the immersion manifold **114** via a quick-disconnect connector **140** (i.e., a first quick-disconnect connector). The quick-disconnect connector **140** is mounted along the downstream side **118**, near the left side **120**. The quick-disconnect connector **140** facilitates quick, easy, and toolless connection and disconnection of the immersion conduit **126** from the immersion manifold **114**. The immersion manifold **114** is generally a coolant supply source that delivers the immersion coolant **134** to the immersion conduit **126**. For example, the immersion manifold **114** supplies fresh, cold liquid coolant **134** into each chassis **110**.

(26) Accumulated immersion coolant **134** is drained into the drainage manifold **117**, which provides a flow outlet towards a drainage source. As explained below in more detail, the drainage manifold **117** receives the immersion coolant **134** either via the overflow path **134***b* or the drainage path **134***c* (illustrated in FIG. **8**).

(27) Referring to FIG. **6**, the chassis **110** further includes, mounted within, a direct cooling system **142** that works simultaneous with the immersion conduit **126** to cool the heat-generating components **136**. Thus, the direct cooling system **142** and the immersion conduit **126** provide a hybrid cooling system that enhances cooling aspects, advantageously contributing to high

performance of the heat-generating components **136**.
(28) The direct cooling system **142** includes at least one cold plate **144** that is positioned within the internal enclosure **124** and is configured for mounting in direct contact with at least one of the heat-generating components **136**, such as a CPU chip or a GPU chip. The cold plate **144** has an inlet connector **146** and an outlet connector **148**. According to other examples, the direct cooling system **142** includes two or more cold plates **144**. The example of FIG. **6** illustrates an example with two cold plates **144**.
(29) The direct cooling system **142** further includes a supply conduit **150** for delivering a direct coolant **152** in cooled form within conduits of the cold plate **144**. At one end, the supply conduit **150** is in flow communication with the inlet connector **146**. At another end, the supply conduit **150** is in flow communication with the cold manifold **115**, which supplies the direct coolant **152** in the cooled form.
(30) The direct cooling system **142** also includes a return conduit **154** for removing the direct coolant **152**, in heated form, from the cold plate **144**. At one end, the return conduit **154** is in flow communication with the outlet connector **148**. At another end, the return conduit **154** is in flow communication with the hot manifold **116**, which removes the direct coolant **152**.
(31) According to one exemplary embodiment, the direct coolant **152** is the same as the immersion coolant **134**. In another example, the direct coolant **152** is different than the immersion coolant **134**. In yet another, more specific example, the direct coolant **152** is a dielectric fluid, such as water, that is more efficient in heat transfer than the immersion coolant. The immersion coolant is generally a non-dielectric fluid, such as an oil-based coolant.
(32) The direct cooling system **142** further includes quick-disconnect connectors **140** for quick coupling or decoupling of the supply conduit **150** and the return conduit **154**. Accordingly, the supply conduit **150** can be quickly coupled or decoupled, via a respective quick-disconnect connector **140** (i.e., a second quick-disconnect connector) without using tools, from the cold manifold **115**. Similarly, the return conduit **154** can be quickly coupled or decoupled, via a respective quick-disconnect connector **140** (i.e., a third quick-disconnect connector) without using tools, from the hot manifold **116**.
(33) Each of the supply and return conduits **150**, **154** are routed and shaped to achieve the flow of the direct coolant **152** between the respective manifolds **115**, **116** and the cold plate **144**. According to the illustrated example, one of the supply conduits **150** has a diagonal section **150***a* continuous between a straight entry section **150***b* and a straight exit section **150***c*. According to another one of the supply conduits **150**, a diagonal section **150***d* has a greater angle of change between a straight entry section **150***e* and a straight exit section **150***f*. The change in angle accommodates a greater distance between the cold manifold **115** and the respective cold plate **144**.
(34) Similarly, one of the return conduits **154** has a diagonal section **154***a* that extends continuously between a straight entry section **154***b* and a straight exit section **154***c*. According to another one of the return conduits **154**, a diagonal section **154***d* has a greater angle of change between a straight entry section **154***e* and a straight exit section **154***f*. The change in angle accommodates a greater distance between the hot manifold **116** and the respective cold plate **144**.
(35) Referring to FIGS. **7**A and **7**B, the chassis **110** has a flap mechanism **156** that is movable between a closed position (illustrated in FIG. **7**A) and an open position (illustrated in FIG. **7**B). Referring specifically to FIG. **7**A, the flap mechanism **156** includes a flap handle **158** and a flap door **160**. The flap door **160** is rotatably coupled to the chassis **110** via a flap rod **162**, which extends across the rear opening **125** near (but below) the height H**1** of the downstream side **118**. The flap door **160** extends between two opposing sides **125***a*, **125***b* of the rear opening **125**.
(36) The flap door **160** is generally in the form of a plate **164** having a height H**2** that does not fully block the rear opening **125**. The height H**2** of the flap door **160** is smaller than the height H**1** of the four sides **118-121**. At opposing ends of the plate **164**, along the height H**2**, the flap door **160** has inwardly curved ends **166**, **168**. The inwardly curved ends **166**, **168** include a pivoting end **166** and

an actuating end **168**. The pivoting end **166** is configured with an internal hole, which receives within the flap rod **162**, and the actuating end **168** is configured with a similar internal hole, which receives securely within an actuator portion **170** of the flap handle **158**.

