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— *as to the identity of the inventor (Rule 4.17(i))*

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

[Continued on next page]

(54) Title: HARD DISK DRIVE CAGES WITH THERMAL PADS

(57) Abstract: In one example, a system for cooling a computing device includes a hard disk drive (HDD) cage housing an HDD, a thermally conductive pad coupled to the cage, and an HDD fan coupled to the cage. In one example, a computing device includes a housing, a hard disk drive (HDD) cage, an HDD fan coupled to the cage between the cage and the housing, and a thermal pad coupled to the cage, wherein the thermal pad is to conduct heat produced by the HDD throughout the cage. In one example, a hard disk drive (HDD) cooling system includes a hard disk drive (HDD) cage and a thermal conductive element coupled to the HDD cage to direct heat produced by an HDD into the cage.

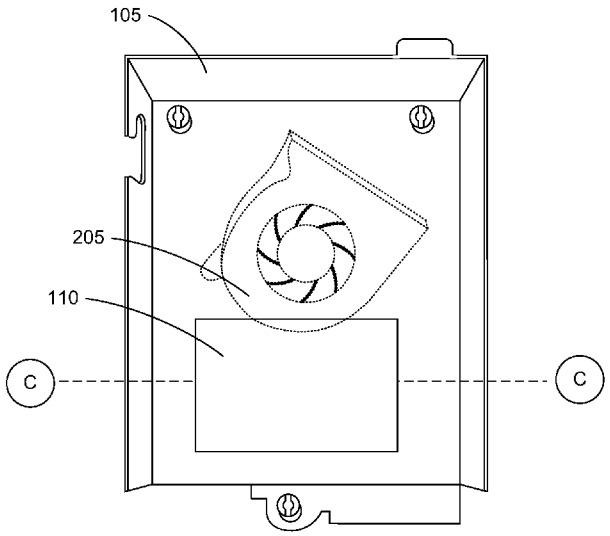

Fig. 3A

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HARD DISK DRIVE CAGES WITH THERMAL PADS

BACKGROUND

[0001] With the increased speed and power consumption associated with processors, graphic cards, random access memory (RAM), and other computer components, heat generated by these devices has increased as well. These components, in order to operate properly, are to be kept within a specified operating temperature range in order to prevent instability, malfunctioning, and damage to these components. Excess heat applied to these components in the computing device may permanently damage these devices or at least shorten their useful lifespan.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] The accompanying drawings illustrate various examples of the principles described herein and are a part of the specification. The illustrated examples are given merely for illustration, and do not limit the scope of the claims.

[0003] Fig. 1A is a top view of a hard disk drive (HDD) cage according to an example of the principles described herein.

[0004] Fig. 1B is a cross-sectional plane view of an HDD cage according to an example of the principles described herein.

[0005] Fig. 2A is a top view of an HDD cage according to an example of the principles described herein.

[0006] Fig. 2B is a cross-sectional plane view of an HDD cage according to an example of the principles described herein.

[0007] Fig. 3A is a top view of an HDD cage according to an example of the principles described herein.

[0008] Fig. 3B is a cross-sectional plane view of an HDD cage according to an example of the principles described herein.

[0009] Fig. 4 is an isomeric view of an example computing device incorporating an HDD cage according to an example of the principles described herein.

[0010] Fig. 5 is a top view of the computing device of Fig. 4 showing a housing covering the components inside according to an example of the principles described herein.

[0011] Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements.

DETAILED DESCRIPTION

[0012] As briefly mentioned above, heat has an incapacitating effect on the components within a computing device. Most of the heat within a computing device is usually created by the central processing unit (CPU) or graphics processor unit (GPU). Each of these devices consumes a relatively higher amount of energy by, for example, carrying out complicated calculations. Other devices, such as the hard disk drive (HDD) and power converters also create heat. Although HDDs don't consume as much electricity as a CPU or GPU, HDDs may be relatively more sensitive to changes in temperature. Excessive heat applied to an HDD could potentially warp any discs within the HDD causing read problems and loss of data.

[0013] Smaller computing devices operating higher wattage processors can exasperate any issues associated with heat. Where a high wattage CPU, GPU, and HDD are enclosed within a relatively smaller space than with other computing devices, heat can accumulate in stagnant air zones. Although these smaller computing devices may implement, for example, a heat sink coupled to the CPU, hot air may still accumulate around the HDD causing failure of the HDD. Where failure does not actually occur in the HDD, internal

temperature sensors within the computing device may detect that a threshold temperature has been reached and shut down the HDD or the entire computing device in order to prevent any damage. Either way, user satisfaction in connection with the interaction with the computer device may be diminished.

[0014] The present specification describes a system to reduce the likelihood of overheating of an HDD. A computing device may include an HDD cage surrounding an HDD and securing the HDD to a housing of the computing device. In one example, a thermal pad may be coupled to the HDD cage. The thermal pad may direct heat away from the HDD and into the HDD cage causing the HDD cage to dissipate the heat over a relatively larger surface area. In an example, a fan may be coupled to the HDD cage to direct heat dissipated throughout the HDD cage away from the HDD. In an example, a number of vents may be defined in the housing of the computing device through which an airflow of hot air produced by the fan may be expelled from the computing device. In an example, the thermal pad and fan may be coupled to the HDD cage providing a way that the heat around the HDD may be dissipated through the HDD cage and expelled away from the HDD via the fan.

[0015] In an example, systems for cooling a computing device may include a hard disk drive (HDD) cage housing an HDD, a thermally conductive pad coupled to the cage, and an HDD fan coupled to the cage.

[0016] In an example, computing devices may include a housing, a hard disk drive (HDD) cage, an HDD fan coupled to the cage between the cage and the housing; and a thermal pad coupled to the cage, wherein the thermal pad is to conduct heat produced by the HDD throughout the cage.

