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Declarations under Rule 4.17:

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[Continued on next page]

(54) **Title**: HEAT SINK WITH MULTIPLE VAPOR CHAMBERS

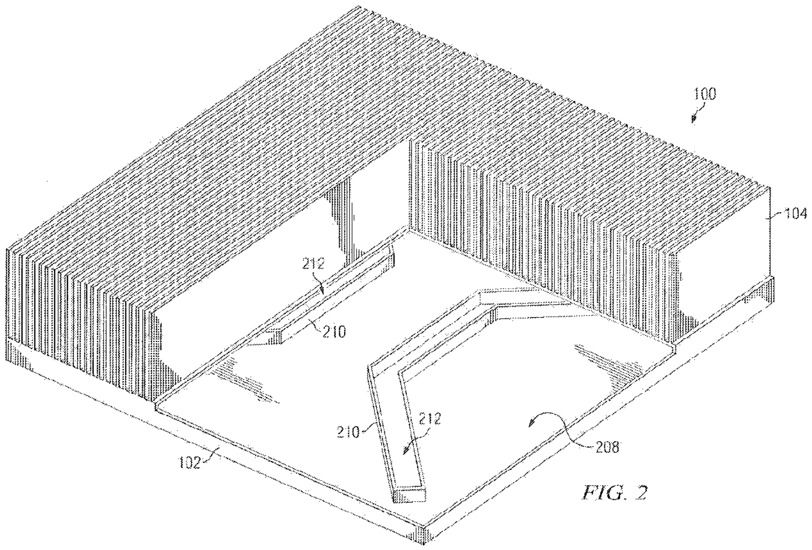

FIG. 2

(57) **Abstract**: A heat sink is disclosed. The heat sink comprises a base (102, 402) with at least one vapor chamber (208, 408) containing a fluid with a first activation point. The base has at least one vapor chamber (212, 412) containing a fluid with a second activation point. The first activation point is different than the second activation point.

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Heat sink with multiple vapor chambers

BACKGROUND

[0001] Computer systems and servers generate large amounts of heat. A significant portion of the heat generated in these systems comes from individual electronic components mounted in the systems, for example the central processing units (CPU). A heat sink is typically mounted to the components to help remove the heat generated by the component. As the chip densities of the components have increased, the heat produced by the components has also increased.

[0002] Some components operate at different power levels depending on the current demands of the system. When the component is operating at full power, it may generate large amounts of heat. When operating at lower power, or when in a standby mode of operation, the amount of heat generated may be significantly reduced, compared to the high power condition. Constructing a heat sink that efficiently removes the heat under all of the operating condition of the component has become a challenge.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] FIG. 1 is a heat sink 100 in an example embodiment of the invention.

[0004] FIG. 2 is an isometric cutaway view of heat sink 100, in an example embodiment of the invention.

[0005] FIG. 3a is a sectional top view of heat sink 100 in an example embodiment of the invention.

[0006] FIG. 3b is a sectional side view of heat sink 100 in an example embodiment of the invention.

[0007] FIG. 4a is a sectional top view of heat sink 400 in an example embodiment of the invention.

[0008] FIG. 4b is a sectional top view of heat sink 401 in an example embodiment of the invention.

[0009] FIG. 4c is a sectional top view of heat sink 402 in an example embodiment of the invention.

[0010] FIG. 4d is a sectional top view of heat sink 403 in an example embodiment of the invention.

[0011] FIG. 4e is a sectional side view of heat sink 403 from figure 4d in an example embodiment of the invention.

DETAILED DESCRIPTION

[0012] FIG. 1 - 4, and the following description depict specific examples to teach those skilled in the art how to make and use the best mode of the invention. For the purpose of teaching inventive principles, some conventional aspects have been simplified or omitted. Those skilled in the art will appreciate variations from these examples that fall within the scope of the invention. Those skilled in the art will appreciate that the features described below can be combined in various ways to form multiple variations of the invention. As a result, the invention is not limited to the specific examples described below, but only by the claims and their equivalents.

[0013] Figure 1 is a heat sink 100 in an example embodiment of the invention. Heat sink 100 is comprised of a base or body 102 and a plurality of fins 104. Heat sink 100 may be constructed of any material with a high thermal conductivity, for example copper, platinum, aluminum, iron, etc. Fins 104 are formed on the top surface of base 102 and are positioned in parallel rows with gaps between the fins. In operation, air is typically forced through the gaps between the parallel rows of fins to remove heat from heat sink 100.

[0014] Heat sink 100 is typically positioned on top of a component that requires cooling, for example component 106. In some example embodiments of the invention, the bottom of heat sink 100 may have a cavity sized to accept component 106 such that component 106 contacts heat sink 100 on the top and the four sides of component 106. A thermal grease may be placed between component 106 and heat sink 100 to increase the thermal coupling between the two parts.

