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ANZAI(10) **Pub. No.: US 2011/0100604 A1**(43) **Pub. Date: May 5, 2011**(54) **HEAT RADIATING DEVICE AND
MANUFACTURING METHOD OF HEAT
RADIATING DEVICE****Publication Classification**

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(52) **U.S. Cl.** **165/104.21**; 165/181; 29/890.032
(57) **ABSTRACT**

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Kawasaki-shi (JP)(21) Appl. No.: **12/914,987**(22) Filed: **Oct. 28, 2010**(30) **Foreign Application Priority Data**

Oct. 30, 2009 (JP) 2009-249729

A heat radiating device for radiating heat of a circuit, includes a heat pipe which has a first straight portion and a second straight portion parallel with the first straight portion, and a curved portion connected to the first and second straight portions, a first base which is in contact with the circuit and is joined at a first surface thereof opposite to a surface thereof facing the circuit, to the first straight portion; a plurality of first fins which are provided on the first surface, have flat surfaces perpendicular to the first straight portion, and cross the second straight portion; a second base which has a second surface perpendicular to the first base and the first straight portion and is joined to the first heat pipe; and a plurality of second fins which are provided on the second surface and extend to a direction perpendicular to the second surface.

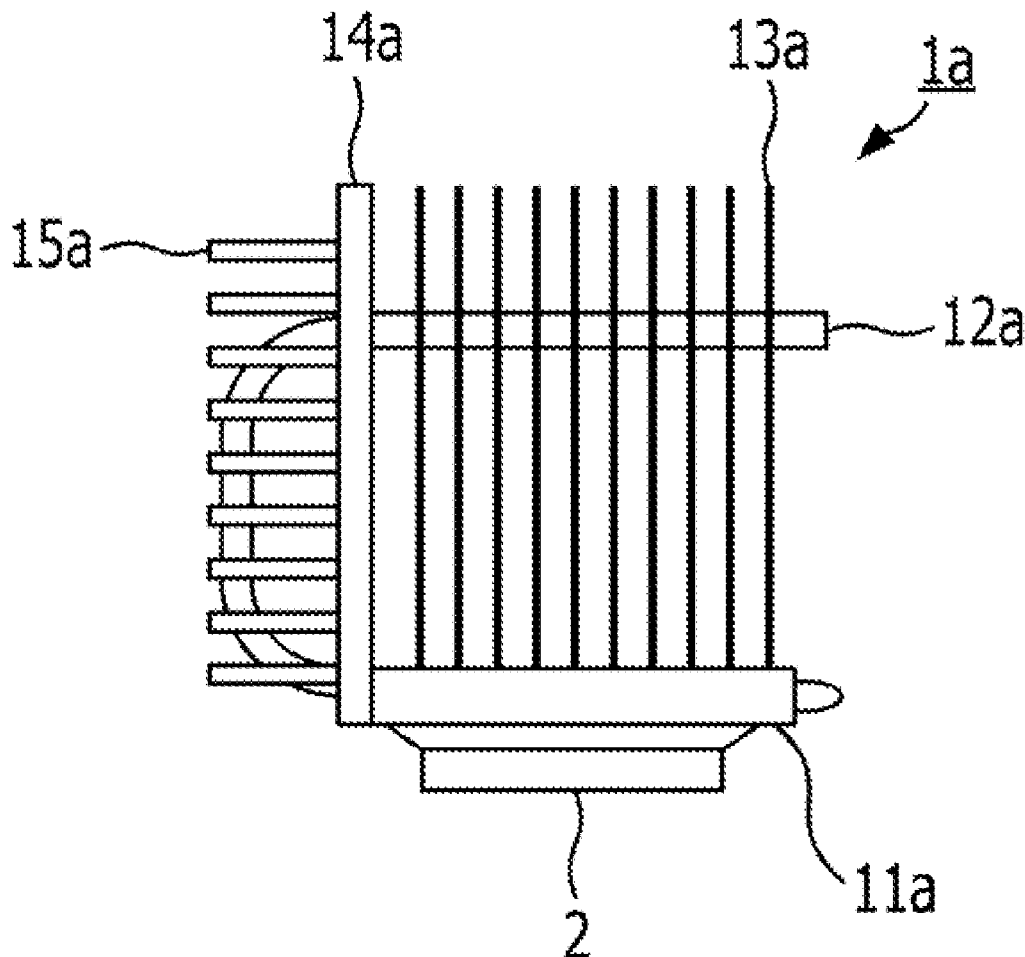


FIG. 1

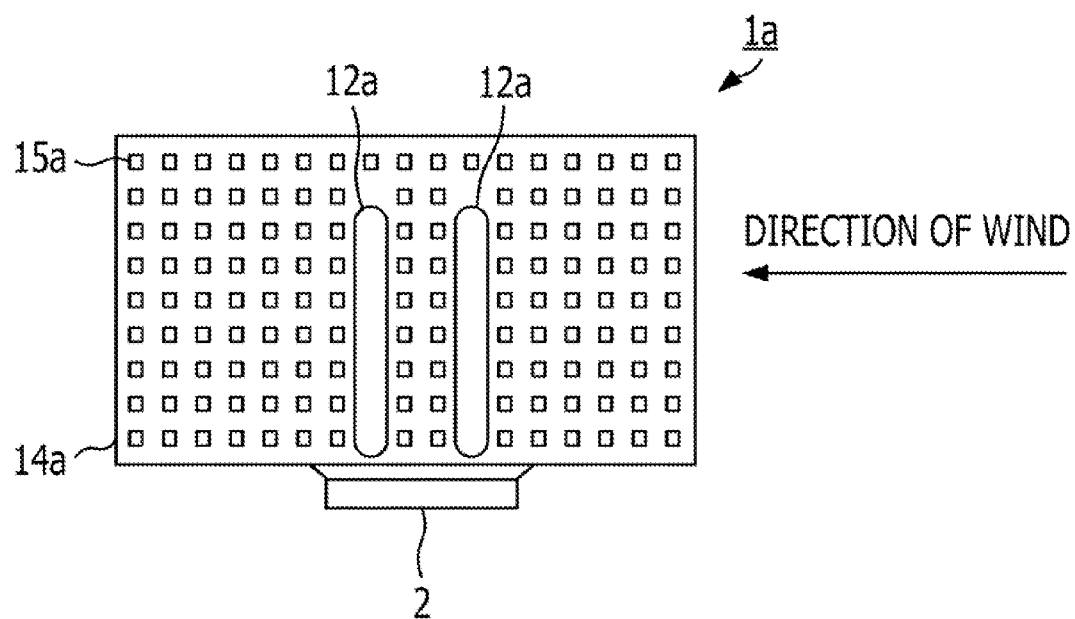


FIG. 2

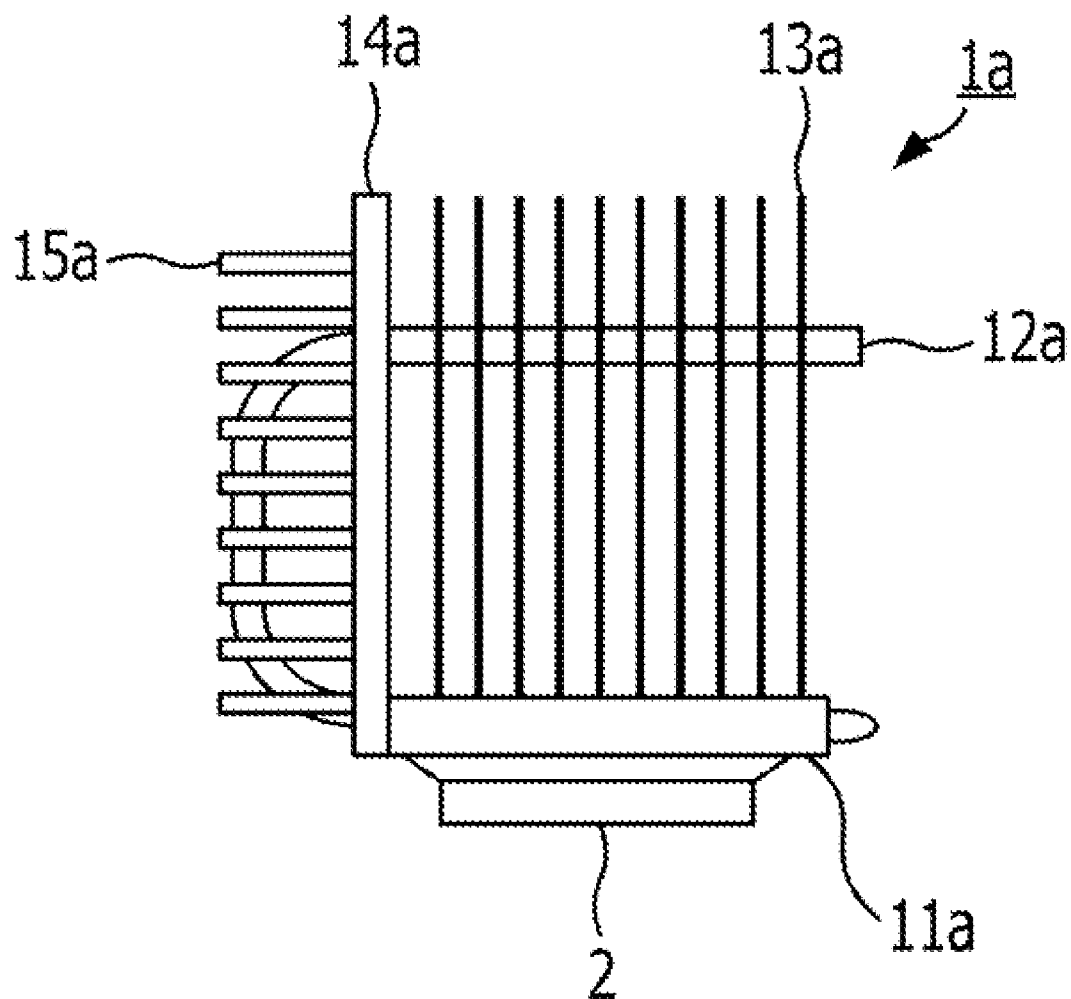


FIG. 3

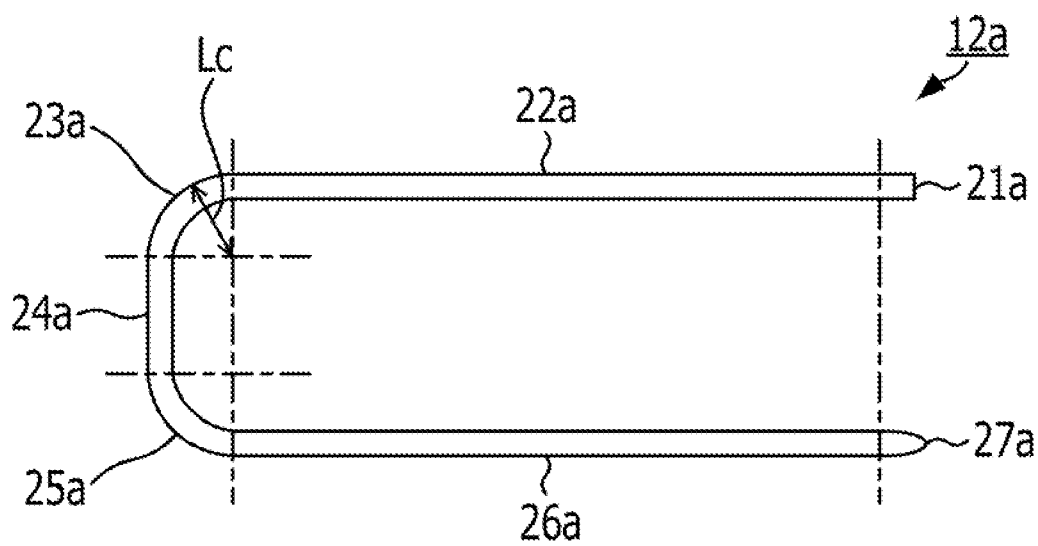


FIG. 4

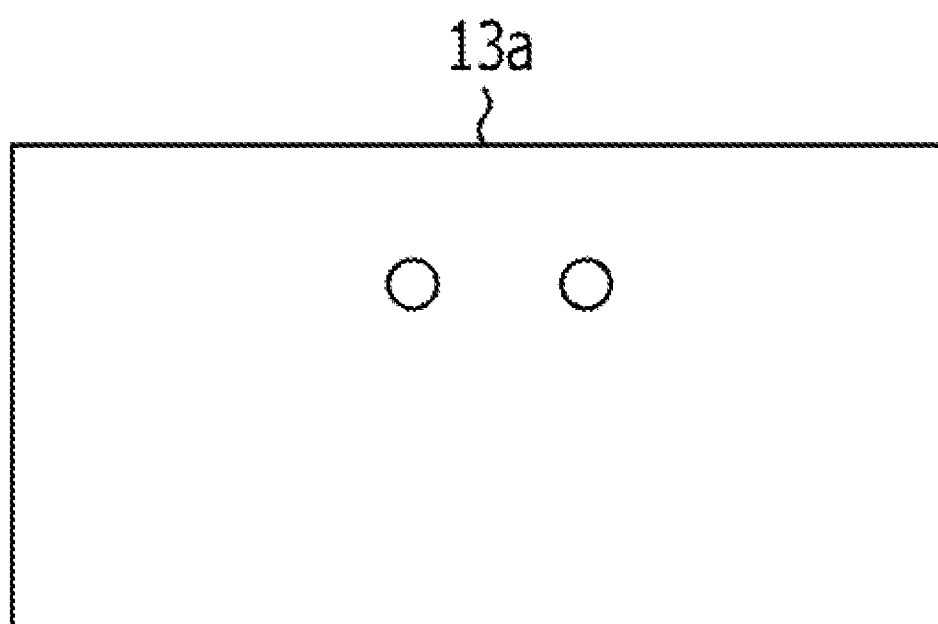


