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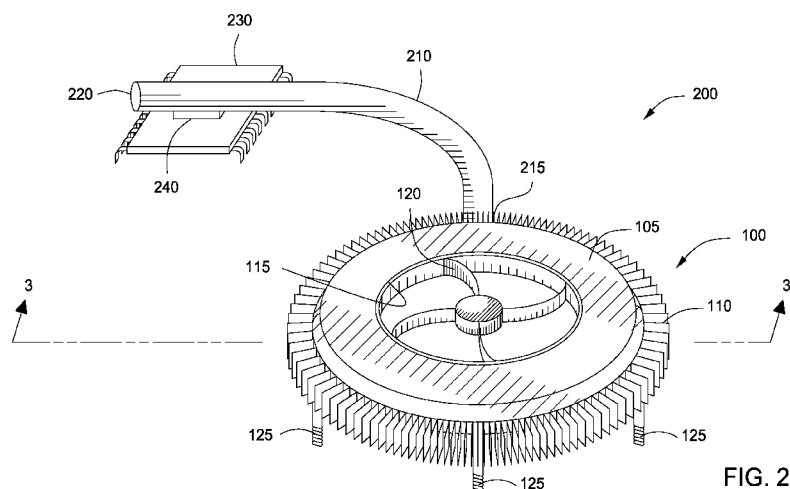
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(57) **Abstract:** A system for cooling a heat producing device is provided. The system can have a first, closed-loop, vapor chamber (105) forming an aperture (115). At least one heat-producing device can be thermally connected to the first vapor chamber (105). An air mover (120) can be at least partially disposed within the aperture (115) such that at least a portion of the discharge airflow 370, 380 passes over at least a portion of the first vapor chamber (105).

CLOSED-LOOP VAPOR CHAMBER

BACKGROUND OF THE INVENTION

Description of the Related Art

[0001] Heat dissipation in portable electronic devices is problematic at best due to the small footprint, limited space, and lack of power typically associated with such devices. A fan is often disposed within the electronic device to assist in the dissipation of heat generated by the electronic components disposed therein. The use of a fan for cooling has practical limitations however, as the airflow through the confines of the enclosure housing the electronic device is frequently limited and may bypass the actual heat generating components. Solutions involving various means for heat transfer within the enclosure are often unsatisfactory or provide only marginal performance enhancements over the use of a fan alone.

SUMMARY OF THE INVENTION

[0002] A system for cooling a heat producing device is provided. The system can have a first vapor chamber. The first vapor chamber can be a closed-loop vapor chamber, forming an aperture therein. At least one heat producing device can be thermally connected to the first vapor chamber. An air mover can be at least partially disposed within the aperture such that at least a portion of the discharge airflow passes over at least a portion of the first vapor chamber.

[0003] A method for cooling a heat producing device is also provided. An air mover adapted to at least partially discharge airflow radially outward can be at least partially disposed within an aperture formed by a closed-loop first vapor chamber. The first vapor chamber can form at least a portion of the air mover

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housing. A heat producing device can be thermally connected to the first vapor chamber. At least a portion of the heat introduced to the first vapor chamber can be removed by directing at least a portion of the air mover discharge airflow over at least a portion of the first vapor chamber.

[0004] Another system for cooling a heat producing device is also provided. The system can have a first vapor chamber comprising a sealed, hollow member forming a closed-loop about an aperture. At least one heat transfer enhancement device selected from the group of devices consisting of: one or more fins and one or more flutes can be disposed about the exterior surface of the first vapor chamber. At least one end of a second vapor chamber, having a first end and a second end can be fluidly connected to the first vapor chamber. At least one heat producing device can be thermally connected to the second vapor chamber. A plurality of support devices can be disposed about the first vapor chamber. An air mover having a discharge airflow at least partially passing over at least a portion of the at least one heat transfer enhancement can be disposed within the aperture formed by the first vapor chamber.

[0005] As used herein the term "vapor chamber" can refer to any one of a variety of hollow, sealed, heat transfer devices that function to absorb heat from a first location via an evaporative process occurring within the vapor chamber and to reject all or a portion of the absorbed heat at a second location via a condensation process occurring within the vapor chamber. A wick is used to transport the condensed coolant from the second location to the first location within the heat transfer device. The wick at least partially covers all or a portion of the inner surface of the heat transfer device.

[0006] As used herein, the terms "connect," "connection," or "connected" refer to "in direct connection with" or "in connection with via another element or member."

[0007] As used herein, the terms "thermally connect" or "thermally connected" refer to a direct connection between two or more primary components through which thermal energy can flow or to an indirect connection wherein thermal

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energy can flow between two or more primary components linked by one or more intermediate components.

[0008] As used herein, the terms “fluidly connect” or “fluidly connected” refer to a direct connection between two or more primary components through which a liquid or gaseous fluid can flow or to an indirect connection wherein a liquid or gaseous fluid can flow between two or more primary components linked by one or more intermediate components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Advantages of one or more disclosed embodiments may become apparent upon reading the following detailed description and upon reference to the drawings in which:

[0010] Fig. 1 is an isometric view of an illustrative closed-loop vapor chamber, according to one or more embodiments described herein;

[0011] Fig. 2 is an isometric view of another illustrative closed-loop vapor chamber system using the illustrative closed-loop vapor chamber depicted in Fig.1, according to one or more embodiments described herein;

[0012] Fig. 3 is a cross-sectional view of the illustrative closed-loop vapor chamber system depicted in Fig. 2 along line 3-3, according to one or more embodiments described herein;

[0013] Fig. 4 is an isometric view of yet another illustrative closed-loop vapor chamber system using the illustrative closed-loop vapor chamber system depicted in Fig.1, according to one or more embodiments described herein; and

[0014] Fig. 5 is a cross-sectional view of the illustrative closed-loop vapor chamber system depicted in Fig. 4 along line 5-5, according to one or more embodiments described herein.

