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SPECIFICATION
FOLDED FIN HEAT SINK AND FAN ATTACHMENT

Field of the Invention

The present invention is related to heat sinks, particularly those for use in cooling, CPUs.

Background of the Invention

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In many industries, and in the computer industry in particular, there is a need for low cost high performance removal of heat. For instance, in the semiconductor industry, many semiconductors create so much heat that they will actually melt if that heat is not removed. Because of this a large industry has blossomed which makes heat sinks, or devices which can pull the heat away from the heat producing item and disperse that heat into the atmosphere.

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Typically for semiconductors, a piece of aluminum is extruded into a shape and the aluminum is then screwed down or clamped to the semiconductor. The extrusion is designed to have a flat plane on the bottom which contacts the semiconductor, and many fins or thin vertical protrusions directed out of the base which makes up the flat plane. Most extrusions used for this purpose look like an upside down comb.

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The limitations on the extrusions are numerous. The height of each fin is limited by the thickness of the fin. The amount of fins per inch is limited by the thickness and the height. This limitation on density of fins on an extrusion reduces the efficiency of the heat removal.

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To make up for this limitation in density that extrusions have, an extrusion used for a heat sink goes through many secondary operations after it is extruded. First, in many instances the base of the heat sink is machined for flatness in order to make smooth contact with the heat producing substrate it is attached to. Then the bars of extrusion which are typically 8 feet in length are cut down to a particular size, usually 2 inches for a typical semiconductor. The next step is to cross cut the extrusion which means the fins are cut perpendicular to the plane in which they run in order to create more surface area. This

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increase in surface area is a very important step in increasing the efficiency of the heat sink. After this, the heat sink is usually stamped in order to form mounting holes and locations and then it is anodized and deburred. In all, making an extrusion is an expensive and lengthy process.

5 U.S. Patent No. 5,329,426 (Villani) is an example of a method that may be used to attach such an extrusion directly to a heat generating chip carrier. A spring is used to clip the solid heat sink to a pair of braces supporting the chip carrier package.

10 In the computer industry, extrusions make up an overwhelming, majority of the market for cooling the most popular chips. Another heat sink which is typically only used in the highest performance applications because of cost constraints and manufacturing limitations is to use a convoluted fin, also known as folded fin. This fin is a piece of aluminum bent into an up and down or reciprocating wave pattern. Because both sides of the aluminum sheet are exposed to air, more effective surface area is present. U.S. Patent No. 5,494,098 (Morosas) is an example of a method for making a heat sink from folded fin. The
15 fins are brazed to a top wall and a bottom wall to form an integral unit. Thereafter a milling operation is performed further adding to the assembly cost.

Summary of the Invention

20 Embodiments of the present invention are directed to a folded fin heat sink, and a method of assembling the folded fin heat sink. A sheet of aluminum or other heat conductive material is folded in a wave-like pattern forming an alternating series of ridges and troughs. The aluminum sheet may be solid or have predefined cutouts. The folded fin is placed either directly on a heat producing element or on a separate conductive base plate, which is then
25 used for making contact with the heat producing element. A clamping device holds the folded fin against the base plate with the troughs in thermal contact with the base plate. In the preferred embodiment, the clamping device, is a spring mechanism which applies pressure to the troughs of the folded fin. A plurality of tabs depending from the spring mechanism may be forced into latching engagement beneath an edge of the base plate to tension the spring to
30 press the folded fin against the plate. When the base plate forms a separate heat sink

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assembly, the assembly is then attached to a substrate to be cooled with the base plate against the substrate.

The spring of an embodiment of the invention includes a plurality of parallel linkages. Each link fits into one of the troughs of the folded fin. In the embodiment, a pair of
5 cross-bars are connected, perpendicular to the linkages, to opposite ends of the linkage. Applying pressure to the cross-bars moves the tabs until they hook on beneath the base plate. Placing the assembled heat sink onto a substrate to be cooled, the tabs can be pushed further until they engage the substrate.