FIG. 5

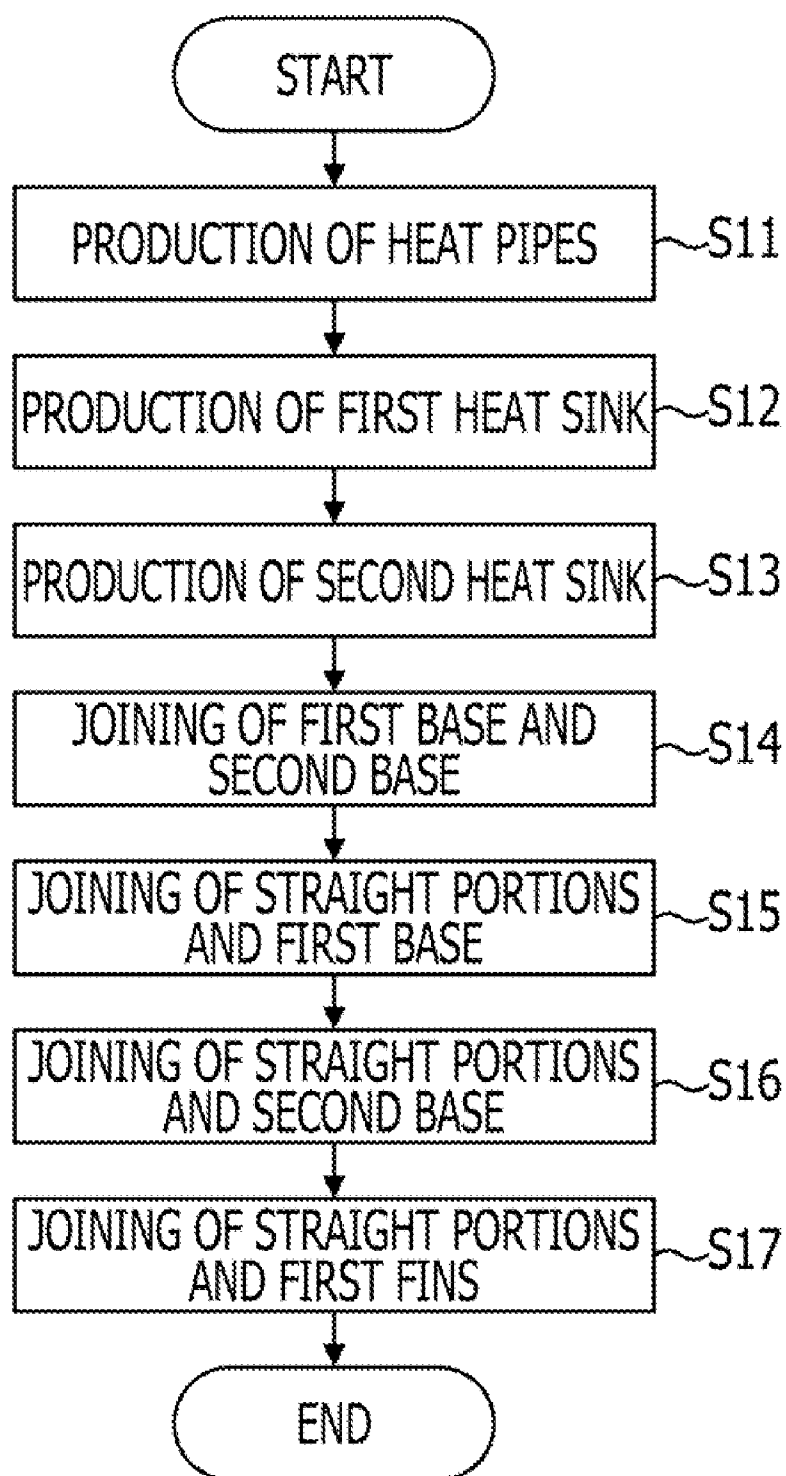


FIG. 6

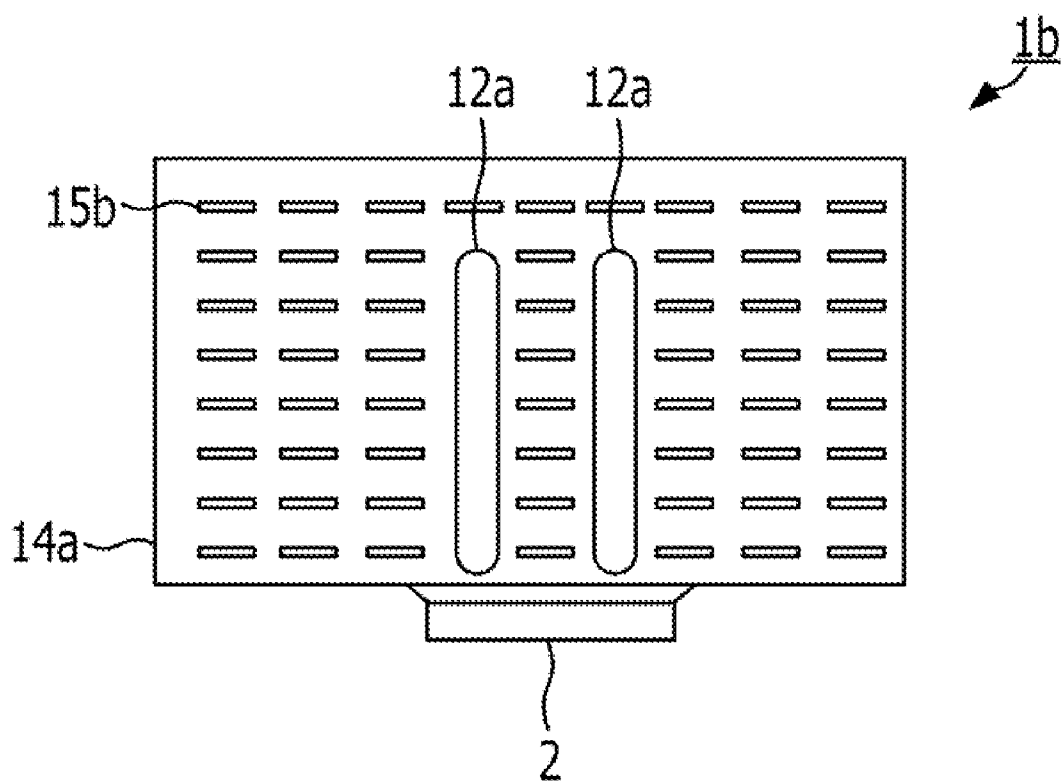


FIG. 7

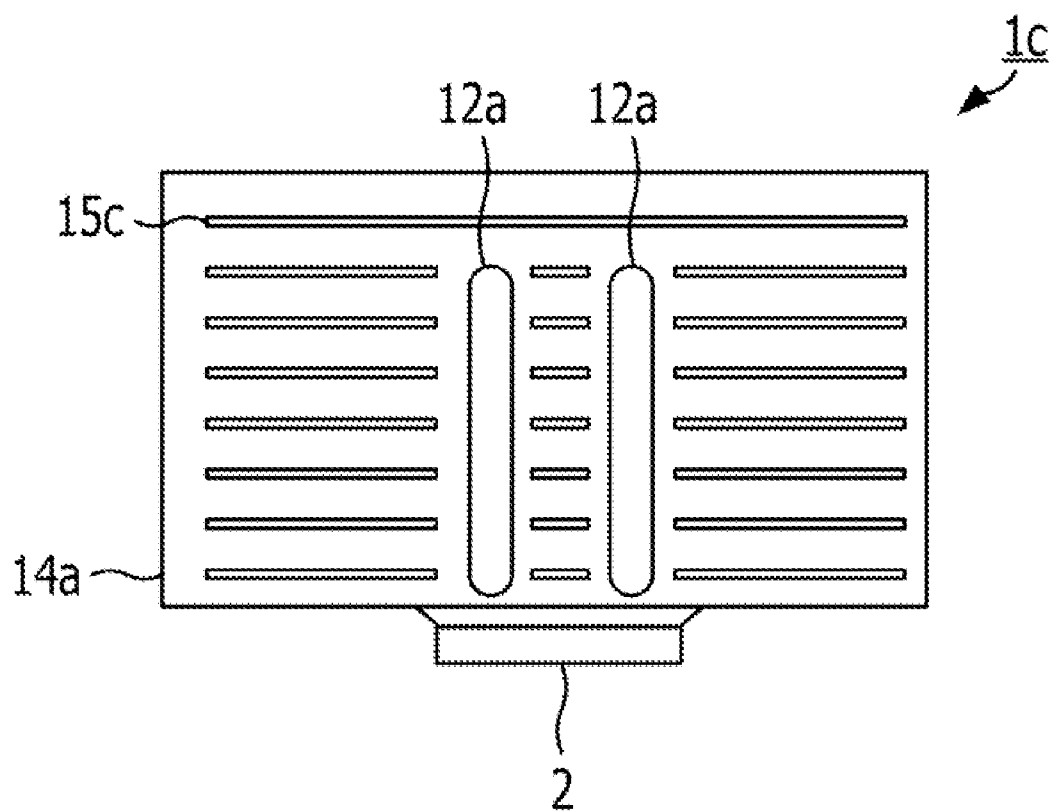


FIG. 8

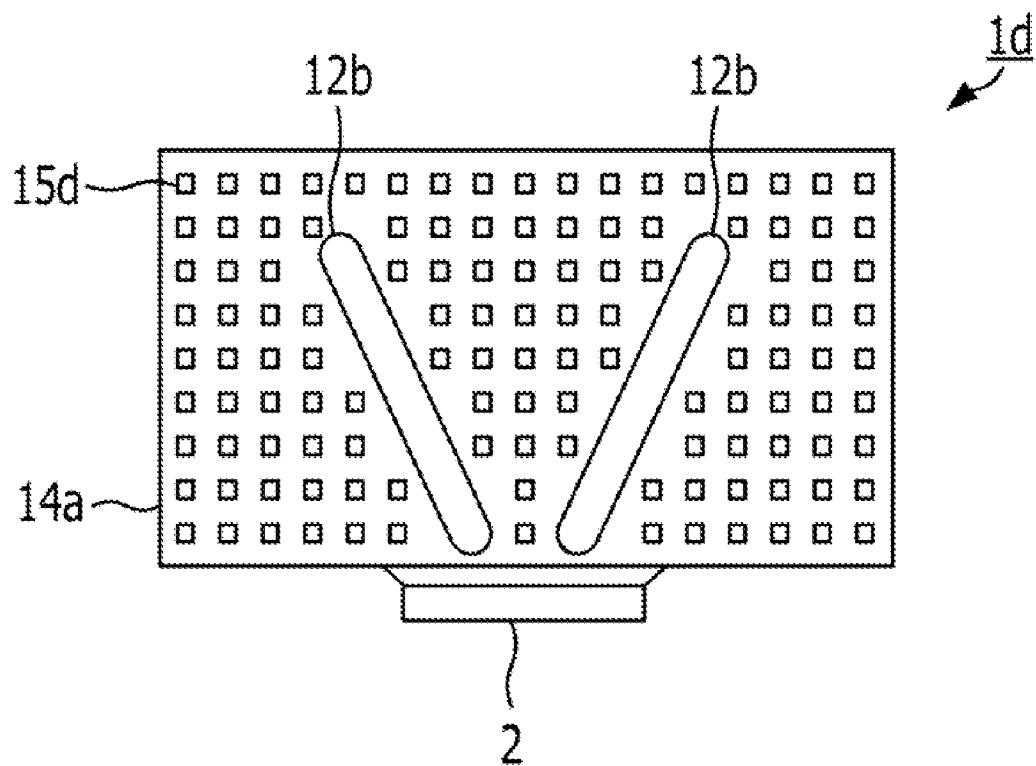


FIG. 9

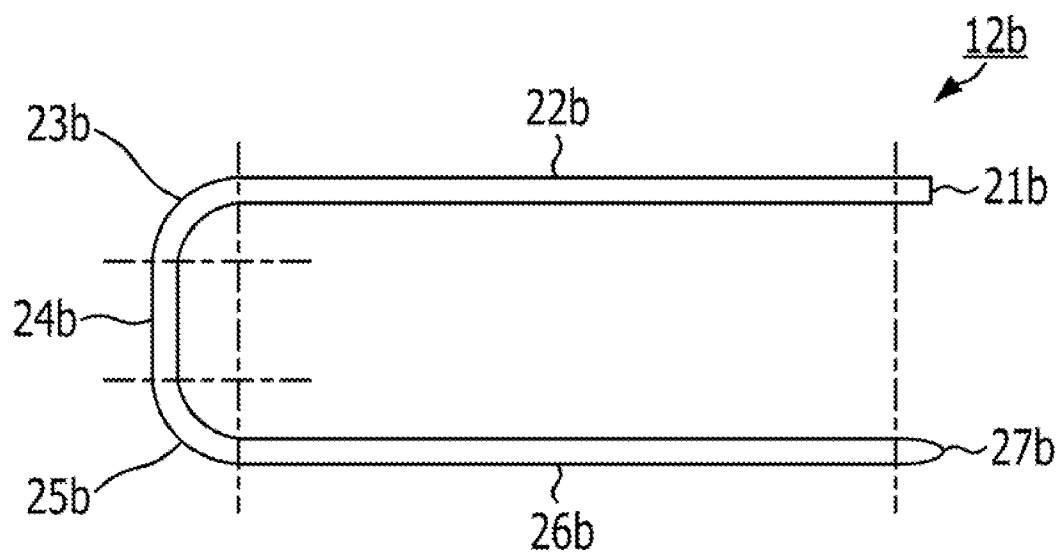


FIG. 10

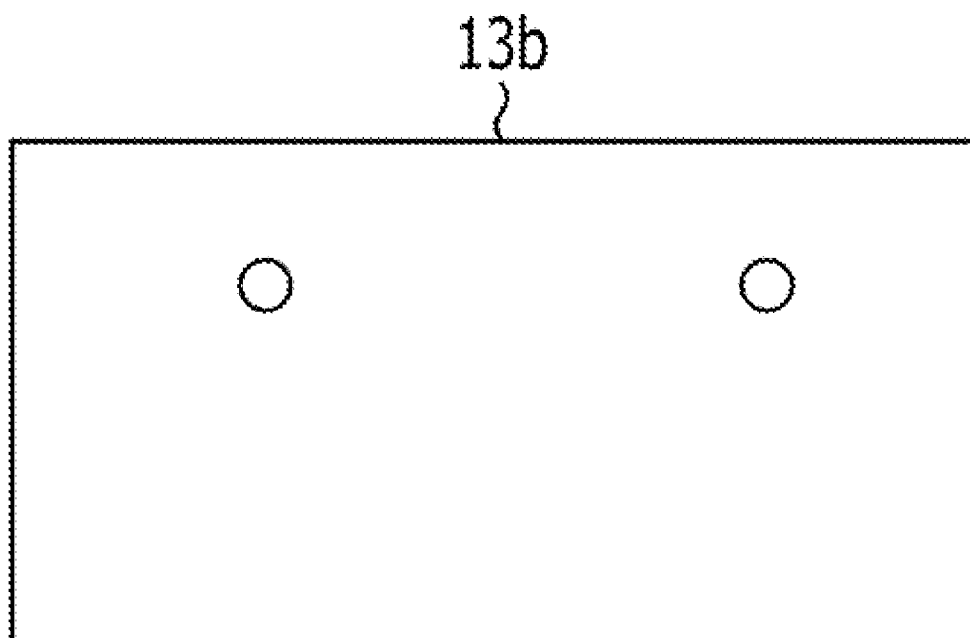


FIG. 11

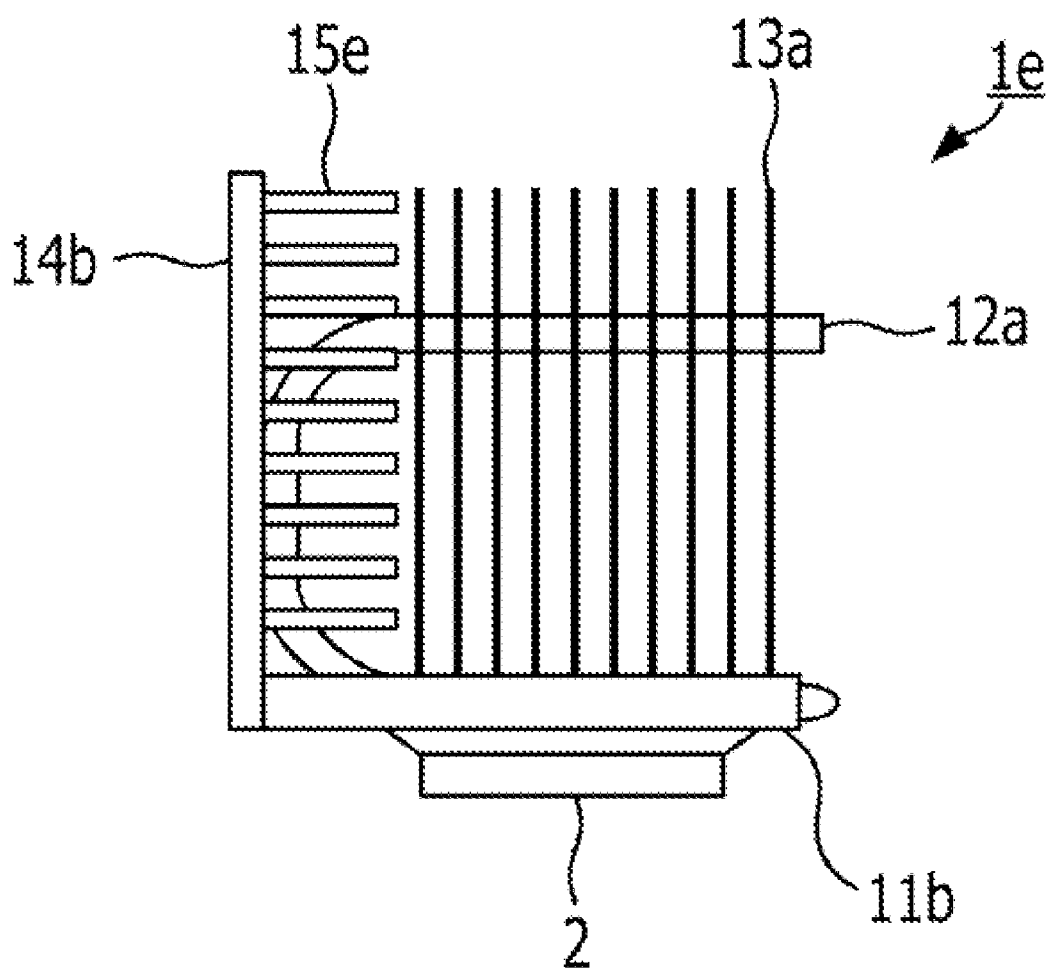


FIG. 12

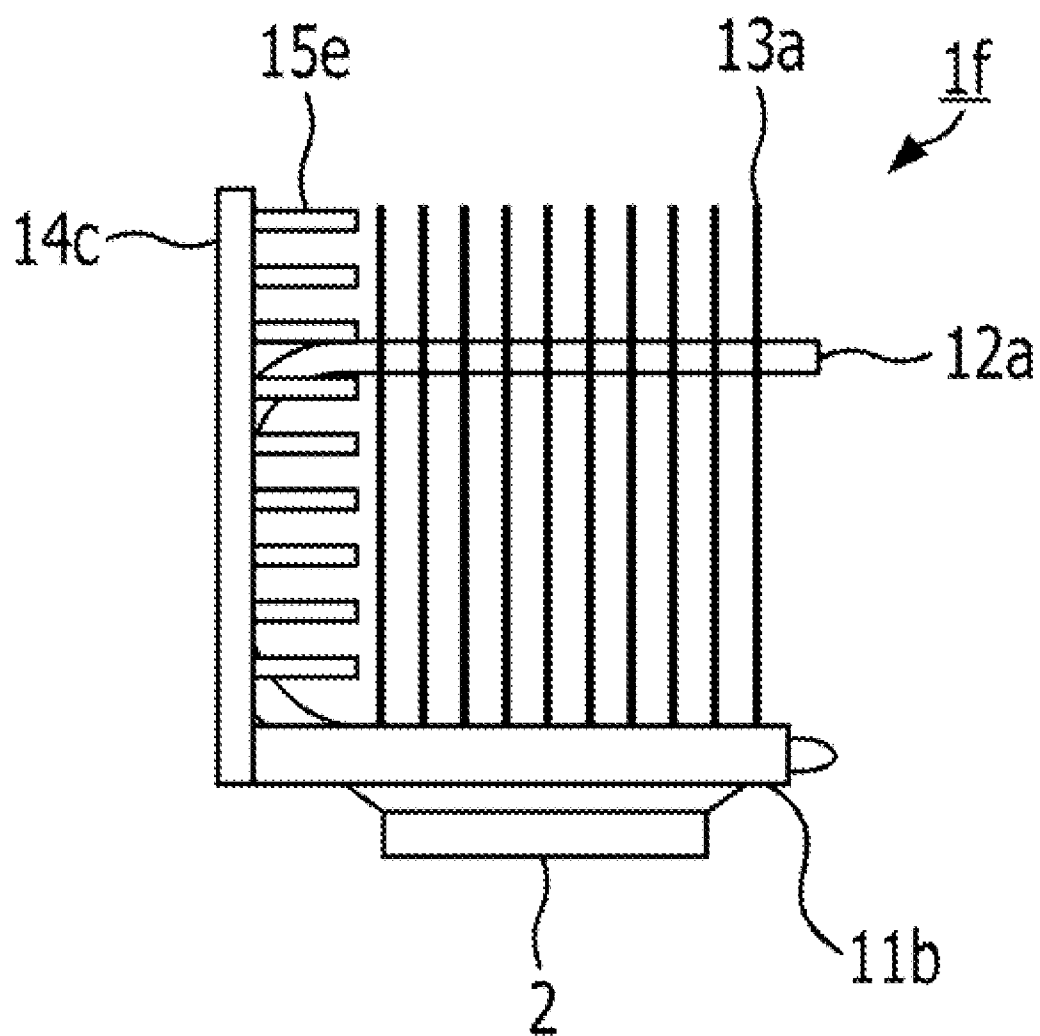


FIG. 13

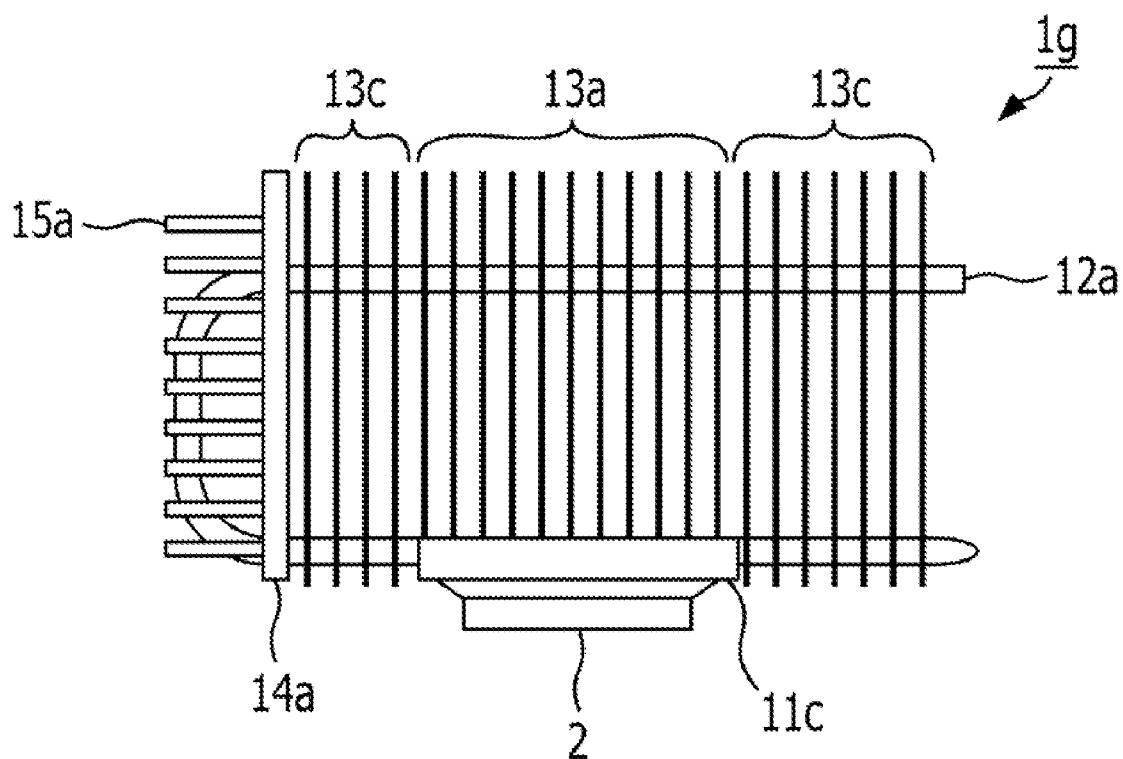


FIG. 14

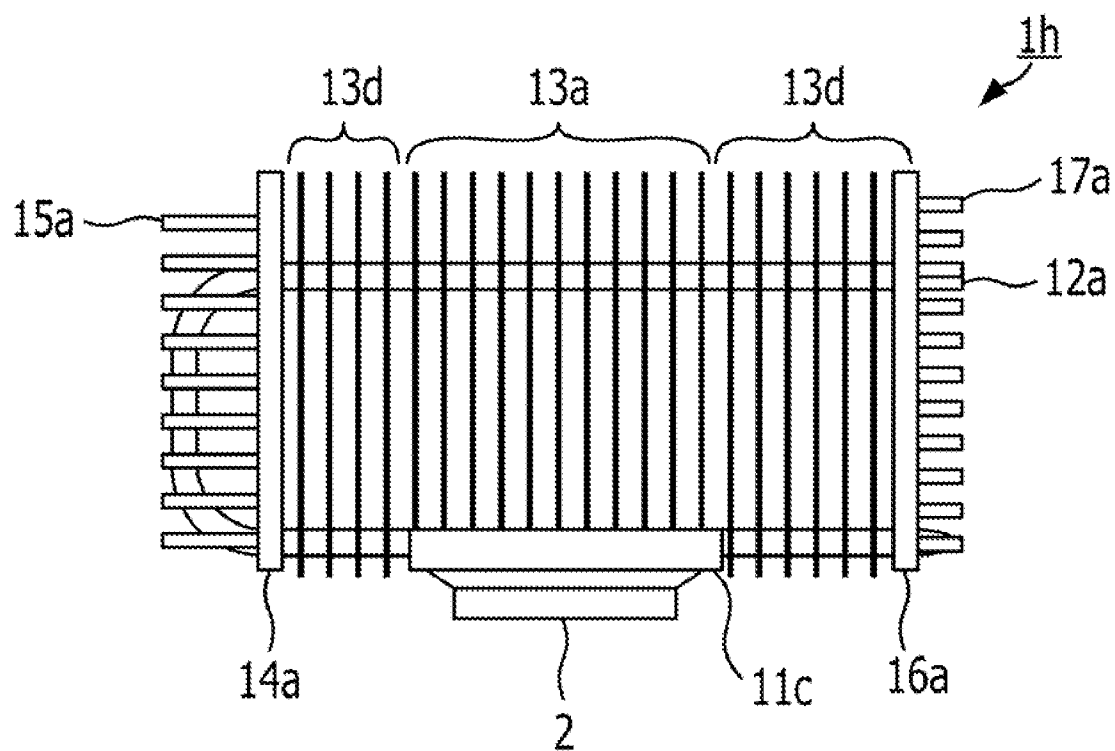


FIG. 15

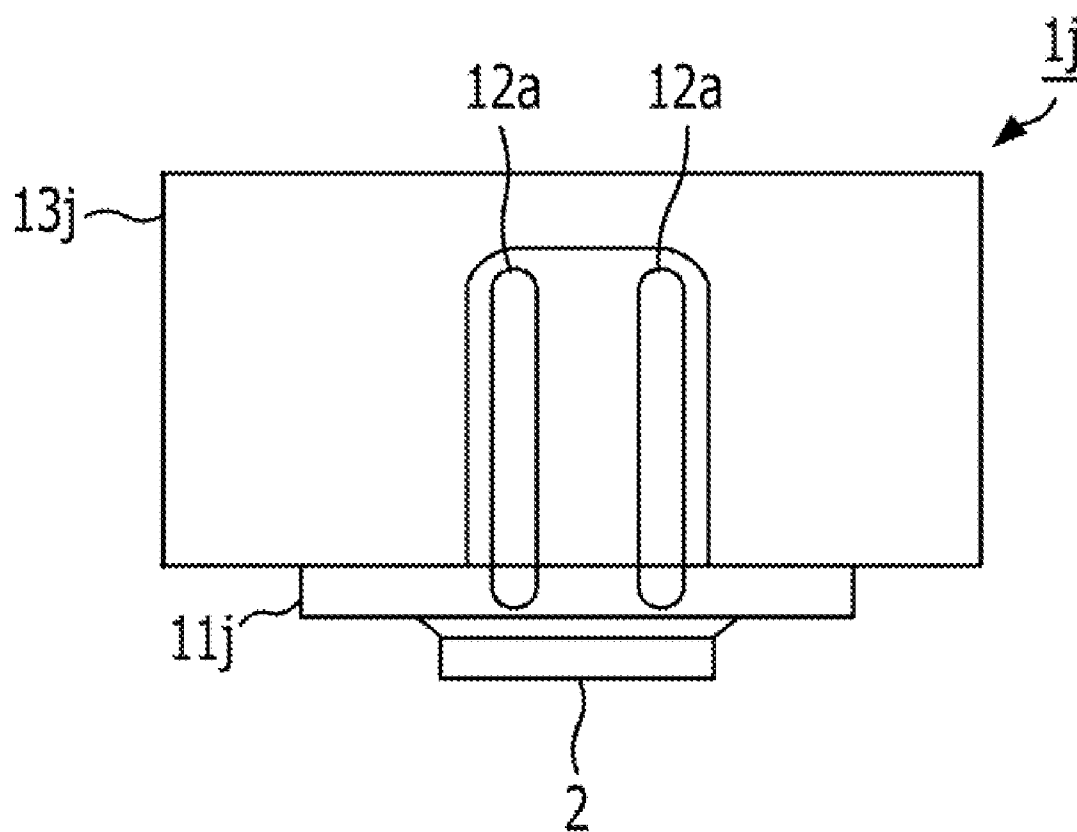


FIG. 16

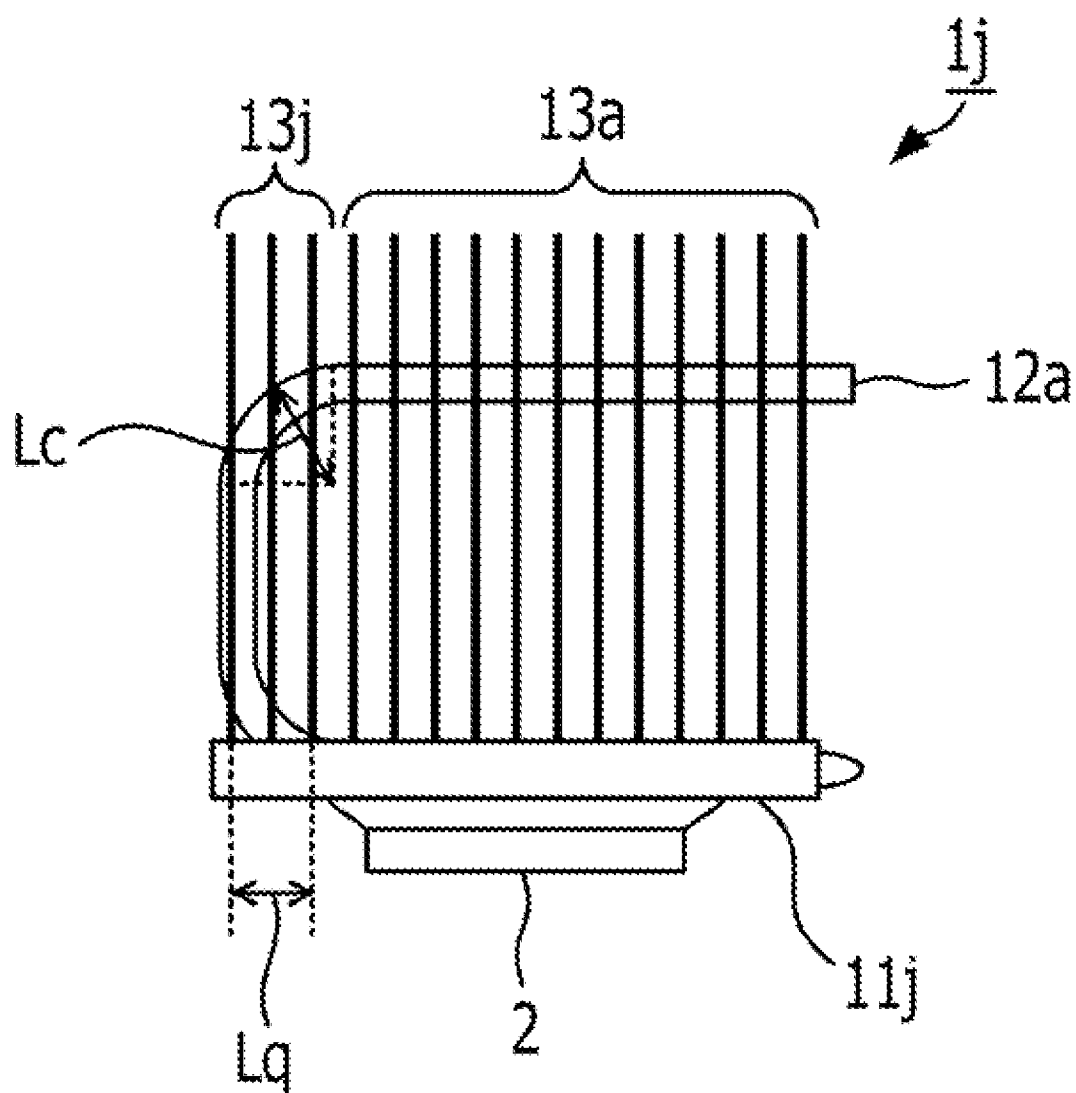


FIG. 17

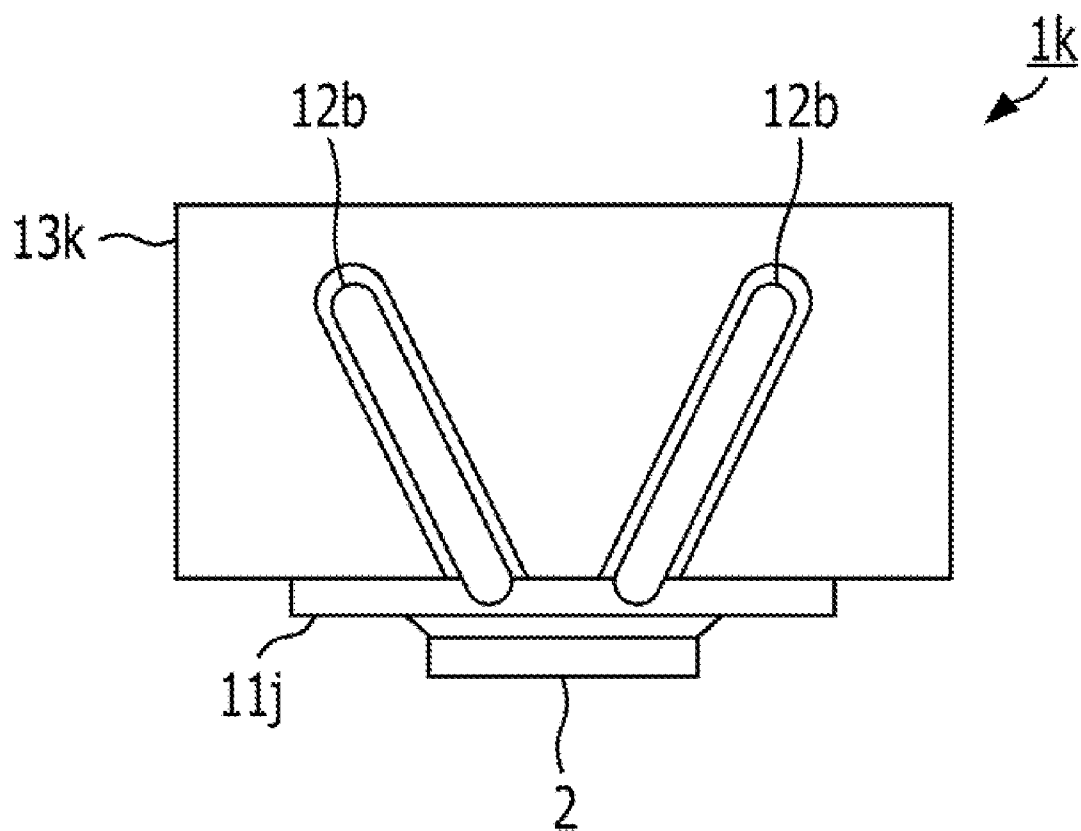
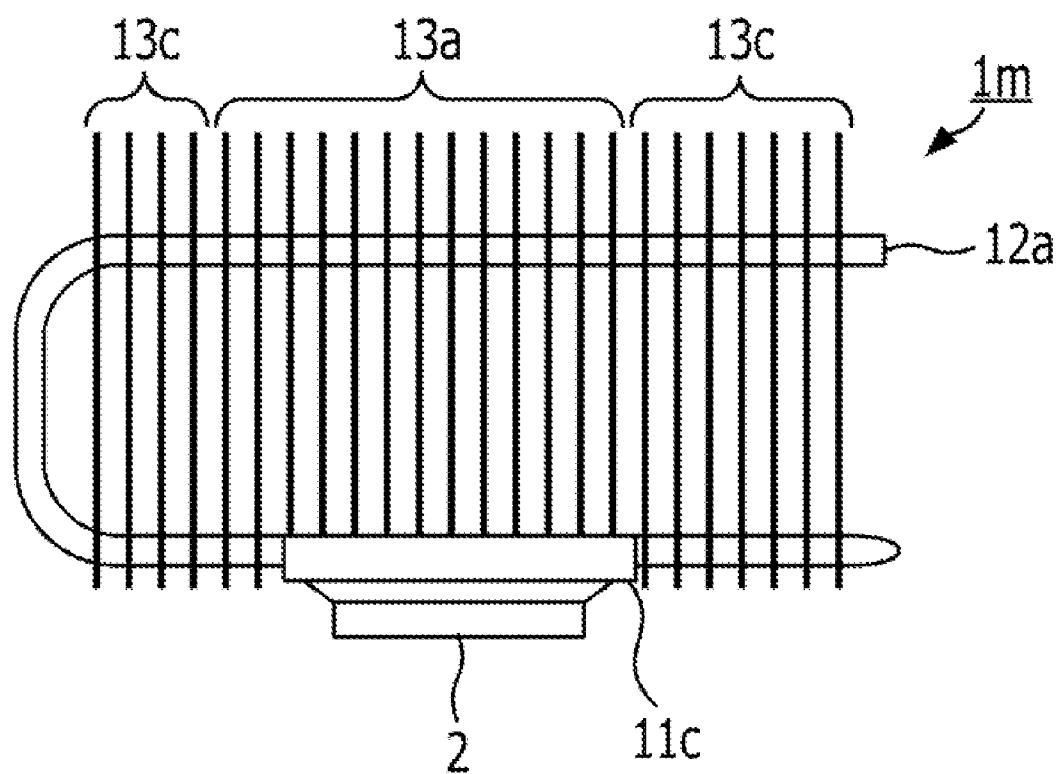


FIG. 18



HEAT RADIATING DEVICE AND MANUFACTURING METHOD OF HEAT RADIATING DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2009-249729 filed on Oct. 30, 2009, the entire contents of which are incorporated herein by reference.

FIELD

[0002] The invention relates to a heat radiating device for radiating heat of a circuit and a manufacturing method of the heat radiating device.

BACKGROUND

[0003] An existing heat radiating device will be described, which includes: a heat sink having a plurality of plate-shaped fins; and a substantially U-shaped heat pipe. The substantially U-shaped heat pipe has a straight portion and a curved portion, and the plurality of fins are provided so as to cross the straight portion.

[0004] Thus, the portion of each fin which crosses the heat pipe has a hole for the heat pipe to extend therethrough (see, for example, Japanese Laid-open Patent Publication Nos. 10-107192 and 2004-273632).