DETAILED DESCRIPTION

[0015] Fig. 1 is an isometric view of an illustrative closed-loop vapor chamber 100, according to one or more embodiments. The cooling system 100 depicted in Fig. 1 can include a first vapor chamber 105 having one or more heat transfer enhancement devices 110 partially or completely covering all or a portion of the exterior surface formed by the first vapor chamber 105. In one or more embodiments, the first vapor chamber 105 can form a closed-loop about an aperture 115. In one or more embodiments, an air mover 120 can be partially or completely disposed within the aperture 115. In one or more embodiments, all or a portion of the first vapor chamber 105 can be supported using one or more support devices 125.

[0016] In one or more embodiments, the first vapor chamber 105 can be a hollow, closed-loop, member having any geometric cross-section bounded by a wall forming an interior and an exterior surface. In one or more embodiments, the first vapor chamber 105 can have a circular cross section, an oval cross section, an elliptical cross section, or the like. In one or more embodiments, the first vapor chamber 105 can be formed using a single piece member, for example a pipe or similar tubing. In one or more embodiments, the first vapor chamber 105 can be formed using multiple pieces, for example a top section and a bottom section joined peripherally about an inner and an outer circumference.

[0017] In one or more embodiments, the loop formed by the first vapor chamber 105 can have any closed configuration. In one or more specific embodiments, the closed-loop formed by the first vapor chamber 105 can be circular, forming an annular aperture 115 therein as depicted in Fig. 1. In one or more embodiments, the closed-loop formed by the first vapor chamber 105 can be oval or elliptical, forming an oval or elliptical aperture 115 therein. In one or more specific embodiments, the circular closed-loop formed by the first vapor chamber 105 as depicted in Fig. 1 can have a diameter of from about 2.5cm (1 inch) to about 20cm (8 inches); from about 3.75cm (1.5 inches) to about 15cm (6 inches); or from about 5cm (2 inches) to about 10cm (4 inches). In one or

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more embodiments, the first vapor chamber can be fabricated using any metal alloy or metal containing compound, for example a copper based alloy or a nickel –coated copper based alloy. In one or more embodiments, the first vapor chamber 105 can have an effective thermal conductivity of from about 100 W/m°C to about 500,000 W/m°C; from about 1,000 W/m°C to about 250,000 W/m°C; or from about 2,000 W/m°C to about 200,000 W/m°C.

[0018] In one or more embodiments, one or more heat transfer enhancement devices 110 can be disposed partially or completely about the first vapor chamber 105. The one or more heat transfer enhancement devices 110 can be disposed evenly or unevenly in, on, or about the exterior surface of the first vapor chamber 105. In one or more embodiments, the one or more heat transfer enhancement devices 110 can be integral with the first vapor chamber 105. In one or more embodiments, the one or more heat transfer enhancement devices 110 can be separate from the first vapor chamber 105, being temporarily or permanently attached or otherwise thermally bonded to the first vapor chamber 105.

[0019] In one or more embodiments, the one or more heat transfer enhancement devices 110 can include, but are not limited to one or more fins or similar structures projecting from the surface of the first vapor chamber 105. In one or more specific embodiments, the one or more heat transfer enhancement devices 110 can include a plurality of parallel fins disposed radially about all or a portion of the first vapor chamber 105. In one or more embodiments, the plurality of parallel fins can partially or completely encircle the first vapor chamber 105. In one or more embodiments, the one or more heat transfer enhancement devices 110 can include, one or more external projections integral with the first vapor chamber 105, for example one or more ridges, flute, or similar surface structures disposed in, on, or about the first vapor chamber 105. In one or more embodiments, the one or more heat transfer enhancement devices 110 can be fabricated from the same material as the first vapor chamber 105, for example, from copper or any cuprous (*i.e.*, copper containing) alloy.

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[0020] In one or more embodiments, the air mover 120 can include, but is not limited to, one or more axial flow fans, one or more squirrel cage fans, one or more mixed-flow fans, one or more cross-flow fans, one or more flat blower fans, or the like. In one or more embodiments, the air mover 120 can include a standard, *i.e.* three pin/three wire, cooling fans or a pulse wave modulated ("PWM"), *i.e.* four pin/four wire, cooling fan. In one or more embodiments, the air mover 120 can have a diameter of from about 2.5cm (1 inch) to about 20cm (8 inches); about 3.8cm (1.5 inches) to about 15cm (6 inches); or about 5cm (2 inches) to about 12.5cm (5 inches). In one or more embodiments, the operating voltage of the air mover 120 can be an alternating current ("AC") voltage or a direct current ("DC") voltage. In one or more specific embodiments, the operating voltage of the air mover 120 can range from about -12VDC to about +12VDC, or from about -5VDC to about +5VDC.

[0021] In one or more embodiments, the air mover 120 can be disposed proximate the first vapor chamber 105. In one or more specific embodiments, the air mover 120 can be partially or completely disposed proximate the aperture 115 formed by the first vapor chamber 105. In one or more embodiments, all or a portion of the discharge air from the air mover 120 can be directed axially outward, *i.e.* along the axis of the air mover 120. In one or more embodiments, all or a portion of the discharge air from the air mover 120 can be directed radially outward the air mover 120. In one or more embodiments, a first portion of the discharge air from the air mover 120 can be directed radially outward, with the remaining portion directed axially outward.

[0022] The rotational speed of the air mover 120 can be fixed or variable. In one or more embodiments, the rotational speed of the air mover 120 can be adjusted based upon one or more measured parameters, including but not limited to, temperature, heat load, or the like. In one or more embodiments, the rotational speed of the air mover 120 can be manually adjusted. In one or more embodiments, the air mover 120 can have a rotational speed of from about 100 revolutions per minute ("RPM") to about 50,000 RPM; from about 500 RPM to about 30,000 RPM; or from about 1,000 RPM to about 25,000 RPM.

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[0023] The air mover 120 can be disposed on the same plane as the first vapor chamber 105 or on a plane offset from the plane of the first vapor chamber 105. In one or more embodiments, the air mover 120 can be disposed on a plane partially or completely offset from the plane of the first vapor chamber 105, such that all or a portion of the axial discharge from the air mover 120 flows over, flows across, impacts, or otherwise impinges all or a portion of the first vapor chamber 105. In one or more specific embodiments, the air mover 120 can be disposed on a plane partially or completely offset from the plane of the first vapor chamber 105, such that all or a portion of the radial discharge from the air mover 120 impacts or otherwise impinges all or a portion of the first vapor chamber 105.