[0015] Figure 2 is an isometric cutaway view of heat sink 100, in an example embodiment of the invention. Base 102 forms a first vapor chamber 208. First vapor chamber 208 is rectangular and essentially fills base 102. Positioned inside first vapor chamber 208 are two hollow secondary structures 210. These two hollow structures form two sealed secondary vapor chambers 212. In one example embodiment of the invention, the volume of the first vapor chamber 208 is larger than the combined volumes of the two secondary vapor chambers 212. The first vapor chamber 208 contains a fluid with a first boiling point. The two secondary vapor chambers 212 contain a fluid with a second, different, boiling point. In one example embodiment of the invention the boiling point of the fluid in the first vapor chamber 208 is higher than the boiling point of the fluid in the two secondary vapor chambers 212.

[0016] In operation, when the component 106 is operating at a lower power or in a standby mode, the component 106 will dissipate a first amount of power. When the component 106 is operating in a high power mode, a second, higher amount of power will be dissipated by the component 106. In general, a higher amount of power dissipated by the component 106 will correspond to a higher temperature at the base of the heat sink. When the secondary vapor chambers 212 contain a fluid with a lower boiling point than the fluid in the first vapor chamber 208, the fluid in the secondary vapor chambers will boil at the lower power or standby operating mode of the component. As the component dissipates more power, the fluid in the secondary vapor chambers may saturate (i.e. never get cool enough to condense). Once saturated, the fluid in a vapor chamber has a lower capacity to transfer heat. The fluid in the first vapor chamber (with a higher boiling point) will start to boil as the temperature of the component increases. In this way the fluid in the secondary vapor chambers transfers the heat from the component across the heat sink during lower power operations. As the temperature of the component increases, the fluid inside the first vapor chamber is used to transfer the heat from the component across the heat sink.

[0017] Figure 3a is a sectional top view of heat sink 100 in an example embodiment of the invention. Heat sink 100 comprises first vapor chamber 208 and two secondary vapor chambers 212. Component 106 is positioned under heat sink 100. Figure 3b is a sectional side view of heat sink 100 in an example embodiment of the invention. Arrows 318, 320, 322 and 324 in figures 3a and 3b show the flow of the first fluid inside vapor chamber 208. As component 106 heats up, the first fluid begins to boil directly above component 106. As the first fluid boils and turns into a vapor, the vapor rises as shown by arrows 318 (fig. 3b). The vapor moves across the top of vapor chamber 208 as shown by arrows 320. As the vapor flows across the top of vapor chamber 208, the heat contained in the vapor is transferred into the top of heat sink 100. Air flowing past fins 104 removes the heat from heat sink 100. As the first fluid transfers heat into the top of heat sink 100, the vapor cools and condenses back into a fluid as shown by arrows 322. The cooled fluid flow back to component 106, as shown by arrows 324, to begin the cooling cycle again.

[0018] The second fluid inside the two secondary vapor chambers 212 follows a similar flow pattern. The fluid boils where the vapor chambers are positioned over component 106 and the vapor condenses as the vapor chambers moves away from component 106. When the second fluid in the two secondary vapor chambers 212 has a lower boiling point than the first fluid in the first vapor chamber 208, the second fluid will activate and boil at a lower temperature than the first fluid.

[0019] In one example embodiment of the invention, the fluids inside the first and second vapor chambers may be different working fluids with different boiling points. For example, the fluid in the first vapor chamber may be water and the fluid inside the secondary vapor chambers may be alcohol. In another example embodiment of the invention, the fluids inside the first and second vapor chambers may be the same working fluid, but the different vapor chambers may be filled with different volumes and pressures of the fluid to adjust the boiling point of the fluids in the different vapor chambers to activate at different power and temperatures. In another example embodiment of the invention, the different vapor chambers may have unique surface treatments and/or wicking structures that modify the activation points of the fluids contained in the vapor chamber. In one example embodiment of the invention, the first activation point may be in the range of 35 - 65 degrees C, and the second activation point may be in the range of 60 - 80 degrees C.

[0020] Heat sink 100 is shown with the secondary vapor chamber 212 broken into two separate parts (see figure 2 and 3) with two separate volumes. In some example embodiments of the invention, the secondary vapor chamber may be comprised of one or more separate volumes. Figures 4a is a sectional top view of heat sink 400 in an example embodiment of the invention. Heat sink 400 has a first vapor chamber 408 that fills heat sink base 402. A single secondary vapor chamber 412 is shaped as a star and is centered over component 406. The first vapor chamber 408 is filled with a fluid having a first boiling or activation point. The second vapor chamber 412 is filled with a fluid having a second, different boiling or activation point.

[0021] Figures 4b is a sectional top view of heat sink 401 in an example embodiment of the invention. Heat sink 401 has a first vapor chamber 408 that fills heat sink base 402. Four secondary vapor chambers 412 are positioned inside the first vapor chamber 408. The ends of the four secondary vapor chambers are positioned over component 406. The first vapor chamber 408 is filled with a fluid having a first boiling or activation point. The four secondary vapor chambers 412 are filled with a fluid having a second, different boiling or activation point. In some example embodiments of the invention, the secondary vapor chambers may comprise heat pipes placed inside the first vapor chamber 408, with the cold ends of the heat pipes positioned over component 406. In other example embodiments, the secondary vapor chambers may be structures formed into heat sink base 402.

