US 20010050164A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2001/0050164 A1**

WAGNER et al. (43) **Pub. Date: Dec. 13, 2001**

(54) **COOLING APPARATUS FOR ELECTRONIC DEVICES**

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(*) Notice: This is a publication of a continued prosecution application (CPA) filed under 37 CFR 1.53(d).

(21) Appl. No.: **09/376,627**

(22) Filed: **Aug. 18, 1999**

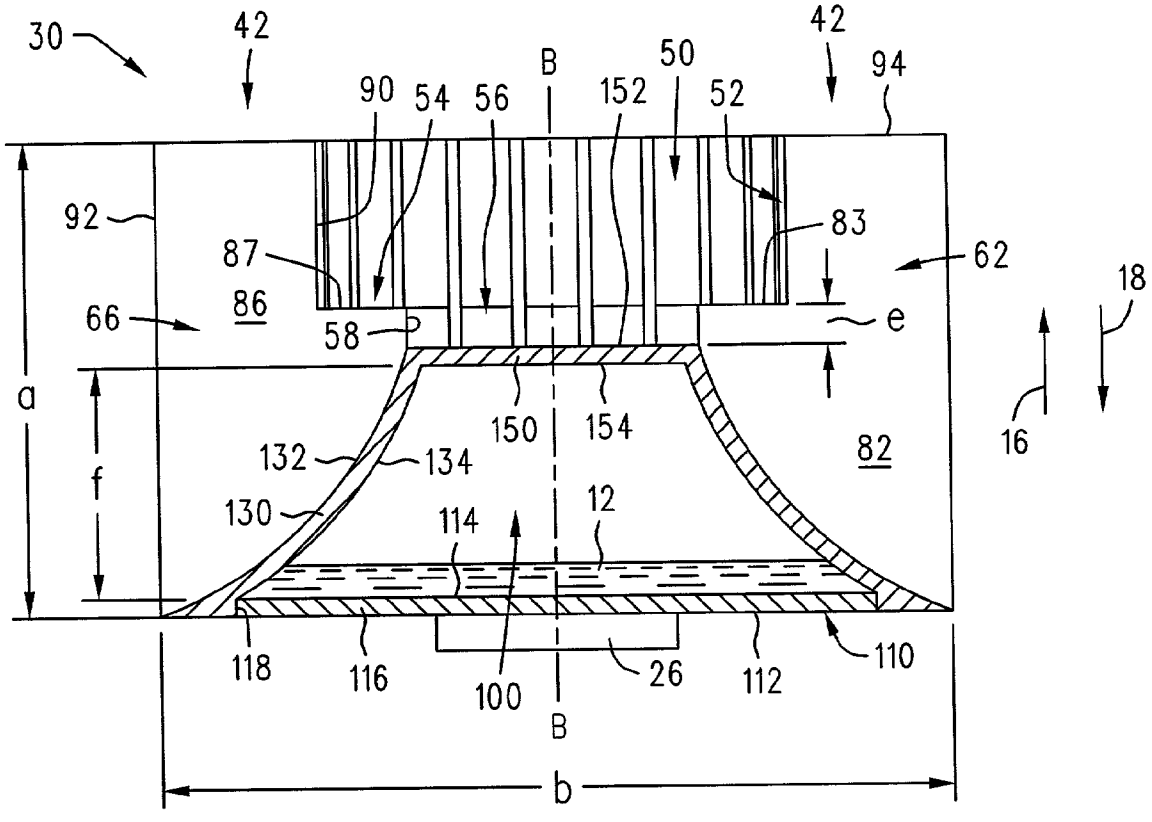
Publication Classification

(51) **Int. Cl.**[7] **H05K 7/20**; H01B 7/42; F28F 7/00; F28D 15/00; H01L 23/34

(52) **U.S. Cl.** **165/104.33**; 165/80.3; 165/185; 361/700; 257/715; 174/15.2

(57) **ABSTRACT**

Disclosed herein is a cooling device primarily for cooling integrated circuits or other electronic devices during operation. The cooling device may include a heat sink portion having a plurality of cooling vanes and a heat pipe chamber. Both the cooling vanes and the heat pipe chamber may be integrally formed within the heat sink portion. Because the heat pipe chamber is integrally formed with the cooling vanes, no joints exist between the condensing surface of the heat pipe chamber and the cooling vanes. This, in turn, allows extremely rapid and efficient heat transfer between the heat pipe chamber and the cooling vanes. The cooling device may include extensions of the main heat pipe chamber which project into each of the cooling vanes. In this manner, the condensing surface of the heat pipe chamber is actually moved into the vanes at a position very close to the surface of the vanes where heat transfer into the atmosphere occurs.



