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(54) Title: COOLING MEMORY MODULES USING WEDGE-SHAPED HEAT SPREADERS IN THERMAL CONTACT WITH COLD PLATE BLADES AND MEMORY MODULES

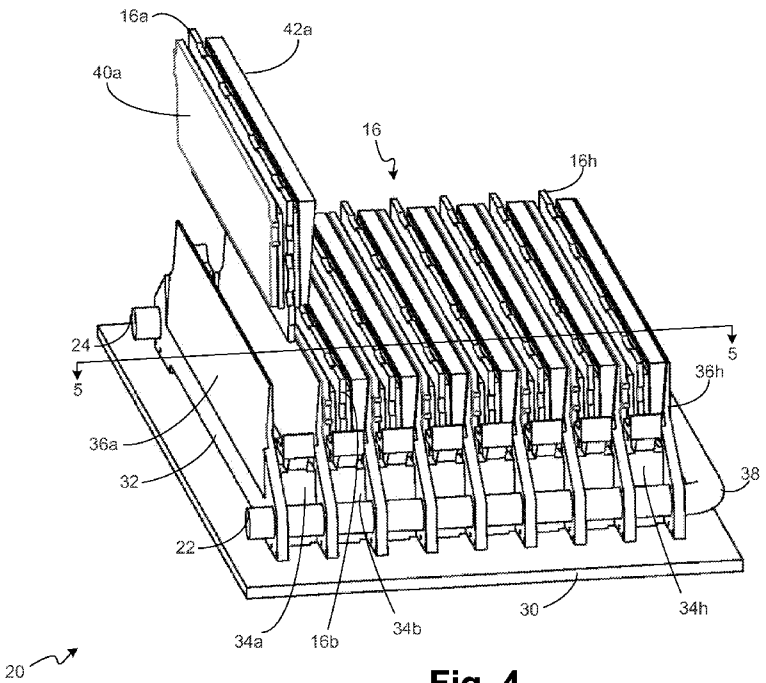

Fig. 4

(57) Abstract: A cold plate has blades arranged to be interleaved with memory modules, and wedgeshaped heat spreaders are attached to the memory modules and are in thermal contact with the blades. A liquid cooling loop is thermally coupled to the blades of the cold plate.

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COOLING MEMORY MODULES USING WEDGE-SHAPED HEAT SPREADERS IN THERMAL CONTACT WITH COLD PLATE BLADES AND MEMORY MODULES

CROSS-REFERENCES TO RELATED APPLICAITONS

[0001] The present patent application is related to the following patent applications: COOLING MEMORY MODULES USING COLD PLATE BLADES COUPLED TO THE MEMORY MODULES VIA CLIPS by Timothy Rau and Glenn C. Simon, and assigned HP Docket Number 200902998-1, A FRAME HAVING FRAME BLADES THAT PARTICIPATE IN COOLING MEMORY by Timothy Rau and Glenn C. Simon, and assigned HP Docket Number 200902999-1, and A COLD PLATE HAVING BLADES THAT INTERLEAVE WITH MEMORY MODULES by Timothy Rau and Glenn C. Simon, and assigned HP Docket Number 200902997-1. All related applications, and the present application, were filed on October 30, 2009.

BACKGROUND

[0002] In the art of computing, individual memory integrated circuits (ICs) are often provided on a dual in-line memory module (DIMM). Often a heat spreader is attached over the memory ICs to dissipate the heat generated by the memory ICs across the length of the DIMM. However, it is often desirable to provide additional cooling.

[0003] Typically DIMM sockets are positioned on a motherboard in close proximity to each other, thereby simplifying routing of memory signal traces on the motherboard and minimizing space used by memory. A typical separation between adjacent DIMMs is 10 millimeters.

[0004] Two methods known in the art for providing additional cooling are air cooling and liquid cooling. Because of the close spacing of adjacent DIMMs, both methods often use space above the DIMM. Typically air cooling uses a solid heat conducting metal or vapor chambers and associated tubing to conduct heat from the heat spreader to a heatsink above the DIMM.

[0005] Typically liquid cooling uses a suitable liquid, such as propylene glycol or ethylene glycol, mixed with water, to conduct heat from the heat spreader to the liquid. The heat is removed as the liquid is pumped through a channel associated with each DIMM. The liquid is

then pumped to a heat exchanger, where heat is removed from the liquid. Typically tubing is coupled to each DIMM along the top of the top of the DIMM.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The Figures depict embodiments, implementations, and configurations of the invention, and not the invention itself.