Heat dissipation can be further enhanced by moving air through a heat sink. A
10 cooling fan assembly embodiment includes an air moving device, such as a fan, mounted in an opening of a housing. The housing mounts to a heat sink so that the air moving device directs air at the heat sink. The housing includes a baffle which obstructs a portion of the direct air path from the air moving device. The baffle extends over all of the air channels formed by the folded fin. Air moves around the baffle into the channels and then behind the
15 baffle and out of the air channels. The housing may also include a hood extending over the heat sink where air is exiting the air channels. The hood is positioned to discourage the exiting air from recirculating through the air moving device.

Other objects and advantages of the invention will become apparent during the following description of the presently preferred embodiments of the invention taken in
20 conjunction with the drawings.

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Brief Description of the Drawings

FIG. 1 is an isometric view of a heat sink assembly of an embodiment of the invention.

5 FIG. 2 is an isometric view of a spring for use in the heat sink assembly of FIG. 1.

FIG. 3 is a plan view of a base plate for use in the heat sink assembly of FIG. 1.

FIG. 4 is an isometric view of a cooling fan assembly of an embodiment of the invention.

10 FIG. 5 is an isometric view of the heat sink assembly of FIG. 1 in conjunction with the cooling fan assembly of FIG. 4.

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Detailed Description of Specific Embodiments

Referring now to Fig. 1, a heat sink assembly 10 of an embodiment of the present invention is shown. The heat sink assembly 10 is made using a convoluted fin or folded fin 12. The folded fin 12 is a thermally conductive sheet that has been folded into a series of alternating ridges 14 and troughs 16. The folded fin 12 advantageously provides a significant amount of surface area from which air can dissipate heat. The presently preferred folded fin is made from an aluminum sheet .254 mm. thick. The height of the fins forming the ridges 14 and troughs 16 depends on the desired application. The taller the fins the more surface area and thus the greater amount of heat dissipation achieved for a given amount of air flow. Holes of various sizes may be cut in the ridges of the folded fin to provide additional pathways for air movement through heat sink. A preferred method for achieving holes in the ridges of the folded fin is to precut holes in the aluminum sheet before it is folded and then to fold it using an indexing machine to align the holes in the sheet with the ridges of the folded fin.

The folded fin 12 is placed on a thermally conductive base plate 18. In order to improve thermal conductivity in accordance with a presently preferred embodiment, a thermally conductive grease is spread over the base plate 18 for improving the thermal contact with the troughs 16 of the folded fin 10. The base plate 18 is a flat, stiff piece of aluminum sheet in accordance with the presently preferred embodiment. The length of the base plate closely approximates the length of the folded fin to be placed thereon. The width of the base plate extends beyond the folded fin on both sides to accommodate a spring clamp 20 which is used to attach the folded fin 12 to the base plate 18. A pair of notches 22 are formed along one edge of the base plate 18. Along the opposite edge, a pair of substantially longer notches 24 are formed along the edge of the base plate. The spring clamp 20 has feet or tabs 30 for engaging with the notches beneath the edge of the base plate.

The spring clamp 20 includes a series of flexible linkages 40 for pressing a trough 16 against the base plate 18. Each flexible linkage included in the presently preferred embodiment includes an abutment portion for making contact with the trough 16 of the folded fin 12. In the present embodiment, the abutment portion is a flat mid-portion 42. The



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preferred embodiment includes a flexible linkage for each of the troughs in the folded fin. Less demanding heat sink applications may make do with fewer flexible linkage. At opposite ends of each flat mid-portion 42, each flexible linkage includes an angled leg portion 44. The angled leg portions extend up from the flat mid-portion to attach to a cross-bar 46. There are two parallel cross-bars, each on an opposite side of the spring clamp 20. Each cross-bar 46 is connected to all of the flexible linkages. When the spring clamp 20 is connected by its tabs 30 to the base plate 18, the spring clamp applies pressure through the flat mid-portions 42 to the troughs 16 of the folded fin to provide excellent thermal contact with the underlying base plate 18.