[0022] In some example embodiments of the invention, the first vapor chamber may be broken into more than one volume. Figures 4c is a sectional top view of heat sink 402 in an example embodiment of the invention. Heat sink 402 has a first vapor chamber 408 that is broken into three separate volumes (408a, 408b, and 408c). Heat sink 402 also has the secondary vapor chamber 412 broken into two separate volumes. The three separate volumes of the first vapor chamber 408 are filled with a fluid having a first boiling or activation point. The two secondary vapor chambers 412 are filled with a fluid having a second, different boiling or activation point.

[0023] Figures 4d is a sectional top view of heat sink 403 in an example embodiment of the invention. Heat sink 403 has the first vapor chamber 408 broken into four separate parts or volumes and the secondary vapor chamber 412 broken into two separate parts or volumes. The four parts of the first vapor chamber 408 are formed as separate parallel columns perpendicular to the long axis of component 406. Two of the separate parts of the first vapor chamber are placed over each end of component 406 with the other two volumes places over the center of component 406. The two parts of the secondary vapor chamber 412 are formed as separate parallel columns perpendicular to the long axis of component 406. The two separate volumes of the secondary vapor chamber are placed in-between the two end volumes of the first vapor chamber and the two center volumes of the first vapor chamber. In one example embodiment of the invention, the four separate parts of the first vapor chamber comprise four separate heat pipes, each having a fluid with the same boiling or activation point. The two separate volumes of the secondary vapor chamber comprise two separate heat pipes have the same boiling or activation point, wherein the boiling point of the fluid in the first vapor chamber is different than the boiling point of the fluid in the secondary vapor chamber.

As can be seen by figure 4c and 4d, the secondary vapor chambers may not be contained inside the first vapor chamber.

[0024] Figure 4e is a sectional side view of heat sink 403 from figure 4d in an example embodiment of the invention. Heat sink 403 comprises base 402, fins 404, vapor chambers 408 and vapor chambers 412. Heat sink 403 is positioned over component 406. Vapor chambers 408 and vapor chambers 412 are located in a chamber or cavity centered over component 406. Vapor chambers 408 are four heat pipes with a first activation temperature. Vapor chambers 412 are two heat pipes with a second, different, activation temperature. In one example embodiment of the invention, the first activation temperature is higher than the second activation temperature.

[0025] In some example embodiments of the invention, the component to be cooled may have more than two different power levels. For example, the component may have a standby mode, a low power operating point, and a high power operating point. In this example embodiment of the invention there may be three or more vapor chambers with different boiling or activation points. For example, in figure 4c a first vapor chamber having a fluid with a first boiling point may be comprised of volume 408b. A second vapor chamber having a fluid with a second boiling point may be comprised of volumes 408a and 408c. A third vapor chamber having a fluid with a third boiling point may be comprised of the two separate volumes 412.

CLAIMS

What is claimed is:

1. A heat sink, comprising:

a base (102, 402);

at least one vapor chamber (208, 408) inside the base having a fluid with a first activation point;

at least one vapor chamber (212, 412) inside the base having a fluid with a second activation point wherein the first activation point is different than the second activation point.

2. The heat sink of claim 1, wherein the fluid with the first activation point and the fluid with the second activation point are the same fluid.

3. The heat sink of claims 1 and 2, wherein a volume of the least one vapor chamber (208, 408) inside the base having a fluid with a first activation point is larger than a volume of the at least one vapor chamber (212, 412) inside the base having a fluid with a second activation point.

4. The heat sink of claims 1, 2 and 3, wherein the first activation point is higher than the second activation point.

5. The heat sink of claims 1, 2, 3 and 4, wherein the at least one vapor chamber (212, 412) inside the base having a fluid with a second activation point is contained inside the at least one vapor chamber (208, 408) inside the base having a fluid with a first activation point.

6. The heat sink of claims 1, 2, 3, 4 and 5, wherein the at least one vapor chamber (212, 412) inside the base having a fluid with a second activation point is comprised of at least one heat pipe.

7. The heat sink of claims 1, 2, 3, 4, 5 and 6, wherein the at least one vapor chamber (212, 412) inside the base having a fluid with a first activation point is comprised of at least one heat pipe.

8. The heat sink of claims 1, 2, 3, 4, 5, 6 and 7, wherein: the first activation point is between 60 and 80 degrees C and the second activation point is between 35 and 65 degrees C.

9. The heat sink of claims 1, 2, 3, 4, 5, 6, 7 and 8, further comprising:

a least one vapor chamber inside the base having a fluid with a third activation point wherein the third activation point is different than the first or second activation point.

10. A method for cooling a component, comprising:

activating a fluid, inside a first vapor chamber in a heat sink mounted on the component, at a first temperature;

activating a fluid, inside a second vapor chamber in the heat sink mounted on the component, at a second temperature, wherein the first temperature is different than the second temperature.