[0017] In an example, a hard disk drive (HDD) cooling systems may include a hard disk drive (HDD) cage and a thermal conductive element coupled to the HDD cage to direct heat produced by an HDD into the cage.

[0018] As used in the present specification and in the appended claims, the term “thermal conductive element” is meant to be understood as a passive heat exchanger that cools a device by dissipating heat into the surrounding medium. In one example, the heat sink is a thermally conductive

pad or thermal pad. A thermal pad may be a preformed piece of solid material that conducts heat such as silicone.

[0019] Additionally as used in the present specification and in the appended claims, the term "a number of" or similar language is meant to be understood broadly as any positive number comprising 1 to infinity.

[0020] In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present systems and methods. It will be apparent, however, to one skilled in the art that the present apparatus, systems and methods may be practiced without these specific details. Reference in the specification to "an example" or similar language means that a particular feature, structure, or characteristic described in connection with that example is included as described, but may not be included in other examples.

[0021] Figs. 1A and 1B are diagrams of an HDD cage (105) according to an example of the principles described herein. Fig. 1A is a top view of the HDD cage (105) while Fig. 1B is a cross-sectional plane view of the HDD cage (105). The HDD cage (105) may include a number of bolts or other securing devices used to both secure the HDD cage (105) to a housing of a computing device as well as secure the HDD to the interior of the HDD cage (105) itself. In one example, the HDD cage (105) may be secured to a bottom chassis of a computing device housing thereby providing support to the HDD cage (105) and HDD secured within the HDD cage (105).

[0022] The HDD cage (105) may be made of any type of material capable of conducting heat and dissipating that heat throughout the HDD cage (105). In one example, the HDD cage (105) is made of an aluminum alloy. In another example, the HDD cage (105) may be made of aluminum alloy 1050A, 6061, 6063 or other similar alloys. In an example, the HDD cage (105) may be made of copper. In an example, the HDD cage (105) may be made of a ceramic material.

[0023] In one example, the HDD cage (105) may be formed to encompass the entire HDD. In this example, the HDD cage (105) may include a top surface, a bottom surface, a front surface, a back surface, and two side

surfaces. This may allow the HDD to be kept cool from other heat sources within the computing device while still having heat conducted away from the HDD via, for example, the HDD cage (105). In another example, a number of surfaces described above may be eliminated. In one example, the top surface may not be formed in order to allow for rising heat to be expelled away from the HDD. As will be described below in more detail, the housing for the computing device may be provided comprising a number of vents or holes defined therein through which this rising heat may escape from the computing device.

[0024] The HDD cage (105) may further include a heat sink such as a thermal pad (110) coupled to the interior surface of the HDD cage (105). Fig. 1B shows a cross section view of the HDD cage (105) and thermal pad (110) cut along line "A" as indicated in Fig. 1A. The thermal pad (110) may be made of any thermally conductive material. In one example the thermal pad (110) may be coupled to the bottom surface of the HDD cage (105) at any location on the bottom surface. In an example, thermal pad (110) may be coupled to a portion of the bottom surface of the HDD cage (105) directly below where the hottest portion of the HDD will be located when inserted into the HDD cage (105).

[0025] The thermal pad (110) may be of any thickness. In one example, the thickness of the thermal pad (110) may be sufficient to touch the HDD when the HDD is placed in and secured to the HDD cage (105). In another example, the thickness of the thermal pad (110) may be such that the thermal pad (110) may be compacted when the HDD is inserted and coupled to the HDD cage (105).

[0026] During operation of the computing device and more specifically during operation of the HDD inserted into the HDD cage (105), the heat produced by the HDD will be conducted, via the thermal pad (110), into the heat conductive material forming the HDD cage (105). The heat will be dissipated via the HDD cage (105) due to the increased surface area and the materials making the HDD cage (105). This dissipation of heat will prevent the components within the HDD from being subjected to extreme heats thereby preventing, for example, warping of the disks within the HDD.

[0027] Figs. 2A and 2B are diagrams of an HDD cage (105) according to an example of the principles described herein. Fig. 2A is a top view of the HDD cage (105) while Fig. 1B is a cross-sectional plane view of the HDD cage (105); Fig. 2B showing a cross section view of the HDD cage (105) and an HDD fan (205) cut along line "B" as indicated in Fig. 2A. Similar to Figs. 1A and 1B respectively, Figs. 2A and 2B both include an HDD cage (105) that is meant to secure an HDD within a computing device. In addition to the HDD cage (105) Figs. 2A and 2B show an HDD fan (205) coupled to the HDD cage (105).

[0028] In one example, the HDD fan (205) may be coupled to the underside of the bottom surface of the HDD cage (105). In this example, the heat dissipated by the HDD cage (105) may be brought into the intake (210) portion of the HDD fan (205) and expelled out the exhaust (215). Because the HDD fan (205) is coupled to the underside of the bottom surface of the HDD cage (105), the heat from the HDD distributed throughout the HDD cage (105) may be more easily removed than if the HDD fan (205) was inside the HDD cage (105) with the HDD. Additionally, any stagnant heated air located at or around the HDD cage (105) and the HDD may be blown out and away from the HDD either directly via the intake (210) of the HDD fan (205) or via fluidic movement of the air.

[0029] In an example, the HDD fan (205) may be placed directly below the HDD via an HDD fan (205) void defined in the HDD cage (105). Placement of the HDD fan (205) void may be determined by placement of other features such as a thermal pad (110). In this example, the placement of HDD fan (205) void and the HDD fan (205) may be dictated by where on the bottom surface of the HDD cage (105) a thermal pad (110) is to be place. Any location on the bottom surface of the HDD cage (105) where the thermal pad (110) is not to be coupled, the HDD fan (205) void may be defined. Similar to the examples shown in Figs. 2A and 2B, the HDD fan (205) may remove heat dissipated into the HDD cage (105). The HDD fan (205) placed in the described HDD fan (205) void may also remove heated air directly around the HDD.