[0007] Figure 1 is a functional block diagram of computer, having a cooling loop for cooling memory, in accordance with embodiments of the present invention.

[0008] Figure 2 shows a board, which may be a motherboard, system board, or other type of circuit board, a bank of memory modules sockets, and a cold plate having blades, in accordance with embodiments of the present invention.

[0009] Figure 3 shows the cold plate, board, and memory module sockets of Figure 2 after the cold plate has been mounted to the board, in accordance with embodiments of the present invention.

[0010] Figure 4 shows a cold plate and board as in Figure 3, along with memory modules having wedge-shaped heat spreaders, in accordance with embodiments of the present invention.

[0011] Figure 5 is a sectional view taken along line 5-5 of Figure 4 showing orientations of the memory modules, wedge-shaped heat spreaders, and cold plate blades, in accordance with embodiments of the present invention.

[0012] Figure 6 is a block diagram of a cold plate wherein cooling liquid is routed through each blade, in accordance with embodiments of the present invention.

[0013] Figure 7 is a flowchart illustrating how embodiments of the present invention cool memory modules.

DETAILED DESCRIPTION

[0014] In the foregoing description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these details. While the invention has been disclosed with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover such modifications and variations as fall within the true spirit and scope of the invention.

[0015] The Figures show many elements that are members of a plurality of similar elements. In general, individual elements of the plurality will be referenced by a numeral followed by a letter, while similar elements may be referenced collectively or generically by the numeral. For example, a group of blades may be referenced as blades 36, an individual blade may be referenced as blade 36d, and a blade may be referenced generically as a blade 36.

[0016] As discussed in the Background section above, commercially available dual in-line memory module (DIMM) cooling solutions use space above the DIMMs to facilitate cooling. In prior art air cooled memory configurations, heatsinks are typically positioned above the DIMMs. Furthermore, cooling fans and air channels are often needed to move air over the heatsinks.

[0017] Commercially available liquid cooling solutions have a liquid inlet and outlet for each DIMM. The inlets and outlets, along with the associated tubing, consume space above the DIMMs. Furthermore, the need to connect tubing to the inlet and outlet of each DIMM makes assembly and servicing cumbersome.

[0018] In accordance with embodiments of the present invention, a cold plate having a liquid inlet and outlet is provided for each block of DIMMs. The cold plate is included in a liquid cooling loop. DIMM sockets are attached to a motherboard, system board, or other type of circuit board, and may have a standard spacing of 10 millimeters between adjacent DIMM sockets. The cold plate includes a series of blades that are positioned proximate to and interleaved with the DIMM sockets, with the blades cooled by the liquid cooling loop. Each blade as a sloped surface and a surface that is not sloped. A wedge-shaped heat spreader is attached to a first surface of each DIMM. When the DIMM is installed, the wedge-shaped heat spreader is in thermal contact with a sloped surface of a blade, and urges a second surface of the DIMM into thermal contact with a surface of a blade that is not sloped. Embodiments of the

present invention use little additional space compared to a standard bank of DIMMs of the prior art. Installation and servicing are simplified, since DIMMs can be added or removed, as in the prior art, without having to disturb the liquid cooling loop.

[0019] Figure 1 is a functional block diagram of computer 10, in accordance with embodiments of the present invention. Details of the cold plate and wedge-shaped heat spreader structures, in accordance with embodiments of the present invention, will be shown in other figures.

[0020] Computer system 10 includes one or more central processing units (CPUs) 12, core logic 14, DIMMs 16, bus 18, cold plate and wedge-shaped heat spreaders 20 (which includes blades/wedge-shaped heat spreaders 17, liquid inlet 22, and liquid outlet 24), tubing 26, and liquid cooling loop pump/cooling unit 28.

[0021] CPUs 12 represents CPUs know in the art, such as several CPUs in discrete packages and multi-core CPUs in a single package. Core logic 14 represents core logic known in the art, such as a south bridge, a north bridge, memory controllers, I/O controllers, and the like. As the art of computing continues to advance, some of these functions, such as the memory controllers, are provided in the CPU package. Bus 18 represents one or more buses known in the art for connecting CPUs 12, core logic 14, and DIMMs 16.