[0024] In one or more specific embodiments, the air mover 120 can be disposed such that all or a portion of the axial discharge from the air mover 120 can flow across, over, impact, or otherwise impinge all or a portion of the heat transfer enhancement devices 110 disposed in, on, or about the first vapor chamber 105. In one or more specific embodiments, the air mover 120 can be disposed such that all or a portion of the radial discharge from the air mover 120 can flow over, across, impact, or otherwise impinge all or a portion of the heat transfer enhancement devices 110 disposed in, on, or about the first vapor chamber 105.

[0025] In one or more embodiments, the air mover 120 can be permanently or detachably attached to all or a portion of the first vapor chamber 105. In one or more embodiments, the air mover 120 can be mechanically or physically attached to all or a portion of the first vapor chamber 105. In one or more embodiments, the air mover 120 can be independent, having no mechanical or physical attachment or connection to the first vapor chamber 105.

[0026] In one or more embodiments, the first vapor chamber 105 can be supported from an underlying structure using one or more support devices 125. In one or more specific embodiments, the underlying structure can be a circuit board disposed in, on, or about a portable electronic. In one or more specific

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embodiments, the portable electronic device can be a computing device including, but not limited to, any device having a processor, memory, and at least one input or output device, typical examples of computing devices can include, but are not limited to, portable computers, desktop computers, workstations, handheld electronic devices such as personal digital assistants ("PDAs"), cellular devices and the like. In one or more embodiments, the attachment of the first vapor chamber 105 to the underlying structure can be via rigid physical or mechanical attachment using one or more support device 125, for example via one or more posts, pins, or threaded fasteners such as screws, bolts, or studs.

[0027] In one or more embodiments, the attachment of the first vapor chamber 105 to the underlying structure can be via a plurality of spring clips or other floating-type, shock or vibration absorbing or dampening, support devices 125. In one or more embodiments, a four-point, floating-type support device 125, as depicted in Fig. 1, can physically or mechanically attach the first vapor chamber 105 to the underlying structure.

[0028] Fig. 2 is an isometric view of another illustrative closed-loop vapor chamber system 200 making use of the illustrative closed-loop vapor chamber 100 depicted in Fig.1, according to one or more embodiments. In one or more embodiments the system 200 can include the closed-loop vapor chamber system 100 depicted in Fig. 1, fluidly and thermally connected to a second vapor chamber 210. In one or more embodiments, a heat producing device 230 can be thermally connected to the second vapor chamber 210 via a thermal member 240. In one or more embodiments, the thermal member 240 can be attached, bonded, or otherwise permanently or temporarily connected to the heat producing device 230.

[0029] The system 200 depicted in Fig. 2 can transfer all or a portion of the heat generated by the heat producing device 230 via the second vapor chamber 210 to the first vapor chamber 100. In one or more embodiments, all or a portion of the heat introduced to the first vapor chamber 100 by the second vapor

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chamber 200 can be rejected or otherwise expelled from the first vapor chamber 105 via the air mover 120 discharge flowing across the heat transfer enhancement devices 110 disposed about the first vapor chamber 105.

[0030] In one or more embodiments, the second vapor chamber 210 can be a hollow member having any cross-section bounded by a wall forming an interior and an exterior surface. The second vapor chamber 210 can have a first end 215 and a second end 220. The second vapor chamber 210 can have any physical size, shape, or configuration. In one or more embodiments, the second vapor chamber 210 can have any closed cross-section, for example circular, oval, an elliptical, or the like. In one or more embodiments, the second vapor chamber 210 can be a single-piece hollow member member, for example a pipe or similar tubing. In one or more embodiments, the second vapor chamber 210 can be a multi-piece hollow member having, for example, a top section and a bottom section joined peripherally about an inner and an outer circumference.

[0031] In one or more embodiments, the second vapor chamber 210 can be fluidly and mechanically connected at the first end 215 to the first vapor chamber 105. In one or more embodiments, the second vapor chamber 210 can be detachably attached, for example using a threaded connection, at the first end 215 with the first vapor chamber 105. In one or more embodiments, the second vapor chamber 210 can be permanently attached, for example by soldering, welding, or brazing, at the first end 215 with the first vapor chamber 105.

[0032] The second vapor chamber 210 can have any length. In one or more embodiments, the second vapor chamber 210 can have a length of about 2.5cm (about 1 inch) or more; about 5cm (about 2 inches) or more; about 10cm (about 4 inches) or more; about 20cm (about 8 inches) or more; or about 25cm (about 12 inches) or more. In one or more embodiments, the second vapor chamber 210 can be fabricated using any metal alloy or metal containing compound, for example a copper based alloy or a nickel-coated copper based alloy. In one or

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more embodiments, the second vapor chamber 210 can have an effective thermal conductivity of from about 100 W/m°C to about 500,000 W/m°C; from about 1,000 W/m°C to about 250,000 W/m°C; or from about 2,000W/m°C to about 200,000 W/m°C.

[0033] Although not depicted in Fig. 2, in one or more embodiments, one or more heat transfer enhancement devices can be disposed partially or completely about the second vapor chamber 210. The one or more heat transfer enhancement devices can be disposed evenly or unevenly in, on, or about the exterior surface of the second vapor chamber 210. In one or more embodiments, the one or more heat transfer enhancement devices can be integral with the second vapor chamber 210. In one or more embodiments, the one or more heat transfer enhancement devices can be distinct from the second vapor chamber 210, temporarily or permanently attached or otherwise thermally bonded to the second vapor chamber 210.

[0034] In one or more embodiments, the one or more heat transfer enhancement devices can include, but are not limited to one or more fins or similar structures projecting from the surface of the second vapor chamber 210. In one or more specific embodiments, the one or more heat transfer enhancement devices can include a plurality of parallel fins disposed axially along all or a portion of the second vapor chamber 210. In one or more embodiments, the plurality of parallel fins can partially or completely encircle the second vapor chamber 210. In one or more embodiments, the one or more heat transfer enhancement devices can include, one or more external projections integral with the second vapor chamber 210, for example one or more ridges, flute, or similar surface structures disposed in, on, or about the first vapor chamber 210.

