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Card cage system for hybrid cooling of computer circuit cards

Abstract

Disclosed herein is a computer circuit card cage system configured to house one or more computer circuit cards. The computer circuit card cage system can comprise a housing comprising one or more walls having one or more apertures formed therein. The computer circuit card cage system can further comprise one or more support rails supported on one or more of the walls and configured to support a computer circuit card. The one or more support rails can have one or more apertures formed therein to facilitate flow of a fluid through the one or more support rails. The flow path of the fluid is through the one or more apertures in the walls of the housing, and the one or more apertures in the support rails.

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Background/Summary

BACKGROUND

(1) Computer circuit cards and expansion cards are ubiquitous in modern society and are used in the operation of computer systems in a wide variety of computing applications. Computer circuit cards having high power density tend to operate at high temperatures and are difficult to cool. Bulky and large liquid cooling systems are often implemented into card cages that hold the cards in order to provide adequate cooling to the computer circuit cards. However, computer circuit cards and card cages are often used in systems that only allow a small amount of space to be used for the installation of the computer circuit cards and card cages. As such, large liquid cooling systems cannot be used to cool the computer circuit cards as there is not enough room in a space-constrained system to accommodate the liquid cooling systems. Often only one mode of heat transfer/cooling (e.g., conduction support rails or forced air cooling) can be utilized within a card cage to cool computer circuit cards in space-constrained computing systems. Additional heat transfer and/or cooling operations or systems are often needed to adequately cool computer cards. Therefore, in order to ensure proper operating temperature and predictable desired operation of computer circuit cards, improvements and innovations to cooling systems for cooling computer cards in limited-space systems continue to be developed.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) Features and advantages of the invention will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, features of the invention; and, wherein:
(2) FIG. **1** illustrates an isometric view of a card cage system in accordance with an example of the present disclosure.
(3) FIGS. **2***a* and **2***b*, respectively, illustrate isometric views of internal configurations of the card cage system of FIG. **1**, viewed from a first side and a second side.
(4) FIG. **3** illustrates a front view of the card cage system of FIG. **1**.
(5) FIG. **4***a* illustrates a side view of a first side of the card cage system of FIG. **1**.
(6) FIG. **4***b* illustrates cross-sectional view of the card cage system of FIG. **1**, taken along line AA of the card cage system shown in FIG. **3**.
(7) FIG. **5***a* illustrates a side view of a second side of the card cage system of FIG. **1**.
(8) FIG. **5***b* illustrates a side view of the second side of the card cage system of FIG. **5***a* with a fan and cover removed.
(9) FIG. **6** illustrates cross-sectional view of the card cage system of FIG. **1**, taken along line BB of the card cage system shown in FIG. **3**.
(10) FIG. **7** illustrates a front view of the card cage system of FIG. **1**.
(11) FIG. **8** illustrates a close up view of section C from FIG. **7**.
(12) FIG. **9** illustrates a front view of the card cage system of FIG. **1** and shows airflow within the card cage system.
(13) Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended.
DETAILED DESCRIPTION
(14) As used herein, the term “substantially” refers to the complete or nearly complete extent or degree of an action, characteristic, property, state, structure, item, or result. For example, an object that is “substantially” enclosed would mean that the object is either completely enclosed or nearly completely enclosed. The exact allowable degree of deviation from absolute completeness may in some cases depend on the specific context. However, generally speaking the nearness of completion will be so as to have the same overall result as if absolute and total completion were obtained. The use of “substantially” is equally applicable when used in a negative connotation to refer to the complete or near complete lack of an action, characteristic, property, state, structure, item, or result.
(15) As used herein, “adjacent” refers to the proximity of two structures or elements. Particularly, elements that are identified as being “adjacent” may be either abutting or connected. Such elements may also be near or close to each other without necessarily contacting each other. The exact degree of proximity may in some cases depend on the specific context.
(16) An initial overview of the inventive concepts are provided below and then specific examples are described in further detail later. This initial summary is intended to aid readers in understanding the examples more quickly, but is not intended to identify key features or essential features of the examples, nor is it intended to limit the scope of the claimed subject matter.
(17) Disclosed herein is a computer circuit card cage system configured to house one or more computer circuit cards. The computer circuit card cage system can comprise a housing including one or more walls having one or more apertures formed therein. The card cage system can further comprise one or more support rails supported on one or more of the one or more walls. The support rails can each be configured to support a computer circuit card. The one or more support rails can have one or more apertures formed therein to facilitate flow of a fluid through the one or more support rails. A flow path of the fluid can be through the one or more apertures in the walls of the

housing, and the one or more apertures in the support rails.

