US010638639B1

(12) **United States Patent**
Garner et al.

(10) **Patent No.: US 10,638,639 B1**
(45) **Date of Patent: Apr. 28, 2020**

(54) **DOUBLE SIDED HEAT EXCHANGER COOLING UNIT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 78 days.

(21) Appl. No.: **15/176,947**

(22) Filed: **Jun. 8, 2016**

Related U.S. Application Data

(60) Provisional application No. 62/202,534, filed on Aug. 7, 2015.

(51) **Int. Cl.**
H05K 7/20 (2006.01)
F28D 15/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H05K 7/20154*** (2013.01); ***F28D 15/0266*** (2013.01); ***F28D 15/0275*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H05K 7/20409; H05K 7/20518; H05K 7/20154; H05K 7/202039; H05K 7/20436;
(Continued)

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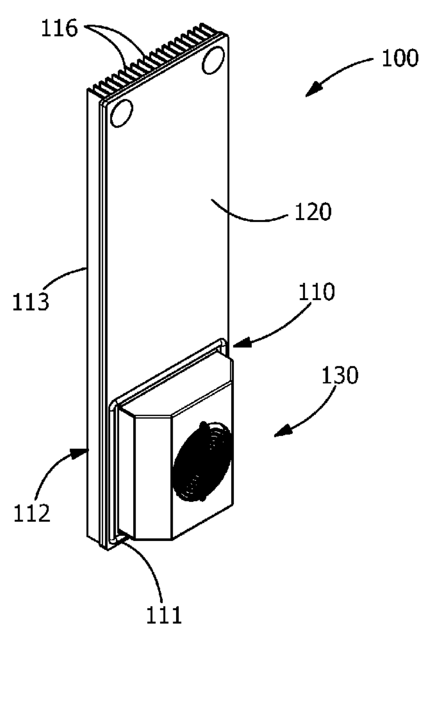
(57) **ABSTRACT**

A cooling unit positioned between a first gas stream and a second gas stream, the first gas stream and the second gas stream having no direct fluid contact therebetween. The cooling unit includes a double-sided heat exchanger with a first side that is in thermal communication with the first gas stream and a second side that is in thermal communication with the second gas stream. The double-sided heat exchanger provides a direct path of thermal conduction between the first gas stream and the second gas stream. First fins are provided on the first side of the double-sided heat exchanger and second fins are provided on the second side of the double-sided heat exchanger. A first surface area of the first side of the double-sided heat exchanger is at least 5% greater than a second surface area of the second side of the double-sided heat exchanger.

22 Claims, 6 Drawing Sheets



(51) **Int. Cl.**
F28F 21/08 (2006.01)
F28F 21/02 (2006.01)
F28F 3/02 (2006.01)

(52) **U.S. Cl.**
CPC ***F28F 3/02*** (2013.01); ***F28F 21/02*** (2013.01); ***F28F 21/084*** (2013.01); ***F28F 21/085*** (2013.01); ***H05K 7/20336*** (2013.01); ***H05K 7/20409*** (2013.01); ***H05K 7/20518*** (2013.01); *F28D 2015/0216* (2013.01); *F28F 2250/08* (2013.01)

(58) **Field of Classification Search**
CPC H05K 7/20472; F28D 15/0266; F28D 15/0275; F28F 3/02; H01L 23/367; H01L 23/3677; H01L 21/4882; H01L 21/4871
See application file for complete search history.

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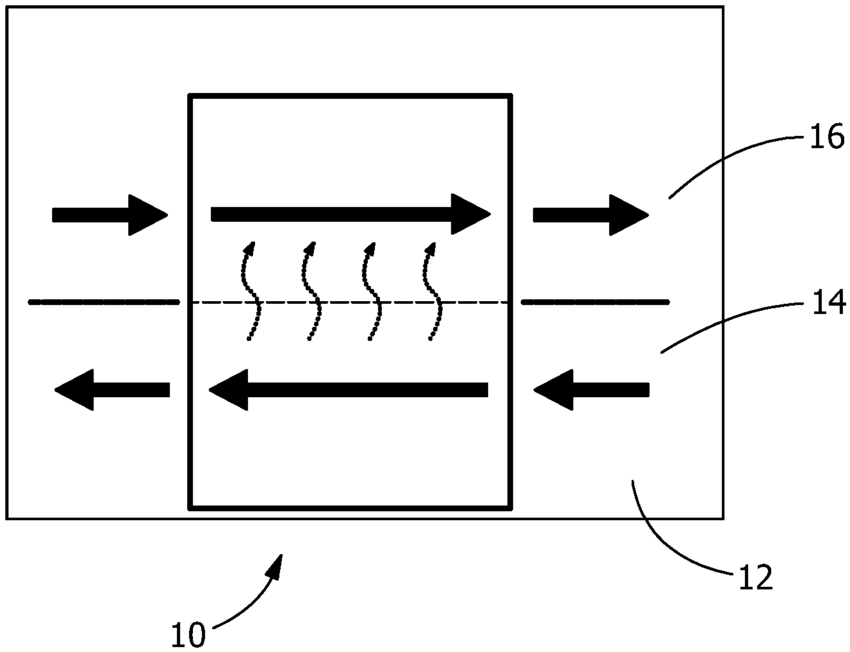