[0035] In one or more embodiments, the thermal member 240 can be disposed at any location along on or about the second vapor chamber 210. In one or more embodiments, the thermal member 240 can provide a thermally conductive pathway from the one or more heat producing devices 230 to the

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second vapor chamber 210. In one or more embodiments, the thermal member 240 can have any size, shape, geometry or physical orientation. In one or more embodiments, the thermal member 240 can include one or more pickups for the heat producing devices 230.

[0036] The thermal member 240 can be single-piece or multi-piece. In one or more embodiments, the thermal member 240 can be disposed proximate the heat producing device 230. In one or more embodiments, thermal member 240 can be thermally connected or otherwise temporarily or permanently bonded to the heat producing device using a thermal mastic or similar material. In one or more embodiments, the thermal member 240 can be thermally connected to the heat producing device by disposing all or a portion of the thermal member 240 in direct contact with all or all or a portion of the heat producing device 230.

[0037] The thermal member 240 can be fabricated using any thermally conductive material. In one or more embodiments, the thermal member 240 can be fabricated from copper or a cuprous alloy. In one or more embodiments, the thermal member 240 can be fabricated using carbon nanotubes having a greater in-plane thermal conductivity than out-of-plane thermal conductivity. In one or more embodiments, the one or more thermal members 240 can have a thermal conductivity of from about 10 W/m°C to about 10,000 W/m°C; from about 25 W/m°C to about 5,000 W/m°C; or from about 50 W/m°C to about 2,500 W/m°C.

[0038] In one or more embodiments, the heat producing device 230 can be any electronic component that, when in operation, increases in temperature. In one or more embodiments, the heat producing device 230 can include, but is not limited to, a power supply, a voltage regulator, an integrated circuit, a solid state drive ("SSD"), a rotating magnetic hard disk drive ("HDD"), a central processing unit ("CPU"), a graphical processing unit ("GPU"), or the like. In one or more embodiments, the heat producing device 230 can be a surface or socket mount integrated circuit suitable for use in a computing device, for example, portable

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computers, desktop computers, workstations, handheld electronic devices such as personal digital assistants ("PDAs"), cellular devices, and the like.

[0039] In one or more embodiments, the heat producing device 230 can have an operating surface temperature of about 25°C or more; about 50°C or more; about 75°C or more; or about 100°C or more. In one or more embodiments, the heat producing device 230 can have a power consumption of about 10W or more; about 25W or more; about 50W or more; or about 100W or more.

[0040] Fig. 3 is a cross-sectional view of the illustrative closed-loop vapor chamber system 200 depicted in Fig. 2 along line 3-3, according to one or more embodiments. Fig. 3 depicts an exemplary internal structure within the first vapor chamber 105. In one or more specific embodiments, the first vapor chamber 105 can include an interior surface 310, an exterior surface 320, a wick 330, and an internal void space 340.

[0041] In one or more embodiments, a wick 330 can be partially or completely disposed on or about all or a portion of the interior surface 310 of the first vapor chamber 105. In one or more specific embodiments, the wick 330 can be a metallic mesh bonded to the interior surface 310 of the first vapor chamber 105. In one or more embodiments, the wick 330 can be a sintered metal having a plurality of interconnected void spaces disposed therein, for example a layer containing sintered copper or a layer containing a sintered cuprous alloy. In one or more embodiments, the wick 330 can be deposited on the interior surface 310 of the first vapor chamber 105 as a uniform or near uniform layer. In one or more embodiments, the wick 330 can be deposited on the interior surface 310 of the first vapor chamber 105 as a non-uniform layer. In one or more embodiments, the wick 330 can be a layer having a thickness of from about 0.1mm to about 10mm; from about 0.5mm to about 7.5mm; or from about 0.75mm to about 5mm.

[0042] Fig. 3 also more clearly depicts an exemplary spatial relationship between the first vapor chamber 105 and the air mover 120. In one or more embodiments, as depicted in Fig. 3, the longitudinal centerline 350 of the first

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vapor chamber 105 can be offset from the longitudinal centerline 360 of the air mover 120. Although not depicted in Fig. 3, in one or more embodiments, the longitudinal centerlines 350, 360 of the first vapor chamber 105 and the air mover 120, respectively, can coincide or, stated alternatively, the longitudinal centerlines 350, 360 can be coplanar.

[0043] Fig. 3 also more clearly depicts an exemplary discharge airflow 370, 380 generated by the air mover 120. In one or more embodiments, all or a portion of the airflow from the air mover 120 can flow radially outward as depicted in Fig. 3 by flow arrows 370. In one or more embodiments, all or a portion of the radially outward airflow 370 from the air mover 120 can flow in, around, through, and about the one or more heat transfer enhancement devices 110 disposed on the exterior surface 310 of the first vapor chamber 105. In one or more embodiments, all or a portion of the airflow from the air mover 120 can flow axially outward as depicted in Fig. 3 by flow arrows 380. Although the axial airflow 380 is depicted in Fig. 3 as exiting the air mover in an upward direction, it should be noted that the axial airflow 380 can be directed either upwardly or downwardly along the longitudinal axis of the air mover 120 with equal efficiency and effectiveness. In one or more embodiments, all or a portion of the axial airflow 380 from the air mover 120 can flow in, around, through, and about the one or more heat transfer enhancement devices 110 disposed on the exterior surface 310 of the first vapor chamber 105. In one or more embodiments, all or a portion of the first vapor chamber 105 can form all or a portion of the housing for the air mover 120.

[0044] The terms “upward,” “downward,” “upwardly,” and “downwardly” and other like terms used herein refer to relative positions to another and are not intended, nor should be interpreted, to denote a particular absolute direction or spatial orientation.