[0030] The HDD fan (205) may be positioned such that the exhaust (215) drives the heated air away from the HDD at a specific angle relative to a front face (220) of the HDD cage (105). In one example, the angle as indicated by the 2 in Fig. 2A may be 45 degrees. In this example, the exhaust (215) of the HDD fan (205) may direct any hot air towards a rear portion of the computing device and potentially towards a fan duct associated with a CPU and CPU fan used within the computing device. As will be discussed below, this may allow the airflow produced from the HDD fan (205) exhaust (215) to supplement the airflow produced from a CPU fan as well as move stagnant air out of the computing device and away from other devices within the computing device.

[0031] Figs. 3A and 3B are diagrams of an HDD cage (105) according to an example of the principles described herein. Fig. 3A is a top view of the HDD cage (105) while Fig. 3B is a cross-sectional plane view of the HDD cage (105); Fig. 3B showing a cross section view of the HDD cage (105), thermal pad (110), and HDD fan (205) cut along line "C" as indicated in Fig. 3A. Similar to Figs. 1A, 1B respectively and also 2A, and 2B respectively, Figs. 3A and 3B both include an HDD cage (105) that is meant to secure an HDD within a computing device. In the example shown in Figs. 3A and 3B, however, a thermal pad (110) and HDD fan (205) are used to dissipate heat from the HDD and transport heated air away from the HDD respectively.

[0032] Although Figs. 3A and 3B show a layout of the thermal pad (110) and HDD fan (205) relative to the HDD cage (105), many examples exist and the present specification contemplates the use of the HDD fan (205), thermal pad (110), and HDD cage (105) in any number of configurations. In one example, any number of HDD fan (205) voids may be defined in the HDD cage (105) such that the HDD fan (205) can remove heat directly away from the HDD as well as the HDD cage (105) dissipating the heat. Additionally, any number of thermal pads (110) may be coupled to the bottom interior surface of the HDD cage (105) to help dissipate the heat from the HDD into the HDD cage (105).

[0033] Fig. 4 is an isomeric view of an example computing device (400) incorporating an HDD cage (105) according to an example of the principles described herein. The computing device (400) may be any type of electronic device such as, a desktop computer, a laptop computer, mobile devices, gaming systems, and tablets, among other electronic devices. The computing device (400) may include an HDD (405), an HDD cage (105), a CPU fan (410), a CPU (415), and a fan duct (420). The computing device (400) of Fig. 4 does not show the HDD fan (205) or thermal pad (110) as described in Figs. 1A-3B. The thermal pad (110) and HDD fan (205) are covered by the HDD (405) and HDD cage (105).

[0034] Like the HDD fan (205), the CPU fan (410) may produce a flow of air over the CPU (415) in order to cool down the CPU. The CPU (415) may produce heat during operation and the CPU fan (410) as well as a number of heat sinks may be used to cool off the CPU (415). As the air from the CPU fan (410) is pushed over the CPU (415) and heat sinks, the air may be pushed out of the computing device (400) via a fan duct (420) located towards the back of the computing device (400). Although the fan duct (420) may be used by the CPU fan (410) as an exit to discharge hot air from the computing device (400), the fan duct (420) may also be an exit through which hot air from the HDD fan (205) may be pushed out from the computing device (400). Consequently, the HDD fan (205) and CPU fan (410) may work together to form a continuous flow of air into and out of the computing device (400). Each air flow from the HDD fan (205) and CPU fan (410) may supplement each other such that airflow out of the computing device (400) is increased.

[0035] The airflows associated with each of the HDD fan (205) and CPU fans (410) are shown in dashed arrows in Fig. 4. The airflow associated with the HDD fan (205) may intake air from around the HDD as well as from outside the computing device (400) and expel hot air out the back end of the computing device (400) and towards the fan duct (420) as described above. The airflow associated with the CPU fan (410) may intake air from outside the computing device (400) through a number of vents defined in a top housing of the computing device (400). The air may enter the CPU fan (410) and flow

across the CPU (415) and out through the fan duct (420) as also indicated by the dashed arrows.

[0036] In one example, the computing device (400) may include a high powered CPU (415) and may be enclosed in a housing that is relatively small to accommodate the heat of the CPU (415). For example, the CPU fan (410) may be a 65 Watt CPU and the housing of the computing device (400) may include 1 liter of space or less. With these characteristics, the heat produced by the CPU (415), the HDD (405), a graphics processor unit, a power converter, and other devices in the computing device (400) may be relatively higher than with a computing device (400) developed to include additional space to accommodate for the additional heat produced. The CPU fan (410) may help with the excessive heat, but eventually the computing device (400) may overheat and fail or shutdown. The excessive heat may accumulate at or around the HDD (405) causing additional failures in the HDD. The thermal pad (Figs. 1A, 1B, 3A, and 3B; 110) (not shown in Fig. 4) coupled to the HDD cage (105) helps to distribute any heat experienced by the HDD (405) and the HDD fan (205) may be used to evacuate the heated air from under the HDD (405) and within any unoccupied space within the computing device (400). By implementing the HDD fan (205), the computing device (400) is capable of operating within or under a predetermined temperature. By coupling the thermal pad (110) to the HDD cage (105), heat experienced by the HDD (405) may be absorbed into and distributed throughout the HDD cage (105).