Referring now to Fig. 2, the spring clamp 20 is shown in greater detail. The tabs 30 depend from the spring clamp 20. In particular, the tabs 30 depend down from the cross-bar 46. There are four tabs in the presently preferred embodiment of the spring clamp 20. A "tab" is defined as any clamping mechanism formed by a projection or member that may be used to engage beneath an edge of a plate. The invention may also be formed by substituting a clamping mechanism capable of engaging the base plate in ways other than latching beneath an edge such as latching onto other clamp receiving members and corresponding opening added to a base plate. A stem 48 connects the tab 30 to the cross-bar 46. The stem 48 is narrow so that it may move within a correspondingly narrow slot or notch in the base plate or substrate to be cooled. The tab of the embodiment in Fig. 2 is stepped. A first step 52 juts out from the stem 48. The first step 52 extends out from opposite sides of the stem 48. The first steps 52 are wider than the narrow slots. Thus, the first steps 52 butt against an edge of the base plate adjacent a narrow slot. A second step 54 extending beneath each of the first steps permits engagement beneath an edge of the base plate in an area of a wider slot or notch region. A wider slot or notch region is dimensioned so as to permit the first steps 52 to fit therein but to be too narrow to permit the second steps 54 to fit therein. The tabs 30 are further provided with a bent portion 56 at the end of the tab furthest from the cross-bar 46. The bent portion 56 bends inward such that the four bent portions 56 may be used to clamp onto a substrate to be cooled. While bent portions are shown in the present embodiment, any projections capable of grabbing onto a substrate may be substituted for the bent portions. The spring clamp 20 of the presently preferred embodiment is advantageously entirely formed



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from a single piece of resilient metal sheet. Referring now to Fig. 3, a preferred base plate 18 is illustrated. The base plate 18 has clamp receiving openings that are located for accepting a clamp mechanism such as the tabs from the spring clamp 20. The clamp receiving openings are the notch region, discussed above in the present embodiment. Each of the notches includes a wide slot and a narrow slot. The wide slots fit a stem 48 or a first step 52 but not a second step 54. The narrow slots are only wide enough for the stems 48 to fit therein. Along one edge of the base plate 18, the short notches 22 each include a wide slot portion 62 which leads to a narrow slot portion 64. Along the opposite edge of the base plate, the long slots 24 each include a wide slot region 66 and a narrow slot 68. The narrow slot 68 is substantially longer than the narrow slot 64 found on the opposite side of the base plate. In assembling the heat sink assembly, the long narrow slot 68 accommodates the stems 48 on one side of the spring 20 to be inserted therein and slide along those long slots 68. Thus, the tabs 30 on the opposite side of the spring 20 can be lowered beneath the base plate beyond the edge of the base plate. The tabs 30 are brought into position against the slots 22 and the cross-bars 46 are pushed on to force the tabs 30 toward the base plate until the wide second steps 54 engage the edge of the base plate beneath the wide slot 62. On the opposite side of the base plate 18, the tabs 30 are to be pushed outwards moving their stems 48 through the narrow slot 68 until the first steps 52 fall into the wide slot 66 and the second steps 54 engage beneath the base plate 18. Thus, all four tabs will be in engagement beneath the base plate holding the folded fin against the base plate. All the tabs will have their second step 54 engaged beneath an edge of the base plate and their first step 52 will butt against the base plate edge adjacent the narrow slot. Opposing tabs are, thus, forced apart from the relaxed position of the spring clamp 20. This provides a heat sink assembly that can be shipped. The heat sink assembly is ready for placement against a flat substrate to be cooled.