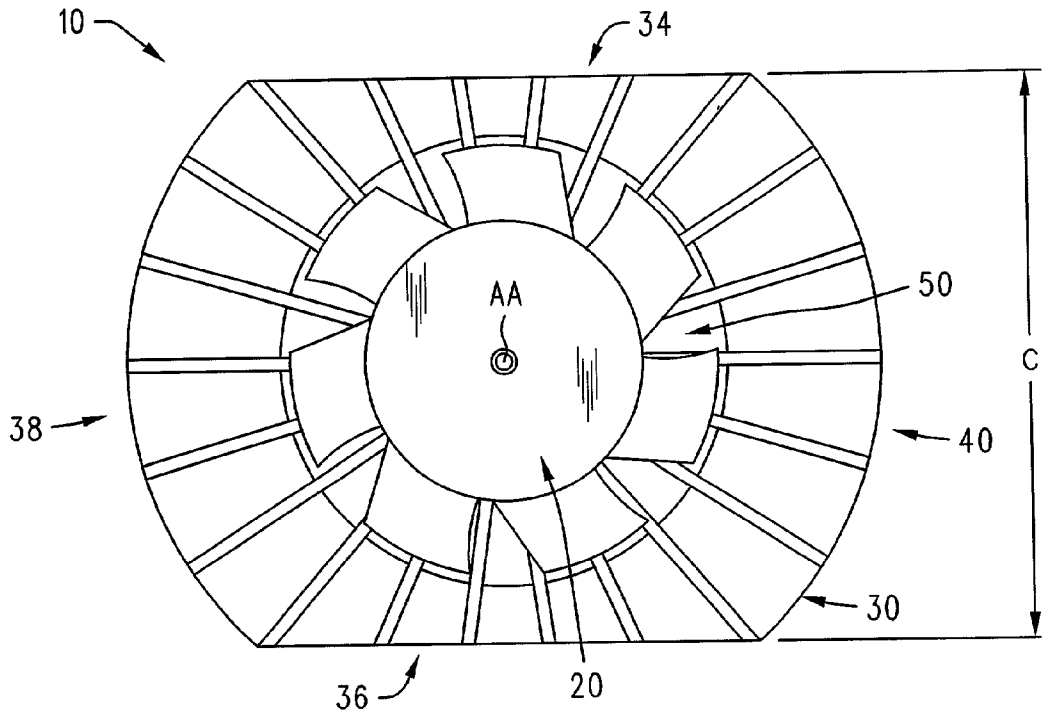

10
34
AA
50
C
38
40
30
36
20

FIG. 1

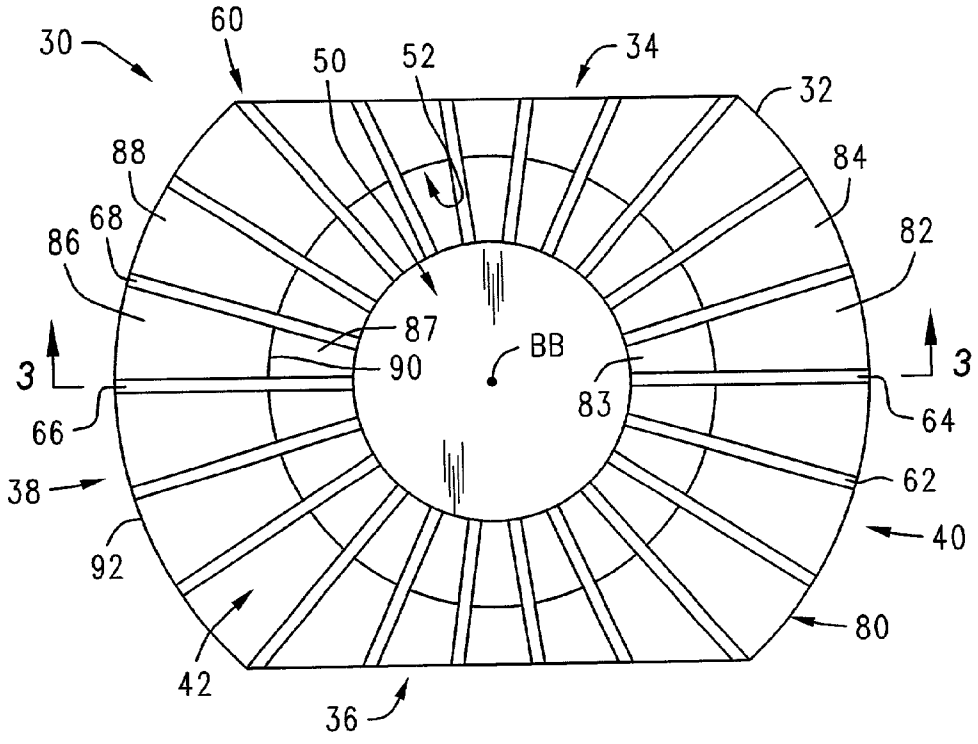

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60
50
52
34
32
88
84
68
86
82
87
BB
90
3
3
83
66
64
38
62
40
92
80
42
36