[0045] In operation, the temperature of the heat producing device 230 can increase. For example, in one or more embodiments, the heat producing device 230 can be a CPU disposed in a laptop computer. In one or more

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embodiments, as the heat producing device 230 increases in temperature, all or a portion of the heat can be transmitted or otherwise transferred to the thermal member 240. In one or more embodiments, the thermal member 240 can conduct all or a portion of the heat to the second vapor chamber 210. In one or more embodiments, as the heat is transferred from the thermal member 240 to the second vapor chamber 210, liquid contained within the wick 330 inside of the second vapor chamber can partially or completely vaporize, thereby absorbing all or a portion of the heat transferred to the second vapor chamber 210. Fresh liquid within the wick 330 can flow via capillary action to a location proximate the thermal member 240. By permitting the near-constant vaporization of fresh liquid in the area proximate the thermal member 240, heat transfer from the heat producing device 230 to the second vapor chamber 210 can be facilitated.

[0046] In one or more embodiments, all or a portion of the vaporized liquid in the second vapor chamber 210 can flow into the void space 340 existent within the first vapor chamber 105. In one or more embodiments, the airflow across the first vapor chamber 105 and/or the heat transfer enhancement devices 110, can remove all or a portion of the heat transferred or otherwise communicated to the first vapor chamber 105. In one or more embodiments, upon removal of sufficient heat from the first vapor chamber 105, the vaporized liquid can condense, flowing into the wick 330 disposed on or about the inner surface 310 of the first vapor chamber. Capillary action can then draw the condensed liquid back to the region of the second vapor chamber 210 proximate the thermal member 240.

[0047] Fig. 4 is an isometric view of yet another illustrative closed-loop vapor chamber system 400 using the illustrative closed-loop vapor chamber system 100 depicted in Fig.1, according to one or more embodiments. In one or more embodiments, the second vapor chamber 210 can be connected at the first end 215 and at the second end 220 to the first vapor chamber 105.

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[0048] Fig. 5 is a cross-sectional view of the illustrative closed-loop vapor chamber system 400 depicted in Fig. 4 along line 5–5, according to one or more embodiments. Fig. 5 depicts an exemplary internal structure within the second vapor chamber 210. In one or more specific embodiments, the second vapor chamber 210 can include an interior surface 510, an exterior surface 520, a wick 530, and an internal void space 540.

[0049] In one or more embodiments, a wick 530 can be partially or completely disposed on or about all or a portion of the interior surface 510 of the second vapor chamber 210. In one or more embodiments, the wick 530 can be a mesh bonded to the interior surface 510 of the second vapor chamber 210. In one or more specific embodiments, the wick 530 can be a metallic mesh bonded to the interior surface 510 of the second vapor chamber 210. In one or more embodiments, the wick 530 can be a sintered metal having a plurality of interconnected void spaces therein, for example a layer containing sintered copper or a layer containing sintered cuprous alloy. In one or more embodiments, the wick 530 can be deposited on the interior surface 510 of the second vapor chamber 210 as a uniform or near uniform layer. In one or more embodiments, the wick 530 can be deposited on the interior surface 510 of the first vapor chamber 210 as a non-uniform layer. In one or more embodiments, the wick 530 can have a thickness of from about 0.1mm to about 10mm; from about 0.5mm to about 7.5mm; or from about 0.75mm to about 5mm.

[0050] Certain embodiments and features have been described using a set of numerical upper limits and a set of numerical lower limits. It should be appreciated that ranges from any lower limit to any upper limit are contemplated unless otherwise indicated. Certain lower limits, upper limits and ranges appear in one or more claims below. All numerical values are “about” or “approximately” the indicated value, and take into account experimental error and variations that would be expected by a person having ordinary skill in the art.

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[0051] Various terms have been defined above. To the extent a term used in a claim is not defined above, it should be given the broadest definition persons in the pertinent art have given that term as reflected in at least one printed publication or issued patent. Furthermore, all patents, test procedures, and other documents cited in this application are fully incorporated by reference to the extent such disclosure is not inconsistent with this application and for all jurisdictions in which such incorporation is permitted.

[0052] While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

CLAIMS:

What is claimed is:

- 1.) A system for cooling a heat producing device, comprising:
 - a first vapor chamber (105);
 - wherein the first vapor chamber comprises a closed-loop forming an aperture (115) therein;
 - wherein at least one heat producing device is thermally connected to the first vapor chamber; and
 - an air mover (120) disposed at least partially within the aperture;
 - wherein at least a portion of the air mover discharge airflow passes over at least a portion of the first vapor chamber.
- 2.) The system of claim 1, further comprising:
 - a second vapor chamber (210) having a first end (215) and a second end (220);
 - wherein at least one end is fluidly connected to the first vapor chamber (105); and
 - wherein at least one heat producing device (230) is thermally connected to the second vapor chamber via a thermal member (240).
- 3.) The system of claim 1, further comprising one or more heat transfer enhancement devices (110) disposed about the surface formed by the exterior of the first vapor chamber (105); wherein at least a portion of the air mover discharge passes about the one or more heat transfer enhancement devices.
- 4.) The system of claim 3, wherein the one or more heat transfer enhancement devices (110) are selected from the group of devices consisting of: one or more fins and one or more flutes.

- 5.) The system of claim 1, further comprising a plurality of support devices (125) disposed about the first vapor chamber (105); wherein the plurality of support devices comprises at least four floating-mount spring clips.
- 6.) The system of claim 1, wherein one or more sintered metals (330) are disposed along at least a portion of an interior surface (310) formed by the first vapor chamber (105).
- 7.) The system of claim 1, wherein the air mover (120) comprises a fan having at least a portion of the discharge airflow radially outward about the perimeter of the fan.
- 8.) The system of claim 1, wherein the air mover (120) comprises a laptop flat blower fan.
- 9.) A method for cooling a heat producing device comprising:
 - disposing an air mover (120) at least partially within an aperture (115) formed by a first, closed-loop, vapor chamber (105);
 - wherein the air mover airflow is adapted to at least partially discharge radially outward (370); and
 - wherein an exterior surface (320) of the first vapor chamber forms at least a portion of the air mover housing;
 - thermally connecting the heat producing device (230) to the first vapor chamber; and
 - directing at least a portion of the air mover (120) discharge airflow across at least a portion of the first vapor chamber (105) to remove at least a portion of the heat therein.
- 10.) The method of claim 9 wherein thermally connecting the heat producing device (230) to the first vapor chamber (105) comprises:

fluidly connecting at least one end of a second vapor chamber (210) having a first end (215) and a second end (220) to the first vapor chamber (105);

thermally connecting the heat producing device (230) to the second vapor chamber via a thermal member (240);

removing at least a portion of the heat generated by the heat producing device (230) via the second vapor chamber; and

conveying at least a portion of the heat within the second vapor chamber to the first vapor chamber.