11. The method for cooling a component of claim 10, wherein the fluid inside the first vapor chamber is a different fluid than the fluid inside the second vapor chamber.

12. The method for cooling a component of claim 10 and 11, wherein a volume of the first vapor chamber is larger than a volume of the second vapor chamber.

13. The method for cooling a component of claim 10, 11 and 12, wherein the first vapor chamber and the second vapor chamber are heat pipes.

14. The method for cooling a component of claim 10, 11, 12 and 13, wherein the second vapor chamber is broken into at least two parts.

15. The method for cooling a component of claim 10, 11, 12, 13 and 14, further comprising:

activating a fluid inside a third vapor chamber in the heat sink mounted on the component at a third temperature, wherein the third temperature is different than the first or second temperature.

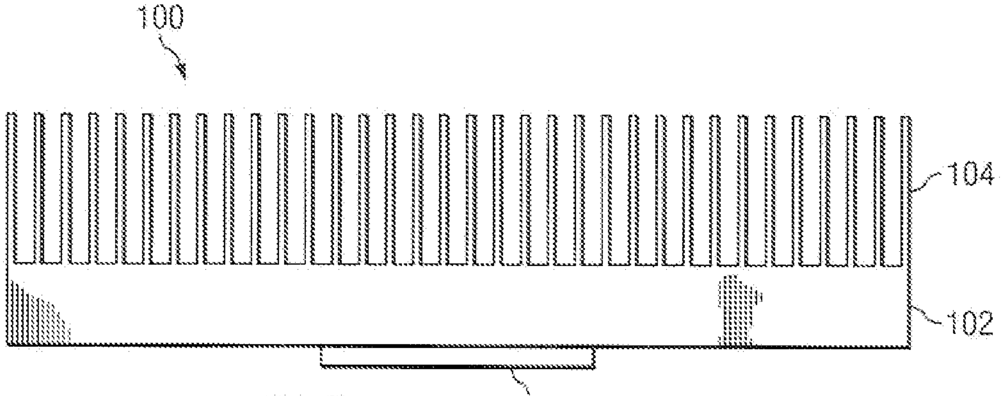
100
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FIG. 1

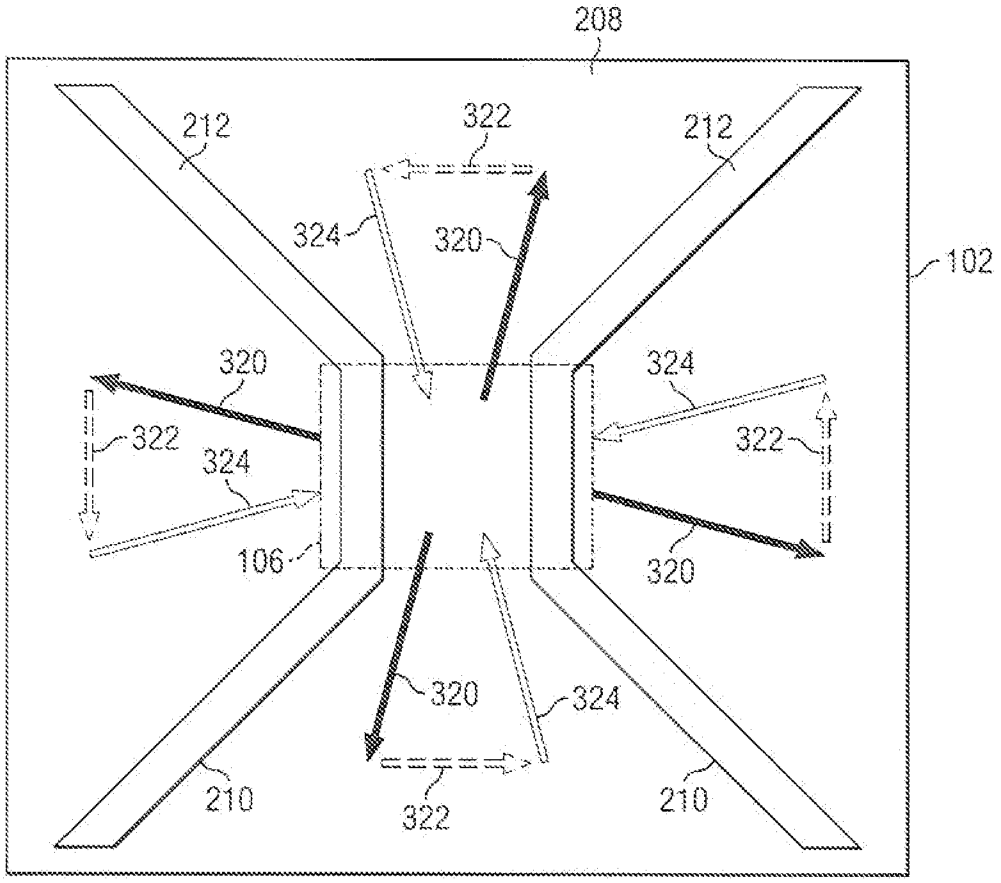
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FIG. 3a