[0005] As a related art, a heat radiating device is known, in which a plurality of fins are further provided near the curved portion and each have a notch so that the fin avoids interference with the curved portion (see, for example, Japanese Laid-open Patent Publication No. 11-351769).

SUMMARY

[0006] According to an embodiment, a heat radiating device for radiating heat of a circuit, includes a heat pipe which has a first straight portion and a second straight portion parallel with the first straight portion, and a curved portion connected to the first and second straight portions, a first base which is in contact with the circuit and is joined at a first surface thereof opposite to a surface thereof facing the circuit, to the first straight portion; a plurality of first fins which are provided on the first surface, have flat surfaces perpendicular to the first straight portion, and cross the second straight portion; a second base which has a second surface perpendicular to the first base and the first straight portion and is joined to the first heat pipe; and a plurality of second fins which are provided on the second surface and extend to a direction perpendicular to the second surface.

[0007] The object and advantages of the invention will be realized and achieved by means of the elements and combinations particularly pointed out in the claims.

[0008] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 is a front view of a heat radiating device according to a first embodiment;

[0010] FIG. 2 is a right side view of the heat radiating device according to the first embodiment;

[0011] FIG. 3 is a right side view of a heat pipe;

[0012] FIG. 4 is a front view of a plate fin according to the first embodiment;