(37) The flap handle **158** has a lever portion **172** that extends along the right side **121** of the chassis **110**, near the bottom side **123** of the chassis **110**. The lever portion **172** is continuously connected in a general perpendicular configuration with the actuator portion **170**. In turn, the actuator portion **170** is coupled to the flap door **160**, for moving the flap door **160**.

(38) In the closed position (FIG. **7**A), the flap mechanism **156** prevents accumulated coolant **134***a* from draining from the chassis **110**. In the open position (FIG. **7**B), the flap mechanism **156** allows the accumulated coolant **134***a* to drain from the chassis **110**.

(39) More specifically, referring now to FIG. **7**B, the flap door **160** rotates along a pivoting axis **176**, which is along and coincident with an axis of the flap rod **162**. The rotation of the flap door **160** along the pivoting axis **176** moves the flap door **160** between the open and closed positions.

(40) The movement of the flap door **160** is achieved via a pulling or pushing force of the flap handle **158**, to which the flap door **160** is connected. When the flap door **160** moves away from the downstream side **118**, in a direction **190**, the flap handle **158** causes the flap door **160** to rotate towards the open position. As a result, the accumulated coolant **134***a* drain in an opposite flow direction relative to the direction **190** in which the flap door **160** generally rotates.

(41) The chassis **110** further has an outlet duct **178** mounted to the rear opening **125** for draining the accumulated coolant **134***a*. The outlet duct **178** has two curved sides **180**, **182** extending generally perpendicular from a duct base **184**. The curved sides **180**, **182** flare inwardly from a connecting side **186** to an outlet side **188**. Thus, the connecting side **186** is larger than the outlet side **188**, achieving a funneling effect when draining the immersion coolant. Each of the curved sides **180**, **182** has a height that is generally the same as the height H**1** of the chassis **110**.

(42) Referring to FIG. **8**, draining the accumulated coolant **134***a* from the chassis **110** occurs in two ways. A first way is to have overflow of the accumulated coolant **134***a* flow along the overflow path **134***b*, above the flap door **160**. The overflow occurs in part based on the difference in height between (a) the height H**1** of the chassis **110** and (b) the lower height H**2** of the flap door **160**. This first way is typically during operation of the heat-generating components **136**. A second way is to drain the accumulated coolant **134***a* by opening the flap door **160**. The drainage process typically occurs when one or more components in the chassis **110** requires servicing, which requires removal of the immersion coolant **166**. The system **100** is generally turned OFF, discontinuing computing operation while servicing occurs. The drainage occurs below the flap door **160**, along a drainage path **134***c*, into the outlet duct **178**, and subsequently into the drainage manifold **117**.

(43) The drainage manifold **117** collects the received coolant, e.g., liquid, and routes the heated coolant to a heat exchanger system (not shown) to dissipate the heat carried in the heated coolant and provide fresh cold coolant. The heat exchanger system may include pump mechanisms to circulate the coolant and heat exchange infrastructure such as fans or liquid to liquid heat transfer to dissipate the heat from the heated coolant.

(44) Referring to FIG. **9**, the immersion coolant **134** fills the enclosure **124** of the chassis **110**, in a default cooling operating state. The immersion coolant **134** is supplied via the immersion conduit **126**. Specifically, the upstream member **128** of the immersion conduit **126** inserts the immersion coolant **134** via the supply holes **132**.

(45) The immersion coolant **134** is delivered from the immersion manifold **114**, filling up the enclosure **124** to cool the heat-generating components **136**. In other words, the heat-generating components **136** are fully immersed in the immersion coolant **134**.

(46) The flow path of the immersion coolant **134** includes an initial path **190***a* along the lateral member **130**, a secondary path **190***b* along the upstream member **128**, a cooling path **190***c* over the heat-generating components **136**, and a non-cooling path **190***d* past the heat-generating components **136**. Eventually, the immersion coolant **134** is drained into the drainage manifold **117**.