The heat sink assembly of the illustrated embodiment is particularly suited for operation with a Pentium II microprocessor chip manufactured by Intel. The Pentium II has a thermal plate on which a heat sink may be attached. The thermal plate has a number of oval slots. With the four tabs 30 engaged in their wide slots, they are positioned so that the heat sink 10 may be placed on the Pentium II thermal plate with the tabs dropping into the slots of the thermal plate. With the heat sink in place on the thermal plate, it is a simple matter to



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push down on both cross-bars 46 to attach the heat sink to the thermal plate. In the preinstallation condition, all of the tabs 30 are in their wide slots. In the short slots 22, the tabs are held in wide slot 62. In the long slots 24, the tabs are held in the wide slots 66. Thus, for all of the tabs 30, the step between the wide slot and the narrow slot in the base plate prevents the tabs from compressing closer to each other. Thus, during the simple process of pressing the two cross-bars 46 down towards the base plate, the tabs 30 are pushed below the base plate into the thermal plate slots. When the first steps 52 are pushed below the base plate 18, the stems 48 are free to move within the narrow slots towards one another. The tabs are held apart by the bent portions 56 against the edge walls of the slots in the thermal plate. The tabs are pushed down until the bent portions 56 fit beneath the slot edges in the thermal plate. The resilience of the spring then urges the tabs to spring back toward their opposing tab. Thus, the bent portions 56 of the tabs snap onto the thermal plate firmly attaching the heat sink assembly thereto. Thus, the simple movement of the cross-bars down causes the tabs 30 to move down so that the tabs 30 may catch beneath the thermal plate of the Pentium II. Moreover, with the tabs forced down by the bent portions 56 being extended below the thermal plate, the tension on the spring clamp 20 provides significant pressure against the troughs of the folded fin against the base plate 18. The dimensions of the spring clamp 20 and base plate 18 are such that with the tabs attached to a Pentium II thermal plate, in accordance with a presently preferred embodiment, the force may be about 30 lbs. of pressure between the base plate 18 and the thermal plate. The thermal contact between the base plate 18 and the thermal plate can be further enhanced by applying a layer of thermally conductive grease to the underside of the base plate 18. In the presently preferred embodiment, a non-silicon based grease is used. The heat sink assembly as described herein advantageously permits clamping of a folded fin to a base plate and attachment of the heat sink assembly to a substrate to be cooled using the same action of pushing the cross-bars 46 towards the base plate of the heat sink assembly. The spring clamp 20 performs both the function of clamping the folded fin to the base plate and clamping the heat sink assembly to a substrate to be cooled.

While the heat sink assembly 10 is highly efficient for its size at dissipating heat, nevertheless microprocessors such as the Pentium 11 generate a tremendous amount of heat



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such that an air flow will be required through the folded fin to obtain sufficient cooling. The air flow may be provided by a fan in the chassis of the computer or it may be provided by a fan dedicated to the microprocessor. A particular microprocessor fan with shroud assembly of an embodiment of the present invention is illustrated in Figs. 4 and 5. The cooling fan assembly 100 includes a housing 110. An air moving device, preferably a fan 120, is mounted on top of the housing 110. An opening 114 in the housing accommodates the fan 120. The fan 120 blows into a chamber formed by the housing 110. The fan 120 directs air perpendicular to the base plate 18. The chamber is bordered by a right sidewall 116, a left sidewall 117 and a front sidewall 118. The cooling assembly 100 mounts on a plastic heat sink support 130 on the motherboard to complete the air chamber.

In accordance with an embodiment of the invention, a baffle 140 extends from front sidewall into the chamber obstructing air flow from the fan 120. The baffle extends from the left sidewall to the right sidewall. In the preferred embodiment, the baffle 140 extends about half way across the chamber. Thus, a portion of the air blown from the fan 120 is directly blocked by the baffle 140. The baffled housing thus directs air from the fan around the baffle and into the channels formed by the folded fin. By using the baffle 140 to redirect the air into the channels, improved cooling efficiency is achieved. The baffle 140 also protects the air moving in the channels behind the baffle from turbulence or interference by air blown from the fan. Thus, air movement through the channels is improved. The cooling fan assembly 100 may be likewise useful with other heat sinks formed with a plurality of parallel channels. Such channels may be formed as in the prior art from an extruded metal heat sink.