FIG. 2

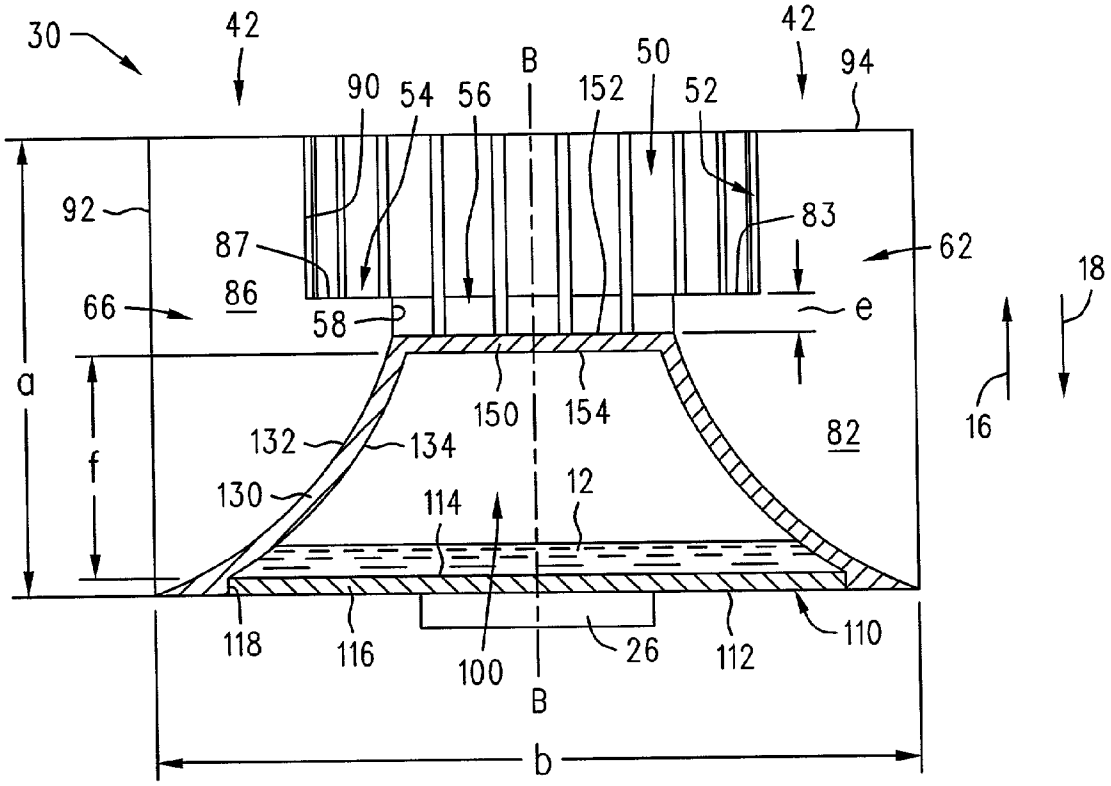

30
42
42
B
50
90
54
56
152
52
94
92
83
62
87
18
86
66
58
e
a
f
150
154
82
16
132
134
130
114
12
118
116
100
26
112
110
B
b

FIG. 3

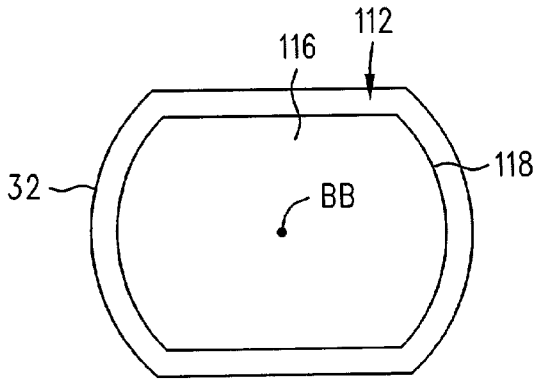

112
116
118
32
BB

FIG. 4

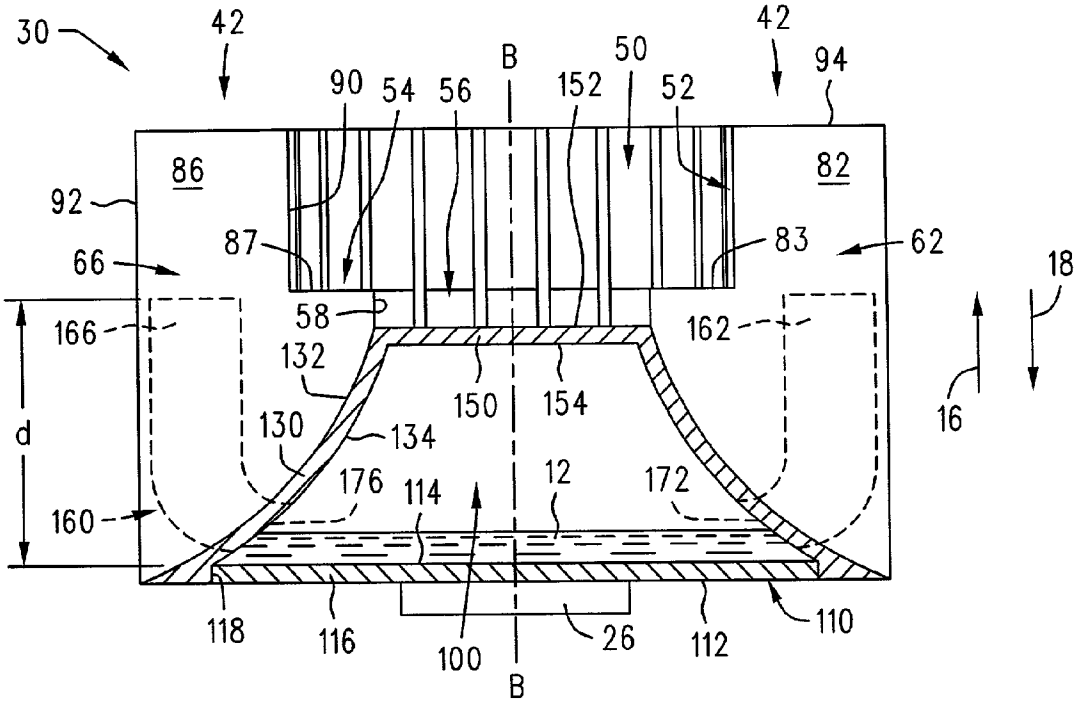

30
42
42
B
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56
152
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94
86
82
92
87
83
62
66
18
58
166
162
132
150
154
16
d
130
134
176
114
12
172
160
118
116
100
26
112
110
B

FIG. 5

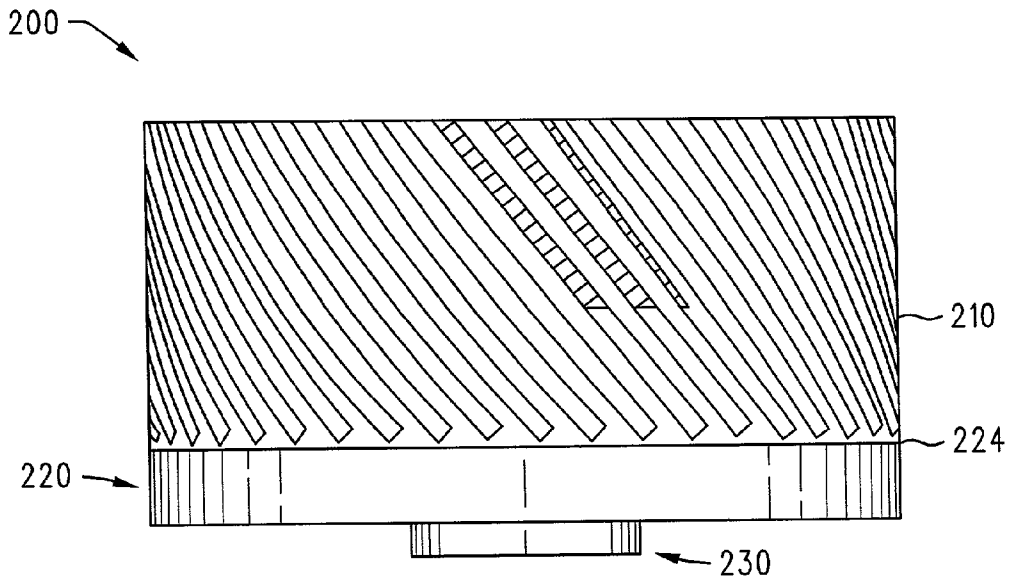

200
210
224
220
230

FIG. 6

COOLING APPARATUS FOR ELECTRONIC DEVICES

FIELD OF THE INVENTION

[0001] The present invention relates generally to cooling devices and, more particularly, to cooling devices for removing heat from an electronic devices.