(18) Further disclosed herein is a method for configuring computer circuit card cage system configured to house one or more computer circuit cards. The method can comprise configuring the card cage system to comprise a housing comprising one or more walls having one or more apertures formed therein. The method can further comprise configuring the card cage system to comprise one or more support rails supported on one or more of the walls and configured to support a computer circuit card. The method can further comprise configuring the one or more support rails to have one or more apertures formed therein to facilitate flow of a fluid through the one or more support rails. A flow path of the fluid can be through the one or more apertures in the walls of the housing, and the one or more apertures in the support rails.

(19) To further describe the present technology, examples are now provided with reference to the figures. With reference to FIG. **1**, illustrated is a card cage system **100** in accordance with an example of the present disclosure. Card cage system **100** can be configured to house one or more computer circuit cards therein. As shown, the card cage can comprise a housing **101** comprising a plurality of walls. For example, the housing **101** of the card cage system **100** can include a first side wall **102**, and a second side wall **104** disposed parallel and opposite to the first side wall **102**. A rear wall **106** can abut the first side wall **102** and the second side wall **104** at a rear of the card cage system **100**, Furthermore, a top wall **108** can abut the first side wall **102**, the second side wall **104**, and the rear wall **106** at a top of the card cage system **100**. A bottom wall **110** can abut the first side wall **102**, the second side wall **104**, and the rear wall **106** at a bottom of the card cage system **100**.

(20) The first side wall **102**, the second side wall **104**, the rear wall **106**, the top wall **108**, and the bottom wall **110** of the card cage system **100** can together form and define a circuit card storage cavity **112** configured to receive and hold one or more computer circuit cards (e.g., see, for example, computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d*). The card cage system **100** can include a plurality of support rails that each contact and support one or more of the computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d*.

(21) Additionally, as shown in FIG. **1**, the card cage system **100** can further include an aperture cover **116** that covers one of the side walls (e.g., second side wall **104**, as shown) of the card cage system **100**. A fan **118** can be attached to and supported by the aperture cover **116**. As will be described in more detail below, the fan **118** can operate to drive a cooling fluid (e.g., ambient air or other gas) through the card cage system **100**. Although the term "air" is used within this disclosure, the disclosure is not intended to be limited in any way to this specific type of fluid. Indeed, the cooling fluid can comprise any known fluid for cooling or heating that can be used within the card cage system **100**.

(22) Further details of the card cage system **100** are shown and described with reference to FIGS. **2***a* and **2***b*. FIGS. **2***a* and **2***b* illustrate card cage system **100** with top wall **108** and circuit cards **114***a*, **114***b*, **114***c*, and **114***d* removed to more clearly show the internal configuration of the card cage system **100**.

(23) FIG. **2***a* illustrates an isometric view of the card cage system **100** as seen with the second side wall **104** closest to the viewer. As shown in FIG. **2***a*, the first side wall **102** can comprise a plurality of support rails **120***a*, **120***b*, **120***c*, and **120***d* that are supported on an inner side **103***a* of the first side wall **102**. Each of the support rails **120***a*, **120***b*, **120***c*, and **120***d* can comprise a support surface **121***a*, **121***b*, **121***c*, and **121***d* for one of the computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d*. The computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* can be configured to contact and interface with the respective support surfaces **121***a*, **121***b*, **121***c*, and **121***d* of support rails **120***a*, **120***b*, **120***c*, and **120***d*.