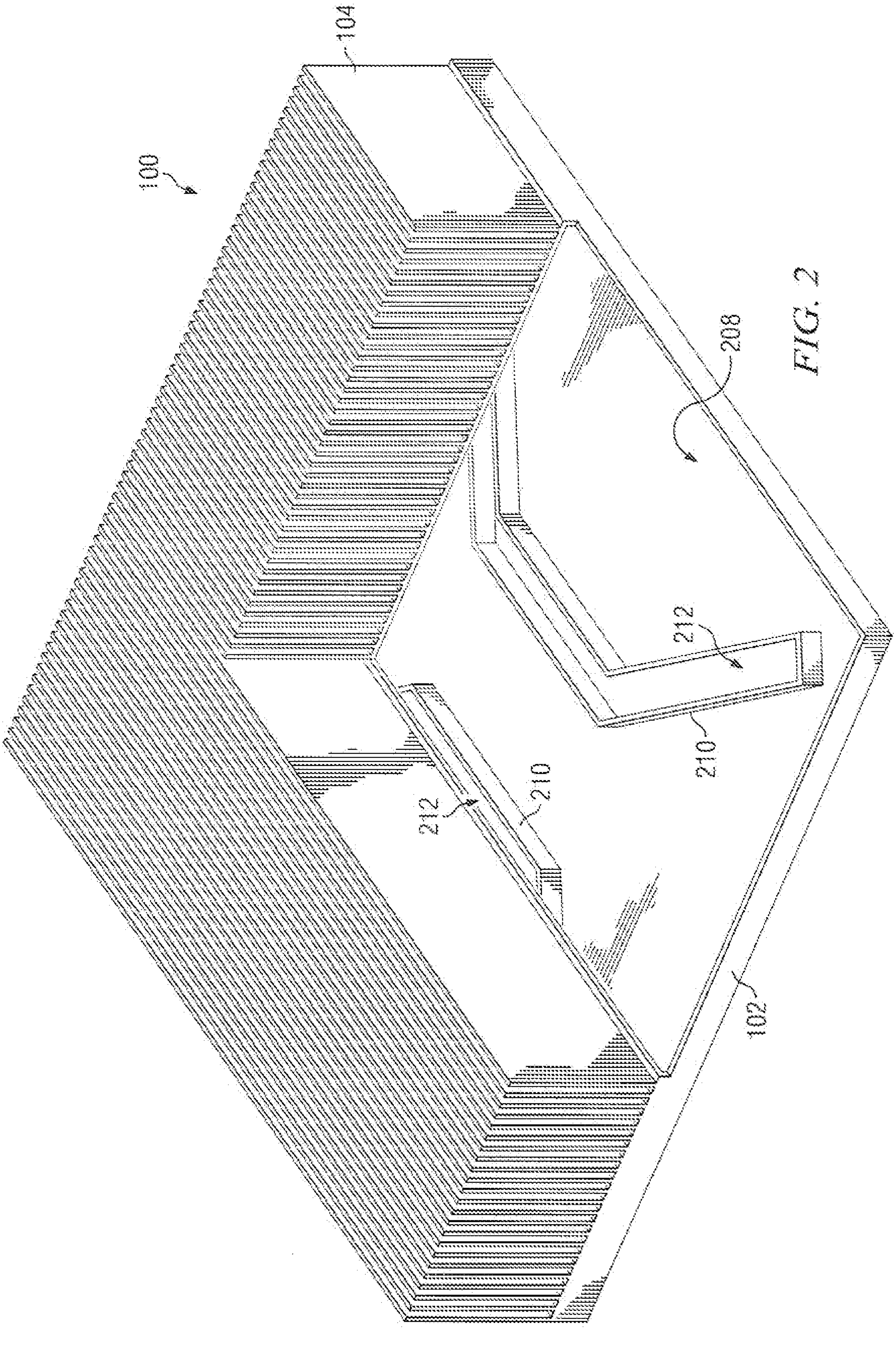

FIG. 2

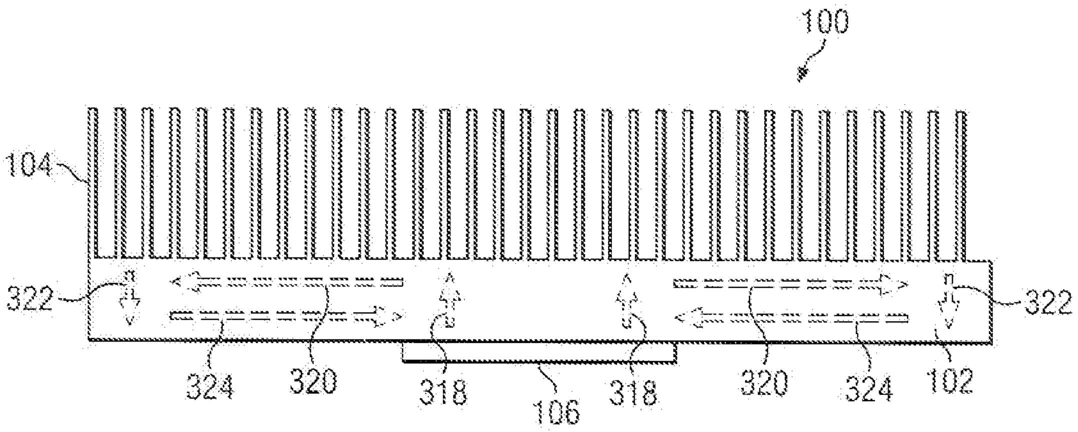
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FIG. 3b

