US 20030155105A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2003/0155105 A1
Garner (43) Pub. Date: Aug. 21, 2003

(54) VAPOR CHAMBER HAVING INTEGRAL CAPTIVE FASTENERS

(76) Inventor: **Scott D. Garner**, Lititz, PA (US)

Correspondence Address:
DUANE MORRIS, LLP
ATTN: WILLIAM H. MURRAY
ONE LIBERTY PLACE
1650 MARKET STREET
PHILADELPHIA, PA 19103-7396 (US)

(21) Appl. No.: **10/231,994**

(22) Filed: **Aug. 30, 2002**

Related U.S. Application Data

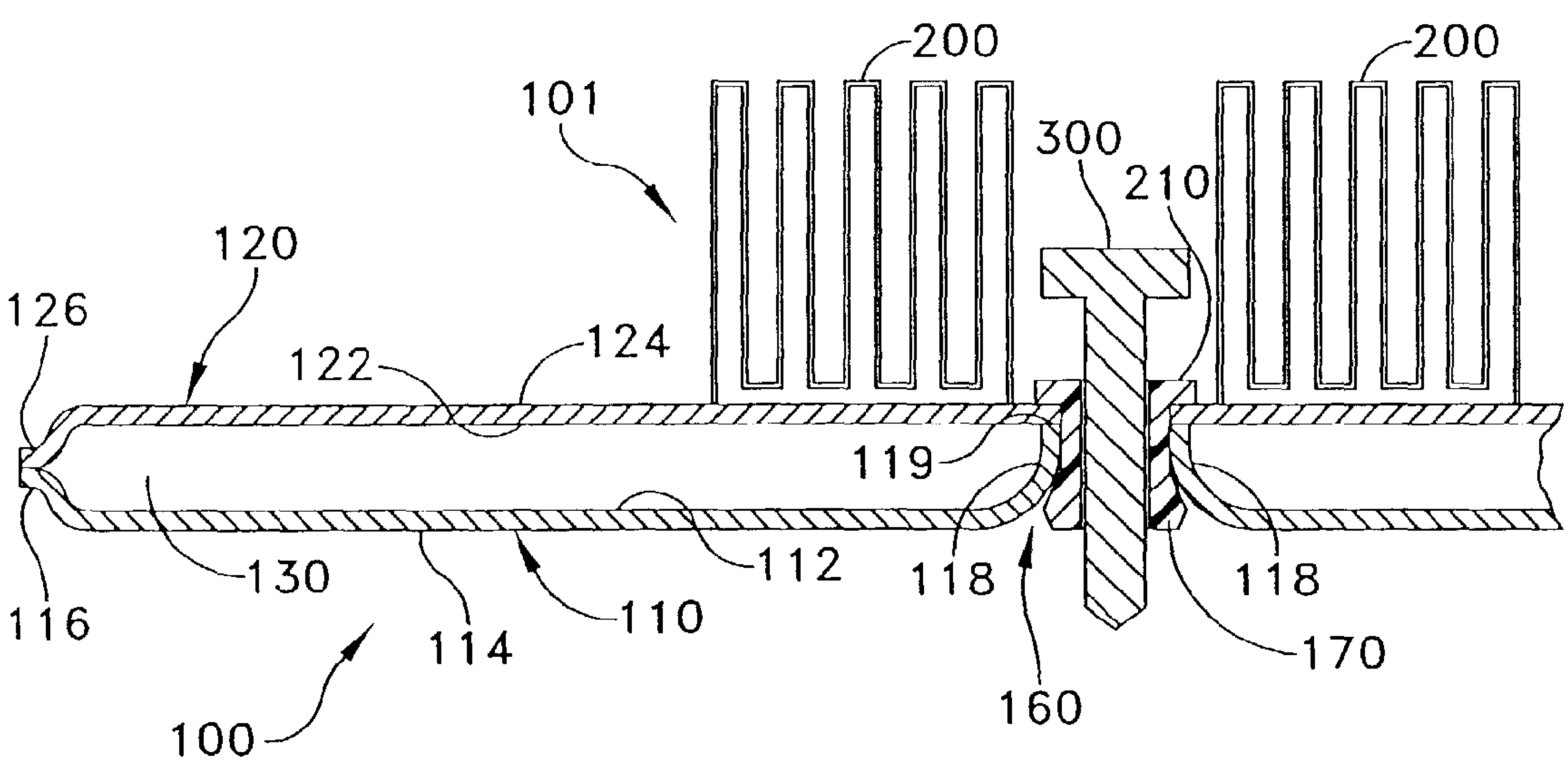
(62) Division of application No. 10/076,930, filed on Feb. 15, 2002.