[0022] Liquid cooling loop pump/cooling unit 28 pumps and cools liquid coolant using techniques know in the art. Any suitable coolant liquid, such as propylene glycol or ethylene glycol, mixed with water, can be used. The liquid may be cooled using a simple heat exchanger and fan, or by more advanced techniques, such as Peltier coolers or heat pumps. Also, note that the function provided by unit 28 may be implemented at a variety of levels, such as in the computer system, within a rack, within a row of racks, or within a data center. It is also possible to integrate the liquid cooling function with a data center air conditioning system.

[0023] Note that it may also be desirable to cool CPUs 12 using a liquid cooling loop. In such a configuration, the loop can also flow through the CPUs, or a separate loop may be provided. For simplicity, the liquid cooling loop is only shown as cooling DIMMs 16. The liquid flows through tubing 26 in the direction show by the arrows in the tubing. The cold plate of cold plate and wedge-shaped heat spreaders 20 includes an inlet 22 and an outlet 24, both of which are coupled to tubing 26.

[0024] The liquid cooling loop is in thermal contact with blades/wedge-shaped heat spreaders 17. In Figure 1, blades/wedge-shaped heat spreaders 17 are shown generically in block diagram form, and include blades associated with the cold plate of cold plate and wedge-shaped heat spreaders 20, and wedge-shaped heat spreaders thermally coupling the DIMMs 16 to the blades, as will be shown in other figures and discussed in greater detail below.

[0025] Figure 2 shows a board 30 and a cold plate 32, in accordance with embodiments of the present invention. Board 30 may be a motherboard, system board, or other type of circuit board. Board 30 includes DIMM sockets 34, which comprise individual DIMM sockets 34a-34h, with labels for DIMM sockets 34a and 34h shown in Figure 2.

[0026] Cold plate 32 includes liquid inlet 22 and liquid outlet 24, as shown in Figure 1. Cold plate 32 also includes blades 36, which comprise individual blades 36a-36i, with labels for blades 36a and 36i shown in Figure 2. Cooling loop 38 includes inlet 22 and outlet 24, and ends of blades 36 are thermally coupled to cooling loop 38. The configurations shown in the figures herein support eight DIMMs. However, those skilled in the art will recognize that additional or fewer DIMMs may be supported by embodiments on the present invention. In a configuration supporting eight DIMMs as shown in Figure 2, nine blades 36 are provided.

[0027] Figure 3 shows cold plate 32 and board 30 after cold plate 32 has been mounted to board 30. The blades 36a-36i of cold plate 32 are interleaved with DIMM sockets 34a and 34h such that each DIMM socket 34 is adjacent to a pair of blades 36. Note that each DIMM socket 34 has a pair or retainment/release latches, such as latch 37.

[0028] Figure 4 shows cold plate 32 and board 30 as in Figure 3, along with DIMMs 16. DIMMs 16b-16h are installed into DIMM sockets 34b-34h, respectively, and DIMM 16a is shown above DIMM socket 34a. Each DIMM includes a heat spreader and a wedge-shaped heat spreader. For example, DIMM 16a includes heat spreader 40a and wedge-shaped heat spreader 42a. In one embodiment, the wedge-shaped heat spreaders are attached to the DIMMs using resilient compressible adhesive thermal interface pads. For standard "off-the-shelf" DIMMs having heat spreaders already attached, a wedge-shaped heat can be added to a side of each DIMM. Note that if DIMMs without heat spreaders are used, the wedge-shaped heat spreader may be affixed directly to the memory ICs. The wedge-shaped heat spreaders may be affixed by the memory installer, or alternatively, DIMMs may be shipped from a memory vendor with wedge-shaped heat spreaders installed.

[0029] Figure 5 is a sectional view taken along line 5-5 of Figure 4 showing the orientations of the DIMMs 16, blades 36, and wedge-shaped heat spreaders 42. Note that the sectional view of Figure 5 shows DIMM 16a installed.

[0030] In Figure 5, dual sided DIMMs 16a-16h with heat spreaders 40a-40h are shown. Accordingly, each DIMM 16 is inserted in a DIMM socket 34, and includes memory ICs 44 (44a-44h) on both sides of the DIMM, and a heat spreader 40. Those skilled in the art will recognize that single-sided DIMMs may also be used with embodiments of the present invention, and DIMMs without heat spreaders may be used.