FIG. 1
Prior Art

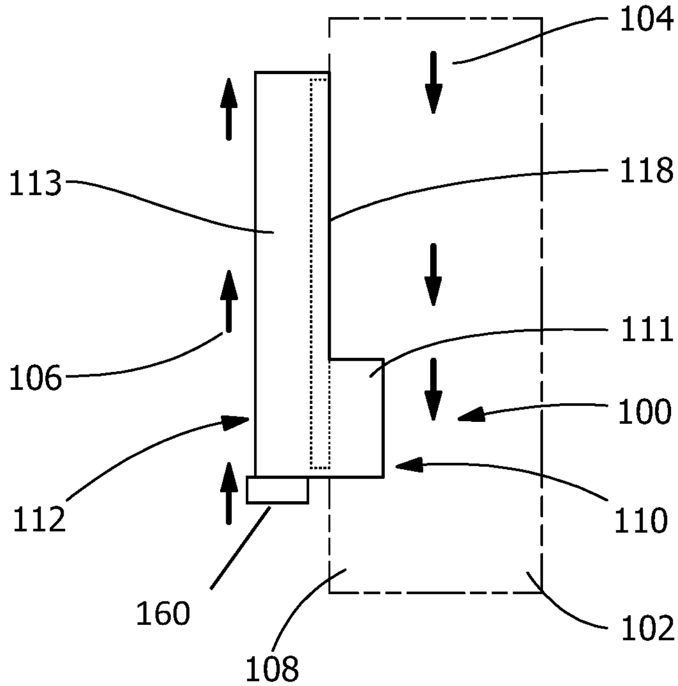

FIG. 3

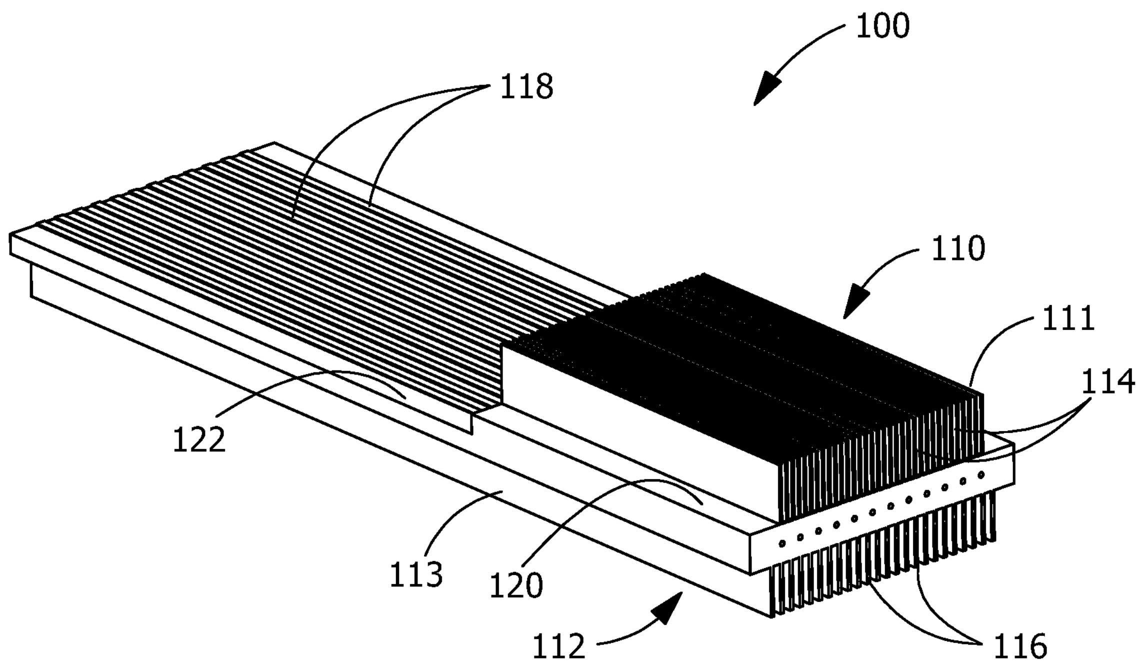

FIG. 2

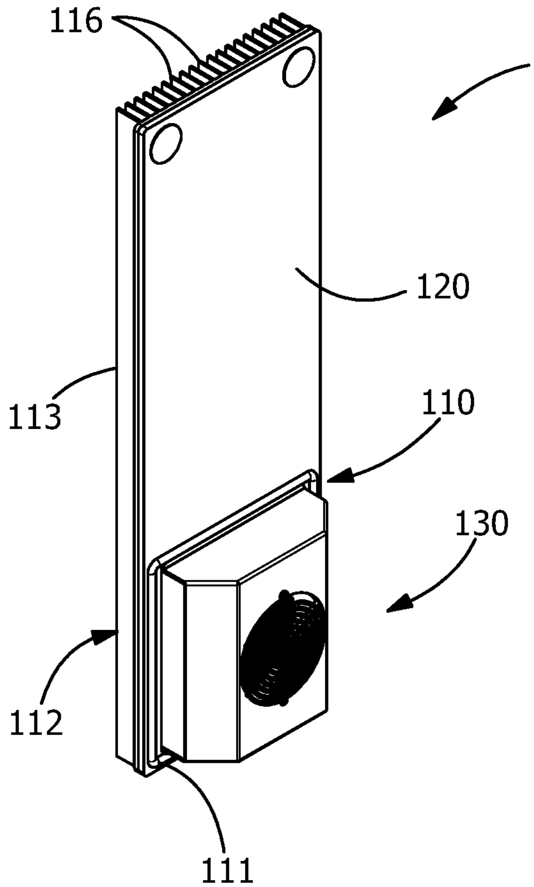

FIG. 4

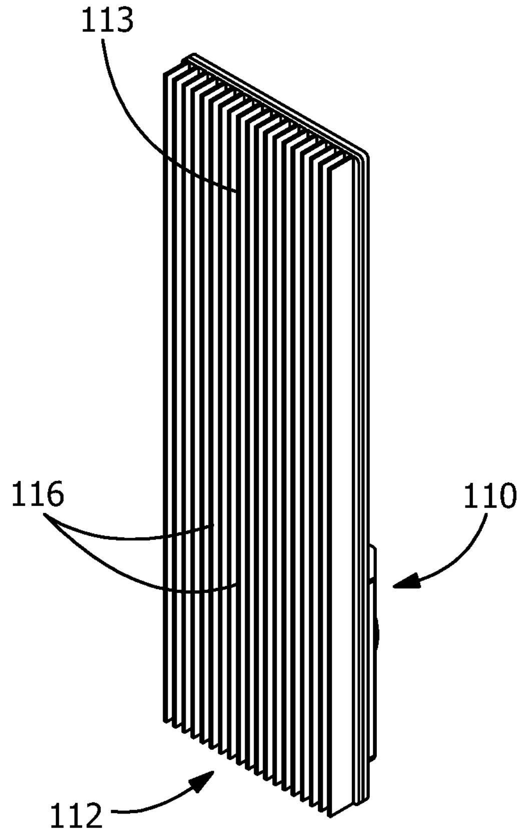

FIG. 5

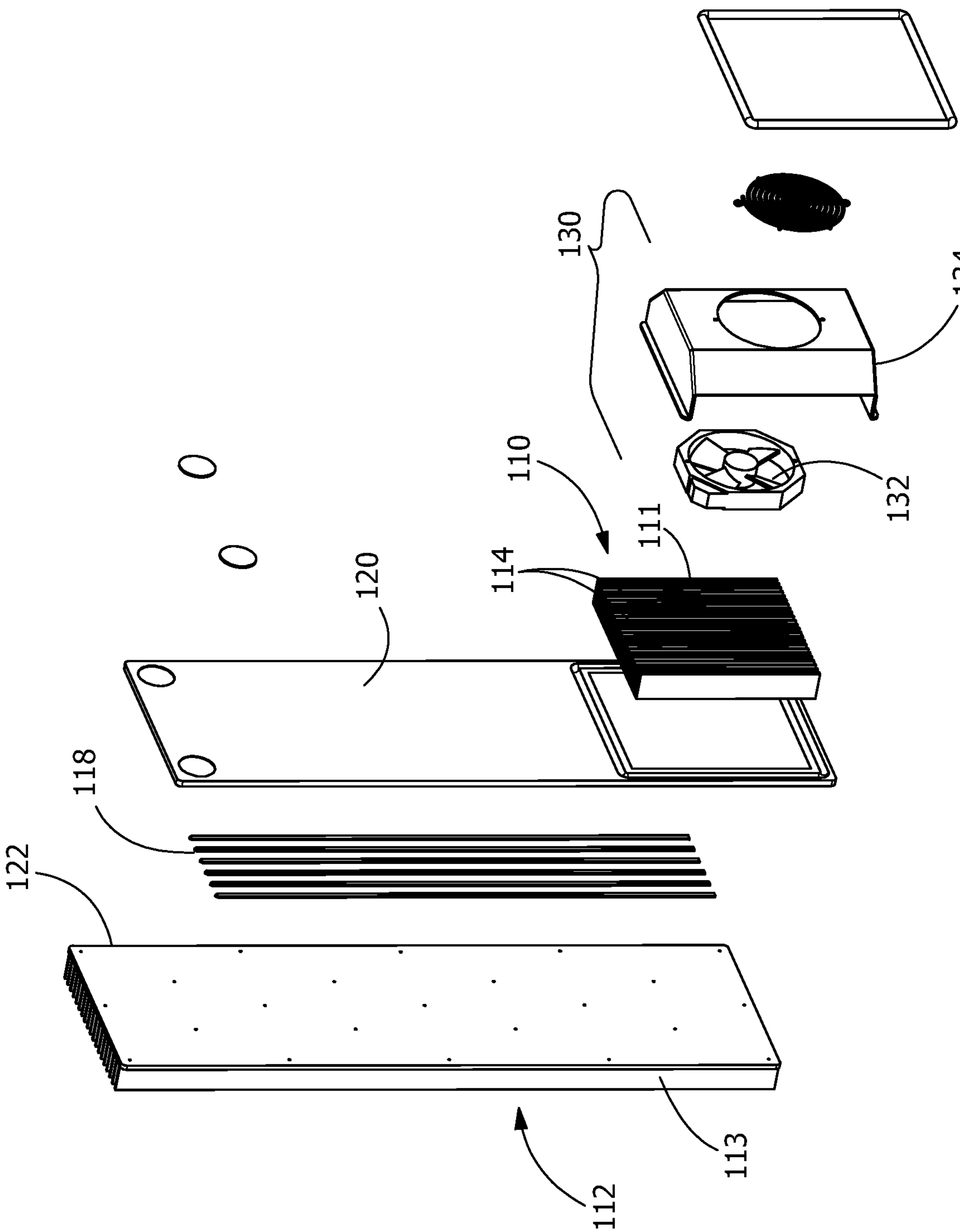

FIG. 6

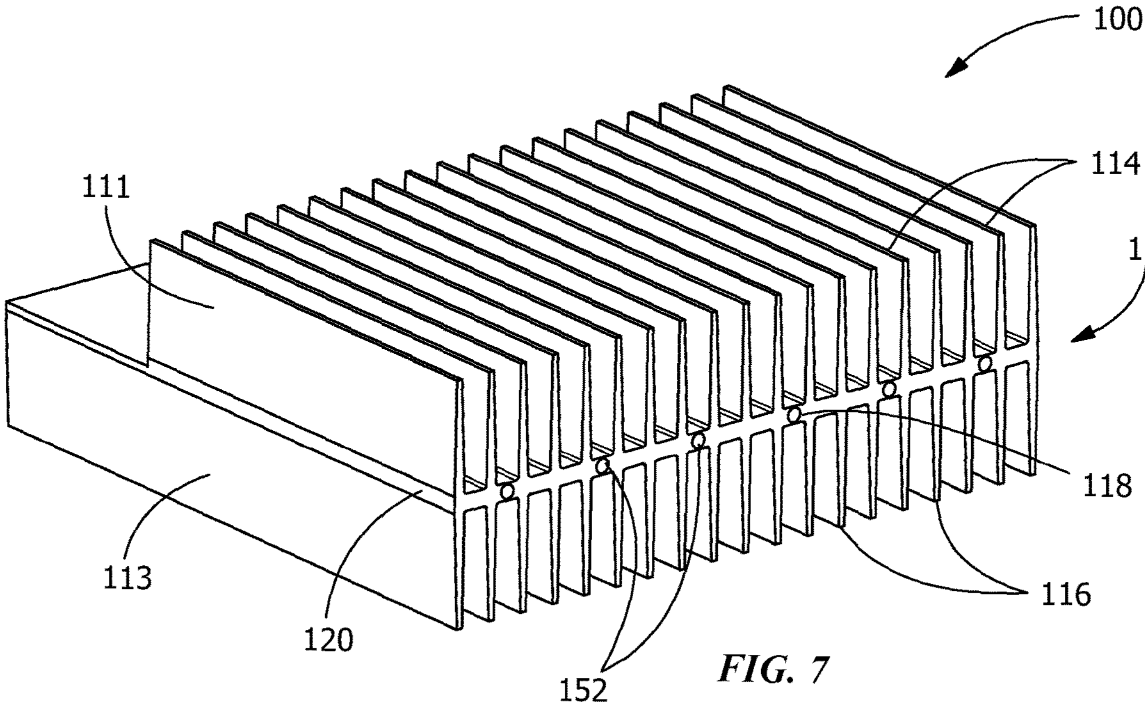
100
114
111
150
118
113
120
116
152

FIG. 7

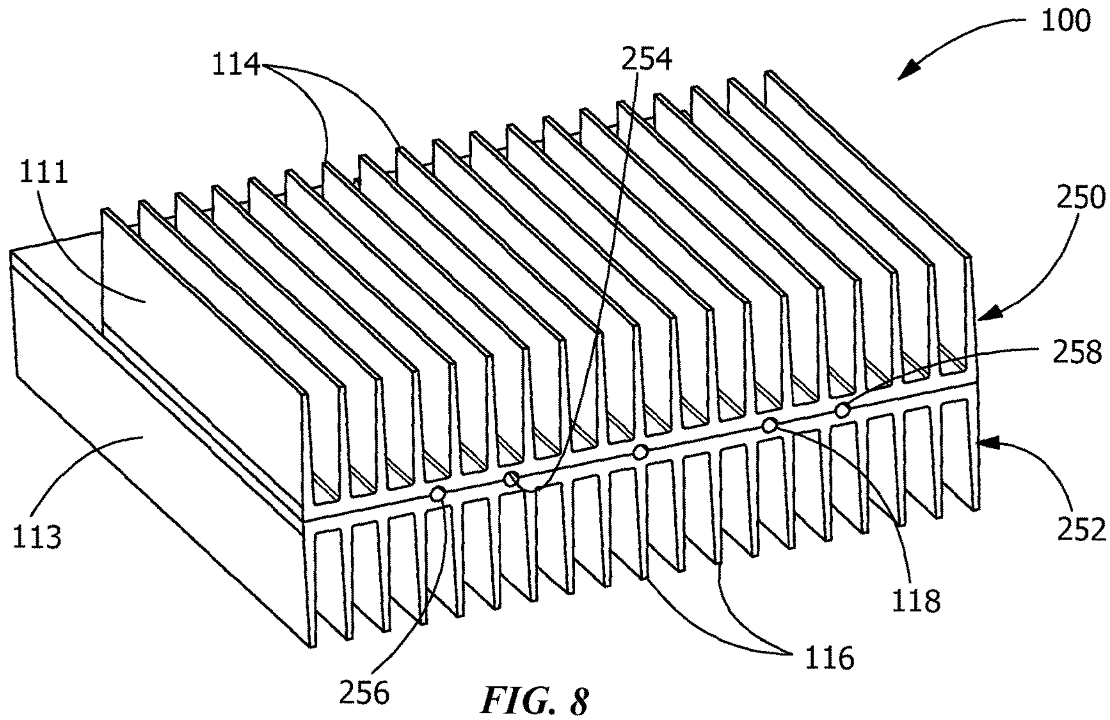
100
114
254
111
250
258
113
252
118
116