[0037] In one example, any number of temperature sensors may be used to help direct the CPU fan (410) and HDD fan (205) individually to be activated. Where a temperature increase is sensed by the temperature sensor associated with the CPU (415), the CPU fan (410) may engage. In this example, the CPU (415) may direct the HDD fan (205) to engage as well when a temperature increase around the CPU (415) is sensed. This may be done to proactively prevent any accumulation of heat at or around the HDD (405) or other components of the computing device (400) as well as help cool the CPU (415). The same may occur where a temperature sensor associated with the HDD (405) senses an increase in temperature. When the HDD fan (205) is

activated, the CPU (415) may direct the CPU fan (410) to engage as well in anticipation of an increase in temperature associated with the CPU and generally within the computing device (400). Consequently, each of the fans (410, 205) can cooperate to cool the devices within the computing device (400) by causing two different and supplemental airflows to flow through the computing device (400).

[0038] Fig. 5 is a top view of the computing device (400) of Fig. 4 showing a housing (505) covering the components inside according to an example of the principles described herein. As briefly describe above, the housing (505) may have a number of vents (510-1, 510-2) defined therein to allow the airflows as described in connection with Fig. 4.

[0039] A first set of vents (510-1) may allow hot air from both the HDD fan (205) and CPU fan (410) to exhaust therethrough in addition to the fan duct (420) associated with the CPU (415) and CPU fan (410). Hot air may tend to rise and these vents provide an additional airflow path by which the hot air in the computing device (400) may be expelled. As second set of vents (510-2) may also expel hot air from the device that is not accumulated by either the HDD fan (205) or CPU fan (410). Additionally, the second set of vents (510-2) may be a source of relatively cooler air from which the CPU fan (410) may draw into the computing device (400). In one example, other vents along a back portion of the computing device (400) may be defined therein to allow the hot air to be pushed out from within the computing device (400).

[0040] The specification and figures describe cooling a computing device using a thermal pad coupled to an HDD cage and an HDD fan coupled to the HDD cage. During testing it was found that use of a HDD cage and thermal pad drastically reduced temperatures within a computing device operating an HDD, a 65 Watt CPU with the internal area of the computing device defined by the computing device's housing of 1 liter or less. The inclusion of the HDD fan as described herein also provided additional airflow of hot air around the HDD, across a number of other densely packed heat producing devices in the computing device and out a number of vents provided in the housing.

[0041] In such a compact computing device, it would not be possible to include a heat sink over the HDD. Instead, the inclusion of a heat sink over the HDD would add additional bulk to the computing device as well as reduce any free space within the housing. There is also a potential that heat would begin to accumulate among the devices of such a densely packed computing device. The thermal pad coupled to the cage provides for a method heat exchange that sufficiently protects the HDD from damage such as warping of the disks.

[0042] The preceding description has been presented to illustrate and describe examples of the principles described. This description is not intended to be exhaustive or to limit these principles to any precise form disclosed. Many modifications and variations are possible in light of the above teaching.

CLAIMS

WHAT IS CLAIMED IS:

1. A system for cooling a computing device, comprising:
a hard disk drive (HDD) cage housing an HDD;
a thermally conductive pad coupled to the cage; and
an HDD fan coupled to the cage.

2. The system of claim 1, wherein the HDD fan is to create a second airflow within the computing device that supplements a first airflow produced by a central processing unit fan associated with a central processing unit within the computing device.

3. The system of claim 2, wherein the HDD fan is placed under the HDD cage and above a chassis of the computing device and blows heat dissipated into the cage via the thermally conductive pad away from the HDD.

4. The system of claim 2, wherein the second airflow is to supplement the first airflow by preventing stagnation of airflow around the HDD produced by the second airflow.

5. The system of claim 4, wherein the computing device further comprises a number of vents defined in an outer housing of the computer device such that the first and second airflows discharge heat therefrom.

6. The system of claim 5, wherein the outer housing of the computing device has a volumetric area of 1 liter or less.

7. The system of claim 5, wherein the computing device further comprises a processor having a thermal design power (TDP) of at least 65 Watts.

8. A computing device, comprising:

a housing;

a hard disk drive (HDD) cage;

an HDD fan coupled to the cage between the cage and the housing; and

a thermal pad coupled to the cage, wherein the thermal pad is to conduct heat produced by the HDD throughout the cage.

9. The computing device of claim 8, wherein the housing comprises a number of vents defined therein.

10. The computing device of claim 8, wherein the HDD fan is positioned relative to the cage such that a first airflow created by the HDD fan is to drive heat away from the HDD at a specific angle relative to the cage and such that the first airflow is to supplement a second airflow produced by a central processing unit fan associated with a CPU within the computing device.

11. The computing device of claim 8, wherein the CPU has a thermal design power (TDP) of at least 65 Watts.

12. The computing device of claim 8, wherein the housing has a volumetric area of 1 liter or less.

13. A hard disk drive (HDD) cooling system, comprising:

an HDD cage; and

a thermal conductive element coupled to the HDD cage to direct heat produced by an HDD into the cage.

14. The HDD cooling system of claim 13, wherein the HDD cage is coupled to an interior surface of a housing of a computing device and wherein the housing comprises a number of vents defined therein wherein heat from the HDD is dissipated through the cage and out of the vents.

15. The HDD cooling system of claim 13, wherein the thermal conductive element is a thermal pad coupled to the HDD cage between the HDD cage and the HDD.