Publication Classification

(51) Int. Cl.[7] **F28D 15/00**
(52) U.S. Cl. **165/104.26**; 165/104.21

(57) **ABSTRACT**

A vapor chamber for spreading heat includes a housing having spaced-apart first and second plates, the first and second plates defining a hollow chamber. At least one opening is defined through the first and second plates, the opening being isolated from the hollow chamber. At least one insert is fitted into each opening. The insert may be a snap-in insert or may be stamped into the opening.



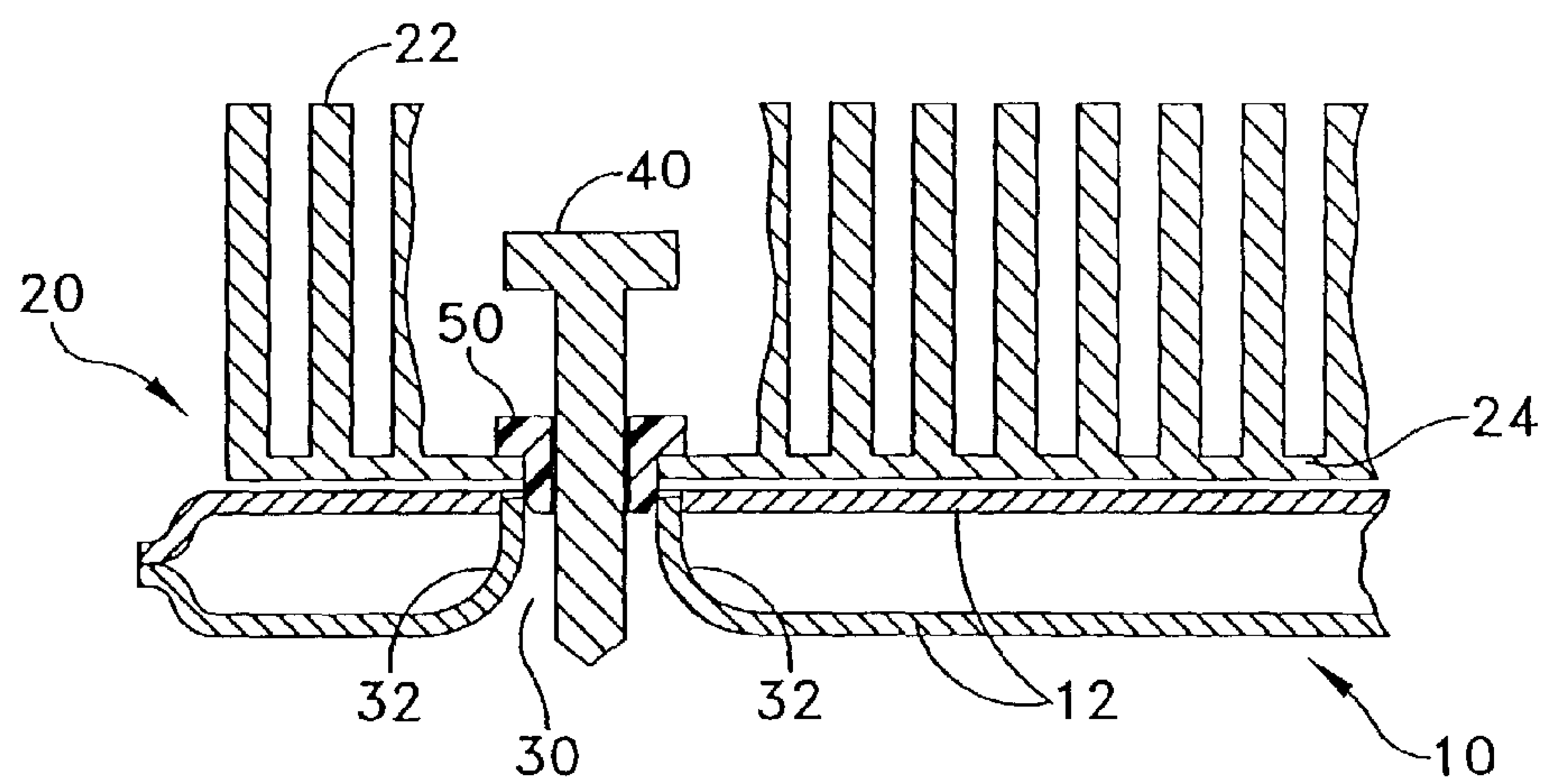


FIG. 1 (PRIOR ART)