256

FIG. 8

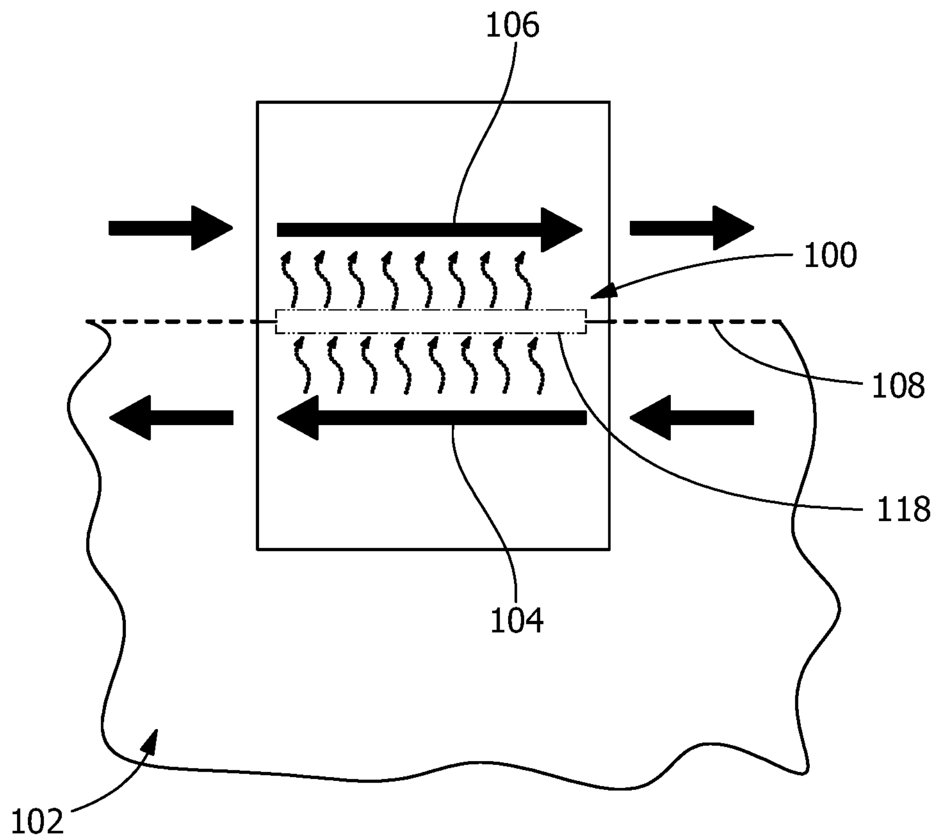

FIG. 9

DOUBLE SIDED HEAT EXCHANGER COOLING UNIT

BACKGROUND OF THE INVENTION

Electrical enclosures are used to house and protect electronics equipment from potentially harmful environments such as high humidity or rain, condensation, solar heat loads, dust and debris, temperature extremes and damaging corrosion. In some cases, the cabinets must be sealed to a standard, typically by National Electrical Manufacturers Association (NEMA). For example, a NEMA 12 cabinet is for indoor use and protects against drips, dust and falling dirt. A NEMA 4 cabinet is for indoor or outdoor use and protects against the same things as NEMA 12 as well as hose directed spray. The sealed nature of these cabinets requires heat transfer from the inside space to the ambient environment while maintaining the NEMA rated seal.