Air moved through the channels of the heat sinks will exit behind the baffle 140 near the front sidewall 118. It is additionally useful to provide a hood 150 extending out from the front sidewall and projecting beyond the baffle 140 so as to deflect air exiting from the heat sink. The object of the hood 150 is to discourage air from recirculating back through the fan 120 into the heat sink. If desired, the hood 150 may be pivotally attached to the housing so that its angle deflection may be adjustable. The housing 110 is provided with feet 160 that snap into place against a processor retention mechanism. The housing 110 may be made from a plastic material. The presently preferred fan is a 3300 RPM Hypro bearing fan.

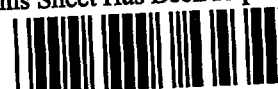
Of course, it should be understood that various changes and modifications to the



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preferred embodiments described above will be apparent to those skilled in the art. For example, the shapes of the flexible linkages and tabs on the spring clamp may be varied and yet still permit the functions of clamping and attachment as described herein. Tab and notch location may also be changed to accommodate the varying needs of the substrates to be cooled. These and other changes can be made without departing from the spirit and scope of the invention and without diminishing its attendant advantages. It is, therefore, intended that such changes and modifications be covered by the following claims.

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CLAIMS:

1. A method for assembling a heat sink comprising:

providing a thermally conductive sheet (12) folded into at least one set of alternating ridges (14) and troughs (16);

5 placing the folded sheet (12) on top of a thermally conductive plate (18);

placing a spring (20) having a plurality of parallel linkages (40) over the folded sheet (12) so that each linkage (40) fits into one of the troughs (16); and

10 applying pressure to the spring (20) so as to hook a tab (30) depending from the spring engagement beneath the plate (18) to form a heat sink assembly (10) wherein the folded sheet (12) is clamped to the plate (18) with the linkages (40) pressing the troughs (16) against the plate (18).

2. The method of claim 1 further comprising placing the heat sink assembly (10)

15 on a substrate to be cooled and applying pressure to the spring (20) so as to hook the tab (30) onto the substrate to hold the thermally conductive plate (18) against the substrate.

3. A method for assembling a heat sink comprising:

20 placing a folded fin (12) which has a plurality of alternating ridges (14) and troughs (16) on top of a thermally conductive plate (18) which has a clamp receiving opening (22, 24);

placing a spring (20) which has a plurality of flexible linkages (40) and a clamp mechanism (30) over the folded fin (12) such that the plurality of flexible linkages (40) fit into the troughs (16) of the folded fin (12);

25 applying pressure on top of the spring (20) to push the clamp mechanism (30) into the clamp receiving opening (22, 24) so that the clamp mechanism (30) engages the thermally conductive plate to hold the folded fin (12) against the thermally conductive plate (18).

4. The method of claim 3 wherein the clamp receiving opening is a notch (22, 24) in an edge of the thermally conductive plate.

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5. The method of claim 3 wherein the clamp mechanism is a plurality of stepped tabs (30) each connected to the spring (20) by a stem (48).

6. A folded fin heat sink comprising:

a folded fin (12) having a plurality of alternating ridges (14) and troughs (16);

a thermally conductive base plate (18); and

a spring (20) having a plurality of flexible linkages (40) and an attachment mechanism in engagement with said base plate, each of the flexible linkages being pressed against one of the troughs (16) of said folded fin (12).

7. The folded fin heat sink of claim 6 wherein said attachment mechanism comprises a tab (30) that latches beneath an edge of said plate (18).

8. The folded fin heat sink of claim 7 wherein the tab is connected to the spring (20) by a stem (48) and a step (54) and said base plate includes at least one notch (22, 24) along an edge with a wide slot portion (62) wide enough to accommodate the step and a narrow slot portion (64) wide enough for the stem (48) but not for the step (54).

9. The folded fin heat sink of claim 6 wherein each flexible linkage (40) comprises a flat midportion (42) for making contact with the trough (16) of said folded fin (12) and an angled leg portion (44) at both ends of the midportion (42), each angled leg portion (44) extending up from the said portion to a crossbar (46) connected to all of the flexible linkages (40).