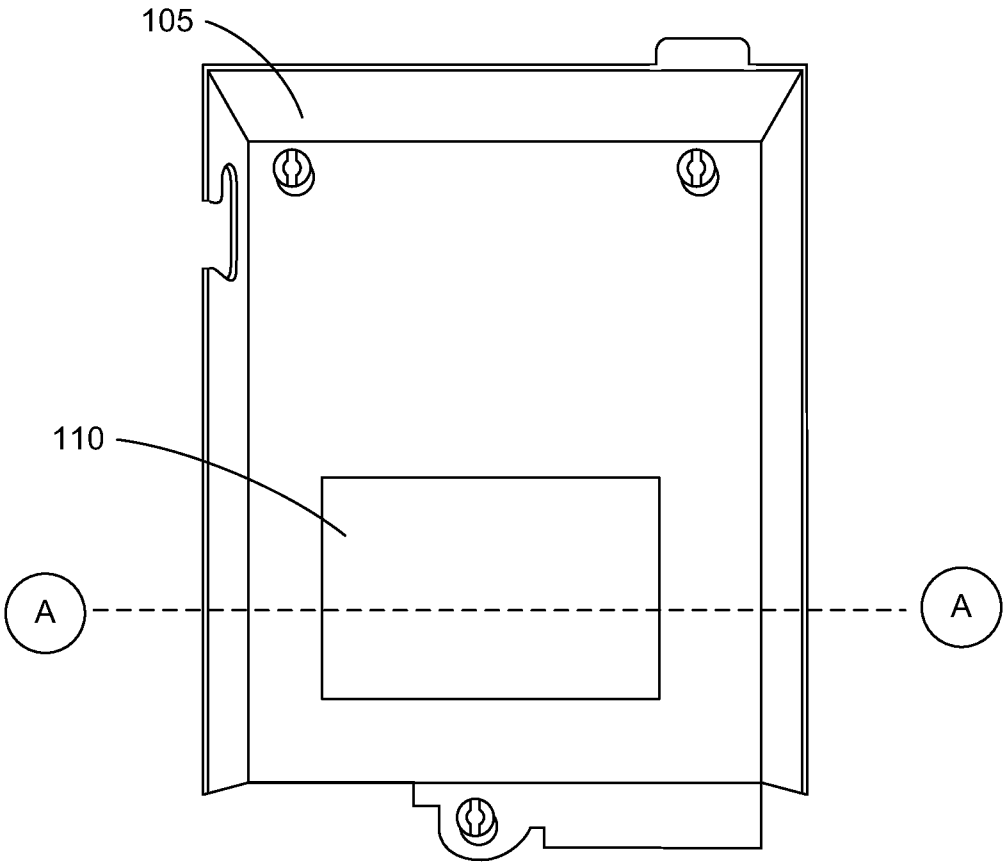

Fig. 1A

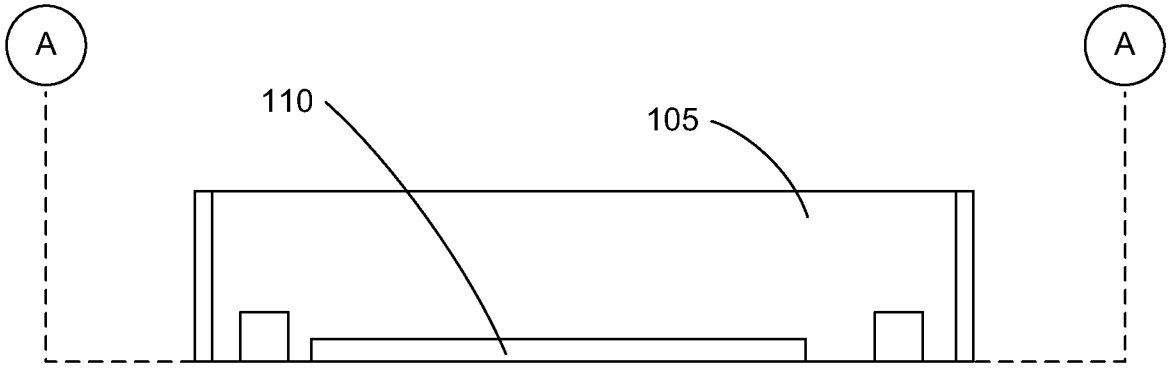

Fig. 1B

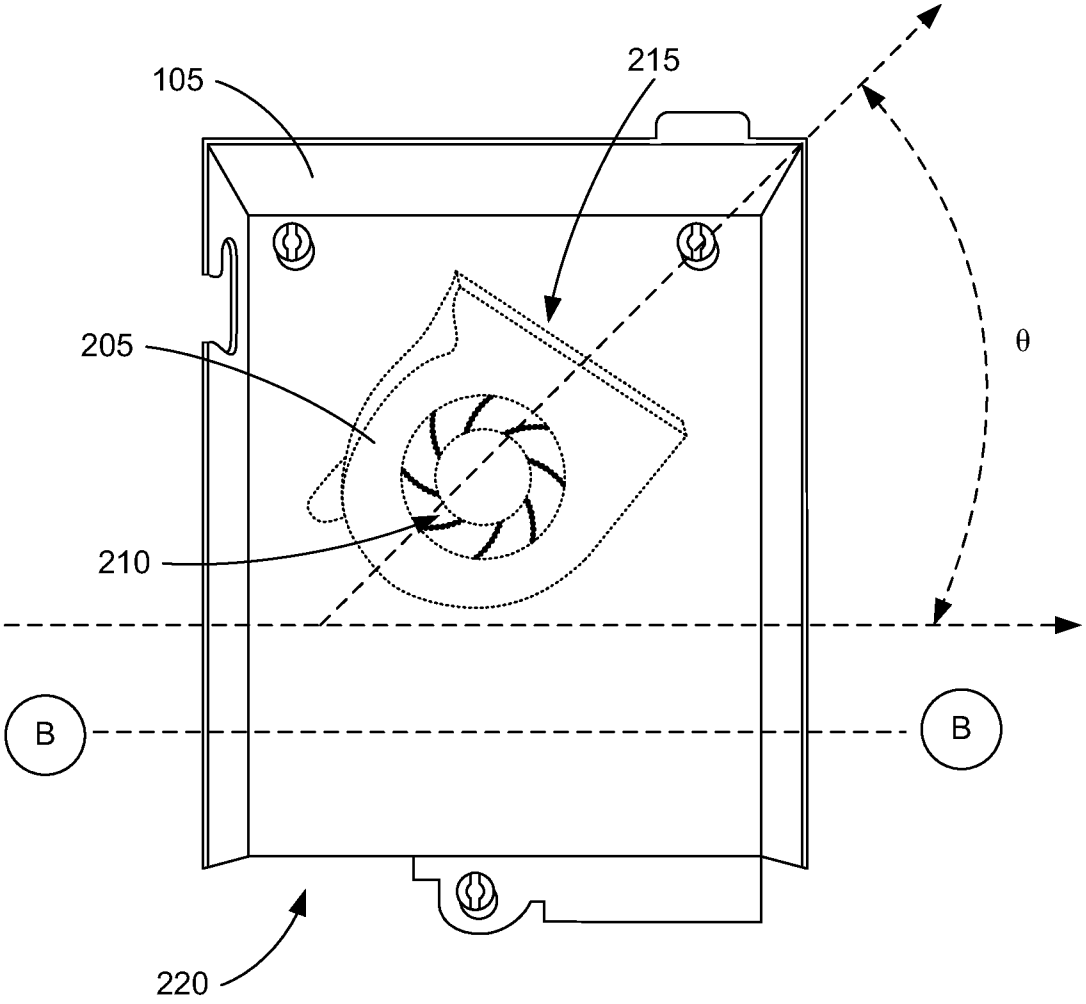

Fig. 2A

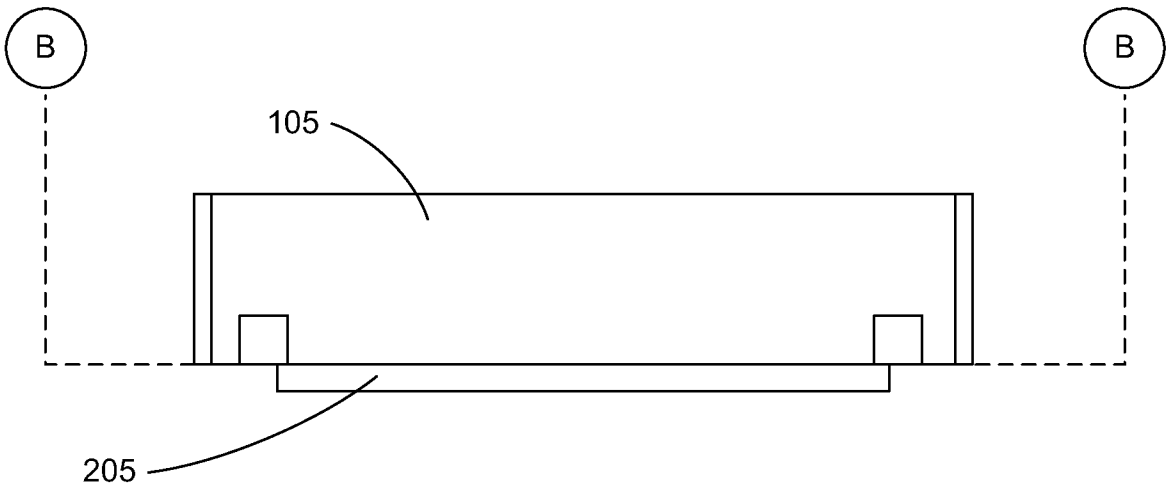

Fig. 2B

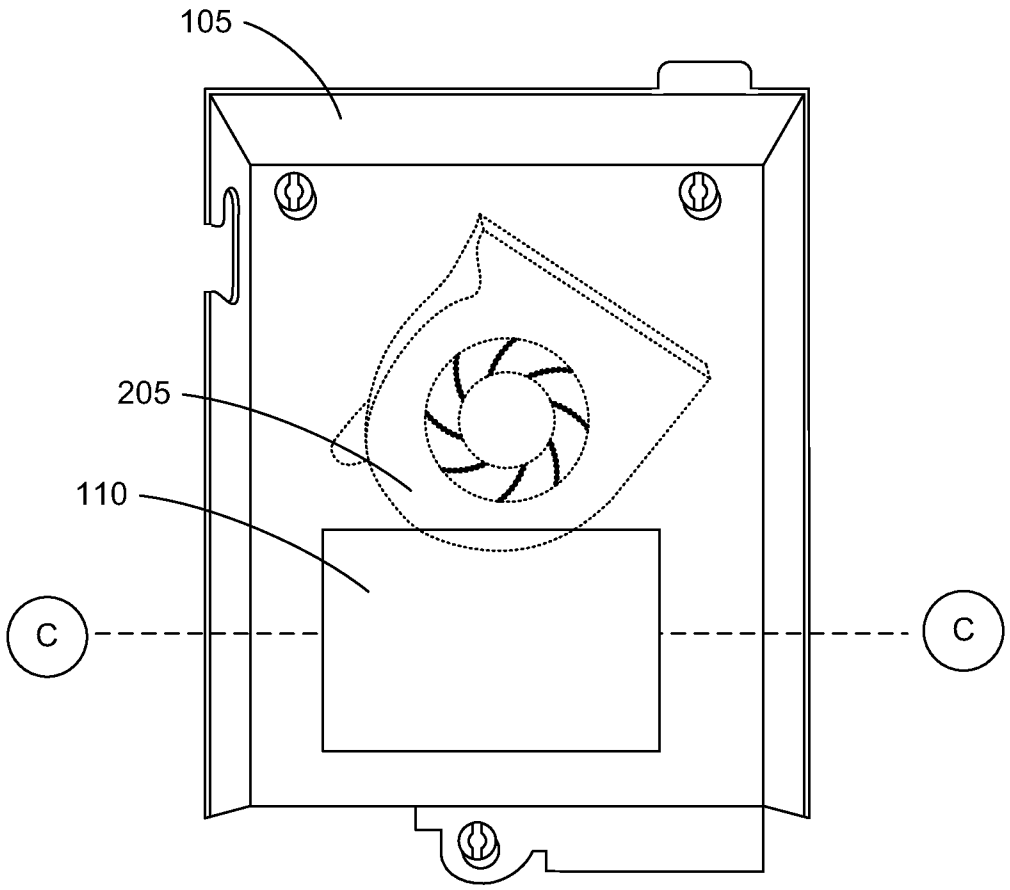

Fig. 3A

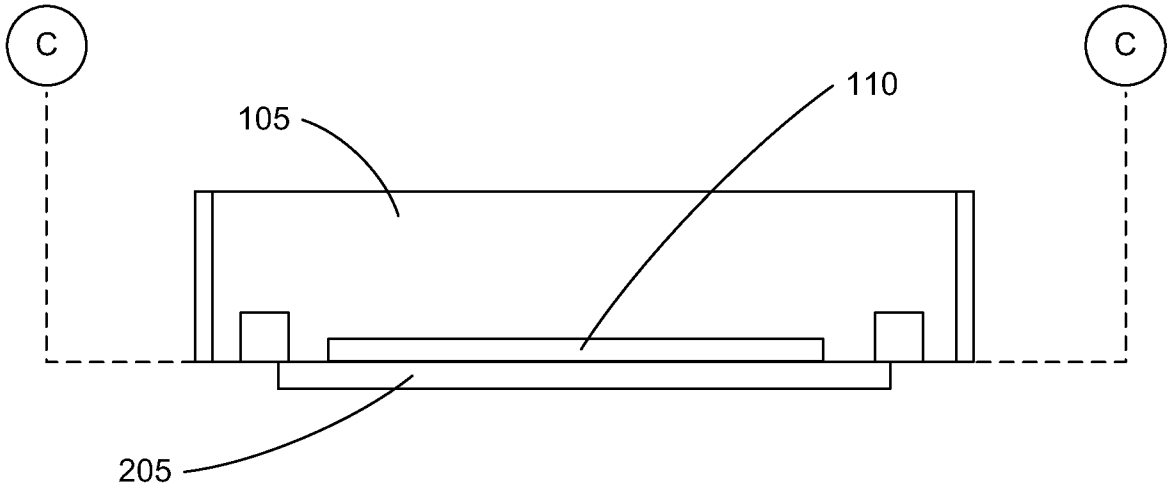

Fig. 3B

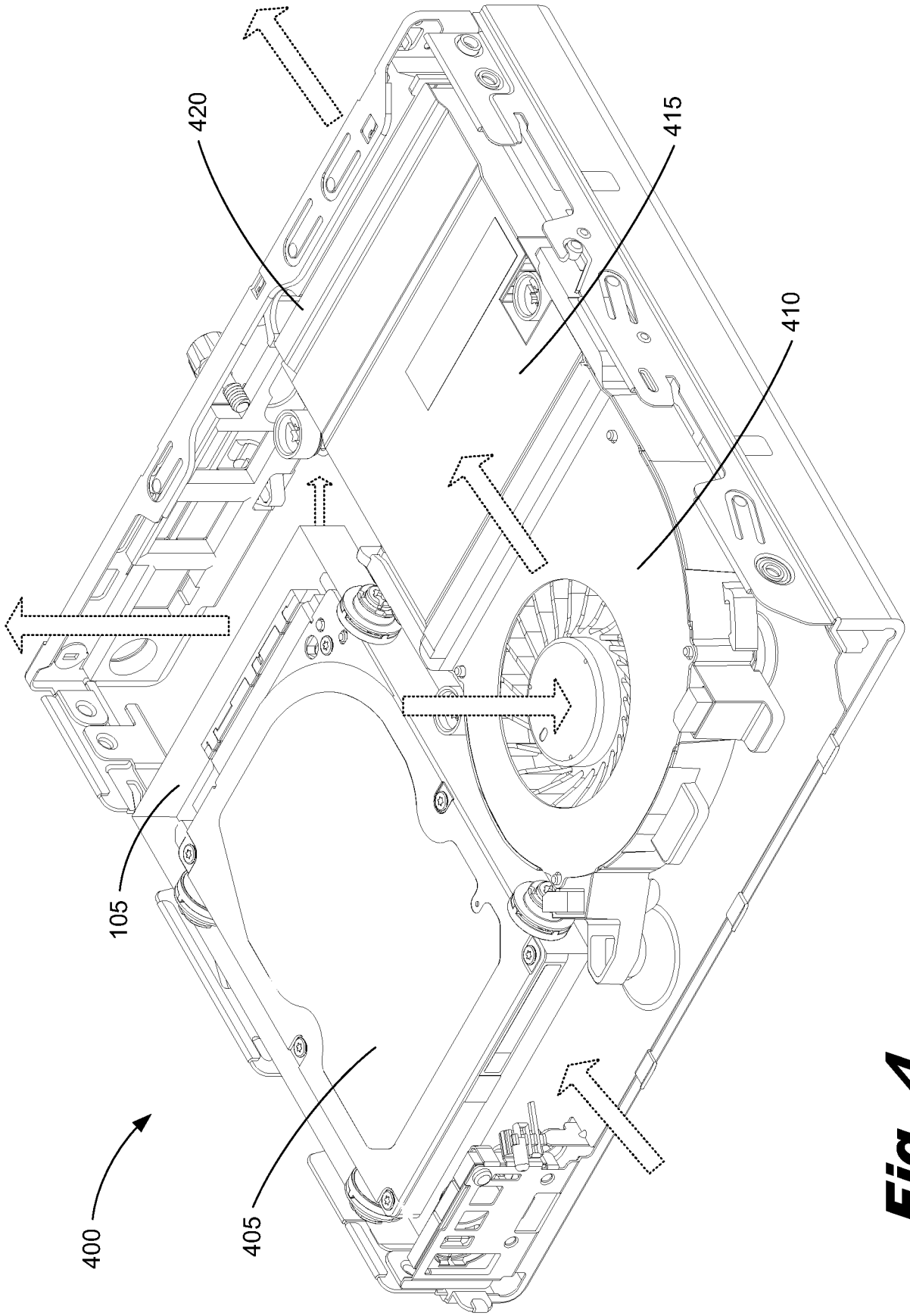

Fig. 4

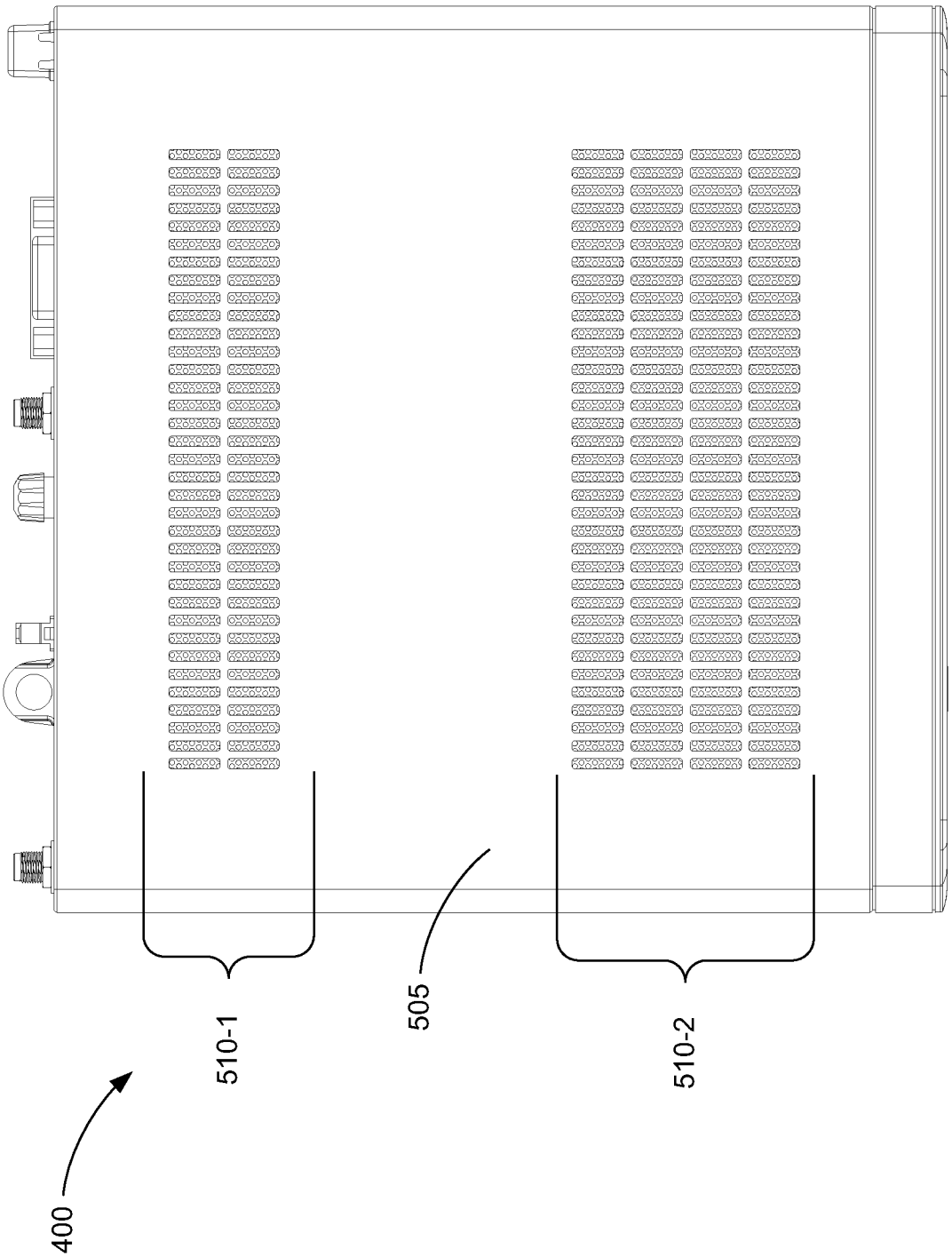