For most electronic components in an enclosure, the suggested maximum allowable air temperature within the enclosure is in the range of 130° F. to 160° F. One common guideline states that for every 18° F. the temperature of an electronic component is elevated beyond its recommended operating temperature, the lifetime of the electronic components is cut in half. In order to increase electrical component lifetime and reduce process downtime due to component failure or replacement, a cooling solution must be chosen. If an enclosure must be sealed from the ambient environment, then a method of transferring heat through some cooling device must be chosen based on the amount of heat that needs to be removed and the ambient conditions around the enclosure.

In cases where the ambient air temperature is suitably low, an air-to-air heat exchanger **10**, as shown diagrammatically in FIG. **1**, can be used to transfer heat from the air **12** inside of the cabinet **14** to the ambient air **16**. An air-to-air heat exchanger **10** transfers heat from the hot air **12** inside the enclosure **14** to the cooler ambient air **16** while maintaining a NEMA seal that prevents external air and other contaminants from entering the enclosure. It is beneficial to use a heat exchanger instead of an air conditioner (AC) when possible because the energy required to operate the cooling system is much lower.

Two key factors influencing the amount of heat that can be transferred from air inside of an enclosure to ambient air are the surface area available for heat transfer and the thermal resistance through the cooling device. Increasing the surface area of a heat exchanger by adding an extended surface or fin structure can increase heat transfer through the heat exchanger.

Lowering the thermal resistance between the internal enclosure air and the external ambient air reduces the difference between the two air temperatures that is necessary to transfer a given amount of heat. This means that with a lower thermal resistance, a lower internal enclosure temperature can be maintained for a given heat load into the enclosure. Air-to-liquid coolers are used for enclosures with high heat loads. These systems transfer heat to a liquid supply that may be a cooling water supply or a chilled liquid loop. In either case there is a requirement for additional equipment or a water supply that may not always be available.

Thermoelectric coolers are commonly used to achieve sub-ambient temperatures within an enclosure, but they are limited in capacity and are very expensive relative to other types of cooling products.

Air conditioners are also used to achieve sub-ambient cooling and are the most common active enclosure cooling product. The drawback to compressor-based cooling systems is that they require greater energy input than air-to-air heat exchangers.

When outside air cannot be introduced to the interior of an enclosure but the maximum temperature of the ambient environment and maximum heat load in the enclosure are suitable, a heat exchanger can be used to transfer heat out of the enclosure while maintaining a seal between the ambient environment and the interior of the enclosure. Heat exchanger products that are currently in use include heat pipe heat exchangers with aluminum finned coils, folded-fin heat exchangers, and plate & fin heat exchangers.

SUMMARY

An object of the invention is to provide a double sided heat exchanger that has a direct path of thermal conduction between a first gas stream on one side of the double sided heat exchanger and a second gas stream on the other side of the double sided heat exchanger.

An object of the invention is to provide a heat exchanger with a lower thermal resistance by providing heat pipes in the heat exchanger. The heat pipes can be embedded between an internal side of a double-sided heat exchanger and the external side, so that heat can be transferred with little thermal resistance to the external side.

An object of the invention is to provide a heat exchanger in which embedded heat pipes ensure uniform temperature distribution across the heat exchanger, allowing for maximum heat transfer efficiency.

An object of the invention is to provide a heat exchanger in which embedded heat pipes may be used to transfer heat from an internal heat sink to an external heat sink that is larger in size. This adds heat transfer area at the exterior surface where heat must be dissipated to ambient air. If the heat transfer characteristics of the external heat sink are improved, then less air flow may be required to dissipate the heat.

An embodiment is directed to an air-to-air heat exchanger that uses heat pipes embedded between two fin stacks, one within the air volume of the enclosure and one outside of the enclosure, to transfer heat from the enclosure to the ambient air. The heat exchanger may include a fan on the inside of the enclosure to force air over the internal fin stack, cooling internal air. A double-sided heat sink is used so that a conduction path exists between the two fin stacks without an interface between two separate heat sinks. Heat pipes embedded into the double-sided heat sink ensure uniform temperature distribution across the plate surface of the heat sinks as well as offer a low thermal resistance pathway for heat transfer. The heat pipes can be used to spread heat to an extended heat sink length on one side of the heat sink asymmetrically, so that one side of the heat sink has a greater surface area.

An embodiment is directed to a cooling unit positioned between a first gas stream and a second gas stream, the first gas stream and the second gas stream having no direct fluid contact therebetween. The cooling unit includes a double-sided heat exchanger with a first side that is in thermal communication with the first gas stream and a second side that is in thermal communication with the second gas stream. The double-sided heat exchanger provides a direct path of thermal conduction between the first gas stream and the second gas stream. First fins are provided on the first side of the double-sided heat exchanger and second fins are provided on the second side of the double-sided heat exchanger. The fins increase the heat exchange between the first gas stream and the second gas stream. The double-sided heat exchanger is made from a thermally conductive material.

An embodiment is directed to a heat exchanger positioned between a first gas stream and a second gas stream, the first gas stream and the second gas stream having no direct fluid contact therebetween. The heat exchanger includes a first side that is in thermal communication with the first gas stream and a second side that is in thermal communication with the second gas stream. The heat exchanger provides a direct path of thermal conduction between the first gas stream and the second gas stream. First fins are provided on the first side of the heat exchanger and second fins are provided on the second side of the heat exchanger. The fins increase the heat transfer between the first gas stream and the second gas stream. A first surface area of the first side of the heat exchanger is at least 5% greater than a second surface area of the second side of the heat exchanger.