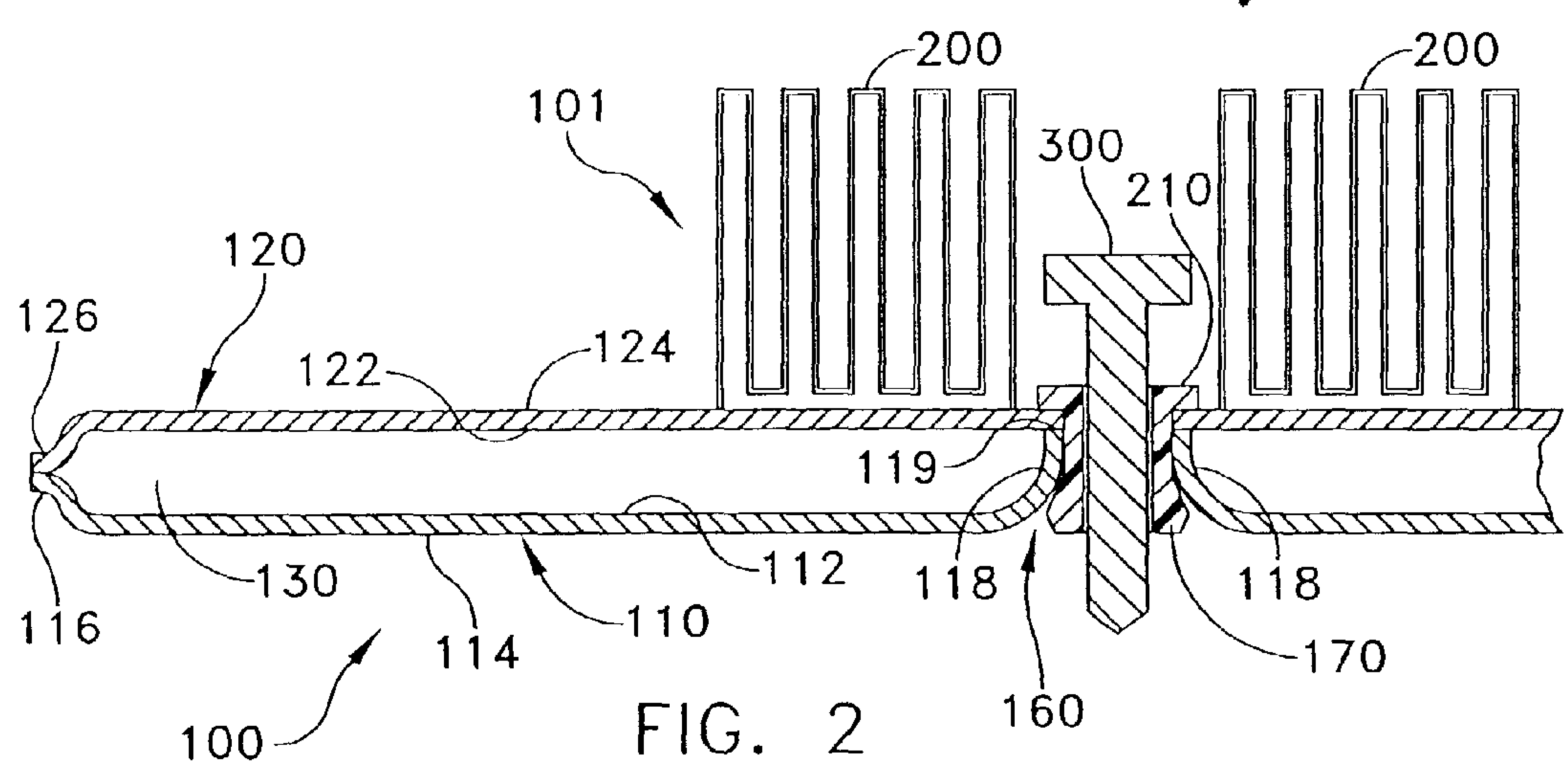


FIG. 2

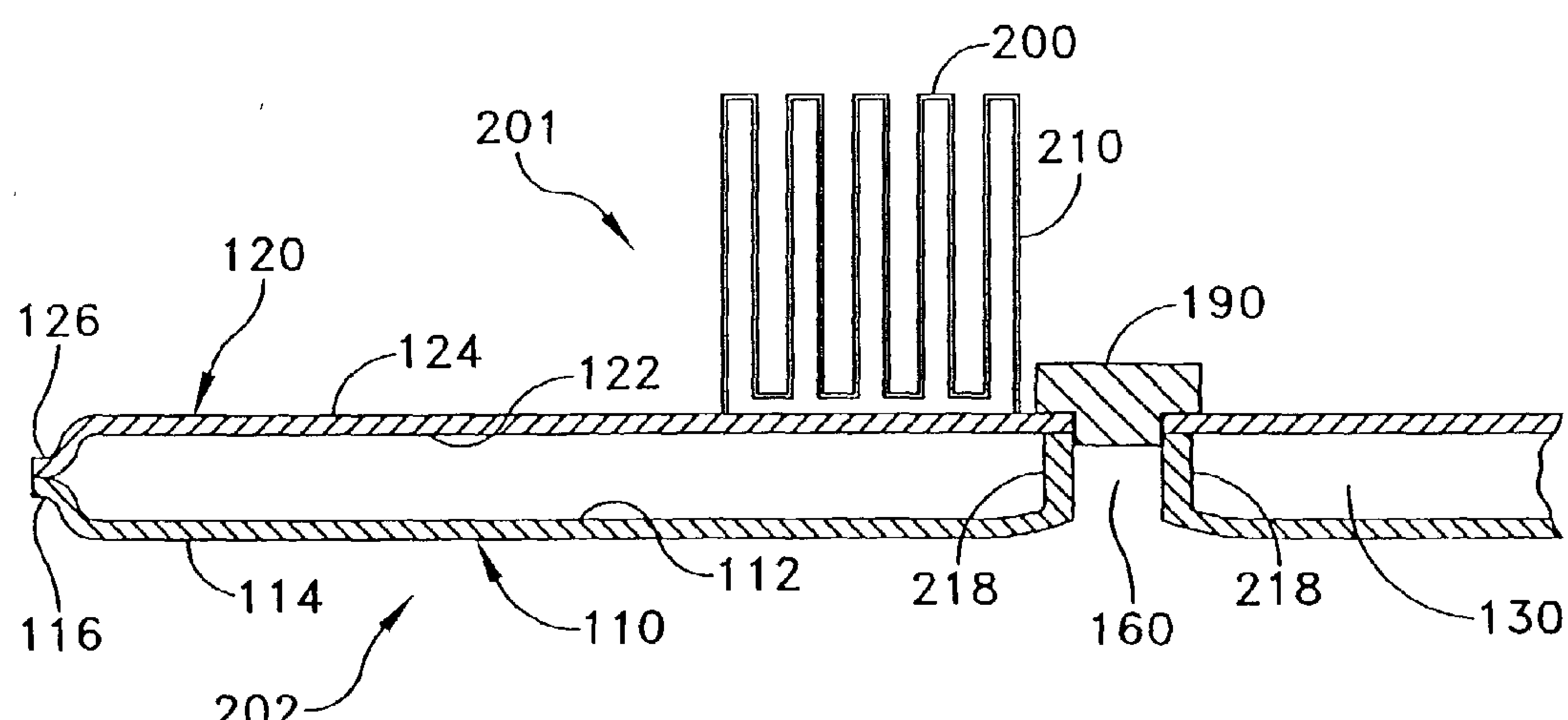


FIG. 3

VAPOR CHAMBER HAVING INTEGRAL CAPTIVE FASTENERS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates generally to heat spreaders, and more specifically to a heat spreader having a vapor chamber.