BACKGROUND OF THE INVENTION

[0002] It is often necessary to remove heat from heat sources. One example of a heat source is an electronic device. Electronic devices, such as integrated circuit devices, are increasingly being used in modern applications. One prevalent example is the computer. The central processing unit or units of most computers, including personal computers, is constructed from an integrated circuit device.

[0003] During normal operation, electronic devices generate significant amounts of heat. If this heat is not continuously removed, the electronic device may overheat, resulting in damage to the device and/or a reduction in operating performance. In order to avoid such overheating, various types of cooling devices have been developed for use in conjunction with electronic devices.

[0004] One type of cooling device is a heat sink cooling device. In such a device, a heat sink is formed of a material, such as aluminum, which readily conducts heat. The heat sink is usually placed on top of and in contact with the electronic device. Due to this contact, heat generated by the electronic device is conducted into the heat sink and away from the electronic device.

[0005] The heat sink may include a plurality of cooling fins in order to increase the surface area of the heat sink and, thus, maximize the transfer of heat from the heat sink into the surrounding air. In this manner, the heat sink draws heat away from the electronic device and transfers the heat into the surrounding air. An example of a heat sink is disclosed in U.S. Pat. No. 5,794,685 of Dean for HEAT SINK DEVICE HAVING RADIAL HEAT AND AIRFLOW PATHS, which is hereby incorporated by reference for all that is disclosed therein.

[0006] In order to enhance the cooling capacity of a heat sink device, an electrically powered fan is often mounted within or adjacent to the heat sink. In operation, the fan causes air to move over and around the fins of the heat sink device, thus cooling the fins by enhancing the transfer of heat from the fins into the ambient air. Examples of heat sink devices including fans are disclosed in U.S. Pat. No. 5,785,116 of Wagner for FAN ASSISTED HEAT SINK DEVICE and U.S. Pat. No. 5,740,013 of Roesner et al. for ELECTRONIC DEVICE ENCLOSURE HAVING ELECTROMAGNETIC ENERGY CONTAINMENT AND HEAT REMOVAL CHARACTERISTICS, which are both hereby incorporated by reference for all that is disclosed therein.

[0007] Over the years, as the power of electronic devices has increased, so has the amount of heat generated by these devices. In order to adequately cool these higher powered electronic devices, cooling devices with greater cooling capacities are required. One strategy for increasing cooling capacity is to provide a heat sink having a base portion with a surface area larger than the surface area of the electronic device being cooled. As can be appreciated, this large area base portion provides a larger radiating surface for dissipating heat into the surrounding air, and thus enhances heat removal from the heat sink. If cooling fins are used, as described above, the larger base portion also allows a greater number of cooling fins to be attached to the heat sink than would otherwise be possible.

[0008] One problem with the larger base portion heat sink described above, is that heat from the electronic device must first travel or conduct through the material forming the base portion before reaching the larger radiating surface. Although materials exhibiting relatively high thermal conductivity, e.g., aluminum and copper, are commonly used in the construction of heat sink devices, even these materials result in an undesirable level of thermal resistance which decreases the cooling ability of the heat sink device.

[0009] In order to address this problem, it is known to provide a heat pipe in association with a heat sink device. The heat pipe is generally located between the heat source being cooled and the larger radiating surface described above. Such a heat pipe generally comprises a partially evacuated chamber which includes a small quantity of working fluid, e.g., water. One wall (the heating wall) of the heat pipe is placed in contact with the heat source while another wall (the radiating or condensing wall) of the heat pipe is located adjacent the radiating surface of the heat sink. In the operation of such a device, the heat source raises the temperature of the heat pipe heating wall, causing the working fluid to vaporize. The resulting vapor then spreads rapidly throughout the heat pipe chamber, ultimately condensing on the cooler radiating wall. Thus, within the heat pipe, heat from the heating wall is transferred to the radiating wall via the latent heat of vaporization of the working fluid. Generally, the use of a heat pipe arrangement, as described above, allows heat to transfer from one surface to another more efficiently than if the heat were merely conducted through a solid material such as aluminum or copper. Examples of cooling devices incorporating heat pipe technology are described in U.S. Pat. No. 5,694,295 of Mochizuki et al. for HEAT PIPE AND PROCESS FOR MANUFACTURING THE SAME, which is hereby incorporated by reference for all that is disclosed therein.

[0010] Although the cooling devices described above generally work well in many applications, it is always desirable to further improve the efficiency and heat removal ability of cooling devices, particularly in view of the increasing cooling needs outlined above.

SUMMARY OF THE INVENTION

[0011] Disclosed herein is a cooling device for cooling heat sources, such as integrated circuits or other electronic devices during operation.

[0012] The cooling device may include a heat sink portion having a plurality of cooling vanes and a heat pipe chamber both integrally formed therewith. Because the heat pipe chamber is integrally formed with the cooling vanes, no joints exist between the condensing surface of the heat pipe chamber and the cooling vanes. This, in turn, allows extremely rapid and efficient heat transfer between the heat pipe chamber and the cooling vanes.

[0013] A separate cover portion on the heat sink serves to seal the heat pipe chamber. This separate cover portion

allows the heat pipe chamber and the remainder of the heat sink to be integrally formed. The separate cover portion may be attached to the remainder of the heat sink after the remainder of the heat sink portion is formed.