(47) Additionally, to achieve the hybrid cooling aspect, the direct coolant **152** flows through the direct cooling system **142** to achieve a higher degree of cooling for the heat-generating components **136**. The direct coolant **152**, e.g., a fresh cold plate fluid, is delivered from the cold manifold **115**. The direct coolant **152** flows initially along an inlet path **192***a* of the supply conduit **150**, from the cold manifold **115** to the cold plate **144**. Then, the direct coolant **152** returns from the cold plate **144** along a return path **192***b* of the return conduit **154**, and into the hot manifold **116**.
(48) Although the disclosed embodiments have been illustrated and described with respect to one or more implementations, equivalent alterations and modifications will occur or be known to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In addition, while a particular feature of the invention may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application.
(49) While various embodiments of the present disclosure have been described above, it should be understood that they have been presented by way of example only, and not limitation. Numerous changes to the disclosed embodiments can be made in accordance with the disclosure herein, without departing from the spirit or scope of the disclosure. Thus, the breadth and scope of the present disclosure should not be limited by any of the above described embodiments. Rather, the scope of the disclosure should be defined in accordance with the following claims and their equivalents.

Claims

1. A hybrid cooling system for an information technology (IT) device, the hybrid cooling system comprising: a chassis having a peripheral wall that extends between a chassis base and an open top surface, the peripheral wall forming an enclosure between an upstream side and a downstream side, the chassis being configured to receive heat-generating components of the IT device within the enclosure; an immersion conduit for delivering an immersion coolant within the enclosure, the immersion coolant filling the enclosure to immerse the heat-generating components; an outlet duct for draining overflow of the immersion coolant accumulated in the enclosure; a cold plate positioned within the enclosure and configured for mounting in direct contact with at least one of the heat-generating components, the cold plate having an inlet connector and an outlet connector; a supply conduit for delivering a direct coolant in cooled form within the cold plate, the supply conduit being in flow communication with the inlet connector; and a return conduit for removing the direct coolant in heated form from the cold plate, the return conduit being in flow communication with the outlet connector; wherein the chassis has a rear opening in the downstream side, the rear opening blocked by a movable flap in a closed position, the movable flap having a flap height that is lower than a wall height of the peripheral wall.
2. The hybrid cooling system of claim 1, wherein the outlet duct automatically receives the overflow of the immersion coolant when an accumulation of the immersion coolant reaches the flap height.
3. The hybrid cooling system of claim 1, wherein the movable flap is rotatable between the closed position, in which at least some of the immersion coolant accumulates in the enclosure, and an open position, in which at least some of the immersion coolant drains from the enclosure.
4. The hybrid cooling system of claim 1, wherein the immersion conduit is routed alongside a lateral side the peripheral wall that extends between the upstream side and the downstream side.
5. The hybrid cooling system of claim 4, wherein the immersion conduit has an inlet end that is fluidly coupled with an immersion quick-disconnect connector, the immersion quick-disconnect connector being mounted in the downstream side near the lateral side.
6. The hybrid cooling system of claim 5, wherein the immersion conduit has an immersion-delivery

side positioned along the upstream side, the immersion conduit delivering the immersion coolant near the upstream side.

7. The hybrid cooling system of claim 1, wherein the direct coolant is different than the immersion fluid.

8. The hybrid cooling system of claim 7, wherein the direct coolant is a dielectric fluid and the immersion fluid is a non-dielectric fluid.

9. The hybrid cooling system of claim 1, further comprising: another cold plate positioned within the enclosure and configured for mounting in direct contact with at least one of the heat-generating components, the another cold plate having another inlet connector and another outlet connector; another supply conduit for delivering another direct coolant in cooled form within the cold plate, the another supply conduit being in flow communication with the another inlet connector; and another return conduit for removing the another direct coolant in heated form from the another cold plate, the another return conduit being in flow communication with the another outlet connector.

10. A method for hybrid cooling of an information technology (IT) system, the method comprising: providing a chassis with a peripheral wall extending between a chassis base and an open top surface, the peripheral wall forming an enclosure between an upstream side and a downstream side, the peripheral wall having a rear opening blocked with a flap, the flap being movable between a closed position and an open position, the movable flap having a flap height that is lower than a wall height of the peripheral wall; receiving heat-generating components of the IT system into the chassis, at least one of the heat-generating components being in direct contact with a cold plate; delivering an immersion coolant within and filling, at least in part, the enclosure to fully immerse the heat-generating components; automatically draining, in the closed position, overflow of the immersion coolant accumulated in the enclosure; delivering a direct coolant in cooled form within the cold plate; and removing the direct coolant in heated form from the cold plate.

11. The method of claim 10, further comprising, in response to manually moving the flap from the closed position to the open position, draining the immersion coolant from the enclosure.

12. The method of claim 11, further comprising rotating the moving the flap between the closed position and the open position.

13. The method of claim 10, further comprising receiving the immersion coolant from a supply manifold.

14. The method of claim 10, further comprising draining the immersion coolant into a recycle manifold.