(24) Each of the support rails **120***a*, **120***b*, **120***c*, and **120***d* can be wholly or partially made of, or coated in, a thermally conductive material. The thermally conductive material can facilitate thermal conduction of heat generated by computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* away from the computer circuit cards through the thermally conductive support rails and allow for the heat to be

dissipated to the ambient environment in order to cool computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d*.
(25) FIG. **2***b* illustrates an isometric view of the card cage system **100** as seen with the first side wall **102** closest to the viewer. As shown in FIGS. **1** and **2***a*, the second side wall **104** can comprise a plurality of support rails **122***a*, **122***b*, **122***c*, and **122***d* that are supported on an inner side **105***a* of the second side wall **104**. Each of the support rails **122***a*, **122***b*, **122***c*, and **122***d* can comprise a support surface **123***a*, **123***b*, **123***c*, and **123***d* for one of the computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d*. The computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* can be configured to contact and interface with the respective support surfaces **123***a*, **123***b*, **123***c*, and **123***d* of support rails **122***a*, **122***b*, **122***c*, and **122***d*.
(26) Each of the support rails **122***a*, **122***b*, **122***c*, and **122***d* can be wholly or partially made of, or coated in, a thermally conductive material. Example materials include, but are not limited to, aluminum, copper, graphite, thermally conductive ceramics, and others that will be apparent to those skilled in the art. Example coatings can include, but are not limited to, thermal grease, paste, gel, graphite, graphite pads, phase change materials, and others that will be apparent to those skilled in the art. The thermally conductive material can facilitate thermal conduction of heat generated by computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* away from the computer circuit cards and allow for the heat to be dissipated to the ambient environment in order to cool computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d*.
(27) FIG. **3** illustrates a front view of the card cage system **100** with computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* removed. The second side wall **104** and the first side wall **102** are positioned opposite to each other. The first side wall **102** and the second side wall **104** define, at least in part, the circuit card storage cavity **112** between the first side wall **102** and the second side wall **104**. The circuit card storage cavity **112** is configured to store one or more computer circuit cards on the support surfaces of the support rails.
(28) As shown, the first side wall **102** comprises the first support rails **120***a*, **120***b*, **120***c*, and **120***d* each disposed in locations that are spaced apart from each other. The second side wall **104** comprises the second support rails **122***a*, **122***b*, **122***c*, and **122***d* each disposed in locations that are spaced apart from each other substantially the same as the first support rails. In other words, support rail **120***a* is substantially located on a same plane as support rail **122***a* such that the support surface **121***a* and the support surface **123***a* are on a same plane to support a computer circuit card.
(29) The support surfaces **121***a* and **123***a* of the support rail **120***a* on first side wall **102** and its correspondingly positioned support rail **122***a* on second side wall **104** at least partially define a first circuit card slot **124***a* within the circuit card storage cavity **112** of card cage system **100**. Similarly, the support surfaces **121***b* and **123***b* of the support rail **120***b* and correspondingly positioned support rail **122***b* at least partially define a second circuit card slot **124***b*, The support surfaces **121***c* and **123***c* of the support rail **120***c* and correspondingly positioned support rail **122***c* at least partially define a third circuit card slot **124***c*. The support surfaces **121***d* and **123***d* of the support rail **120***d* and correspondingly positioned support rail **122***d* at least partially define a fourth circuit card slot **124***d*. Each of the card slots **124***a*, **124***b*, **124***c*, and **124***d* are configured to receive a computer circuit card therein and to support the computer circuit card on the support surfaces of each card slot (e.g., see FIG. **1**).
(30) FIG. **4***a* illustrates a side view of the first side wall **102** of the card cage system **100** showing the outer side **103***b* of first side wall **102**. A plurality of apertures **125** (e.g., including apertures **125***a*, **125***b*, and **125***c*) can be formed in the first side wall **102**. As illustrated according to one example, three rows of apertures **125** can be formed in the first side wall **102** including first apertures **125***a*, second apertures **125***b*, and third apertures **125***c*.
(31) Additionally, fins **119** can be formed or supported on first side wall **102** and each fin **122** can be disposed between apertures **125** formed through first side wall **102**. Fins **119** can help to aid in heat transfer. The fins **119** are extensions on exterior surface of first side wall **102** of card cage

system **100**. Fins such as the fins **119** increase the rate of heat transfer to or from the card cage system **100** by increasing convection between the ambient environment and first side wall **102**. Convection is increased by increasing the surface area of the first side wall **102**, which in turn increases the heat transfer rate and aids in cooling computer circuit cards **114** housed within card cage system **100**.