[0013] FIG. 5 is a flowchart of a manufacturing method of the heat radiating device according to the first embodiment;

[0014] FIG. 6 is a front view of a heat radiating device according to a second embodiment;

[0015] FIG. 7 is a front view of a heat radiating device according to a third embodiment;

[0016] FIG. 8 is a right side view of a heat radiating device according to a fourth embodiment;

[0017] FIG. 9 is a right side view of a heat pipe according to the fourth embodiment;

[0018] FIG. 10 is a front view of a first fin according to the fourth embodiment;

[0019] FIG. 11 is a right side view of a heat radiating device according to a fifth embodiment;

[0020] FIG. 12 is a right side view of a heat radiating device according to a sixth embodiment;

[0021] FIG. 13 is a right side view of a heat radiating device according to a seventh embodiment;

[0022] FIG. 14 is a right side view of a heat radiating device according to an eighth embodiment;

[0023] FIG. 15 is a front view of a heat radiating device according to a comparative example 1;

[0024] FIG. 16 is a right side view of the heat radiating device according to the comparative example 1;

[0025] FIG. 17 is a front view of a heat radiating device according to a comparative example 3; and

[0026] FIG. 18 is a right side view of a heat radiating device according to a comparative example 4.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[0027] Hereinafter, embodiments of the invention will be described with reference to the drawings.

First Embodiment

[0028] Hereinafter, a first embodiment of the invention will be described.