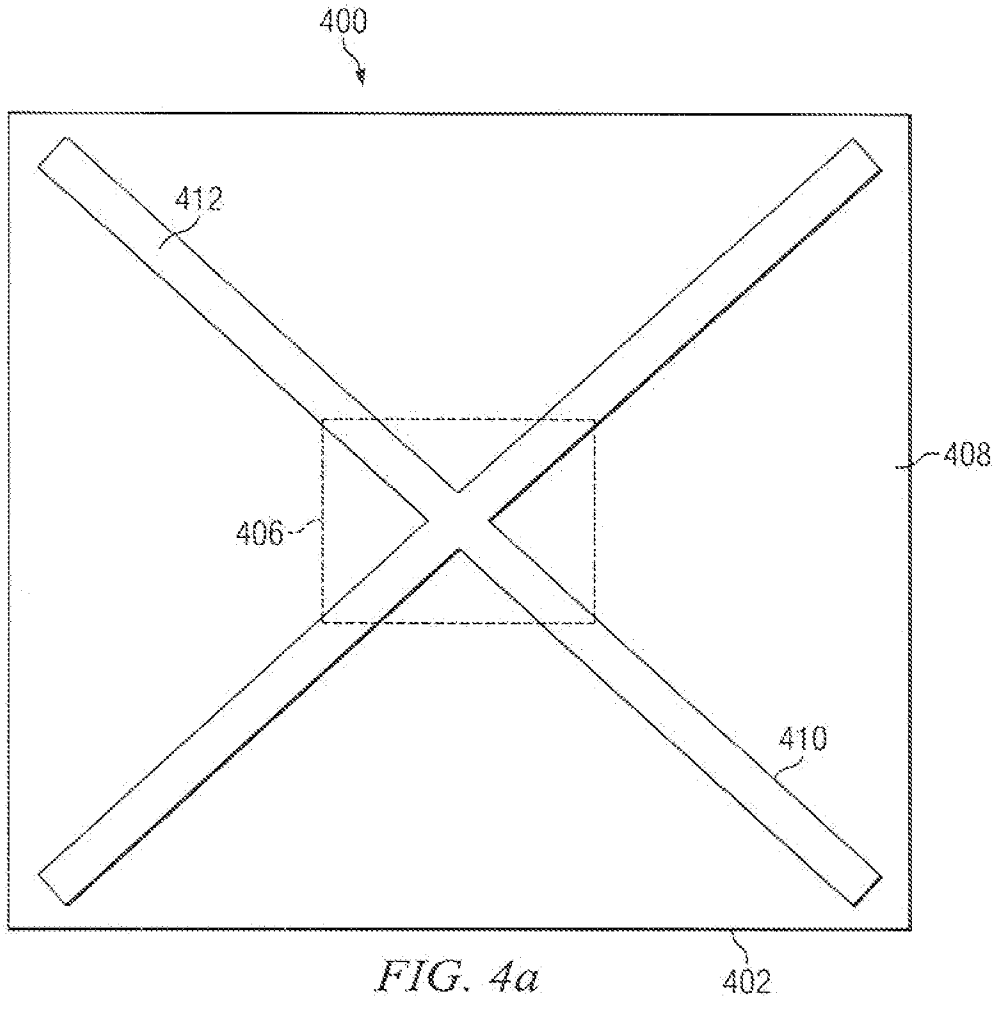
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FIG. 4a