[0014] The cooling device may include extensions of the main heat pipe chamber which project into one or more of the cooling vanes. In this manner, the condensing surface of the heat pipe chamber is actually extended into the vanes to a position very close to the surface of the vanes where heat transfer into the atmosphere occurs.

[0015] Also disclosed herein is a cooling device in which a separate heat pipe device is mechanically attached to a highly efficient heat sink.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] **FIG. 1** is a top plan view of a cooling device mounted on a heat source, the cooling device including a heat sink and a fan operatively associated therewith.

[0017] **FIG. 2** is a top plan view of the heat sink of the cooling device of **FIG. 1**.

[0018] **FIG. 3** is a cross-sectional elevation view taken along the line **3-3** in **FIG. 2**.

[0019] **FIG. 4** is a bottom plan view of the heat sink of **FIG. 2**.

[0020] **FIG. 5** is a cross-sectional elevation view, similar to **FIG. 3**, of another embodiment of the cooling device of **FIG. 1**.

[0021] **FIG. 6** is a front elevational view of another embodiment of the cooling device of **FIG. 1**, mounted on a heat source.

DETAILED DESCRIPTION OF THE INVENTION

[0022] FIGS. **1-6**, in general, illustrate a cooling device **10** for dissipating heat from a heat source **26**. The cooling device **10** may include a chamber **100** enclosed by at least a first wall portion **110** and a second wall portion **130**. The first wall portion **110** may include a first wall portion outer surface **112** adapted to contact the heat source **26** and a first wall portion inner surface **114** oppositely disposed relative to the first wall portion outer surface **112**. The first wall portion inner surface **114** may face the chamber **100**. The second wall portion **130** may include a second wall portion inner surface **134** facing the chamber **100** and a second wall portion outer surface **132** oppositely disposed with respect to the second wall portion inner surface **134**. A plurality of cooling vanes **80** may extend from the second wall portion outer surface **132**. The plurality of cooling vanes **80** may be integrally formed with the second wall portion **130**.

[0023] FIGS. **1-6** further illustrate, in general, a cooling device **10** for dissipating heat from a heat source **26**. The cooling device **10** may include a chamber **100** defined by at least one wall portion **110**, **130**, **150** and a plurality of fins **80** extending from the at least one wall portion **110**, **130**, **150**. The chamber **100** extends into at least one of the plurality of fins **80**.

[0024] FIGS. **1-6** further illustrate, in general, a method of making a cooling device **10** including integrally forming a plurality of cooling vanes **80** into a heat sink portion **30** and integrally forming a chamber **100** within the heat sink portion **30**.

[0025] Having thus described the apparatus and method in general, they will now be described in further detail.

[0026] For purposes of the description set forth herein, unless otherwise specified, certain directional terms shall, when used herein, have the meanings set forth below. The terms "radial" and "radially" are with reference to the axis B-B, e.g., **FIG. 3**, and generally refer to directions normal to this axis. The terms "up", "upper", "upwardly" and the like refer the direction indicated by the arrow **16**, **FIG. 3**. The terms "down", "lower", "downwardly" and the like refer to the direction indicated by the arrow **18**, **FIG. 3**.

[0027] It is to be understood that the above terms are defined for illustration purposes only. In actual use, the cooling device described herein may be mounted in any position, thus making terms such as "up" and "down" relative to the orientation of the cooling device.

[0028] Referring now to FIGS. **1-4**, an improved cooling device **10** is illustrated. Cooling device **10** may be mounted to a heat source **26**, **FIG. 3**, in a conventional manner for the purpose of removing heat from the heat source **26** during operation thereof. Heat source **26** may, for example, be an integrated circuit device.

[0029] Referring to **FIG. 1**, cooling device **10** may include a fan **20** mounted within a fan chamber **50** of a heat sink **30**. The fan **20** may be rotatable about a fan rotation axis A-A. The fan **20** may be driven by a 12 volt DC brushless motor. Fan **20** may, for example, be of the type commercially available from Matsushita Electric Company of Japan, sold as a "PANAFLO" Model FBA06A12U1A (with its housing removed). Fan **20** may, for example, have a height (measured along the axis A-A) of about 25 mm and a diameter (at the tips of the fan blades) of about 57 mm.

[0030] Referring to **FIG. 3**, the heat sink **30** may include a substantially planar bottom surface **112**, which is adapted to contact the upper surface of a heat source, such as the heat source **26**. Heat sink **30** may include a central axis B-B which may extend in a perpendicular manner relative to the bottom surface **112**. When the fan **20** is installed within the heat sink **30**, as illustrated, for example, in **FIG. 1**, the fan rotation axis A-A will be superimposed on the heat sink central axis B-B.

[0031] Referring to **FIGS. 2 and 3**, the fan chamber **50** may be generally cylindrical in shape and may be adapted to receive the fan **20** in a manner as shown in **FIG. 1**. A plurality of slots **60**, such as the individual slots **62**, **64**, **66** and **68**, may extend radially outwardly from the fan chamber **30** to the outer periphery **32** of the heat sink **30**. A plurality of cooling vanes **80**, such as the individual cooling vanes **82**, **84**, **86**, **88** may also extend radially outwardly from the fan chamber **30** to the outer periphery **32**. As can be appreciated, one of the cooling vanes **80** will extend between every two of the slots **60** as illustrated, for example, with reference to the cooling vane **82** extending between the slots **62** and **64** and the cooling vane **86** extending between the slots **66** and **68**.