(32) FIG. **4***b* illustrates a cross-sectional view of card cage system **100** taken along line AA shown in FIG. **3**. The support rails **120***a*, **120***b*, **120***c*, and **120***d* are illustrated supported on the inner side **103***a* of first side wall **102**. The support rails **120***a*, **120***b*, **120***c*, and **120***d* being "supported" on the first side wall **102** can include the support rails **120***a*, **120***b*, **120***c*, and **120***d* being integrally formed with the first side wall **102** and can also include the support rails **120***a*, **120***b*, **120***c*, and **120***d* being formed separately from the first side wall **102** and attached thereto.

(33) As shown in FIG. **4***b*, apertures **126***a*, **126***b*, and **126***c* can be formed through each of the support rails **120***a*, **120***b*, and **120***c*. The apertures **125***a*, **125***b*, **125***c* in the first side wall **102** can extend from the outer side **103***b* through the entire thickness and out through the inner side **103***a* of the first side wall **102**. The apertures **126***a*, **126***b*, and **126***c* can extend through the entire thickness of the support rails **120***a*, **120***b*, and **120***c*. The apertures **125***a*, **125***b*, and **125***c* of the first side wall **102** can substantially align with the apertures **126***a*, **126***b*, and **126***c* of the support rails **120***a*, **120***b*, and **120***c* to provide a fluid flow path for a cooling fluid (e.g., ambient air or other gaseous fluid) through the first side wall **102** and the support rails **120***a*, **120***b*, and **120***c*.

(34) FIGS. **5***a*, **5***b*, and **6** illustrate various views of the second side wall **104**. FIG. **5***a* illustrates a side view of the card cage system **100** showing the second side wall **104** as viewed from outside the card cage system **100**. FIG. **5***a* illustrates the outer side **105***b* of second side wall **104**. The second side wall **104** can support a forced air system **115** configured to force a cooling fluid (e.g., air) through one or more of the apertures **125** and **126** of the first side wall **102** and the second side wall **104**. The forced air system **115** can comprise an aperture cover **116** supported on the second side wall **104** at a position to surround and cover a plurality of apertures **128** (see FIG. **5***b*) formed in the second side wall **104**. The forced air system **115** can further comprise a fan **118** supported on the cover **116** configured to operate to force fluid through each of the apertures **128** through either blowing or suction of fluid through the apertures **128**. The cover **116** and apertures **128** can together function as a fan manifold defining one or more air channels through which fluid driven by the fan flows. The air channels of the manifold can comprise the air channels of the apertures **128** and an air chamber **130** defined by the cover **116** in which fluid is made to flow by operation of the fan **118**. Additionally, a fan manifold may be modified to include individual channels formed in the cover **116**, or tubes and passages from the apertures **128** to the fan **118**.

(35) FIG. **5***b* illustrates a side view of the second side wall **104** of the card cage system **100** showing the outer side **105***b* of second side wall **104** with the cover **116** and the fan **118** removed. A plurality of apertures **127** (including apertures **127***a*, **127***b*, and **127***c*) can be formed in the second side wall **104**. As illustrated according to one example, three rows of apertures **127** can be formed in the second side wall **104** including first apertures **127***a*, second apertures **127***b*, and third apertures **127***c*.

(36) FIG. **6** illustrates a cross-sectional view of card cage system **100** taken along line BB shown in FIG. **3**. The support rails **122***a*, **122***b*, **122***c*, and **122***d* are illustrated supported on the inner side **105***a* of second side wall **104**. The support rails **122***a*, **122***b*, **122***c*, and **122***d* being "supported" on the second side wall **104** can include the support rails **122***a*, **122***b*, **122***c*, and **122***d* being integrally formed with the second side wall **104** and can also include the support rails **122***a*, **122***b*, **122***c*, and **122***d* being formed separately from the second side wall **104** and attached thereto.