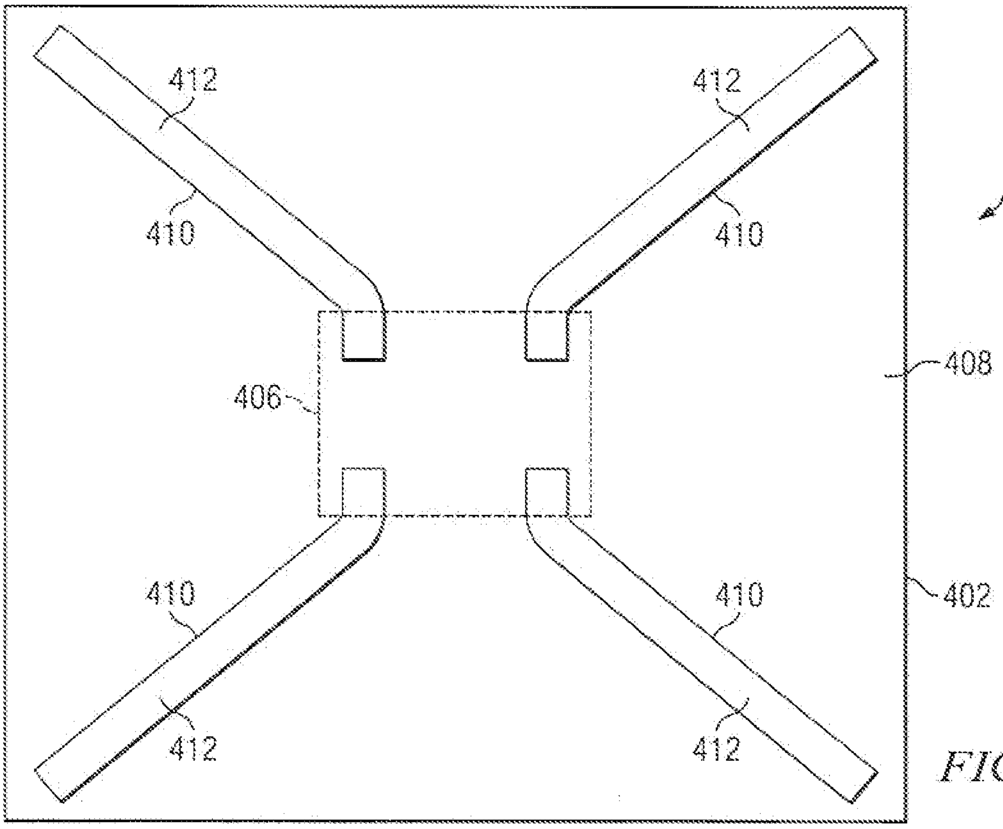
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FIG. 4b

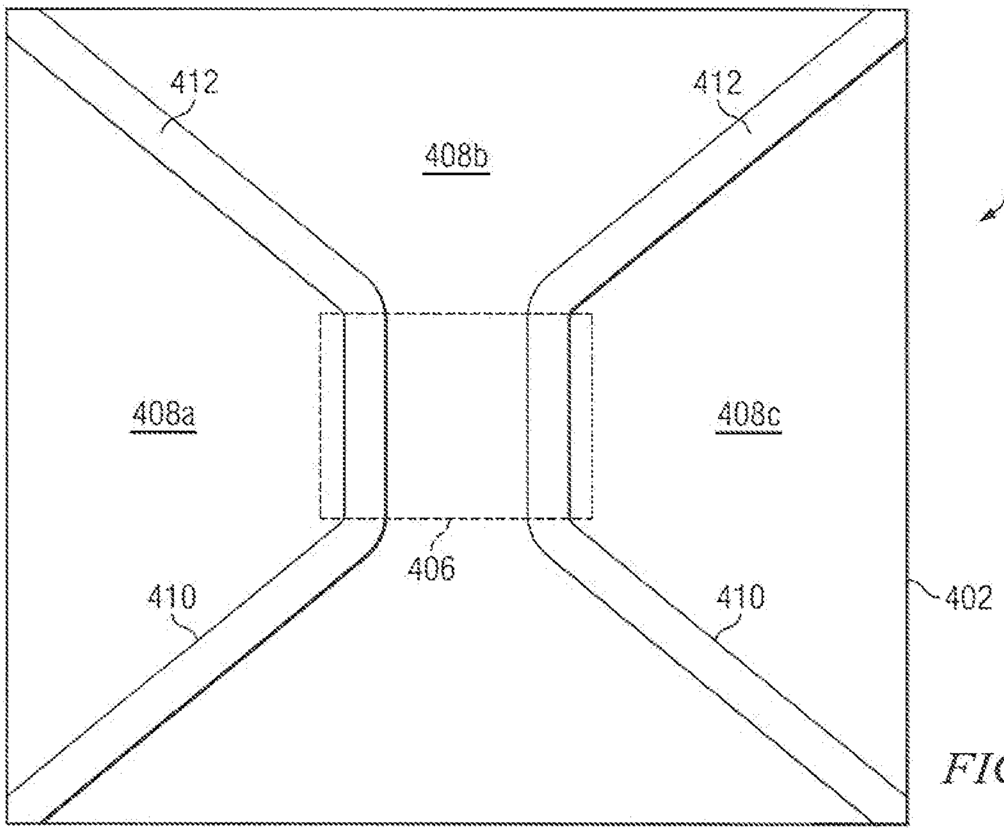
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FIG. 4c