[0029] FIG. 1 is a front view of a heat radiating device 1a according to the first embodiment. FIG. 2 is a right side view of the heat radiating device 1a according to the first embodiment. The heat radiating device 1a includes a first base 11a, two heat pipes 12a, a plurality of first fins 13a, a second base 14a, and a plurality of second fins 15a.

[0030] The first base 11a and the plurality of first fins 13a constitute a first heat sink. The second base 14a and the plurality of second fins 15a constitute a second heat sink.

[0031] An arrow in the front view of the heat radiating device 1a indicates the direction of a wind sent from the outside to the heat radiating device 1a for cooling. The direction of the wind is from right to left. Note that the direction of the wind may be from left to right. Here, the left in the right side view of the heat radiating device 1a is defined as a front of the heat radiating device 1a, and the right in the right side view of the heat radiating device 1a is defined as a rear of the heat radiating device 1a.

[0032] The heat radiating device 1a is provided on a package 2. The package 2 is a circuit, and is, for example, an LSI (Large Scale Integration) such as a CPU (Central Processing Unit).

[0033] The first base 11a is a plate, and is parallel with the upper surface of the package 2, the direction of the wind,

straight portions 22a, and straight portions 26a. The lower surface of the first base 11a is in contact with the upper surface of the package 2 via a thermal grease.

[0034] A region of the upper surface of the first base 11a above the upper surface of the package 2 is defined as a package region. The width of the upper surface of the package 2 in the right-left direction is defined as a package width.