[0003] 2. Description of Related Art

[0004] As integrated circuit chips decrease in size and increase in power, the heat sinks required to maintain a desired temperature have grown to have a much larger footprint than the chips. Heat sinks are most effective when there is a uniform heat flux applied over the entire heat input surface. When a heat sink with a large heat input surface is attached to a heat source with a much smaller contact area, there is significant resistance to the flow of heat to the other portions of the heat sink which are not in direct contact with the integrated circuit chip. Higher power and smaller heat sources, or heat sources which are offset from the center of the heat sink, increase the resistance to heat flow to the balance of the heat sink. This phenomenon can cause great differences in the heat transfer rate from various parts of the heat sink. The effect of this unbalanced heat transfer is reduced performance of the integrated circuit chip and decreased reliability due to high operating temperatures.

[0005] Conventional approaches to handling the increased heat flux from the heat source include increasing the size of the heat sink, increasing the thickness of the heat sink surface which contacts the device to be cooled, increasing the air flow which cools the heat sink, and/or reducing the temperature of the cooling air. However, these approaches increase weight, noise, system complexity, and expense.

[0006] Currently, an advantageous mechanism for overcoming the resistance to heat flow in a heat sink is to attach a vapor chamber to a base of the heat sink, such as in the Therma-Base™ heat spreader manufactured by Thermacore, Inc. of Lancaster, Pa. This vapor chamber is a vacuum vessel with a saturated wick structure lining the inside walls. As heat is applied to the base of the vapor chamber, the working fluid at that location vaporizes. Wherever the vapor comes into contact with a cooler wall surface it will condense, releasing its latent heat of vaporization. The condensed fluid returns to the heat source via capillary action in the wick structure. As in a heat pipe, the thermal resistance associated with the vapor spreading is negligible, providing an effective means of spreading the heat from a concentrated source to a large surface.

[0007] **FIG. 1** shows a prior art assembly comprising a vapor-chamber-type heat spreader **10** and a finned heat sink **20**. The heat sink **20** is a cold-forged or machined heat sink having fins **22** attached to a base plate **24**. The base plate **24** and heat spreader **10** have openings **30** therethrough to receive fasteners **40** for fastening the heat spreader **10** and heat sink **20** to a heat generating device (not shown). The openings **30** through the vapor chamber **10** are formed in depressions **32** cast in one of the plates **12** of the vapor chamber **10** so that the vapor chamber **10** remains a sealed evacuated envelope. An insert **50**, such as a PEM insert, is stamped into the openings **30** of the base plate **24**. The inserts **50** receive and retain the fasteners **40**.

[0008] In the Therma-Base™ heat sink assembly, the heat spreader **10** is attached to a base **24** of the finned heat sink **20** by soldering, adhesion bonding, brazing or the like. Through-holes **30** are provided through the heat spreader **10** and base **24** for insertion of fasteners **40** for mounting the heat sink **20** to the heat input source. The base is typically a solid conductive metal, such as aluminum, for example. Inserts **50** for captively holding the fasteners are mounted to the base **24** of the finned heat sink **20**. The base **20** must be cold forged or machined, and adds weight and volume to the system..

[0009] An improved mounting structure for a heat sink with a vapor-chamber-type heat spreader is desired.

SUMMARY OF THE INVENTION

[0010] The present invention is a heat spreader comprising a housing having first and second plates defining a hollow chamber therebetween. At least one opening is defined through each of said first and second plates of the housing. The housing has a surface defining at least one passage connecting the openings of the first and second plates. The passage is isolated from the chamber. At least one insert is adapted for receiving a fastener. The at least one insert is mounted directly into the at least one passage.

[0011] Another aspect of the invention is a heat spreader comprising a housing including first and second plates that define a hollow vapor chamber therebetween. At least one depression is formed in one of the plates which projects into the vapor chamber and is bonded to the other of the plates. The housing has an opening that penetrates through the depression and the other of the plates. An insert is adapted to receive a fastener. The insert is mounted directly into the opening.