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10. The heat sink of claim 6 further comprising an air moving device (120) above said folded fin (12) and oriented to blow air in a direction down into the troughs (16), a chamber (110) around said folded fin (12) and a baffle (140) between said air moving device (120) and said folded fin (12) and extending over said plurality of ridges (14) and troughs (16) so that air from said air moving device (120) is directed into said folded fin (12) where said folded fin is unobstructed by said baffle (140) and along the ridges (14) and troughs (16) of said folded fin (12) behind said baffle (140).

11. An active heat sink comprising:

a thermally conductive heat sink assembly having a flat surface (18) for making thermal contact with a heat generating device and having a series of parallel channels formed by ridges (14) and troughs (16) for directing air flow along said assembly (100);

a housing (110) forming a chamber around the parallel channels of said heat sink assembly (100);

an air moving device (120) mounted in an opening (114) in said housing (110) and oriented to direct air at said heat sink assembly; and

a baffle (140) between said air moving device (120) and said heat sink assembly and extending over said series of channels so that air from said air moving device (120) is directed into said heat sink assembly where said assembly is unobstructed by said baffle (140) and along the channels of said heat sink assembly behind said baffle (140).

12. The heat sink of claim 11 wherein said air moving device (120) is oriented to direct air perpendicular to the flat surface of said heat sink assembly (100).

13. The active heat sink of claim 11 further comprising a hood (150) extending across the series of channels to deflect exiting air from the series of channels away from said air moving device (120) to discourage recirculation of the exiting air back into the heat sink assembly (100).



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14. An electronic device cooling fan assembly comprising:

a housing (110) having a top with an opening therein, a left sidewall (117), a right sidewall (116) and a front sidewall (118) extending from the top and the left and right sidewalls so as to form a chamber;

5 an air moving device (120) mounted onto said housing (110) for moving air through the opening; and

a baffle (140) extending from the front sidewall (118) of the housing (110) and across from the left sidewall (117) to the right sidewall (118), said baffle (140) being directly in the path of a portion of the air from said air moving device (120) so as to block off a portion of
10 the chamber.

15 15. The cooling fan assembly of claim 14 further comprising a hood (150) extending out from the front sidewall (118) of said housing (110) and projecting beyond said baffle (140) so as to deflect air from behind said baffle (140) away from the air moving device (120).

16. The cooling fan assembly of claim 15 wherein said hood (150) is pivotally attached to said housing (110).

20 17. A heat sink comprising:

a thermally conductive sheet (12) folded into at least one set of alternating ridges (14) and troughs (16), said sheet having a bottom formed by at least one of the troughs (16):

a thermally conductive plate (18); and

25 a clamp mechanism (20) including an abutment portion (40) for pushing said folded thermally conductive sheet against said plate (18), a tab (30) for latching beneath an edge of said plate (18) and means for clamping (30) the plate onto a substrate to be cooled.



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18. A method for assembling a heat sink comprising:

folding a thermally conductive sheet (12) to form alternating ridges (14) on top and
troughs (16) on bottom;

5 placing a clamp mechanism (20) on top of said folded thermally conductive sheet
(12);

clamping said folded thermally conductive sheet (12) to a thermally conductive plate
(18) to force the bottom of said folded thermally conductive sheet (12) against the thermally
conductive plate (18) and form a clamped heat sink assembly; and

10 attaching the clamped heat sink assembly to a substrate to be cooled with the plate
(18) in contact with the substrate.

19. A method for assembling a heat sink comprising:

folding a thermally conductive sheet (12) to form alternating ridges (14) on top and
troughs (16) on bottom;

15 placing a resilient clamp member (20) on said folded thermally conductive sheet (12);
forcing a tab (20) depending from said resilient clamp member (20) into engagement
beneath an edge of a thermally conductive plate (18) to hold the bottom of said folded
thermally conductive sheet (12) clamped against the thermally conductive plate (18) and form
a clamped heat sink assembly; and

20 attaching the clamped heat sink assembly to a substrate to be cooled with the plate in
contact with the substrate.



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