[0035] FIG. 3 is a right side view of the heat pipe 12a. Each heat pipe 12a includes: a spinning portion 21a which is a rear end portion on the upper side; the straight portion 22a connected thereto, which is a straight pipe extending in the front-rear direction on the upper side; a curved portion 23a connected thereto, which is an arcuate pipe on the upper side; a middle portion 24a connected thereto, which is a straight pipe extending in the up-down direction; a curved portion 25a connected thereto, which is an arcuate pipe on the lower side; the straight portion 26a connected thereto, which is a straight pipe extending in the front-rear direction on the lower side; and a sealed portion 27a connected thereto, which is a rear end portion on the lower side.

[0036] The spinning portion 21a is sealed by spinning before injection of an operating fluid. After the injection of the operating fluid, the sealed portion 27a is sealed and machined into a tapered shape. The two straight portions 22a and the two straight portions 26a are parallel with each other, are parallel with the upper surface of the package 2, and are perpendicular to the direction of the wind. The two middle portions 24a are parallel with each other, are perpendicular to the upper surface of the package 2, and are perpendicular to the direction of the wind. The widths of the two heat pipes 12a in the right-left direction are constant and substantially equal to or smaller than the package width. Note that the middle portions 24a may be omitted.

[0037] Further, although not required, it may be preferred that the length of each straight portion 22a and the length of each straight portion 26a are substantially equal to each other.

[0038] The upper surface of the first base 11a has two grooves for burying the two straight portions 26a therein. The two grooves are parallel with each other and extend in the package region of the first base 11a. The straight portions 26a are buried in the grooves and joined (e.g., brazed or soldered) to the grooves.

[0039] Each first fin 13a is a plate (plate fin). Each first fin 13a is provided on the upper surface of the first base 11a, and is provided on the upper side of the first base 11a and perpendicularly to the straight portions 22a and the straight portions 26a. Thus, a plurality of spaces are formed as wind paths so as to extend in the right-left direction. The first fins 13a have substantially the same shape, and each have two holes, as shown in the front view of the first fin 13a in FIG. 4, for the two straight portions 22a to extend therethrough. The distance between the outermost points of the two holes in the right-left direction is substantially equal to or smaller than the package width. The two holes and the straight portions 22a are joined to each other.

[0040] Further, the plurality of first fins 13a are parallel with each other, and are aligned in the front-rear direction at predetermined fin intervals through the entire area of the straight portions 26a in the front-rear direction.

[0041] The lower end part of the rear surface of the second base 14a is joined to the front surface of the first base 11a. The second base 14a is perpendicular to the straight portions 22a and the straight portions 26a. The second base 14a has four holes for the two straight portions 22a and the two straight

portions 26a to extend therethrough. The four holes, and the straight portions 22a and the straight portions 26a are joined to each other. The curved portions 23a, the middle portions 24a, and the curved portions 25a are provided in front of the second base 14a.

[0042] Although not required, it may be preferred that the length of the combination of the first base 11a and the second base 14a in the front-rear direction is substantially equal to the length of each of the straight portions 22a and the straight portions 26a in the front-rear direction.

[0043] Each second fin 15a is pin-shaped (a pin fin), and is a pillar parallel with the straight portions 22a and the straight portions 26a. Each second fin 15a is provided on the front surface of the second base 14a, and is provided in front of the second base 14a and perpendicularly to the second base 14a. The plurality of second fins 15a are parallel with each other, and are aligned in a matrix pattern on the front surface of the second base 14a. In other words, the plurality of second fins 15a are arranged in the right-left direction and in the up-down direction. Thus, a plurality of spaces are formed as wind paths so as to extend in the right-left direction. Note that the plurality of second fins 15a are located at positions in the above matrix, other than the positions interfering with the curved portions 23a, the middle portions 24a, and the curved portions 25a.

[0044] The materials of the first base 11a, the heat pipes 12a, and the first fins 13a are, for example, copper. The materials of the second base 14a and the second fins 15a are, for example, aluminum. Note that the materials of the first base 11a, the heat pipes 12a, and the first fins 13a may be aluminum. Also note that the materials of the second base 14a and the second fins 15a may be, for example, copper.

[0045] Hereinafter, a manufacturing method of the heat radiating device 1a will be described.

[0046] FIG. 5 is a flowchart showing the manufacturing method of the heat radiating device 1a according to the first embodiment.

[0047] In the manufacturing method, the heat pipes 12a are produced (S11). In the manufacturing method, the first heat sink is produced by providing the first fins 13a on the upper surface of the first base 11a (S12). In the manufacturing method, the second heat sink is produced by providing the second fins 15a on the front surface of the second base 14a using cold forging (S13).

[0048] In the manufacturing method, the front surface of the first base 11a and the rear surface of the second base 14a are joined (brazed) to each other (S14). In the manufacturing method, the straight portions 26a of the heat pipes 12a and the grooves of the first base 11a are joined to each other (S15). In the manufacturing method, the straight portions 22a of the heat pipes 12a and the holes of the second base 14a are joined to each other, and the straight portions 26a of the heat pipes 12a and the holes of the second base 14a are joined to each other (S16). In the manufacturing method, the straight portions 22a of the heat pipe 12a and the holes of the first fins 13a are joined to each other (S17).

[0049] During the production of each heat pipe 12a, in a state where the sealed portion 27a is opened, a liquid such as water or ammonia is injected into the heat pipe 12a, and the sealed portion 27a is sealed.

[0050] During the production of the first heat sink, the holes for the straight portions 22a to extend therethrough are bored in the first fins 13a by machining.

[0051] Prior to cold forging, a die is prepared, which has holes at positions corresponding to the arrangement of the second fins **15a** on the front surface of the second base **14a**. During the production of the second heat sink, the second base **14a** and the plurality of second fins **15a** are produced by extruding aluminum from the die using cold forging. A die which does not have holes at positions interfering with the curved portions **23a**, the middle portions **24a**, and the curved portions **25a** is prepared, and the arrangement of the second fins **15a** is determined. Thus, the second fins **15a** having a flexible arrangement are easily produced at a low cost.

[0052] Note that after a plurality of fins arranged in a matrix pattern are produced, fins at the positions interfering with the heat pipes **12a** may be removed by machining. In this case, this machining is performed only for removing small fins, and thus is simpler and cheaper than machining for boring a hole in a plate fin.

Second Embodiment

[0053] Hereinafter, a second embodiment of the invention will be described.

[0054] FIG. 6 is a front view of a heat radiating device **1b** according to a second embodiment. In the heat radiating device **1b**, the same reference numerals as those in the heat radiating device **1a** indicate the same or equivalent components as the indicated components in the heat radiating device **1a**, and the description thereof is omitted here. The heat radiating device **1b** has a plurality of second fins **15b** instead of the plurality of second fins **15a**.

[0055] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1b** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The second base **14a** and the plurality of second fins **15b** constitute a second heat sink. The direction of a wind is the same as that in the first embodiment.

[0056] Each second fin **15b** is rectangle-shaped (strip-shaped) (a rectangle-shaped fin), and is a plate perpendicular to the up-down direction. Each second fin **15b** is provided in front of the second base **14a**, perpendicularly to the second base **14a**, and on the front surface of the second base **14a**. The plurality of second fins **15b** are parallel with each other, and arranged in a matrix pattern on the front surface of the second base **14a**. In other words, the plurality of second fins **15b** are aligned in the right-left direction and in the up-down direction. Thus, a plurality of spaces are formed as wind paths so as to extend in the right-left direction. Note that the plurality of second fins **15b** are located at positions in the above matrix, other than the positions interfering with the curved portions **23a**, middle portions **24a**, and the curved portions **25a**.

[0057] By this structure, the second embodiment provides a substantially similar effect as that of the first embodiment.

Third Embodiment

[0058] Hereinafter, a third embodiment of the invention will be described.

[0059] FIG. 7 is a front view of a heat radiating device **1c** according to a third embodiment. In the heat radiating device **1c**, the same reference numerals as those in the heat radiating device **1a** indicate the same or equivalent components as the indicated components in the heat radiating device **1a**, and the

description thereof is omitted here. The heat radiating device **1c** has a plurality of second fins **15c** instead of the plurality of second fins **15a**.

[0060] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1c** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The second base **14a** and the plurality of second fins **15c** constitute a second heat sink. The direction of a wind is the same as that in the first embodiment.

[0061] Each second fin **15c** is a plate (plate fin), and is a plate perpendicular to the up-down direction. Each second fin **15c** is provided on the front surface of the second base **14a**, and is provided in front of the second base **14a** and perpendicularly to the second base **14a**. The plurality of second fins **15c** are parallel with each other, and are arranged in the up-down direction at regular intervals. Thus, a plurality of spaces are formed as wind paths so as to extend in the right-left direction. Note that some or all of the second fins **15c** are provided with notches for avoiding interference with the curved portions **23a**, the middle portions **24a**, and the curved portions **25a**.

[0062] By this structure, the third embodiment provides a substantially similar effect as that of the first embodiment.

Fourth Embodiment

[0063] Hereinafter, a fourth embodiment of the invention will be described.

[0064] FIG. 8 is a right side view of a heat radiating device **1d** according to the fourth embodiment. In the heat radiating device **1d**, the same reference numerals as those in the heat radiating device **1a** indicate the same or equivalent components as the indicated components in the heat radiating device **1a**, and the description thereof is omitted here. The heat radiating device **1d** has two heat pipes **12b** instead of the two heat pipes **12a**, has a plurality of first fins **13b** instead of the plurality of first fins **13a**, and has a plurality of second fins **15d** instead of the plurality of second fins **15a**.

[0065] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1d** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The first base **11a** and the plurality of first fins **13b** constitute a first heat sink. The second base **14a** and the plurality of second fins **15d** constitute a second heat sink. The direction of a wind is the same as that in the first embodiment.

[0066] FIG. 9 is a right side view of a heat pipe according to the fourth embodiment. The structure of each heat pipe **12b** is substantially the same as that of each heat pipe **12a**. Each heat pipe **12b** has a spinning portion **21b**, a straight portion **22b**, a curved portion **23b**, a middle portion **24b**, a curved portion **25b**, a straight portion **26b**, and a sealed portion **27b**, which are respectively substantially the same as the spinning portion **21a**, the straight portion **22a**, the curved portion **23a**, the middle portion **24a**, the curved portion **25a**, the straight portion **26a**, and the sealed portion **27a**. Note that the middle portion **24b** may be omitted.

[0067] The upper surface of the first base **11a** has two grooves for burying the two straight portions **26b** therein. The

two grooves extend in the package region of the first base **11a**. The straight portions **26b** are buried in the grooves and joined to the grooves.

[0068] The interval between the two straight portions **22b** is larger than the interval between the two straight portions **26b**. Thus, the interval between the upper parts of the two middle portions **24b** is larger than the interval between the lower parts thereof.

[0069] FIG. 10 is a front view of the first fin **13b** according to the fourth embodiment. Each first fin **13b** is similar to each first fin **13a**, and has two holes for the two straight portions **22b** to extend therethrough. Note that the interval between the two holes in the first fin **13b** is larger than the interval between the two holes in the first fin **13a**.

[0070] The plurality of second fins **15d** are substantially the same as the plurality of second fins **15a**. Note that the plurality of second fins **15d** are located at positions in the above matrix, other than the positions interfering with the curved portions **23b**, the middle portions **24b**, and the curved portions **25b**.

[0071] By this structure, the fourth embodiment provides a substantially similar effect as that of the first embodiment.

[0072] Further, since the interval between the two straight portions **22b** is larger than the interval between the two straight portions **26b**, the heat radiation efficiency of the heat radiating device **1d** is higher than the heat radiation efficiency of the heat radiating device **1a**.

Fifth Embodiment

[0073] Hereinafter, a fifth embodiment of the invention will be described.