[0012] Another aspect of the invention is a heat sink comprising: a housing including first and second plates with an enclosed vapor chamber therebetween. At least one depression is formed in one of the plates which projects into the vapor chamber and is bonded to the other of the plates. The depression has an opening defined therethrough, so as to define an isolated passage through the vapor chamber. An insert is directly mounted into the opening and shaped to receive a fastener. At least one fin is attached to the one of the plates of the housing.

[0013] Another aspect of the invention is a method for forming a heat spreader comprising the steps of: joining first and second plates to define a hollow vapor chamber therebetween; forming at least one depression in one of the plates, so that the depression projects into the vapor chamber and is bonded to the other of the plates; penetrating the depression and the other of the plates; and mounting an insert directly into the opening, said insert being adapted to receive a fastener.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] These and other objects, features and advantages of the present invention will be more fully disclosed in, or rendered obvious by, the following detailed description of the preferred embodiment of the invention, which is to be considered together with the accompanying drawings wherein like numbers refer to like parts and further wherein:

[0015] **FIG. 1** is a cross-sectional view of a prior art heat sink assembly.

[0016] **FIG. 2** is a cross-sectional view of one embodiment of the present invention showing a snap-in insert.

[0017] **FIG. 3** is a cross-sectional view of another embodiment of the present invention showing a stamped-in insert.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0018] Referring to **FIG. 2**, an exemplary heat sink **101** according to one embodiment of the present invention comprises a heat spreader **100** enclosing a vapor chamber **130** and including an insert **170**, and a captive fastener **300**. The heat sink assembly **101** may have one or more fins **200** attached directly to the housing **110**, **120** of the heat spreader **100**.

[0019] The heat spreader **100** of the exemplary embodiment comprises a first plate **110** and a second plate **120** defining a hollow chamber **130** therebetween. Heat spreader **100** has a wick structure (not shown) preferably on both plates, and a working fluid (not shown). At least one opening **160** is defined through the vapor chamber **100**, as explained below, and at least one insert **170** is mounted directly into each respective opening **160**.

[0020] The first plate **110** and second plate **120** have inside surfaces **112** and **122**, respectively, outside surfaces **114** and **124**, respectively, and peripheral lips **116** and **126**, respectively. The bottom (first) plate **110** has at least one depression **118** formed therein. Alternatively, the depressions may be formed in the top (second) plate **120**. The first plate **110** and second plate **120** are spaced apart and sealed at their peripheral lips **116** and **126** defining a hollow chamber **130** between the plates.

[0021] Referring again to **FIG. 2**, the heat spreader **100** is assembled in the following manner. The inside surfaces **112** and **122** of the first and second plates are covered with a wick structure (not shown), such as a sintered metal capillary wick. The first plate **110** and second plate **120** are sealed together at their peripheral lips **116** and **126** by, for example, welding, brazing or soldering or the like. The vapor chamber **130** is evacuated to remove all non-condensible gases. A suitable quantity of working fluid is placed within the vapor chamber **130**, to form a functioning vapor chamber two phase heat spreader.

[0022] Depressions or dimples **118** which project into the vapor chamber **130** of heat spreader **100** are formed in the first plate **110**. The depressions **118** are formed and dimensioned so that when first plate **110** and second plate **120** are joined, the surfaces contact and can be joined to form a gas or leak tight seal, resulting in a through hole in the vapor chamber heat sink **100**. The passage defined by the surface of the depression **118** connects the holes in the first and second plates **110**, **120**. Because the openings or passages **160** within the depressions **118** are isolated from the vapor chamber **100**, the vacuum integrity of the vapor chamber **100** is not compromised. The edges **119** of the depressions **118** of the first plate **110** around the openings **160** remain sealed to the inside surface **122** of the second plate **120**. In addition to providing a means for forming openings **160** in the vapor chamber **100**, the depressions **118** also assure that the spacing between the first plate **110** and second plate **120** are maintained, even where pressure differentials between the inside volume of the vapor chamber **100** and surrounding environment might otherwise cause the plates **110** and **120** to deflect toward each other. The depressions **118**, which essentially form columns within the vapor chamber **130**, prevent the plates **110**, **120** from bowing inward, and therefore maintain the flat surface **114** for contact with the heat source, such as an integrated circuit chip (not shown).