(37) As shown in FIG. **6**, apertures **128***a*, **128***b*, and **128***c* can be formed through each of the support rails **122***a*, **122***b*, and **122***c*. The apertures **127***a*, **127***b*, **127***c* of the second side wall **104** can extend from the outer side **105***b* through the entire thickness and out through the inner side **105***a* of the second side wall **104**. The apertures **128***a*, **128***b*, and **128***c* of the support rails can extend

through the entire thickness of the support rails **122***a*, **122***b*, and **122***c*. The apertures **127***a*, **127***b*, and **127***c* of the second side wall **104** can substantially align with the apertures **128***a*, **128***b*, and **128***c* of the support rails **120***a*, **120***b*, and **120***c* to provide a fluid flow path for a cooling fluid (e.g., ambient air or other gaseous fluid) through the first side wall **102** and the support rails **120***a*, **120***b*, and **120***c*.

(38) As shown in FIGS. **4***b* and **6**, apertures are not necessarily formed in all support rails. Apertures can be formed in one or more of the support rails, up to all support rails in the card cage system **100**. Furthermore, it will be appreciated that the support rails described herein may be either integrally formed with the side walls or may be made separately from and then attached to the side walls. In a configuration where the support rails are integrally formed with the side wall, each aperture may be a single aperture formed through both the side wall and the support rail. In an alternative configuration, where the support rails are formed separately from the side wall and then attached to the side wall, separate apertures can be formed in the side wall and in the support rails. The support rails can be attached to the side wall such that the apertures in the side wall substantially align with the apertures of the support rails to form a fluid flow path through the side wall and the support rail.

(39) For clarity, not all apertures are individually identified in FIGS. **4***a*, **4***b*, **5***b*, and **6**, however, as shown, the apertures **125** and **126** are arranged over a majority of the lengths of support rails **120***a*, **120***b*, **120***c* **122***a*, **122***b*, and **122***c*. The apertures **125** and **126** can be formed through an entire thickness of first side wall **102** and the second side wall **104**, respectively, such that the apertures are accessible from both sides of the first side wall **102** and the second side wall **104**. Accordingly, a fluid, such as any gas or ambient air, can pass through the first side wall **102** along a fluid flow path through apertures **125** of the first side wall **102**. A fluid, such as any gas or ambient air, can further pass through the second side wall **104** along a fluid flow path through apertures **126** of the second side wall **104**. Furthermore, FIGS. **4***a***-6** show that apertures **125** and **126** have an oblong oval shape as formed in the support rails and side walls. However, the shape of the apertures is not intended to be limited in any way by this disclosure. Any shape of aperture can be used.

(40) FIG. **7** illustrates a front view of the card cage system **100** with computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* being supported in the card cage system **100**. The computer circuit card **114***a* is supported on at least the support surface **121***a* of the support rail **120***a*, the computer circuit card **114***b* is supported on at least the support surface **121***b* of the support rail **120***b*, the computer circuit card **114***c* is supported on at least the support surface **121***c* of the support rail **120***c*, and the computer circuit card **114***d* is supported on at least the support surface **121***d* of the support rail **120***d*.

(41) Each of the computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* can be in physical contact with their respective support surfaces **121***a*, **121***b*, **121***c*, and **121***d*. With each computer circuit card in contact with a thermally conductive support rail, the heat generated by each computer circuit card during operation can be conducted away from the computer circuit cards to facilitate cooling of the computer circuit cards.

(42) FIG. **8** illustrates a close up view of section C from FIG. **7**. FIG. **8** shows the flow of heat H by conduction through the computer circuit card **114***a* to thermally conductive support rail **120***a*, to first side wall **102**, and finally out to the ambient environment. Other computer circuit cards **114***b*, **114***c*, and **114***d* are cooled in a manner similar to that shown in FIG. **8**.