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/039938

A. CLASSIFICATION OF SUBJECT MATTER

G11B 33/14(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)
G11B 33/14; H05K 7/20; G06F 1/20; H01R 12/00

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: Hard Disk Drive (HDD), cooling, thermally conductive pad, HDD fan, airflow, cage, Thermal Design Power (TDP), computing device, and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2010-0309623 A1 (MEI-YIN YEH et al.) 09 December 2010 See paragraphs [0023]-[0028]; claim 1; and figures 2A-2B.	1-15
Y	US 2012-0002363 A1 (IKKI TATSUKAMI et al.) 05 January 2012 See paragraphs [0080]-[0103], [0133], [0152]; claim 1; and figures 5, 10-21, 37, 45.	1-15
A	US 6377455 B1 (JACOB NELIK) 23 April 2002 See column 4, line 28 - column 5, line 27; claim 9; and figures 3-5.	1-15
A	US 2010-0309624 A1 (MEI-YIN YEH et al.) 09 December 2010 See paragraphs [0021]-[0031]; claim 1; and figures 2A-2B.	1-15
A	US 2005-0277308 A1 (KEITH KIRBY et al.) 15 December 2005 See paragraphs [0039]-[0051]; claim 1; and figures 1a-1c.	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 March 2016 (29.03.2016)	**14 April 2016 (14.04.2016)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2015/039938

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