[0023] Although openings **160** have been described as being formed through depressions **118**, it should be understood that such openings could be formed in the housing of heat spreader **100** in other ways. For example, the heat spreader **100** could be pre-formed with hollow columns or spacers between the first and second plates.

[0024] In one embodiment of the invention, as shown in **FIG. 2, a** snap-in plastic insert **170** is mounted directly into the openings **160** in the vapor chamber **100**, without mounting the insert to a base plate of a heat sink. The insert **170** is adapted to receive captive fasteners **300**. The snap-in plastic inserts **170** may be specially designed and formed to fit the openings **160** through the heat spreader **100** or alternatively, the openings **160** may be formed to fit commercially available off-the-shelf plastic snap-in inserts **170**. Because these inserts **170** are flared at the bottom, they are self-retaining. Thus, the insert does not require an oversized diameter or an interference fit with the portion of opening **160** having the narrowest diameter. The number of depressions **118** and openings **160** through the heat spreader **100** may vary depending on the number of fasteners **300** desired for attachment of the heat spreader **100** to the heat generating source (not shown). The heat source abuts the outside surface **114** of the first plate **110**.

[0025] In another variation of the device of **FIG. 2**, the plastic insert **170** may be of an anchor type that is sized to be smaller in diameter than opening **160** before the fastener **300** is inserted, and flares out to grasp the opening when the fastener **300** is inserted.

[0026] According to another embodiment of a heat sink **201**, as shown in **FIG. 3**, an insert **190**, such as a PEM broaching nut insert (Manufactured by Penn Engineering and Manufacturing Corp., of Danboro, Pa.), is stamped into the openings **160**, which are under-sized to provide a tight interference fit. In order to form the structure required for the insert **190**, the first plate **110** has excess material at the location of the depressions **218** to provide extra strength to withstand the stamping of the insert **190**. The extra material is provided by using a plate that is thicker in the surface **218** of the opening than in the remainder of the plate **110**.

[0027] In addition to the through holes provided in the depressions **118** (or **218**) or columns, the vapor chamber **130** may also include spacers, which may be solid and which extend between and contact the first and second plates of the housing. These spacers (not shown) also prevent the plates from bowing inward, and therefore assist in maintaining the vital flat surface for contact with the heat generating source.

[0028] Referring again to **FIGS. 2 and 3**, according to another aspect of the exemplary embodiments, a folded fin **200** may be directly attached to the outside surface **124** of the second plate **120** of the heat spreader **100** by soldering, adhesion bonding, brazing, or the like. The folded fin **200** includes openings **210** aligned with the openings **160** of the heat spreader **100** to allow for the receipt of the fasteners **300**. Fasteners **300** are inserted into the openings **210** of the folded fin **200** and the inserts **170** in the embodiment of **FIG. 2** (or **190** in the embodiment of **FIG. 3**) of the heat spreader **100**. The fasteners **300** secure the heat sink assembly **101** to the heat generating source. The type of fasteners may vary depending on particular application for which the heat sink assembly is being used.

[**0029**] The folded fin **200** is formed from a single folded metal sheet which is preferably made of copper or aluminum. By folding the fins over themselves, the folded fin assembly provides a large surface area in a small space. Folded fin technology maximizes surface area and minimizes pressure drop, thus increasing the flow of heat from the heat generating source to the air. Preferably, the folded fin has an open top design to allow for air flow. Also preferably, the folded fin has a maximum fin height of about 10 cm (4 inches), a maximum fin flow length of about 61 cm (24 inches), a minimum fin thickness of about 0.005 cm (0.002 inches), a maximum fin thickness of about 0.1 cm (0.040 inches), a minimum fin density of about 0.8 fins per cm (2 fins per inch) and a maximum fin density of about 32 fins per cm (80 fins per inch).

[**0030**] The folded fin does not include the base structure contained in the typical cold-forged or machined heat sink. Thus, the use of a folded fin reduces the weight and volume of the heat transfer assembly. This reduced weight and volume simplifies and speeds the design cycle and can eliminate the need for complex bracing required for heavier heat transfer assemblies having finned heat sinks with base structures.