[0031] Wedge-shaped heat spreaders 42 are coupled to a first side of each DIMM 16 via resilient compressible thermal interface pads (45a-45h). The Cho-Therm® line of thermal interface materials from Chomerics division of Parker Hannifin Corporation includes resilient compressible thermal interface pads suitable for use with embodiments of the present invention.

[0032] As the DIMMs 16 are inserted in DIMM sockets 34, the sloped surfaces of blades 36 and wedge-shaped heat spreaders 42 cooperate to urge DIMMs 16 toward the non-sloped surfaces of blades 36. In addition, as the DIMMs are inserted, the resilient compressible thermal interface pads (45a-45h) are compressed, and the DIMMs are locked into place using the pair of latches at the ends of each DIMM socket 34. Since the interface pads 45 remain compressed after DIMMs 16 are installed, interface pads continue to maintain lateral force, thereby maintaining thermal coupling at both sides of each DIMM 16, while also compensating for variations caused by thermal expansion and contraction, and variations caused by manufacturing and assembly tolerances.

[0033] In the embodiment shown in Figures 1–4, cold plate 32 includes a single cooling loop 38 that traverses a portion of the perimeter of the DIMMs 16. Each blade 36 of cold plate 32 has two ends coupled to cooling loop 38, and blades 36 and wedge-shaped heat spreaders 42 are made of a material having excellent thermal transfer properties, such as copper, aluminum, steel, and the like.

[0034] While the embodiment shown in Figures 1–4 having a cooling loop 38 that traverses a portion of the perimeter of DIMMs 16 provides acceptable cooling performance, in another embodiment, liquid is routed through each blade of the cold plate. Figure 6 shows a block diagram of this embodiment.

[0035] In Figure 6, blade 48 of cold plate 46 represents a first blade in a series of blades, and blade 50 represents a last blade in the series. Blade 48 includes channel 52, and blade 50 includes channel 54, with each channel carrying cooling liquid through the blade. Cooling loop 56 is configured to route cooling liquid through the channel of each blade. Accordingly, although the embodiment shown in Figure 6 is more complex than the embodiments shown in Figures 1-4, the temperatures along the channels 52 and 54 tend to be more uniform.

[0036] Figure 7 is a flowchart 58 illustrating how embodiments of the present invention cool DIMMs. In block 60, heat is conducted away from a first side of each memory module of the plurality of memory modules to a wedge-shaped heat spreader of the plurality of wedge-shaped heat spreaders. In block 62, heat is conducted away from the plurality of wedge-shaped heat spreaders to the plurality of blades of the cold plate. In block 64, heat is conducted from a second side of each memory module of the plurality of memory modules to a blade of the plurality of blades of the cold plate. Finally, in block 66 heat is conducted from the blades of the cold plate to the liquid flowing in the liquid cooling loop.

[0037] Block 68a, in conjunction with block 66, represents the embodiments shown in Figures 1-4. Accordingly, heat is conducted from the ends of the cold plate blades to the liquid cooling loop. Block 68b, in conjunction with block 66, represents the embodiment shown in Figure 6. Accordingly, cooling liquid is routed through a channel of each blade of the cold plate.

[0038] Embodiments of the present invention provide many advantages over the prior art. Liquid cooling loop connections remain fixed as DIMMs are added or removed. In contrast, prior art liquid cooled memory configurations provide liquid inlets and outlets for each DIMM, thereby causing the addition and removal of DIMMs to be cumbersome and time consuming. With embodiments of the present invention, a single inlet and outlet is provided for a block of DIMMs, and the inlet/outlet connections need only be coupled once during the manufacturing process.

[0039] Embodiments of the present invention require little extra space above the DIMMs, as is shown in the figures. Prior art air and liquid cooling solutions often consume space above the DIMMs. In addition, embodiments of the present invention have a system board "footprint" similar to prior art DIMM blocks. The only extra area required is the area reserved for the cooling loop along the sides of the DIMM block, and the area reserved for the inlets and outlets, and cooling loop connections. Also, space is saved by eliminating the need for cooling fans to direct airflow over the DIMMs. Of course, acoustic levels may also be reduced. Finally,

embodiments of the present invention provide for simple and tool-free memory reconfiguration, since the DIMMs are easily removed by pressing the DIMM socket latches.