- 11.) The method of claim 9, further comprising disposing one or more heat transfer enhancement devices (110) about an exterior surface (320) of the first vapor chamber (105); wherein at least a portion of the air mover discharge airflow (370) passes about the one or more heat transfer enhancement devices.
- 12.) The method of claim 11, wherein the one or more heat transfer enhancement devices (110) are selected from the group of devices consisting of: one or more fins and one or more flutes.
- 13.) The method of claim 9, further comprising disposing a plurality of support devices (125) about the first vapor chamber; wherein the plurality of support devices (125) comprises at least four floating-mount spring clips.
- 14.) A system for cooling a heat producing device (230), comprising:
 - a first vapor chamber (105);
 - wherein the first vapor chamber comprises a sealed, hollow member formed into a closed-loop about an aperture (115);
 - wherein at least one heat transfer enhancement device (110) selected from the group of devices consisting of: one or more fins and one or more flutes is disposed about at least a portion of an exterior surface formed by the first vapor chamber;

a second vapor chamber (210);

wherein the second vapor chamber comprises a hollow member having a first end (215) and a second end (220);

wherein at least one end is fluidly connected to the first vapor chamber; and

wherein the heat producing device (230) is thermally connected to the second vapor chamber via at least one thermal member (240);

a plurality of support devices (125) disposed about the first vapor chamber; and

an air mover (120) disposed within the aperture;

wherein at least a portion of the air mover discharge airflow (370) passes over at least a portion of the at least one heat transfer enhancement device (110).

- 15.) The system of claim 14 further comprising disposing a plurality of support devices (125) about the first vapor chamber (105); wherein the plurality of support devices comprises at least four floating-mount spring clips.