[**0031**] Although the use of a folded fin **200** is preferred, other conventional fin configurations may be used.

[**0032**] The heat spreader **100** and fin configuration **200** of the heat sink assembly **101** will have various features and dimensions depending on the application. In an exemplary embodiment to be used for transferring heat away from an integrated circuit device, the vapor chamber may be approximately 7.6 cm (3.0 inches) by 8.9 cm (3.5 inches) with a total thickness of 0.5 cm (0.200 inch). First plate **110** and second plate **120** may be constructed of OFHC copper 0.08 cm (0.035 inch) thick, and depressions **118** may span the 0.25 cm (0.100 inch) height of the internal volume of the vapor chamber **130**. The wick structure (not shown) may be constructed of sintered copper powder and may average 0.1 cm (0.040 inch) thick. The depressions **118** may have about a 0.63 cm (0.250 inch) outer diameter, and openings **160** may be approximately 0.53 cm (0.210 inches) in diameter.

[**0033**] Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claim should be construed broadly, to include other variants and embodiments of the invention, which may be made by those skilled in the art without departing from the scope and range of equivalents of the invention.

What is claimed is:

1. A heat spreader comprising:

a housing having first and second plates defining a hollow chamber therebetween,

at least one opening defined through each of said first and second plates of said housing, said housing having a surface defining at least one passage connecting the openings of the first and second plates, wherein said passage is isolated from said chamber, and

at least one insert adapted for receiving a fastener, the at least one insert being mounted directly into said at least one passage.

2. A heat spreader comprising:

a housing including first and second plates that define a hollow vapor chamber therebetween;

at least one depression formed in one of said plates which projects into said vapor chamber and is bonded to the other of said plates;

said housing having an opening that penetrates through said depression and the other of said plates; and

an insert adapted to receive a fastener, wherein said insert is mounted directly into said opening.

3. The heat spreader of claim 2, wherein the insert snaps into said opening.

4. The heat spreader of claim 3, wherein the insert is comprised of plastic.

5. The heat spreader of claim 2, further comprising a captive fastener held within the insert.

6. The heat spreader of claim 2, wherein the insert is stamped into said opening.

7. The heat spreader of claim 6, wherein a thickness of said first or second plate is greater in the at least one depression than the thickness of said first or second plate remote from the at least one depression.

8. The heat spreader of claim 2, wherein said first and second plates each include a peripheral lip located at an edge of said housing, said peripheral lips bonded together.

9. The heat spreader of claim 2, wherein said at least one depression comprises a flat surface that is in contact with an inner surface of said other of said plates.

10. The heat spreader of claim 2, wherein each of said plates includes an interior confronting surface and a peripheral lip located at an edge thereof, said peripheral lips being bonded together so as to define the vapor chamber.

11. The heat spreader of claim 2, wherein said depression comprises an annular inner surface of said first plate that is bonded to a corresponding annular edge surface in said second plate.

12. A heat sink comprising:

a housing including first and second plates with an enclosed vapor chamber therebetween;

at least one depression formed in one of said plates which projects into said vapor chamber and is bonded to the other of said plates;

said depression having an opening defined therethrough, so as to define an isolated passage through said vapor chamber;

an insert directly mounted into said opening and shaped to receive a fastener; and

at least one fin directly attached to one of the plates of said housing.

13. The heat sink of claim 12, wherein the fin is a folded fin.

14. The heat sink of claim 13, wherein the insert snaps into said opening.

15. The heat sink of claim 14, wherein the insert is comprised of plastic.

16. The heat sink of claim 12, further comprising a fastener held within the insert.

17. The heat sink of claim 12, wherein the insert is stamped into said opening.

18. A method for forming a heat spreader comprising the steps of:

joining first and second plates to define a hollow vapor chamber therebetween;

forming at least one depression in one of said plates, so that the depression projects into said vapor chamber and is bonded to the other of said plates;

penetrating said depression and the other of said plates to form an passage through the vapor chamber; and

mounting an insert directly into said opening, said insert being adapted to receive a fastener.

19. The method of claim 18, further comprising attaching at least one fin directly to the other of said plates.

20. The method of claim 18, further comprising inserting a fastener into said insert.

* * * * *