[0074] FIG. 11 is a right side view of a heat radiating device **1e** according to the fifth embodiment. In the heat radiating device **1e**, the same reference numerals as those in the heat radiating device **1a** indicate the same or equivalent components as the indicated components in the heat radiating device **1a**, and the description thereof is omitted here. The heat radiating device **1e** has a first base **11b** instead of the first base **11a**, has a second base **14b** instead of the second base **14a**, and has a plurality of second fins **15e** instead of the plurality of second fins **15a**.

[0075] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1e** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The first base **11b** and the plurality of first fins **13a** constitute a first heat sink. The second base **14b** and the plurality of second fins **15e** constitute a second heat sink. The direction of a wind is the same as that in the first embodiment.

[0076] The first base **11b** is a plate, and is parallel with the upper surface of the package **2**, the direction of the wind, the straight portions **22a**, and the straight portions **26a**. The lower surface of the first base **11b** is in contact with the upper surface of the package **2** via a thermal grease. The upper surface of the first base **11b** has two grooves for burying the straight portions **26a** and the curved portions **25a** therein. The straight portions **26a** are buried in the grooves and joined to the grooves.

[0077] The second base **14b** is provided at the frontmost part of the heat radiating device **1e**. The lower end part of the rear surface of the second base **14b** is joined to the front

surface of the first base **11b**. The second base **14b** is perpendicular to the straight portions **22a** and the straight portions **26a**.

[0078] The middle portions **24a** are provided in the rear of the second base **14b**, and are joined to the rear surface of the second base **14b**.

[0079] It may be preferred that the length of the combination of the first base **11b** and the second base **14b** in the front-rear direction is substantially equal to the length of each straight portion **26a** in the front-rear direction.

[0080] Each second fin **15e** is substantially the same as each second fin **15a**. The plurality of second fins **15e** are provided in the rear of the second base **14b**, perpendicularly to the second base **14b**, and on the rear surface of the second base **14b**. The tips of the plurality of second fins **15e** face rearward. Similarly to the plurality of second fins **15a**, the plurality of second fins **15e** are arranged in a matrix pattern on the rear surface of the second base **14b**. The plurality of second fins **15e** are located at positions in the above matrix, other than the positions interfering with the curved portions **23a**, the middle portions **24a**, and the curved portions **25a**.

[0081] By this structure, the fifth embodiment provides substantially the same effect as that of the first embodiment.

[0082] Further, since the heat pipes **12a** are provided in the rear of the second base **14b**, it is unnecessary to bore, in the second base **14b**, holes for the heat pipes **12a** to extend therethrough.

[0083] Moreover, since the plurality of second fins **15e** are provided in the rear of the second base **14b**, the plurality of second fins **15e** do not protrude to the outside of the heat radiating device **1e**. Thus, when handling or mounting the heat radiating device **1e**, the plurality of second fins **15e** are prevented from contacting the outside. For example, a worker can carry the heat radiating device **1e** by grasping the second base **14b**.

Sixth Embodiment

[0084] Hereinafter, a sixth embodiment of the invention will be described.

[0085] FIG. 12 is a right side view of a heat radiating device **1f** according to the sixth embodiment. In the heat radiating device **1f**, the same reference numerals as those in the heat radiating device **1e** indicate the same or equivalent components as the indicated components in the heat radiating device **1e**, and the description thereof is omitted here. The heat radiating device **1f** has a second base **14c** instead of the second base **14b**.

[0086] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1f** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The second base **14c** and the plurality of second fins **15e** constitute a second heat sink. The direction of a wind is the same as that in the first embodiment.

[0087] The second base **14c** is provided at the frontmost part of the heat radiating device **1f**. The rear surface of the second base **14c** has grooves for burying therein the two sets of the curved portion **23a**, the middle portion **24a**, and the curved portion **25a**. The curved portions **23a**, the middle portions **24a**, and the curved portions **25a** are buried in the grooves and joined to the grooves.

[0088] The plurality of second fins **15e** are provided in the rear of the second base **14c**, perpendicularly to the second

base **14c**, and on the rear surface of the second base **14c**. The tips of the plurality of second fins **15e** face rearward.

[0089] By this structure, the sixth embodiment provides a substantially similar effect as that of the fifth embodiment.

[0090] Further, the contact area between the second base **14c** and each heat pipe **12a** in the heat radiating device **1f** is larger than the contact area between the second base **14b** and each heat pipe **12a** in the heat radiating device **1e**. Thus, the heat radiation efficiency of the heat radiating device **1f** is higher than the heat radiation efficiency of the heat radiating device **1e**.

Seventh Embodiment

[0091] Hereinafter, a seventh embodiment of the invention will be described.

[0092] FIG. **13** is a right side view of a heat radiating device **1g** according to the seventh embodiment. In the heat radiating device **1g**, the same reference numerals as those in the heat radiating device **1a** indicate the same or equivalent components as the indicated components in the heat radiating device **1a**, and the description thereof is omitted here. The heat radiating device **1g** has a first base **11c** instead of the first base **11a**, and additionally has a plurality of first fins **13c**.

[0093] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1g** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The first base **11c** and the plurality of first fins **13a** and **13c** constitute a first heat sink. The direction of a wind is the same as that in the first embodiment.

[0094] The upper surface of the first base **11c** is smaller in area than the upper surface of the first base **11a**. The area of the upper surface of the first base **11c** is substantially equal to or larger than the area of the upper surface of the package **2**.

[0095] The plurality of first fins **13a** are provided on the upper surface of the first base **11c**.

[0096] The plurality of first fins **13c** are not in contact with the first base **11c**. Each first fin **13c** has two holes for crossing the straight portions **22a**, and two holes for crossing the straight portions **26a**. The four holes in each first fin **13c**, and the straight portions **22a** and the straight portions **26a**, are joined to each other.

[0097] The plurality of first fins **13a** and the plurality of first fins **13c** are parallel with each other, and are aligned in the front-rear direction at predetermined fin intervals through the entire area of the straight portions **26a** in the front-rear direction. Some of the first fins **13c** are provided in the rear of the first fins **13a**, and the other first fins **13c** are provided in front of the first fins **13a**.

[0098] By this structure, the seventh embodiment provides a substantially similar effect as that of the first embodiment.

[0099] Further, the first base **11c** and the heat pipes **12a** are joined to each other, the heat pipes **12a** and the second base **14a** are joined to each other, and the second fins **15a** are provided on the second base **14a**. Thus, even when the first base **11c** and the second base **14a** are not in contact with each other, heat of the package **2** can be transferred to the second fins **15a**.

Eighth Embodiment

[0100] Hereinafter, an eighth embodiment of the invention will be described.

[0101] FIG. **14** is a right side view of a heat radiating device **1h** according to the eighth embodiment. In the heat radiating device **1h**, the same reference numerals as those in the heat radiating device **1g** indicate the same or equivalent components as the indicated components in the heat radiating device **1g**, and the description thereof is omitted here. The heat radiating device **1h** has a plurality of first fins **13d** instead of the plurality of first fins **13c**, and additionally has a third base **16a** and a plurality of third fins **17a**.

[0102] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1h** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The first base **11c** and the plurality of first fins **13a** and **13d** constitute a first heat sink. The second base **14a** and the plurality of second fins **15a** constitute a second heat sink. The third base **16a** and the plurality of third fins **17a** constitute a third heat sink. The direction of a wind is the same as that in the first embodiment.

[0103] The plurality of first fins **13d** are the plurality of first fins **13c** excluding a rearmost fin which is the first fin **13c** located in the rearmost position.

[0104] The third base **16a** is provided at the position of the rearmost fin. The third base **16a** is a plate, is perpendicular to the straight portions **22a** and the straight portions **26a**, and is parallel with the plurality of first fins **13d**. The third base **16a** has four holes for the rearmost parts of the two straight portions **22a** and the rearmost parts of the two straight portions **26a** to extend therethrough. The four holes, and the straight portions **22a** and the straight portions **26a** are joined to each other.

[0105] Each third fin **17a** is a pin fin, and is a pillar parallel with the straight portions **22a** and the straight portions **26a**. Each third fin **17a** is provided in the rear of the third base **16a**, perpendicularly to the third base **16a**, and on the rear surface of the third base **16a**. The plurality of third fins **17a** are parallel with each other, and are arranged in a matrix pattern on the rear surface of the third base **16a**. In other words, the plurality of third fins **17a** are aligned in the right-left direction and in the up-down direction. Thus, a plurality of spaces are formed as wind paths so as to extend in the right-left direction. Note that the plurality of third fins **17a** are located at positions in the above matrix, other than the positions interfering with the spinning portions **21a** and the sealed portions **27a**.

[0106] It is preferred that the position of the rear end (tip) of each third fin **17a** coincides with the positions of the rear ends of the heat pipes **12a** in the front-rear direction, or is in the rear of the rear ends of the heat pipes **12a**.

[0107] By this structure, the eighth embodiment provides a substantially similar effect as that of the first embodiment.

[0108] Further, since the third base **16a** and the third fins **17a** are provided in the space (dead space) which is in the rear of the first fins **13a** in the heat radiating device **1g** and which is not used for heat radiation, the heat radiation efficiency of the heat radiating device **1h** is higher than the heat radiation efficiency of the heat radiating device **1g**. In other words, the dead space is effectively used.

[0109] Hereinafter, the effects of the first to eighth embodiments will be described using comparative examples 1 to 4.

Comparative Example 1

[0110] Hereinafter, the comparative example 1 will be described.

[0111] FIG. 15 is a front view of a heat radiating device 1j according to the comparative example 1. FIG. 16 is a right side view of the heat radiating device 1j according to the comparative example 1. In the heat radiating device 1j, the same reference numerals as those in the heat radiating device 1a indicate the same or equivalent components as the indicated components in the heat radiating device 1a, and the description thereof is omitted here. The heat radiating device 1j has a first base 11j instead of the first base 11a, and has a plurality of first fins 13j instead of the second base 14a and the plurality of second fins 13a.

[0112] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device 1j are the substantially same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device 1a. The first base 11j, the plurality of first fins 13a, and the plurality of first fins 13j constitute a first heat sink. The direction of a wind is the same as that in the first embodiment.

[0113] The first base 11j is similar to the first base 11a. However, the length of the first base 11j in the front-rear direction is larger than the length of the first base 11a in the front-rear direction. The length of the first base 11j in the front-rear direction is substantially equal to the length, in the front-rear direction, of the combination of the straight portion 22a, the curved portion 23a, the middle portion 24a, the curved portion 25a, and the straight portion 26a.

[0114] The upper surface of the first base 11j has two grooves for burying the two curved portions 25a and the two straight portions 26a therein. The two grooves are parallel with each other and extend in the package region of the first base 11j. The curved portions 25a and the straight portions 26a are buried in the grooves and joined to the grooves.

[0115] The plurality of second fins 13a and the plurality of first fins 13j are provided on the upper side of the first base 11j, perpendicularly to the upper surface of the first base 11j, parallel with the direction of the wind, and on the upper surface of the first base 11j.

[0116] The plurality of first fins 13j have substantially the same shape. Each first fin 13j has one notch for avoiding interference with the two sets of the curved portion 23a, the middle portion 24a, and the curved portion 25a.

[0117] Hereinafter, the first fins 13j of the comparative example 1 and the first fins 13a of the first embodiment will be compared to each other.

[0118] Since the area of each first fin 13j is reduced by the notch, the heat radiation efficiency of each first fin 13j is lower than the heat radiation efficiency of each first fin 13a illustrated in the first embodiment. Since the heat path of each first fin 13j is cut by the notch, the heat radiation efficiency of each first fin 13j are further lower than the heat radiation efficiency of each first fin 13a illustrated in the first embodiment.

[0119] Hereinafter, the first fins 13j of the comparative example 1 and the second base 14a and the second fins 15a of the first embodiment will be compared to each other.

[0120] In the comparative example 1, the thickness of each first fin 13j in the front-rear direction is Tf. The length of the plurality of first fins 13j in the front-rear direction is Lq. The number of the first fins 13j is Nq. In this case, it is preferred that Lq is substantially equal to or greater than Lc.