An embodiment is directed to a double-sided heat exchanger positioned between a first gas stream and a second gas stream, the first gas stream and the second gas stream having no direct fluid contact therebetween. The double-sided heat exchanger has a first side that is in thermal communication with the first gas stream and a second side that is in thermal communication with the second gas stream. The double-sided heat exchanger provides a direct path of thermal conduction between the first gas stream and the second gas stream. Fins are provided on the first side of the double-sided heat exchanger, the fins increase the heat transfer between the first gas stream and the second gas stream. One or more heat pipes are embedded in the double-sided heat exchanger to enhance the heat transfer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a generic air-to-air heat exchanger diagram of the prior art.

FIG. **2** is a top perspective view of an illustrative heat exchanger of the present invention for use in a cabinet.

FIG. **3** is a diagrammatic side view of the heat exchanger of FIG. **2** positioned in a cabinet, with the cabinet shown in phantom to better illustrate the positioning of the heat exchanger.

FIG. **4** is a front perspective view of an alternate illustrative heat exchanger of the present invention for use in a cabinet, the heat exchanger having a fan provided thereon.

FIG. **5** is a back perspective view of the heat exchanger of FIG. **4**.

FIG. **6** is an exploded perspective view of the heat exchanger of FIG. **4**.

FIG. **7** is a portion of a representative heat exchanger formed as a single block, the heat exchanger having openings for heat pipes.

FIG. **8** is a portion of a representative heat exchanger formed from two blocks which are joined together, the heat exchanger having openings for heat pipes formed by the two blocks.

FIG. **9** is a diagrammatic view of an air-to-air heat exchanger according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The description of illustrative embodiments according to principles of the present invention is intended to be read in

connection with the accompanying drawings, which are to be considered part of the entire written description. In the description of embodiments of the invention disclosed herein, any reference to direction or orientation is merely intended for convenience of description and is not intended in any way to limit the scope of the present invention. Relative terms such as “lower,” “upper,” “horizontal,” “vertical,” “above,” “below,” “up,” “down,” “top” and “bottom” as well as derivative thereof (e.g., “horizontally,” “downwardly,” “upwardly,” etc.) should be construed to refer to the orientation as then described or as shown in the drawing under discussion. These relative terms are for convenience of description only and do not require that the apparatus be constructed or operated in a particular orientation unless explicitly indicated as such. Terms such as “attached,” “affixed,” “connected,” “coupled,” “interconnected,” and similar refer to a relationship wherein structures are secured or attached to one another either directly or indirectly through intervening structures, as well as both movable or rigid attachments or relationships, unless expressly described otherwise. Moreover, the features and benefits of the invention are illustrated by reference to the preferred embodiments. Accordingly, the invention expressly should not be limited to such preferred embodiments illustrating some possible non-limiting combination of features that may exist alone or in other combinations of features; the scope of the invention being defined by the claims appended hereto.

In general, as represented diagrammatically in FIG. **9**, an electrical enclosure or cabinet **102** includes a cooling unit with a double-sided heat exchanger **100** positioned between a first gas stream **104** and a second gas stream **106** is disclosed. The double-sided heat exchanger **100** provides a direct path of thermal conduction between the first gas stream **104** and the second gas stream **106**.

Referring to FIG. **3**, a double-sided heat exchanger **100** positioned in an electrical enclosure **102**. The heat exchanger **100** is positioned between a first gas stream **104** provided inside the enclosure **102** and a second gas stream **106** positioned outside the enclosure **102**. The first gas stream **104** and the second gas stream **106** have no direct fluid contact therebetween. The double-sided heat exchanger **100** is positioned in a wall **108** of the enclosure **102** with a first side **110** with a first heat sink **111** in thermal communication with the first gas stream **104** and a second side **112** with a second heat sink **113** in thermal communication with the second gas stream **106**. The double-sided heat exchanger **100** provides a direct path of thermal conduction between the first gas stream **104** and the second gas stream **106**. In the embodiment shown in FIG. **2**, the cooling unit has first fins **114** provided on the first heat sink **111** of the first side **110** of the double-sided heat exchanger **100** and second fins **116** provided on the second heat sink **113** of the second side **112** of the double-sided heat exchanger **100**. Referring to FIG. **2**, the fins **114**, **116** increase the heat transfer between the first gas stream **104** and the second gas stream **106**. However, other embodiments of the heat exchanger, which are not shown, may have fins only on one heat sink, or may have no fins on either heat sink. The double-sided heat exchanger **100** is made from a thermally conductive material. The thermally conductive material may include, but is not limited to, aluminum, aluminum alloy, copper, copper alloy or stainless steel.

Embedded heat pipes **118** are provided between the first heat sink **111** and the second heat sink **113**. The heat pipes **118** extend essentially the entire length or width of either the first heat sink **111** or the second heat sink **113**, whichever is longer.

In the embodiment shown, the second gas stream **106** is a colder fluid stream located outside of an enclosure **102** which houses the double-sided heat exchanger **100**, and the first gas stream **104** is a warmer fluid stream located inside of the enclosure **102** which houses the double-sided heat exchanger **100**. In various embodiments, a surface area of the second side **112** of the double-sided heat exchanger **100** is larger than the surface area of the first side **110** of the double-sided heat exchanger **100**. The surface area of the second side **112** may be 5% greater, 10% greater, 15% greater, 20% greater, 25% greater or greater than 25% greater than the surface area of the first side **110**. In addition, the surface area of the second fins **116** may be 5% greater, 10% greater, 15% greater, 20% greater, 25% greater or greater than 25% greater than the surface area of the first fins **114**. In various embodiments, the second fins **116** of the second side **112** are spaced apart by a distance which is greater than a distance by which the first fins **114** of the first side **110** are spaced apart, therein facilitating thermal conduction to occur by natural convection. The second fins **116** may be spaced apart by 5% greater, 10% greater, 15% greater, 20% greater, 25% greater or greater than 25% greater than the first fins **114**. In addition, the second fins **116** may be thicker than the first fins **114**.

As best shown in FIG. **6**, heat pipes **118** are embedded between a highly conductive layer or plate **120** and a highly conductive layer or plate **122**. The highly conductive layers or plates **120**, **122** may be made from, but are not limited to, aluminum, aluminum alloys, copper or copper alloys. Alternatively, the plates may be integrally molded with or extruded in the heat sinks **111**, **113**.