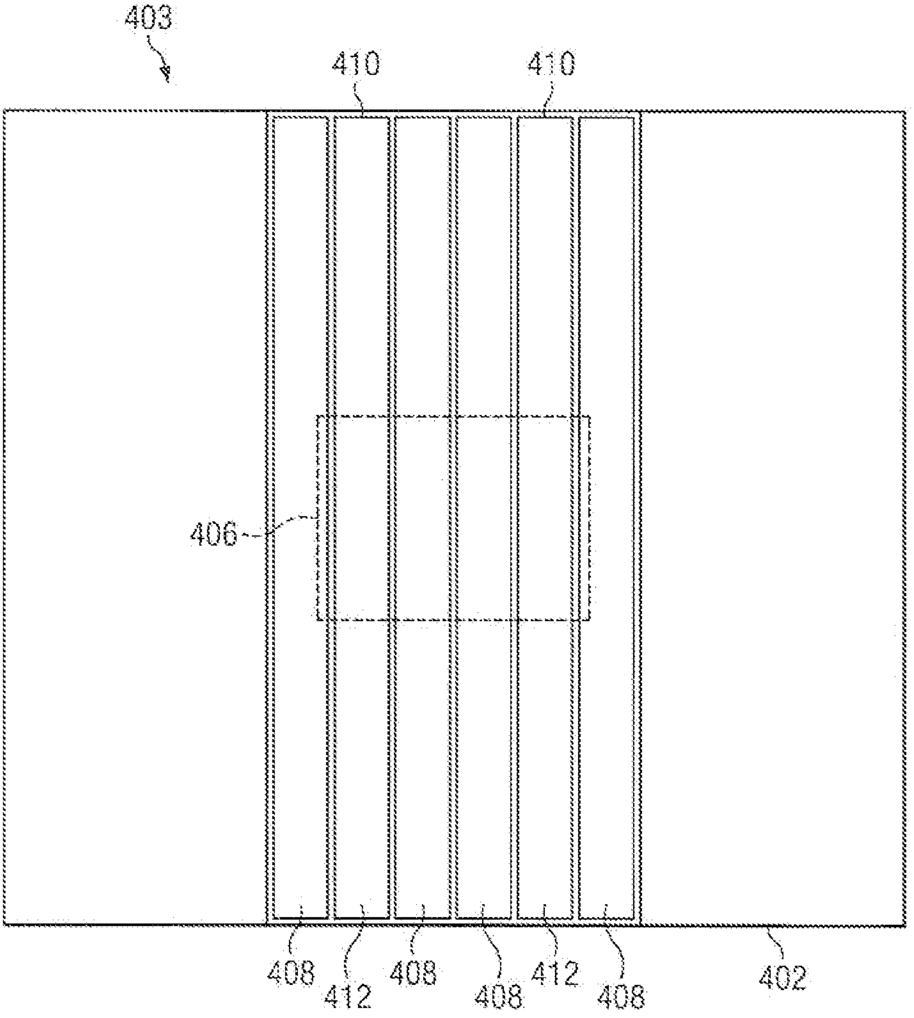
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FIG. 4d

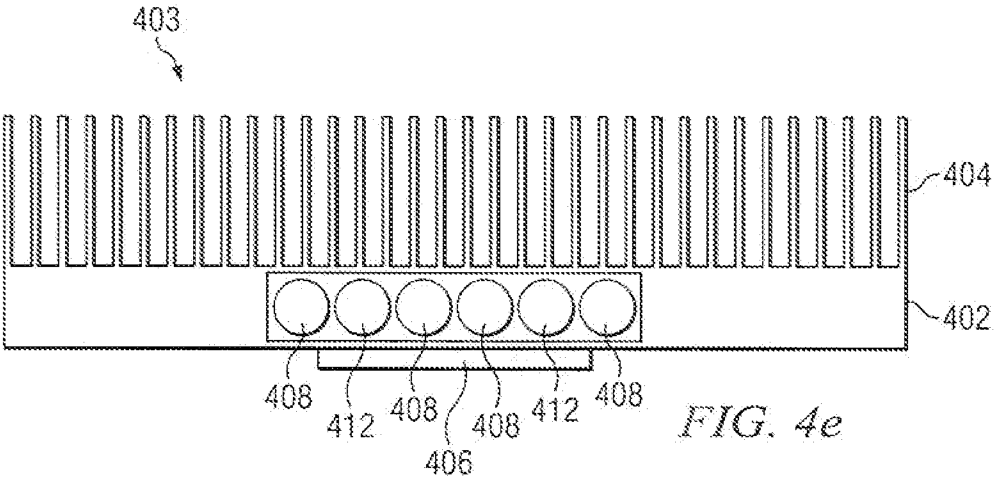
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FIG. 4e

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2010/022087

A. CLASSIFICATION OF SUBJECT MATTER

G06F 1/20(2006.01)i, H05K 7/20(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F 1/20; F28F 7/00; H05K 7/20; F28D 15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: heat sink, vapor, chamber, fluid, pipe

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20060096740 A1 (ZHENG, W. C.) 11 May 2006 See abstract, figures 9-13, and paragraphs [40]-[42].	1-15
A	US 20030121643 A1 (CONNORS, M. J.) 03 July 2003 See abstract, figures 1,4, and claims 1-17.	1-15
A	US 20050128710 A1 (BEITEIMAL, A. H. et al.) 16 June 2005 See abstract, paragraphs [14]-[20], and claims 1-37.	1-15

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search 19 OCTOBER 2010 (19.10.2010)	Date of mailing of the international search report **20 OCTOBER 2010 (20.10.2010)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer AHN, Cheol Yong Telephone No. 82-42-481-8371

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2010/022087

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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