[0040] In the foregoing description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these details. While the invention has been disclosed with respect to a limited number of embodiments, those skilled in the art will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover such modifications and variations as fall within the true spirit and scope of the invention.

CLAIMS

What is claimed is:

1. An apparatus (20) for cooling memory modules (16) comprising:

a cold pate (32, 46) comprising:

a liquid cooling loop (38, 56) having an inlet (22) and an outlet (24); and

a plurality of blades (36, 48, 50) thermally coupled to the cooling loop (38, 56), the plurality of blades (36, 48, 50) arranged to be interleaved with a plurality of memory modules (16); and

a plurality of wedge-shaped heat spreaders (42), with each wedge-shaped heat spreader (42a-42h) of the plurality of wedge-shaped heat spreaders (42) attached to a memory module (16) of the plurality of memory modules (16), and each wedge-shaped heat spreader (42) in thermal contact with a blade (36, 48, 50) of the plurality of blades (36, 48, 50).

2. The apparatus (20) for cooling memory modules (16) according to claim 1 wherein the liquid cooling loop (38) traverses at least a portion of a perimeter of the cold plate (32) and is thermal contact with each blade (36a-36h) of the plurality of blades (36) of the cold plate (32) proximate ends of the blades (36a-36h).

3. The apparatus (20) for cooling memory modules (16) according to claim 1 wherein each blade (48, 50) of the plurality of blades of the cold plate (46) includes a channel (52, 54), and the liquid cooling loop (56) is coupled to each blade (48, 50) and cooling liquid is routed through the channel (52, 54) of each blade (48, 50).

4. The apparatus (20) for cooling memory modules (16) according to claim 1 wherein each blade (36) of the plurality of blades (36) of the cold plate (32) includes a sloped surface and a surface that is not sloped, a wedge-shaped heat spreader (42) is attached to a first side of each memory module (16), a sloped surface of each wedge-shaped heat spreader (42) is in thermal contact with a sloped surface of each blade (36), a second surface of each memory module (16) is in thermal contact with a surface of a blade (36) that is not sloped, and the sloped surfaces cooperate to urge the memory modules and wedge-shaped heat spreaders (42) into thermal contact with the blades (36).

5. The apparatus (20) for cooling memory modules (16) according to claim 1 wherein a resilient compressible thermal interface pad (45) is provided between each wedge-shaped heat spreader (42) and a memory module (16).

6. The apparatus (20) for cooling memory modules (16) according to claim 5 wherein the resilient compressible thermal interface pads (45) are adhesive pads.

7. A computer system (10) comprising

one or more central processing units (12);

a bank of memory modules (16);

core logic (14);

one or more busses (18) coupling the one or more central processing units (12), the bank of memory modules (16), and the core logic (14);

a cold plate (32, 46) having a plurality of blades (36, 48, 50) interleaved with the memory modules (16);

a plurality of wedge-shaped heat spreaders (42), with each wedge-shaped heat spreader (42a-42h) of the plurality of wedge-shaped heat spreaders (42) attached to a memory module (16) of the bank of memory modules (16), and each wedge-shaped heat spreader (42) in thermal contact with a blade (36, 48, 50) of the plurality of blades (36, 48, 50);

a liquid cooling loop (38, 56) having an inlet (22) and an outlet (24), and in thermal contact with the plurality of blades (36, 48, 50) of the cold plate (32, 46); and

a liquid cooling loop pump and cooling unit (28) coupled (26) to the inlet (22) and the outlet (24) of the liquid cooling loop (38, 56).

8. The computer system (10) according to claim 7 wherein the liquid cooling loop (38) traverses at least a portion of a perimeter the cold plate (32) and is in thermal contact with each blade (36a-36h) proximate ends of the blades (36).

9. The computer system (10) according to claim 7 wherein each blade (48, 50) includes a channel (52, 54), and the liquid cooling loop (56) is coupled to each blade (48, 50) and cooling liquid is routed through the channel (52, 54) of each blade (48, 50).

10. The computer system (10) according to claims 7 wherein each blade (36) of the plurality of blades (36) of the cold plate (32) includes a sloped surface and a surface that is not sloped, a wedge-shaped heat spreader (42) is attached to a first side of each memory module (16), a sloped surface of each wedge-shaped heat spreader (42) is in thermal contact with a sloped surface of each blade (36), a second surface of each memory module (16) is in thermal contact with a surface of a blade (36) that is not sloped, and the sloped surfaces cooperate to urge the memory modules (16) and wedge-shaped heat spreaders (42) into thermal contact with the blades (36).