(43) In conduction, heat H is transferred from a first temperature location to a second temperature location. For conduction to operate there must be a temperature difference between the two locations. The transfer of heat H will continue as long as there is a difference in temperature (i.e., a temperature differential) between the two locations, but once the two locations have reached the same temperature, thermal equilibrium is established and the heat transfer stops. As is known by one of skill in the art, conduction causes heat H to flow from a higher temperature location to a lower temperature location. In the example illustrated in FIG. **8**, computer circuit card **114***a* has a

temperature of T**1**, support rail **120***a* of first side wall **102** has a temperature of T**2** and the ambient environment has a temperature of T**3**. For heat H to flow from the computer circuit card **114***a* to the ambient environment, it is assumed that T**1** is greater than T**2**, which is greater than T**3**.

(44) Due to the differences in temperatures, heat H generated by the operation of computer circuit card **114***a* flows to the environment via support rail **120***a* and first side wall **102**. The greater the differences between the temperatures T**1**, T**2**, and/or T**3**, the greater the flow of heat H is away from computer circuit card **114***a*. In other words, the larger the temperature difference, the larger the heat transfer rate. As long as the support rail **120***a* is at a lower temperature T**2** than the computer circuit card **114***a*, heat transfer will continue.

(45) The card cage system **100**, in accordance with an example of the present disclosure, is configured to provide hybrid cooling of computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d*. In addition to conductive cooling of computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* illustrated in FIG. **8**, card cage system **100** provides convective cooling of computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* as well as convective cooling of side walls **102**, **104** and support rails **120***a*, **120***b*, **120***c*, **120***d*, **122***a*, **122***b*, **122***c*, and **122***d* by the flow of cooling air through apertures **125***a*, **125***b*, **125***c*, **125***d*, **126***a*, **126***b*, **126***c*, **126***d*, **127***a*, **127***b*, **127***c*, **127***d*, **128***a*, **128***b*, **128***c*, and **128***d*.

(46) FIG. **9** illustrates the convective cooling of computer circuit cards, side walls, and support rails of card cage system **100**. As shown in FIG. **9**, computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* can be cooled by fluid flow F that enters card cage system **100** through the apertures formed in the one or more of the side walls and support rails. As the fluid flow F enters through the apertures of the first side wall **102** and support rails **120***a*, **120***b*, **120***c*, and **120***d*, the fluid flow F draws heat H**1** from the first side wall **102** (including the support rails **120***a*, **120***b*, **120***c*, and **120***d* supported on the first side wall **102**) to convectively cool the first side wall **102** and support rails **120***a*, **120***b*, **120***c*, and **120***d*. The fan **118** can, according to at least one example, drive fluid flow F to enter card cage system **100** through apertures in the first side wall **102** by actuation of the fan **118**.

(47) The apertures in the first side wall **102** are in fluid communication with the apertures in the second side wall **104** such that fluid flow F continues through card cage system **100** from the first side wall **102** to the second side wall **104** in the cavity **112** between the side walls. As the fluid flow F moves from the first side wall **102** to the second side wall **114**, the fluid flow F draws heat H**2**, H**3**, H**4**, and H**5** from each of the computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* to convectively cool the cards. The fluid flow F then exits through second side wall **104** through the apertures **127***a*, **127***b*, **127***c*, **127***d*, **128***a*, **128***b*, **128***c*, and **128***d* formed in the support rails **122***a*, **122***b*, **122***c*, and **122***d* and the second side wall **104** and draws heat H**6** from the second side wall **104** and the support rails **122***a*, **122***b*, **122***c*, and **122***d* to convectively cool the second side wall **104** and the support rails **122***a*, **122***b*, **122***c*, and **122***d*. The fluid flow F then enters air chamber **130** (indicated as the dashed-dotted-dotted line) defined by cover **116** and is finally exhausted to the ambient environment by the fan **118**.

(48) The examples described herein yield multiple advantages and beneficial effects over the current state of the art. Examples of the present disclosure provide both convective and conductive cooling of computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* in a small constrained space without the need of additional large and bulky liquid cooling systems. Use of both conductive and convective cooling, cools the computer circuit cards **114***a*, **114***b*, **114***c*, and **114***d* more efficiently and more quickly then use of just one of conductive or convective cooling alone.