[0032] As can be appreciated, each of the cooling vanes **80** will have a radially inner face and a radially outer face. With

reference to **FIGS. 2 and 3**, the vane **86**, for example, will have a radially inner face **90** and a radially outer face **92**. As can further be appreciated, the radially outer faces of all of the vanes **80** (e.g., the radially outer face **92** of the vane **86**) together, form the outer periphery **32** of the heat sink **30**. In a similar manner, the radially inner faces of all of the vanes **80** (e.g., the radially inner face **90** of the vane **86**) together, form a generally annular "surface"**52**, **FIG. 1**, which defines the radially outer periphery of the fan chamber **50**. Outer surface **52** may be formed at a radius of about 29 mm from the heat sink central axis B-B. With reference to **FIG. 2**, the width of the slots **60** (as measured in a direction normal to the radial direction) may be substantially constant along their length. As a result, each of the vanes **80** may be thicker at the heat sink outer periphery **32** than at the fan chamber outer surface **52**. Each of the slots **60** may, for example, have a width (as measured in a direction normal to the radial direction) of about 1.6 mm.

[**0033**] Referring again to **FIG. 3, a** portion of the slots **60** and vanes **80** may extend beneath the fan chamber **50** such that an upwardly facing edge portion of the vanes **80** (e.g., the upwardly facing edges **83**, **87** of the vanes **82**, **86**, respectively) form a lower "surface"**54** of the fan chamber **50**. A recess **56** may be formed in the fan chamber lower surface **54**, as shown, in order to facilitate retention of the fan **20**, **FIG. 1**, within the fan chamber **50** in a conventional manner.

[**0034**] With reference to **FIGS. 1 and 2**, the outer periphery **32** of the heat sink **30** may include a pair of substantially flat portions **34**, **36** and a pair of arcuate portions **38**, **40**, as shown. The flat portions **34**, **36** may be provided to facilitate fitting the cooling device **10** into a tightly confined area or to facilitate the use of multiple cooling devices in close proximity as described, for example in U.S. Pat. No. 5,740,013, previously referenced. Alternatively, the heat sink outer periphery **32** may be formed having a completely circular profile or having virtually any desired profile as dictated by the particular cooling application.

[**0035**] Referring again to **FIG. 2**, as can be appreciated, at the outer periphery **32**, the vanes **80** in the arcuate portions **38** and **40** will be generally thicker than the vanes **80** in the flat portions **34**, **36** due to the fact that the vanes **80** in the arcuate portions **38** and **40** have longer radial lengths than do those in the flat portions **34**, **36**.

[**0036**] With reference to **FIGS. 2 and 3**, the vanes **80** generally define a wall portion **42** extending between the fan chamber outer surface **52** and the outer periphery **32** of the heat sink **30**. With reference to **FIG. 3**, heat sink **30** may, for example, have a height "a" extending between the heat sink bottom surface **112** and the upper surface **94** of the vanes **80**. A width "b" may extend between the arcuate portions **38** and **40** at the outer periphery **32**. A width "c", **FIG. 1**, may extend between the flat portions **34** and **36** at the outer periphery **32**. The height "a" may, for example, be about 50 mm. The widths "b" and "c" may, for example, be about 88 mm and about 64 mm, respectively.

[**0037**] Referring now to **FIG. 3**, heat sink **30** may include a chamber **100**, as shown. Chamber **100** may generally be enclosed by a first wall portion **110**, a second wall portion **130** and a third wall portion **150**.

[**0038**] First wall portion **110** may include the outer bottom surface **112**, previously described, and an oppositely disposed inner surface **114**. As can be appreciated, the outer surface **112** will have a shape substantially identical to the shape of the heat sink outer periphery **32**, **FIGS. 1 and 3**. First wall portion **110** may include a separate portion **116** which may be attached to the remainder of the first wall portion **110** at a joint line **118**, as best shown in **FIG. 4**. The separate portion **116** may be attached to the remainder of the first wall portion **110** via any conventional mechanism, such as welding or brazing. In the case where the heat sink **30** is formed having a circular profile, as described above, the separate portion **116** may also have a circular configuration and, thus, may be threadingly attached to the remainder of the first wall portion **110** such that the separate portion **116** can be attached or removed from the remainder of the lower wall **110** by turning the separate portion **116** (about the axis B-B) relative to the remainder of the heat sink **30**. First wall portion **110** has a thickness extending between the first wall portion outer and inner surfaces **112**, **114**.

[**0039**] Referring again to **FIG. 3**, second wall portion **130** may include an outer surface **132** and an inner surface **134**. Second wall portion **130** may have an arcuate profile such that it extends convexly with respect to the interior of the chamber **100**. Second wall portion outer surface **132** and inner surface **134** may each also have arcuate profiles as shown. Second wall portion **130** has a thickness extending between the second wall portion outer and inner surfaces **132**, **134**, which may, for example, be about 2 mm. As can be appreciated, second wall inner surface **134** will have a larger surface area than the first wall portion inner surface **114**, described above.

[**0040**] Third wall portion **150** may include an outer surface **152** and an inner surface **154**. Third wall portion **150** may be substantially cylindrical, having a radius (about the axis B-B), for example, of about 18 mm. Accordingly, the third wall portion outer and inner surfaces **152**, **154** each have a substantially circular shape. Third wall portion **150** has a thickness extending between the third wall portion outer and inner surfaces **152**, **154**, which may, for example, be about 2 mm. As can be appreciated, with reference to **FIG. 3**, the third wall portion outer surface **152** may form a lower surface of the fan chamber recess **56** previously described. The outer surface **152** may be connected to the fan chamber lower surface **54** via a cylindrical surface portion **58**, as shown. Cylindrical surface portion **58** has a height "e" which may, for example, be about 5 mm. The chamber **100** has an interior height "f" which may, for example, be about 20 mm.

[**0041**] Referring again to **FIG. 3, a** partial vacuum may be provided within the chamber **100** and a fluid **12**, e.g., water, may be provided therewithin such that the chamber **100** functions as a heat pipe device. Specifically, the level of vacuum applied may be chosen such that the vaporization point of the liquid **12** is lower than the desired maximum operating temperature of the heat source **26**.