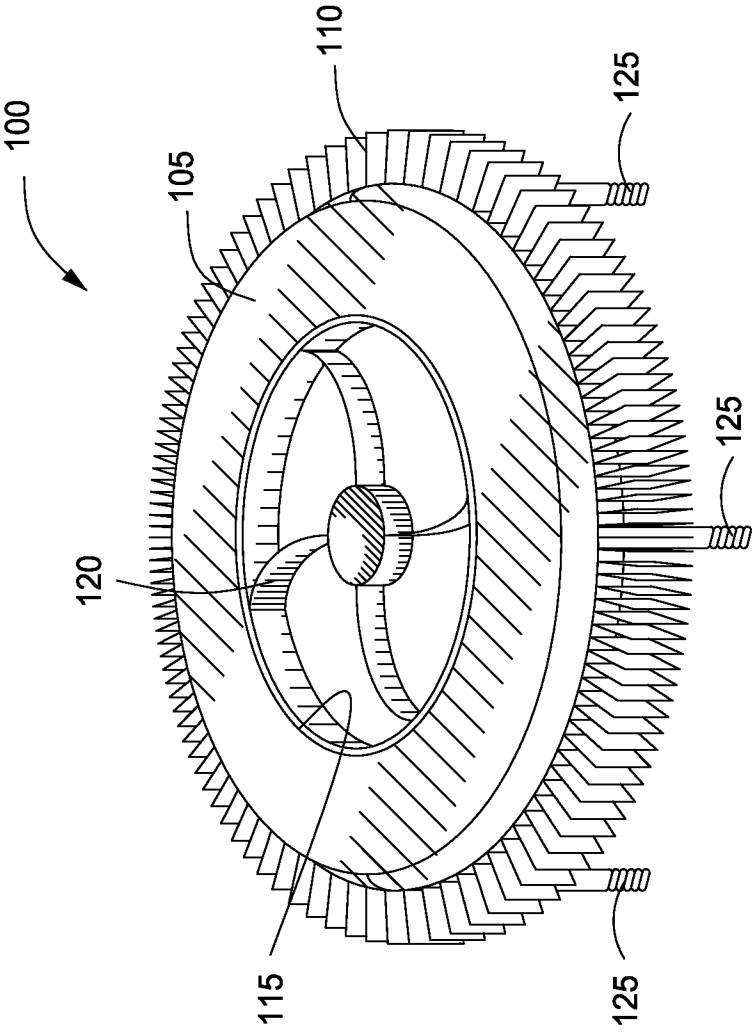


FIG. 1

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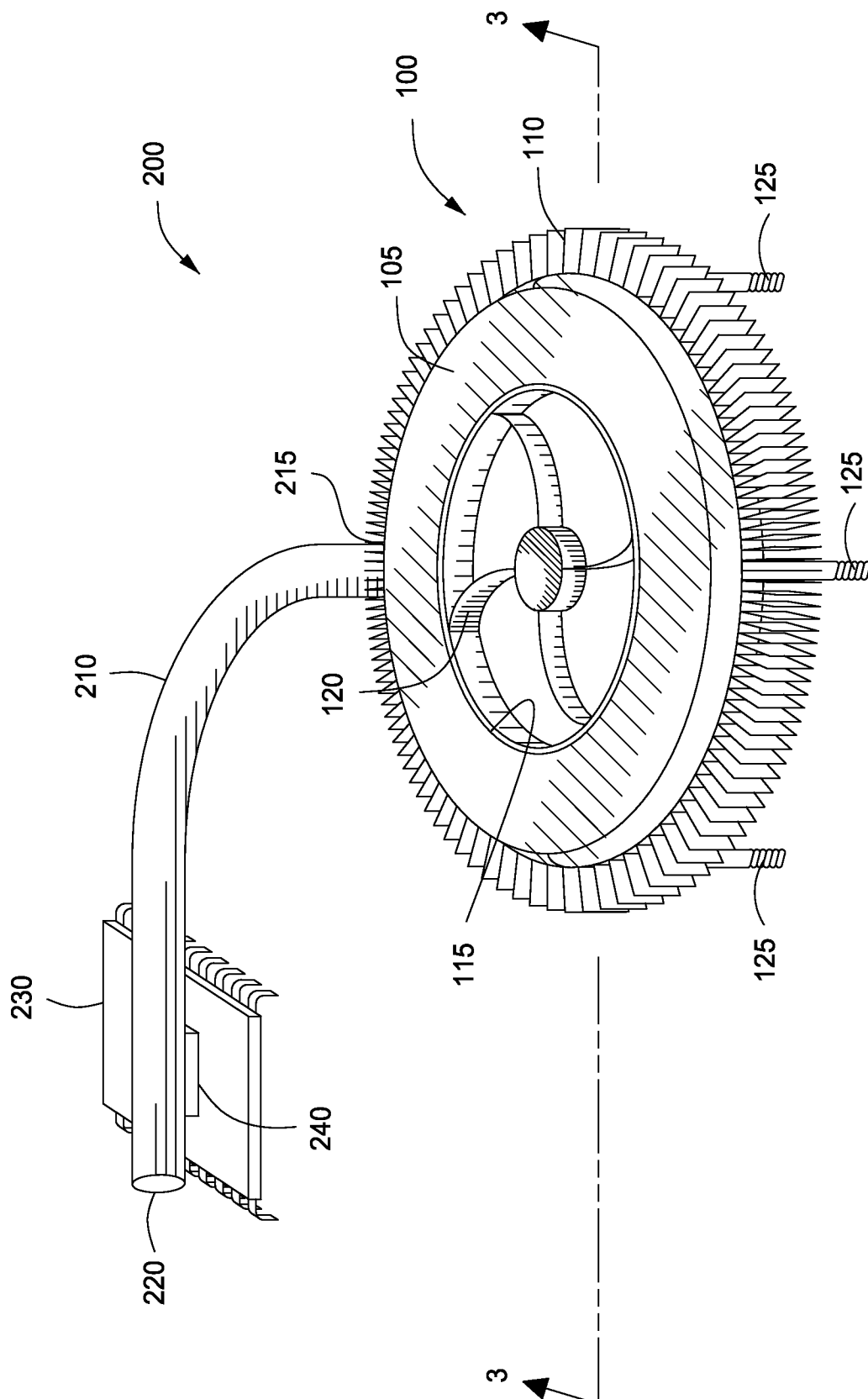