[0121] In the first embodiment, the length of the curved portion 23a, the middle portion 24a, and the curved portion 25a in the front-rear direction (the radius of the curved por-

tion 23a, the radius of the curved portion 25a) is Lc. The thickness of the second base 14a in the front-rear direction is Tb. The length of each second fin 15a in the front-rear direction is Lp. In this case, it is preferred that Lp is substantially equal to or greater than Lc.

[0122] For example, it is defined that $Lc=Lq=Lp=20$ mm, $Tf=0.5$ mm, $Nq=8$, and $Tb=4$ mm. When Tb is equal to $(Tf \times Nq)$ as described above, the contact area between the first fins 13j and the heat pipes 12a of the comparative example 1 is equal to the contact area between the second base 14a and the heat pipes 12a of the first embodiment. Thus, in this case, a heat radiation amount of the first fins 13j of the comparative example 1 is equal to a heat radiation amount of the second base 14a and the second fins 15a of the first embodiment.

[0123] Therefore, in the first to eighth embodiments, where the thickness of the second base 14a, 14b, or 14c in the front-rear direction is Tb, it is preferred that Tb is substantially equal to or greater than $(Tf \times Nq)$. Under this condition, the heat radiation efficiency of each of the first to eighth embodiments is lower than the heat radiation efficiency of the comparative example 1.

Comparative Example 2

[0124] Hereinafter, the comparative example 2 will be described.

[0125] In the comparative example 2 (not illustrated), instead of the notch, each first fin 13j in the heat radiating device 1j has two holes at positions crossing the two sets of the curved portion 23a, the middle portion 24a, and the curved portion 25a. The direction of a wind is the same as that in the first embodiment.

[0126] The heat radiation efficiency of the comparative example 2 is higher than the heat radiation efficiency of the comparative example 1. In the comparative example 2, depending on the position of the first fin 13j in the front-rear direction, the position where the first fin 13j cross the curved portion 23a, the middle portion 24a, and the curved portion 25a, is different. Thus, for producing the plurality of first fins 13j, each having two holes at different positions from the other first fins 13j, so as to fit the shapes of the curved portion 23a, the middle portion 24a, and the curved portion 25a, for example, a plurality of different dies need to be prepared, and different machining needs to be performed for each of a plurality of plates. Therefore, the manufacturing cost of the comparative example 2 is significantly higher than the manufacturing cost of the comparative example 1.

[0127] The second base 14a and the second fins 15a of the first embodiment can be produced by cold forging using one die as described above. Thus, the manufacturing cost of the first embodiment is lower than the manufacturing cost of the comparative example 2. Similarly, the manufacturing cost of each of the second to eighth embodiments is lower than the manufacturing cost of the comparative example 2.

Comparative Example 3

[0128] Further, the comparative example 3 will be described.

[0129] FIG. 17 is a front view of a heat radiating device 1k according to the comparative example 3. In the heat radiating device 1k, the same reference numerals as those in the heat radiating device 1d indicate the same or equivalent components as the indicated components in the heat radiating device 1d, and the description thereof is omitted here. The heat

radiating device **1k** has a first base **11j** which is substantially the same as that of the heat radiating device **1j**, instead of the first base **11a**, and has a plurality of first fins **13k** instead of the plurality of first fins **13b**, the second base **14a**, and the plurality of second fins **15a**.

[0130] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1k** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The first base **11j**, the plurality of first fins **13j**, and the plurality of first fins **13k** constitute a first heat sink. The direction of a wind is the same as that in the first embodiment.

[0131] The upper surface of the first base **11j** has two grooves for burying the two straight portions **26b** therein. The two grooves extend in the package region of the first base **11j**. The straight portions **26b** are buried in the grooves and joined to the grooves.

[0132] The plurality of first fins **13k** have substantially the same shape. Each first fin **13k** has two notches for avoiding interference with the two sets of the curved portion **23b**, the middle portion **24b**, and the curved portion **25b**.

[0133] Hereinafter, the comparative example 3 and the fourth embodiment will be compared to each other.

[0134] Similarly to the comparative example 1, since the area of each first fin **13k** is reduced by the notches, the heat radiation efficiency of each first fin **13k** is lower than the heat radiation efficiency of each first fin **13a**. The notches of each first fin **13k** of the comparative example 3 reduce the contact area between the central portion of the first fin **13k** and the first base **11j**, but the second base **14a** of the fourth embodiment does not have any notch.

[0135] Therefore, because of the same reason of the comparative example 1, under the condition where T_b of the fourth embodiment is equal to or greater than $(T_f \times N_q)$, the heat radiation efficiency of the fourth embodiment is lower than the heat radiation efficiency of the comparative example 3.

Comparative Example 4

[0136] Hereinafter, the comparative example 4 will be described.

[0137] FIG. 18 is a right side view of a heat radiating device **1l** according to the comparative example 4. In the heat radiating device **1l**, the same reference numerals as those in the heat radiating device **1g** indicate the same or equivalent components as the indicated components in the heat radiating device **1g**, and the description thereof is omitted here. The heat radiating device **1l** does not have the second base **14a** and the plurality of second fins **15a**.

[0138] The size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, of the heat radiating device **1m** are substantially the same as the size in the front-rear direction, the size in the right-left direction, and the size in the up-down direction, respectively, of the heat radiating device **1a**. The first base **11c** and the plurality of first fins **13c** constitute a first heat sink. The direction of a wind is the same as that in the first embodiment.

[0139] Hereinafter, the comparative example 4 and the seventh embodiment will be compared to each other.

[0140] The comparative example 4 does not have a heat radiation mechanism, such as the first fins and the second heat sink, in front of the straight portion **22a** and the straight

portion **26a**. On the other hand, the seventh embodiment has the second base **14a** and the second fins **15a**, the heat pipe **12a** and the second base **14a** are joined to each other, and the second fins **15a** are provided on the second base **14a**.

[0141] Therefore, portions which radiate heat from the heat pipes **12a** in the seventh embodiment are more in number than portions which radiate heat from the heat pipes **12a** in the comparative example 4. Thus, the heat radiation efficiency of the seventh embodiment is lower than the heat radiation efficiency of the comparative example 4.

[0142] Hereinafter, a supplemental description will be given for the first to eighth embodiments.

[0143] Some of the first to eighth embodiments may be combined. For example, when the fourth embodiment and the sixth embodiment are combined, the heat radiating device of the sixth embodiment may have the two heat pipes **12b** of the fourth embodiment instead of the two heat pipes **12a**, and the plurality of second fins **15e** may be provided at positions corresponding to the two heat pipes **12b**. In this case, since the interval between the two straight portions **22b** on the upper side is larger than the interval between the two straight portions **26b** on the lower side, both the effect of the fourth embodiment and the effect of the seventh embodiment are provided.

[0144] Note that the number of the heat pipes **12a** or **12b** may be one or may be three or more.

[0145] A first end portion and a third end portion include, for example, the sealed portions **27a** and **27b**. A first straight portion and a third straight portion include, for example, the straight portions **26a** and **26b**. A curved portion include, for example, the curved portions **23a** and **23b**, the middle portions **24a** and **24b**, and the curved portions **25a** and **25b**. A second straight portion and a fourth straight portion include, for example, the straight portions **22a** and **22b**. A second end portion and a fourth end portion include, for example, the spinning portions **21a** and **21b**.

[0146] All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions. Although the embodiments of the present inventions has been described in detail, it should be understood that various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A heat radiating device for radiating heat of a circuit, comprising:

- a first heat pipe which has a first end portion a first straight portion connected to the first end portion, a curved portion connected to the first straight portion, a second straight portion connected to the curved portion and parallel with the first straight portion, and a second end portion connected to the second straight portion;
- a first base which is in contact with the circuit and is joined at a first surface thereof opposite to a surface thereof facing the circuit, to the first straight portion;
- a plurality of first fins which are provided on the first surface, have flat surfaces perpendicular to the first straight portion, and cross the second straight portion;
- a second base which has a second surface perpendicular to the first base and the first straight portion and is joined to the first heat pipe; and

- a plurality of second fins which are provided on the second surface and extend to a direction perpendicular to the second surface.
2. The heat radiating device according to claim 1, wherein a direction of a wind sent to the heat radiating device is parallel to the first base and the second base, the plurality of first fins form therebetween a space which extends in the direction of the wind, and the plurality of second fins form therebetween a space which extends in the direction of the wind.
3. The heat radiating device according to claim 1, further comprising a second heat pipe which has a third end portion, a third straight portion connected to the third end portion, a curved portion connected to the third straight portion, a fourth straight portion connected to the curved portion and parallel with the third straight portion, and a fourth end portion connected to the fourth straight portion, wherein
the first straight portion and the third straight portion are parallel with each other,
the second straight portion and the fourth straight portion are parallel with each other,
the first surface is joined to the third straight portion,
the plurality of first fins cross the fourth straight portion, and
the second base is joined to the second heat pipe.
4. The heat radiating device according to claim 1, further comprising:
a third base which has a third surface perpendicular to the first base and the first straight portion and is joined to the first heat pipe; and
a plurality of third fins which are provided on the third surface, wherein
the second base and the plurality of second fins are provided on a side of the first fins opposite to the first end portion and the second end portion, and
the plurality of third fins, the first end portion, and the second end portion are provided on a side of the third base opposite to the plurality of first fins.
5. The heat radiating device according to claim 1, wherein each of the plurality of second fins has a pin shape perpendicular to the second surface, or has a rectangular shape perpendicular to the second surface and parallel with the first surface.
6. The heat radiating device according to claim 1, wherein the second base and the plurality of second fins are provided on a side of the first fins opposite to the first end portion and the second end portion, and the plurality of second fins are provided on a side of the second base opposite to the plurality of first fins.
7. The heat radiating device according to claim 1, wherein the second base and the plurality of second fins are provided on a side of the first fins opposite to the first end portion and the second end portion, and the second base is provided on a side of the plurality of second fins opposite to the plurality of first fins.

8. The heat radiating device according to claim 1, wherein the second base is joined to the first base.

9. The heat radiating device according to claim 1, wherein a length of the first base along a direction of the first straight portion is shorter than a length of the first straight portion and a length of the second straight portion.

10. The heat radiating device according to claim 1, wherein the plurality of second fins are provided on the second surface by cold forging.

11. A manufacturing method of a heat radiating device for radiating heat of a circuit, comprising:

joining a first straight portion of the first heat pipe which has a first end portion, the first straight portion connected to the first end portion, a curved portion connected to the first straight portion, a second straight portion connected to the curved portion and parallel with the first straight portion, and a second end portion connected to the second straight portion, to a first surface of a first base for contacting the circuit, the first surface being opposite to a surface of the first base which faces the circuit;

mounting, on the first surface, a plurality of first fins which are provided on the first surface and have flat surfaces perpendicular to the first straight portion;

joining the plurality of first fins and the second straight portion so as to cross each other; and

joining, to the first heat pipe, a second base which has a second surface perpendicular to the first base and the first straight portion and on the second surface of which a plurality of second fins are provided so as to be perpendicular to the second surface.

12. The manufacturing method according to claim 11, further comprising providing the plurality of second fins on the second surface by cold forging.

13. The heat radiating device according to claim 1, wherein each of the plurality of second fins has a plate shape perpendicular to an up-down direction of the heat radiation device.

14. The heat radiating device according to claim 1, further comprising a second heat pipe which has a third end portion, a third straight portion connected to the third end portion, a curved portion connected to the third straight portion, a fourth straight portion connected to the curved portion and parallel with the third straight portion, and a fourth end portion connected to the fourth straight portion, wherein

a distance between the first straight portion and the third straight portion is less than a distance between the second straight portion and the fourth straight portion.

15. The heat radiating device according to claim 7, wherein the second base includes at least one groove for burying therein the curved portion of the first heat pipe.

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