Heat pipes **118** may be replaced by a highly conductive layer positioned between the plates **120**, **122**. The highly conductive layer may be made from, but not limited to, pyrolytic graphite, diamond and graphite fiber reinforced composite.

In the embodiment shown in FIGS. **2** and **3**, the plate **122** extends the length of the heat sink **113** and the plate **120** extends the length of the heat sink **111**, thereby allowing portions of the heat pipes **118** to be exposed. In contrast, plates **120** and **122** of FIGS. **4** through **6** are similar in length, thereby covering the entire length of the heat pipes **118**. The plates **120**, **122** and heat pipes **118** are placed in good thermal contact with the heat sinks **111**, **113** to facilitate the heat transfer between the first gas stream **104** and the second gas stream **106**. The heat pipes **118** are used to facilitate the movement of heat from the heat input zone and spread heat throughout the entire heat exchanger **100** while delivering it to the heat output zone.

In various embodiments, a longitudinal axis of the one or more heat pipes **118** is parallel with a longitudinal axis of the first fins **114** and the second fins **116**. In other embodiments, the longitudinal axis of the one or more heat pipes **118** is perpendicular with the longitudinal axis of the first fins **114** and/or the second fins **116**.

One or more variable conductance heat pipes can be used in place of traditional heat pipes to allow the thermal resistance of the entire heat exchanger **100** to be increased when the temperature local to the heat output zone is reduced (such as in a low temperature ambient condition).

The width of the heat sinks **111**, **113** may be essentially identical (as shown in FIGS. **7** and **8**) or they may vary (as shown in FIGS. **2** through **6**), with the heat sink **113** on one side **112** of the double-sided heat exchanger **100** larger than the heat sink **111** on the other side **110**. In the case where the two sides of the double-sided heat exchanger **100** are symmetric, the heat pipes may not be needed. In the case where one side of the double-sided heat exchanger **100** is larger, the heat pipes **118** will extend the length of the larger heat sink **113** in order to spread heat to the entire surface of the larger heat sink **113**. A larger heat sink **113** positioned outside of the enclosure **102** is useful for situations that require natural convection heat dissipation on the heat output side.

As best shown in FIGS. **4** and **6**, fan assemblies **130** with one or more fans **132** enclosed therein can be mounted on the heat sinks **111**. In addition, fan assemblies (not shown) may also be mounted on the heat sinks **113**. The fan **132** facilitates the movement of air through the fins to allow heat to be dissipated by forced convection. In the embodiment shown in FIGS. **4** through **6**, only the heat sink **111** has an internal fan assembly **130** provided thereon. This forces hot air from the first gas stream **104** of the enclosure **102** over the fins **114** of the heat sink **111**, cooling the air. Depending on the application, one or more external fans, such as fan **160** (FIG. **3**) may also be mounted on the heat sink **113** to facilitate the cooling of the heat sink **113**. Both internal fans and external fans can be turned off or not operated when natural convention is sufficient to dissipate the heat.

In FIG. **6**, the fan **132** is mounted in an impingement configuration so that air is drawn into the center of the fins **114** and exhausted from each end. The fan assembly **130** may include a shroud **134** or ductwork that directs air flow in a manner that enhances heat transfer. Other embodiments of the fan assembly **130** and fan **132** may be used without departing from the scope of the invention. For example, a low power fan may be used to enhance natural convection heat transfer on one side.

Referring to FIG. **7**, an alternate embodiment is shown. In this embodiment, the double-sided heat exchanger **100** is formed as a single member or block **150**, with the first fins **114** of the first heat sink **111** and the second fins **116** of the second heat sink **113** formed therein. One or more openings **152** extend through an integral layer or plate **120** formed between the first fins **114** and the second fins **116**. The openings **152** are dimensioned to receive heat pipes **118** therein. The heat pipes **118** are used to move heat from the heat input zone and spread heat throughout the entire heat exchanger **100** while delivering it to the heat output zone.

Referring to FIG. **8**, another alternate embodiment is shown. In this embodiment, the double-sided heat exchanger **100** is formed from two members or blocks **250**, **252**, with the first fins **114** of the first heat sink **111** formed in the first block **250** and the second fins **116** of the second heat sink **113** formed in the second block **252**. Rounded surfaces **254**, **256** are formed on mating sides of the respective blocks **250**, **252**. The rounded surfaces form one or more openings **258** when the blocks **250**, **252** are mated or joined together. The openings **258** are dimensioned to receive heat pipes **118** therein. The heat pipes **118** are used to move heat from the heat input zone and spread heat throughout the entire heat exchanger **100** while delivering it to the heat output zone.

The double sided heat sink exchanger and the enclosure described herein are able to be produced at lower cost than other types of coolers such as heat pipe heat exchangers or thermoelectric coolers.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the spirit and scope of the invention as defined in the accompanying claims. In particular, it will be clear to those skilled in the art that the present invention may be embodied in other specific forms, structures, arrangements, proportions, sizes, and with other elements, materials, and components, without departing from the spirit or essential characteristics thereof. One skilled in the art will appreciate that the invention may be used with many modifications of structure, arrangement, proportions, sizes, materials, and components and otherwise, used in the practice of the invention, which are particularly adapted to specific environments and operative requirements without departing from the principles of the present invention. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being defined by the appended claims, and not limited to the foregoing description or embodiments.

The invention claimed is:

1. A cooling unit positioned between a first gas stream and a second gas stream, the first gas stream and the second gas stream having no direct fluid contact therebetween, the cooling unit comprising:

a double-sided heat exchanger having a first side having a first planar surface area, the first side with a first heat sink that is in thermal communication with the first gas stream, the first side facing the first gas stream, and a second side having a second planar surface area, the second side with a second heat sink that is in thermal communication with the second gas stream, the second side facing the second gas stream, the double-sided heat exchanger providing a direct path of thermal conduction between the first gas stream and the second gas stream, the first planar surface area of the first side of the double-sided heat exchanger is at least 25% greater than the second planar surface area of the second side of the double-sided heat exchanger;

the first heat sink comprising a first conductive plate and first fins, and the second heat sink comprising a second conductive plate and second fins, the first conductive plate having a length greater than a corresponding length of the second conductive plate;

heat pipes provided between the first conductive plate and the second conductive plate, the heat pipes extending along the length of the first conductive plate;

the first fins extending in a direction away from the first conductive plate of the first heat sink of the double-sided heat exchanger, and the second fins extending in a direction away from the second conductive plate of the second heat sink of the double-sided heat exchanger, the first fins and the second fins increase the heat transfer between the first gas stream and the second gas stream;

a fan surrounded by and directly connected to a housing surrounding the first fins and directly attached to the first conductive plate;

the double-sided heat exchanger is made from a thermally conductive material.