11. The computer system (10) according to claim 7 wherein a resilient compressible thermal interface pad (45) is provided between each wedge-shaped heat spreader (42) and a memory module (16).

12. The computer system (10) according to claim 11 wherein the resilient compressible thermal interface pads (45) are adhesive pads.

13. A method (58) for removing heat from a plurality of memory modules cooled by a single liquid cooling loop coupled to interleaved blades of a cold plate, with a plurality of wedge-shaped heat spreaders attached to the memory modules and in thermal contact the blades, the method comprising:

conducting (60) heat from a first side of each memory module of the plurality of memory modules to a wedge-shaped heat spreader of the plurality of wedge-shaped heat spreaders;

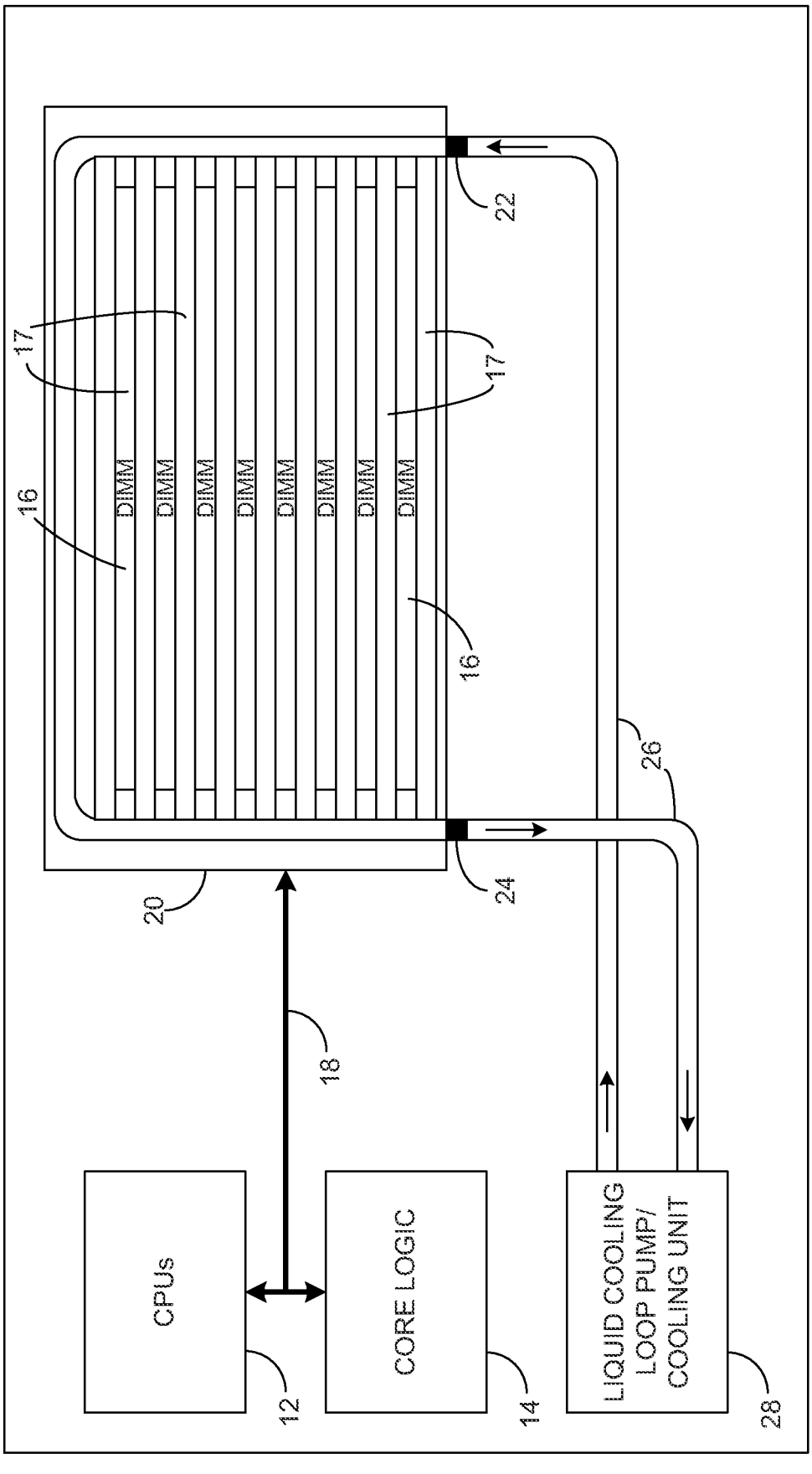
conducting (62) heat from the plurality of wedge-shaped heat spreaders to the plurality of blades of the cold plate;