(49) Additionally, the apertures formed in each of the support rails allows cooling fluid to flow through the support rails, thereby convectively cooling the support rails. Convectively cooling the support rails increases the support rails capacity to conduct heat away from the computer circuit cards. Larger temperature differences yield higher heat transfer rates. Conductive heat transfer rates increase as the temperature difference between two locations of different temperatures increases. Convective cooling of the support rails lowers the temperature of the support rails compared to the computer circuit cards, and therefore increases the heat transfer rate and the amount of heat drawn

away from the computer circuit cards. Accordingly, providing convective cooling to the support rails improves the cooling of the computer circuit cards by: 1) conductively cooling the computer circuit cards through the support rails; 2) convectively cooling the computer circuit cards; and 3) improving the conductive cooling of the computer circuit cards by convectively cooling the support rails that facilitate the conductive cooling of the computer circuit cards. Thereby, the heat transfer and overall cooling of the computer circuit cards is improved by the examples described herein.
(50) While the examples described herein have been mostly directed to the cooling of elements within a card cage system, the principles described herein may also be applied to a system for heating certain elements that need to be heated. Furthermore, examples described herein dispose the fan on a side wall adjacent to apertures of the card cage system. However, the fan (or multiple fans) may be disposed on any other walls of the card cage system as well such as the top, bottom, front, or back walls or others. The fan therefore is not limited to being disposed on a wall with apertures.
(51) Reference was made to the examples illustrated in the drawings and specific language was used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the technology is thereby intended. Alterations and further modifications of the features illustrated herein and additional applications of the examples as illustrated herein are to be considered within the scope of the description.
(52) Although the disclosure may not expressly disclose that some embodiments or features described herein may be combined with other embodiments or features described herein, this disclosure should be read to describe any such combinations that would be practicable by one of ordinary skill in the art. The use of “or” in this disclosure should be understood to mean non-exclusive or, i.e., “and/or,” unless otherwise indicated herein.
(53) Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more examples. In the preceding description, numerous specific details were provided, such as examples of various configurations to provide a thorough understanding of examples of the described technology. It will be recognized, however, that the technology may be practiced without one or more of the specific details, or with other methods, components, devices, etc. In other instances, well-known structures or operations are not shown or described in detail to avoid obscuring aspects of the technology.
(54) Although the subject matter has been described in language specific to structural features and/or operations, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features and operations described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims. Numerous modifications and alternative arrangements may be devised without departing from the spirit and scope of the described technology.

Claims

1. A computer circuit card cage system configured to house one or more computer circuit cards, the computer circuit card cage system comprising: a housing comprising (i) multiple walls each having multiple first apertures formed therein and (ii) a computer circuit card storage cavity defined, at least in part, by the walls, wherein each of the first apertures extends through an entire thickness from an outer side to an inner side of the associated wall of the housing; multiple support rails supported on the walls and configured to support a computer circuit card on support surfaces of the support rails within the computer circuit card storage cavity, each of the support rails having multiple second apertures formed therein along a length of the support rail and configured to facilitate flow of a fluid through the support rail, the multiple second apertures of each support rail substantially aligned with the first apertures of the associated wall of the housing; wherein a flow path of the fluid is through the first apertures in the walls of the housing, through the second

apertures in the support rails, and freely through the computer circuit card storage cavity of the housing between the support rails; and wherein a first support rail of the multiple support rails is supported on a first wall of the multiple walls of the housing and a second support rail corresponding to the first support rail is supported on a second wall of the multiple walls of the housing, the second wall being positioned opposite to the first wall, the first and second support rails configured to support the computer circuit card, the second apertures of each of the first and second support rails opening into the computer circuit card storage cavity; and a forced air system supported on the second wall and configured to force the flow of the fluid through the computer circuit card cage system between the first and second walls.

2. The computer circuit card cage system of claim 1, wherein the support rails are made of a thermally conductive material.

3. The computer circuit card cage system of claim 1, further comprising one or more fins supported by the first wall, at least some of the fins positioned between adjacent ones of the first apertures.