FIG. 2

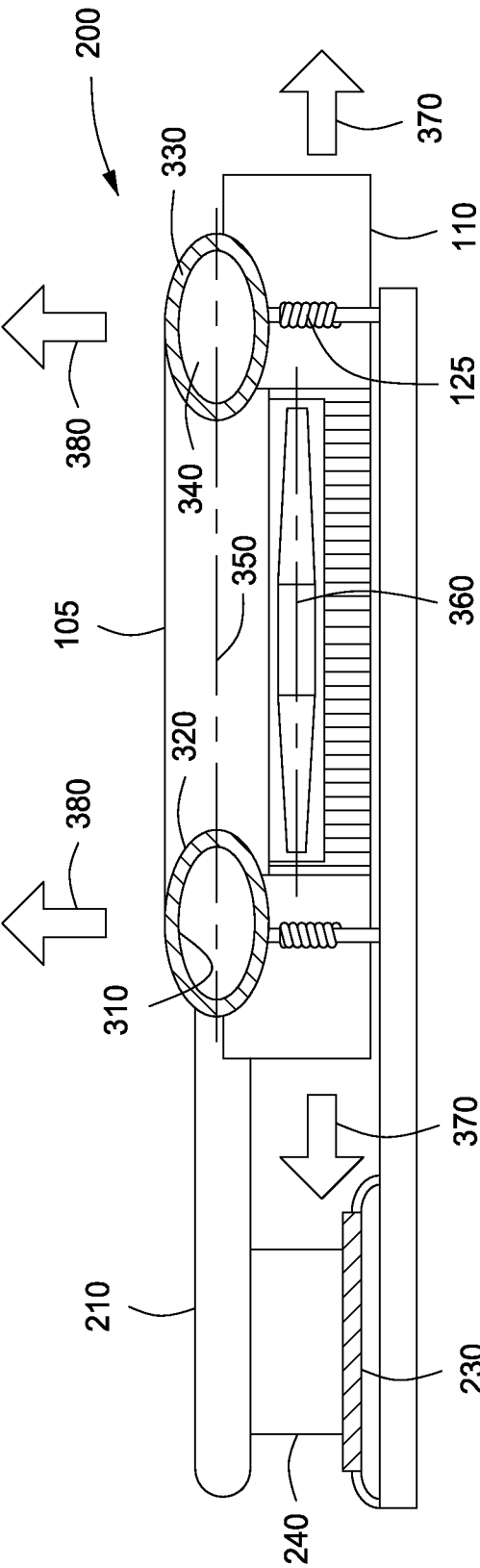


FIG. 3

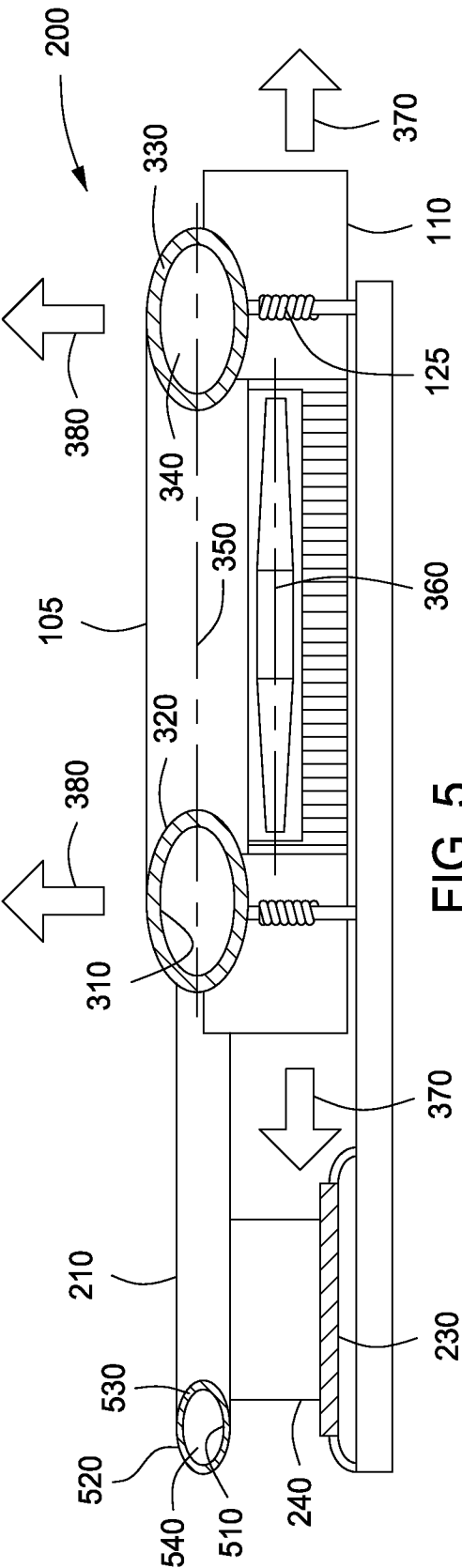
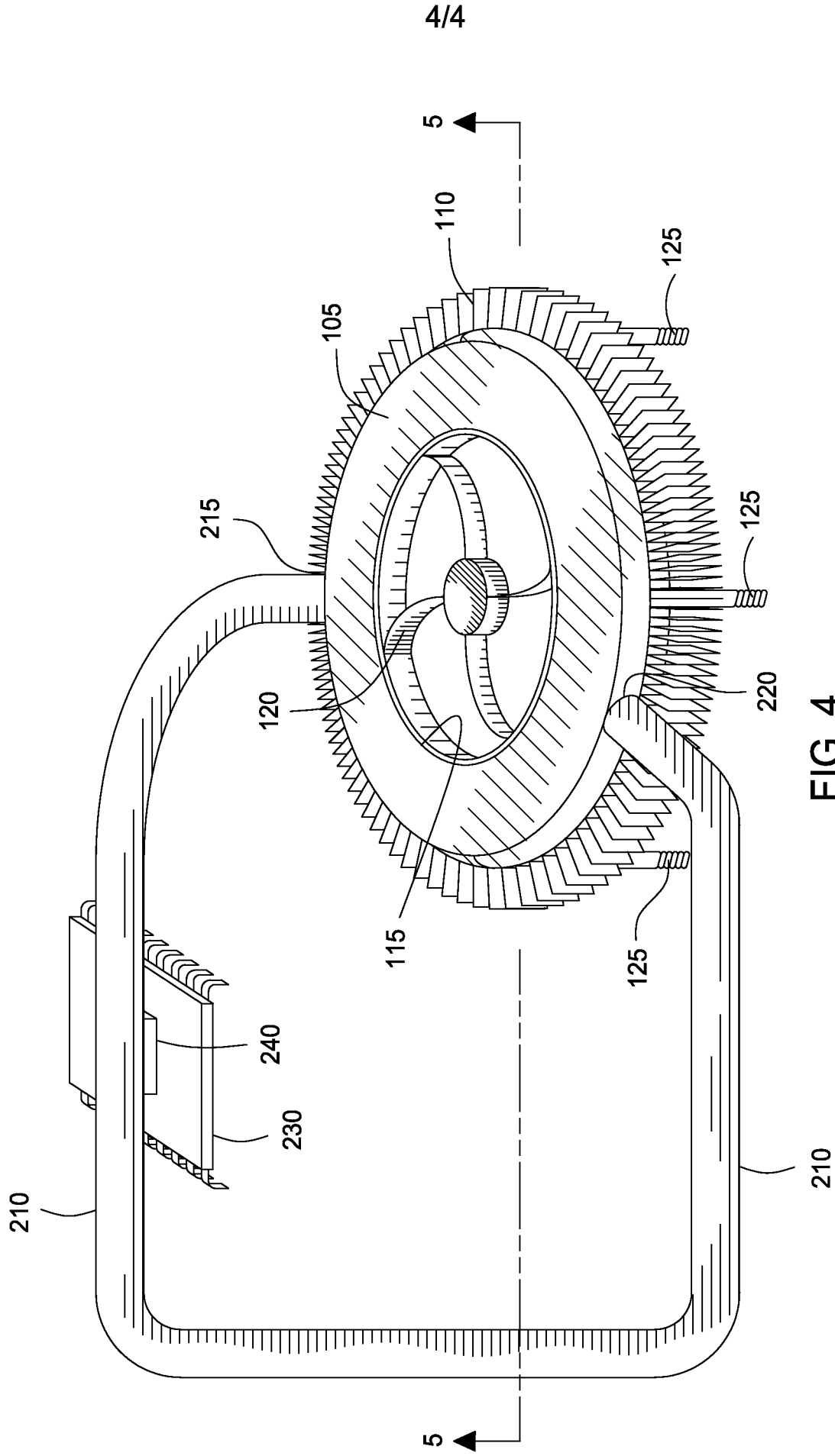


FIG. 5



A. CLASSIFICATION OF SUBJECT MATTER*G06F 1/20(2006.01)i, H01L 23/34(2006.01)i, F28D 15/02(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)

IPC: G06F

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 since 1975

Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

KOMPASS (KIPO internal) & Keywords: "heat producing device, vapor chamber, air mover, fan, discharge airflow, heat dissipating device, heat sink"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2008-277355 A (TOSHIBA CORP.) 13 November 2008	1, 2
Y	See abstract, Fig. 2-7 (including their descriptions), and claims	3-15
Y	US 2005-0047088 A1 (XU et al.) 03 March 2005	3-15
A	See abstract, Fig. 1-3 (including their descriptions), and claims	1, 2
A	JP 2005-093604 A (SONY CORP.) 07 April 2005	1-15
	See abstract, Fig. 4, 11 (including their descriptions), and claims	
A	KR 10-2003-0048661 A (LG INNOTECH CO., LTD.) 25 June 2003	1-15
	See abstract, Fig. 5, and claims	



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

04 DECEMBER 2009 (04.12.2009)

Date of mailing of the international search report

07 DECEMBER 2009 (07.12.2009)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2009/037705

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