[**0042**] In operation, the cooling device **10** may be located such that the bottom surface **112** is in contact with a heat source, such as the heat source **26**. Heat generated by the heat source will, thus, be transferred to the cooling device bottom surface **112**. This heat will thereafter be transferred through the first wall portion **110** to the first wall portion inner surface **114**. This, in turn, will cause the fluid **12** to vaporize. The resulting vapor will then move upwardly and

condense on the inner surface **134** of the second wall portion **130**, which is at a lower temperature than the inner surface **114** of the first wall portion **110**. Heat, thus, is rapidly transferred from the surface **114** to the surface **134** using the latent heat of vaporization of the fluid **12**.

[**0043**] Heat transferred in this manner to the second wall portion inner surface **134** then conducts through the second wall portion **130**. Thereafter, some of the heat is dissipated to the atmosphere directly from the second wall portion outer surface **132** in the area of the slots **60**. The remainder of the heat continues to conduct upwardly into the fins **80** which are integrally formed with the second wall portion **130**. Heat which has conducted into the fins **80** is then dissipated into the atmosphere from the fins **80**. Airflow, provided by the fan **20**, moves across both the fins **80** and the arcuate outer wall **132** in the area of the slots **60** to facilitate this heat dissipation. Thus, both the fins **80** and the second wall portion outer surface **132**, in the area of the slots **60**, serve as heat dissipation surfaces.

[**0044**] The chamber **100**, thus, allows heat to be rapidly and efficiently transferred from a relatively small area, corresponding to the size of the heat source **26**, to a relatively larger area, corresponding to the size of the second wall portion inner surface **134**.

[**0045**] Although it is generally known to provide heat pipe devices in association with heat sinks, prior attempts generally contemplate a heat sink structure which is merely attached to a separately manufactured heat pipe chamber. A device manufactured in this manner, thus, has a joint, or interface, between the heat pipe chamber and the heat sink fins. Although the heat pipe portion tends to conduct heat very efficiently, the necessity for the heat to traverse the joint or interface between the heat pipe chamber and the cooling fins detracts from the overall efficiency of such a device.

[**0046**] The cooling device **10** described herein, on the other hand, is very efficient because there are no joints or interfaces between the heat pipe chamber **100** and the heat dissipation surfaces. This is a result of the fact that, the heat pipe chamber **100** is integrally formed within the heat sink structure **30**.

[**0047**] Referring to **FIGS. 3 and 4**, the separate portion **116** facilitates the one-piece integral manufacture of the heat sink **30**, as described above. Specifically, the heat sink **30**, without the separate portion **116**, may be manufactured in any conventional manner. Heat sink **30** may, for example, be formed in a typical machining operation. Alternatively, for example, heat sink **30** may be formed in a forging, molding or casting operation. The heat sink **30** may be formed from a material which conducts heat relatively well, such as aluminum or copper. After manufacture of the heat sink **30** is completed, the fluid **12** may be added to the chamber and the separate portion **116** may be attached in an air-tight manner, as previously described. Thereafter, the chamber **100** may be partially evacuated such that a partial vacuum exists therein, in a well-known manner. As can be appreciated, the provision of the separate portion **116** allows the heat pipe chamber **100** of the heat sink **30** to be integrally formed with the dissipation surfaces as described above.

[**0048**] As previously described, the provision of the separate portion **116** results in a joint **118** being formed in the heat sink **30**. Referring to **FIGS. 3 and 4**, although this joint **118** is an interface, this interface does not substantially interfere with heat transfer from the heat source **26** to the dissipation surfaces. This is because heat from the heat source **26** will travel directly through the separate portion **116** to the surface **114**. Thereafter, in a manner as described above, the heat may be directly transferred to the fluid **12**. The heat, thus, does not need to cross the interface caused by the joint **118** in order to reach the dissipation surfaces.

[**0049**] The heat pipe chamber **100** may be constructed in a manner as is well known in the art. For example, the amount of fluid **12**, the composition of the fluid **12** and the amount of vacuum in the chamber **100** may all be chosen according to well-known principles, as described, for example, in U.S. Pat. No. 5,694,295, previously referenced.

[**0050**] It is noted that the first wall inner portion **114** may be provided with a roughened surface profile in order to facilitate boiling of the fluid **12**. The use of such a roughened surface is well known and is discussed, for example, in U.S. Pat. No. 5,694,295, previously referenced.

[**0051**] It is further noted that, when the cooling device **10** is located above the heat source to be cooled, the force of gravity is generally sufficient to cause the liquid condensed on the surface **134** to return to the surface **114**. In the event the cooling device is to be located in a position other than above the heat source, however, it may be desirable to incorporate various wicking features into the construction of the chamber **100** in order to assist the condensed liquid in returning to the surface **114**. Such wicking features may also be used in a case where the cooling device **10** is mounted above the heat source in order to enhance the operating efficiency of the heat pipe chamber **100**. Wicking features typically involve structures or surface treatments within the chamber **100** to induce capillary action. Such wicking features are generally well-known in the art; various examples thereof are described, for example, in U.S. Pat. No. 5,694,295, previously referenced.

[**0052**] It is noted that the particular cooling vane configuration illustrated herein in association with the heat sink **30** is provided for exemplary purposes only. In practice, virtually any cooling vane arrangement and number could alternatively used. Heat sink **30** may, for example, be configured having angled cooling vanes as described in U.S. Pat. No. 5,785,116, previously referenced. In addition, it is noted that the fan **20** has been described herein for exemplary purposes only; the heat sink **30** could, alternatively, be of the type not incorporating a fan.

[**0053**] **FIG. 5** illustrates an alternative embodiment of the heat sink **30** of the cooling device **10**. Referring to **FIG. 5, a** plurality of chambers **160** may be provided within the cooling vanes **80**, as shown. Specifically, for example, a chamber **162** may be provided within the cooling vane **82** and a chamber **166** withing the cooling vane **86**. Each of the chambers **160** may communicate with the heat pipe chamber **100** via an opening. With reference to **FIG. 5**, the chambers **162** and **166**, for example, may communicate with the heat pipe chamber **100** via openings **172** and **176**, respectively. Each of the chambers **160** may extend upwardly into the heat sink **30** for a distance "d" which may, for example, be about 30 mm.