4. The computer circuit card cage system of claim 1, wherein the first wall and the second wall define, at least in part, the computer circuit card storage cavity between the first and second walls, the storage cavity being configured to store the one or more computer circuit cards.

5. The computer circuit card cage system of claim 1, wherein the support rails are supported at spaced apart locations within the computer circuit card cage system.

6. The computer circuit card cage system of claim 1, wherein the first and second apertures facilitate the flow of the fluid to or from an ambient environment.

7. The computer circuit card cage system of claim 1, wherein the forced air system is configured to surround and cover the first apertures along the outer side of the second wall.

8. The computer circuit card cage system of claim 1, wherein the forced air system comprises: a fan configured to move the fluid; a fan manifold comprising air channels operable to direct the fluid through the first apertures and the second apertures; and a cover operable to cover the air channels of the fan manifold.

9. The computer circuit card cage system of claim 1, wherein the first and second support rails are operable to support a common computer circuit card.

10. The computer circuit card cage system of claim 1, wherein the second apertures formed through the first support rail and the first apertures formed through first wall are in fluid communication with the second apertures formed through the second support rail and the first apertures formed through second wall to facilitate fluid flow through the computer circuit card storage cavity of the housing between the first wall and the second wall.

11. The computer circuit card cage system of claim 1, wherein the forced air system is configured to force the flow of the fluid through the computer circuit card storage cavity of the housing between the first wall and the second wall via blowing or suction.

12. A method for configuring a computer circuit card cage system configured to house one or more computer circuit cards, the method comprising: configuring the computer circuit card cage system to comprise a housing comprising (i) multiple walls each having multiple first apertures formed therein and (ii) a computer circuit card storage cavity defined, at least in part, by the walls, wherein each of the first apertures extends through an entire thickness from an outer side to an inner side of the associated wall of the housing; configuring the computer circuit card cage system to comprise multiple support rails supported on the walls and configured to support a computer circuit card on support surfaces of the support rails within the computer circuit card storage cavity, each of the support rails having multiple second apertures formed therein along a length of the support rail and configured to facilitate flow of a fluid through the support rail, the multiple second apertures of each support rail substantially aligned with the first apertures of the associated wall of the housing; wherein a flow path of the fluid is through the first apertures in the walls of the housing, through the second apertures in the support rails, and freely through the computer circuit card storage cavity of the housing between the support rails; and wherein a first support rail of the multiple support

rails is supported on a first wall of the multiple walls of the housing and a second support rail corresponding to the first support rail is supported on a second wall of the multiple walls of the housing, the second wall being positioned opposite to the first wall, the first and second support rails configured to support the computer circuit card, the second apertures of each of the first and second support rails opening into the computer circuit card storage cavity; and configuring the computer circuit card cage system to comprise a forced air system supported on the second wall and configured to force the flow of the fluid through the computer circuit card cage system between the first and second walls.

13. The method of claim 12, wherein the support rails are supported at spaced apart locations within the computer circuit card cage system.

14. The method of claim 12, wherein the first and second apertures facilitate the flow of the fluid to or from an ambient environment.

15. The method of claim 12, wherein the forced air system is configured to surround and cover the first apertures along the outer side of the second wall.

16. The method of claim 12, further comprising: configuring the forced air system to comprise: a fan configured to move the fluid; a fan manifold comprising air channels operable to direct the fluid through the first apertures and the second apertures; and a cover operable to cover the air channels of the fan manifold.

17. The method of claim 12, wherein the support rails are made of a thermally conductive material.

18. The method of claim 12, wherein the second apertures formed through the first support rail and the first apertures formed through first wall are in fluid communication with the second apertures formed through the second support rail and the first apertures formed through second wall to facilitate fluid flow through the computer circuit card storage cavity of the housing between the first wall and the second wall.

19. The method of claim 12, wherein the forced air system is configured to force the flow of the fluid through the computer circuit card storage cavity of the housing between the first wall and the second wall via blowing or suction.

20. The method of claim 12, further comprising: configuring the computer circuit card cage system to comprise fins supported by the walls first wall, at least some of the fins positioned between adjacent ones of the first apertures.