2. The cooling unit as recited in claim **1**, wherein a first fin surface area of the first fins of the first side of the double-sided heat exchanger is at least 5% greater than a second fin surface area of the second fins of the second side of the double-sided heat exchanger.

3. The cooling unit as recited in claim **1**, wherein the thermally conductive material is aluminum, aluminum alloy, copper, copper alloy or stainless steel.

4. The cooling unit as recited in claim **1**, wherein at least one heat pipe of the heat pipes has a length having a longitudinal axis parallel with a longitudinal axis of the first fins and the second fins.

5. The cooling unit as recited in claim **1**, wherein a longitudinal axis of at least one heat pipe of the heat pipes is perpendicular with a longitudinal axis of the first fins and the second fins.

6. The cooling unit as recited in claim **1**, wherein the first gas stream is a colder fluid stream located outside of an enclosure which houses the double-sided heat exchanger and the second gas stream is a warmer fluid stream located inside of the enclosure which houses the double-sided heat exchanger.

7. The cooling unit as recited in claim **6**, wherein at least one heat pipe of the heat pipes is a variable conductance heat pipe embedded in the double-sided heat exchanger to reduce the heat transfer when the temperature of the first gas stream drops.

8. The cooling unit as recited in claim **1**, wherein the first gas stream is a colder fluid stream located outside of an enclosure which houses the double-sided heat exchanger and the second gas stream is a warmer fluid stream located inside of the enclosure which houses the double-sided heat exchanger, the first fins are spaced apart by a first distance which is at least 10% greater than a second distance by which the second fins are spaced apart, therein allowing the heat transfer to occur by natural convection.

9. The cooling unit as recited in claim **1**, wherein an external fan located outside of an enclosure which houses the double-sided heat exchanger improves the heat transfer, allowing heat to be dissipated by forced convection.

10. The cooling unit as recited in claim **9**, wherein the external fan is turned off when natural convection is sufficient to dissipate the heat.

11. The cooling unit as recited in claim **1**, wherein the double-sided heat exchanger, including the first fins and second fins, is one piece, thereby eliminating any thermal contact resistance between the first fins of the first heat sink and the second fins of the second heat sink.

12. A cooling unit positioned between a first gas stream and a second gas stream, the first gas stream and the second gas stream having no direct fluid contact therebetween, the cooling unit comprising:

a double-sided heat exchanger having a first side having a first planar surface area, the first side with a first heat sink that is in thermal communication with the first gas stream, the first side facing the first gas stream, and a second side having a second planar surface area, the second side with a second heat sink that is in thermal communication with the second gas stream, the second side facing the second gas stream, the double-sided heat exchanger providing a direct path of thermal conduction between the first gas stream and the second gas stream, the first planar surface area of the first side of the double-sided heat exchanger is at least 25% greater than the second planar surface area of the second side of the double-sided heat exchanger;

the first heat sink comprising a first conductive plate and first fins, and the second heat sink comprising a second conductive plate and second fins, the first conductive plate having a length greater than a corresponding length of the second conductive plate;

the first fins extending in a direction away from the first conductive plate of the first heat sink of the double-sided heat exchanger, and the second fins extending in a direction away from the second conductive plate of the second heat sink of the double-sided heat exchange, the first fins and the second fins increase the heat transfer between the first gas stream and the second gas stream;

- a fan surrounded by and directly connected to a housing surrounding the first fins and directly attached to the first conductive plate;
- a high conductivity layer is provided between the first conductive plate of the first heat sink of the double-sided heat exchanger and the second conductive plate of the second heat sink of the double-sided heat exchanger, the high conductivity layer enhances the thermal conduction of the double-sided heat exchanger.

13. The cooling unit as recited in claim **12**, wherein the double-sided heat exchanger is made from a thermally conductive material, the thermally conductive material is aluminum, aluminum alloy, copper, copper alloy or stainless steel.

14. The cooling unit as recited in claim **12**, wherein the high conductivity layer is made from pyrolytic graphite, diamond or graphite fiber reinforced composite.

15. The cooling unit as recited in claim **12**, wherein the high conductivity layer includes one or more heat pipes.

16. The cooling unit as recited in claim **15**, wherein the one or more heat pipes has a length having a longitudinal axis parallel with a longitudinal axis of the first fins and the second fins.

17. The cooling unit as recited in claim **15**, wherein a longitudinal axis of the one or more heat pipes is perpendicular with a longitudinal axis of the first fins and the second fins.

18. The cooling unit as recited in claim **12**, wherein the first gas stream is a colder fluid stream located outside of an enclosure which houses the double-sided heat exchanger and the second gas stream is a warmer fluid stream located inside of the enclosure which houses the double-sided heat exchanger.

19. The cooling unit as recited in claim **18**, wherein the high conductivity layer is made of one or more variable conductance heat pipes embedded in the double-sided heat exchanger to reduce the heat transfer when the temperature of the first gas stream drops.

20. The cooling unit as recited in claim **18**, wherein the first fins are spaced apart by a first distance which is at least 10% greater than a second distance by which the second fins are spaced apart, therein allowing the heat transfer to occur by natural convection.

21. The cooling unit as recited in claim **12**, wherein an external fan located outside of an enclosure which houses the double-sided heat exchanger improves the heat transfer, allowing heat to be dissipated by forced convection.

22. The cooling unit as recited in claim **12**, wherein the double-sided heat exchanger, including the first fins and second fins, is one piece, thereby eliminating any thermal contact resistance between the first fins of the first heat sink and the second fins of the second heat sink.

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