[**0054**] The cooling vane chambers **160** serve to enhance the operation of the cooling device **10** by allowing the fluid

12 to actually condense within the cooling vanes **80**. This causes heat to be transferred very rapidly and efficiently from the surface **114** to points close to the surface of the cooling vanes **80** where heat may be transferred into the atmosphere. It is noted that the cooling vane chambers **160** may be provided in all of the cooling vanes **80** or only in some of the cooling vanes. The chambers **160** may be formed within the cooling vanes **80**, for example, by any conventional method. The chambers **160** may, for example, be formed by a machining operation. Alternatively, the chambers **160** may be molded or forged directly into the vanes **80** when the heat sink **30** is manufactured.

[**0055**] **FIG. 6** illustrates a further embodiment in which a cooling device **200** include a heat sink portion **210** which is mechanically attached to a substantially cylindrical heat pipe **220**. Heat sink portion **210** may be attached to the heat pipe **220** at a joint line **224** via any conventional method, such as by welding or adhesive bonding. Heat pipe **220** may be substantially similar to the heat pipe chamber **100** previously described except that the heat pipe **220** may be substantially cylindrically shaped and may be formed separately from the heat sink **210**. Heat sink **210** may, for example, be substantially identical to the heat sink structure disclosed in U.S. Pat. No. 5,785,116, previously referenced.

[**0056**] In operation, heat from a heat source **230**, which may, for example, be an integrated circuit device, transfers through the lower wall of the heat pipe **220**. This heat causes the fluid, not shown, within the heat pipe **220** to vaporize. The vapor then travels to the upper interior wall of the heat pipe **220** and thereafter travels through the upper wall of the heat pipe **220**. From there, the heat crosses the joint line **224** and enters the base of the heat sink **210**. The heat then travels through the heat sink **210** and is dissipated into the atmosphere in a manner, for example, as described in U.S. Pat. No. 5,785,116, previously referenced. The heat pipe **220**, thus, allows heat to be rapidly transferred from a relatively small area, corresponding to the heat source **230** to a relatively larger area, corresponding to the size of the base of the heat sink **210**. The cooling device **200**, thus, combines the advantages of a highly efficient heat sink device **210** with a heat pipe **220**.

[**0057**] As can be appreciated, the cooling device **200** will be somewhat less efficient than the cooling device **10** previously described, due to the fact that the cooling device **200** includes a joint line **224** which must be traversed by the heat when the heat source **230** is being cooled. The cooling device **200**, however, may be more easily manufactured than the cooling device **10**.

[**0058**] While an illustrative and presently preferred embodiment of the invention has been described in detail herein, it is to be understood that the inventive concepts may be otherwise variously embodied and employed and that the appended claims are intended to be construed to include such variations except insofar as limited by the prior art.

What is claimed is:

1. A cooling device for dissipating heat from a heat source, said cooling device comprising:

a chamber enclosed by at least a first wall portion and a second wall portion;

said first wall portion including:

a. a first wall portion outer surface adapted to contact said heat source;

b. a first wall portion inner surface oppositely disposed relative to said first wall portion outer surface, said first wall portion inner surface facing said chamber;

said second wall portion including:

a. a second wall portion inner surface facing said chamber;

b. a second wall portion outer surface oppositely disposed with respect to said second wall portion inner surface;

a plurality of cooling vanes extending from said second wall portion outer surface, wherein said plurality of cooling vanes are integrally formed with said second wall portion.

2. The cooling device of claim 1 wherein said chamber is sealed in a substantially air-tight manner.

3. The cooling device of claim 1 and further including a fluid in said chamber.

4. The cooling device of claim 3 wherein said fluid is water.

5. The cooling device of claim 1 wherein said chamber defines a heat pipe.

6. The cooling device of claim 1 wherein at least a portion of said first wall portion is releasably attached to the remainder of said cooling device.

7. The cooling device of claim 6 wherein said at least a portion of said first wall portion is threadingly attached to the remainder of said cooling device.

8. The cooling device of claim 1 wherein said second wall portion outer surface has a curved profile.

9. The cooling device of claim 1 wherein said chamber extends into at least one of said plurality of cooling vanes.

10. The cooling device of claim 1 wherein said first wall portion inner surface has a first surface area, said second wall portion inner surface has a second surface area and said second surface area is larger than said first surface area.

11. A cooling device for dissipating heat from a heat source, said cooling device comp rising:

a chamber defined by at least one wall portion;

a plurality of fins extending from said at least one wall portion;

wherein said chamber extends into at least one of said plurality of fins.

12. The cooling device of claim 11 wherein said chamber is sealed in a substantially air-tight manner.

13. The cooling device of claim 11 and further including a fluid in said chamber.

14. The cooling device of claim 13 wherein said fluid is water.

15. The cooling device of claim 11 wherein said chamber defines a heat pipe.

16. The cooling device of claim 11 wherein said at least one wall portion has a curved profile.

17. A method of making a cooling device comprising:

integrally forming a plurality of cooling vanes into a heat sink portion;

integrally forming a chamber within said heat sink portion.

18. The method of claim 17 and further including substantially sealing said chamber by attaching a cover portion to said heat sink portion.

19. The method of claim 18 and further including adding a fluid into said chamber prior to said attaching a cover portion.

20. The method of claim 19 wherein said fluid is water.

21. The method of claim 17 wherein said chamber defines a heat pipe.

22. The method of claim 18 wherein said attaching said cover portion comprises releasably attaching said cover portion to said heat sink portion.

23. The method of claim 22 wherein said releasably attaching comprises threadingly attaching said cover portion to said heat sink portion.

24. The method of claim 17 wherein said integrally forming a chamber comprises extending said chamber into at least one of said plurality of cooling vanes.

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