conducting (64) heat from a second side of each memory module of the plurality of memory modules to a blade of the plurality of blades of the cold plate; and

conducting (66) heat from the plurality blades of the cold plate to liquid flowing in the liquid cooling loop.

14. The method according to claim 13 wherein conducting (66) heat from the plurality blades of the cold plate to liquid flowing in the liquid cooling loop includes cooling (68a) each blade of the plurality of blades of the cold plate at an end of each blade.

15. The method according to claim 13 wherein conducting (66) heat from the plurality blades of the cold plate to liquid flowing in the liquid cooling loop includes routing (68b) liquid through a channel of each blade of the plurality of blades of the cold plate.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CPUs
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CORE LOGIC
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LIQUID COOLING
LOOP PUMP/
COOLING UNIT
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Fig. 1

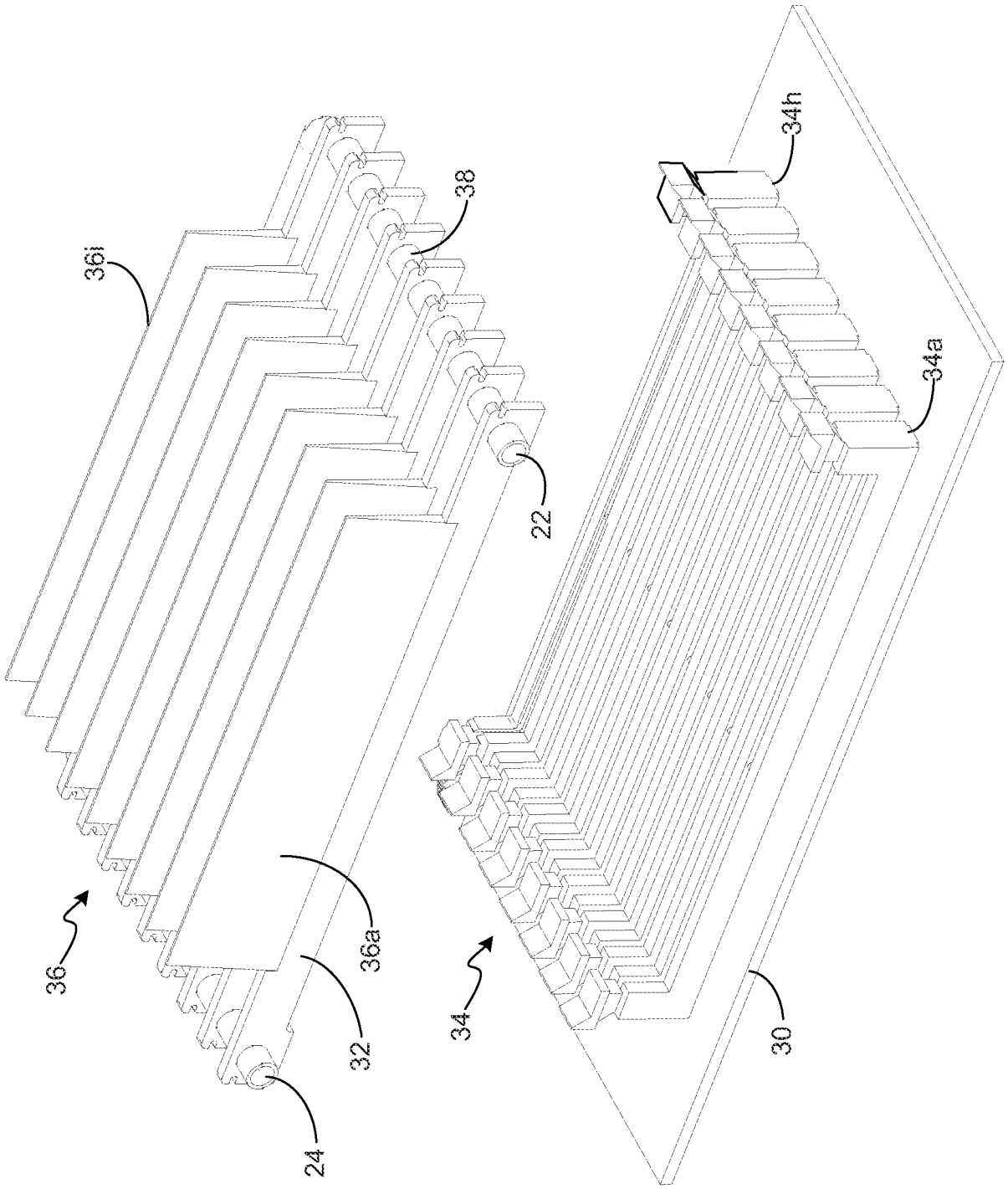

Fig. 2

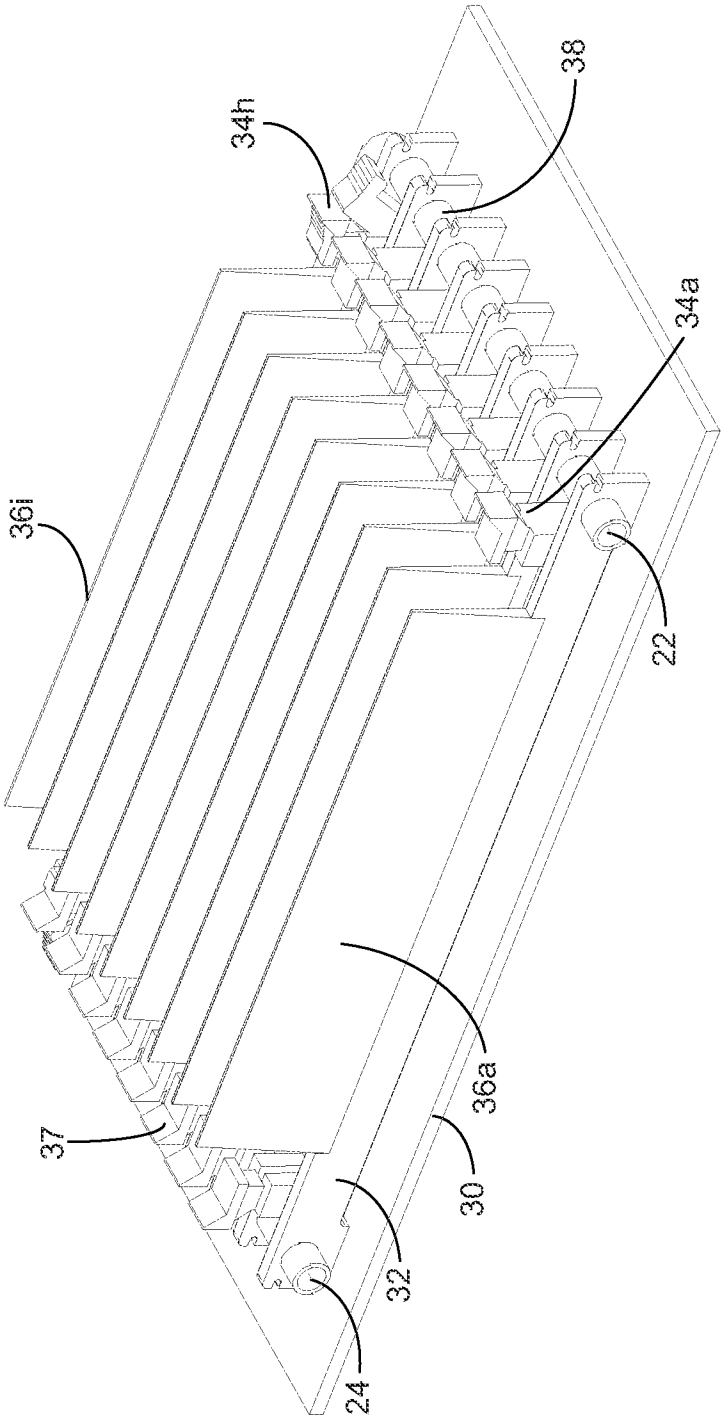

Fig. 3

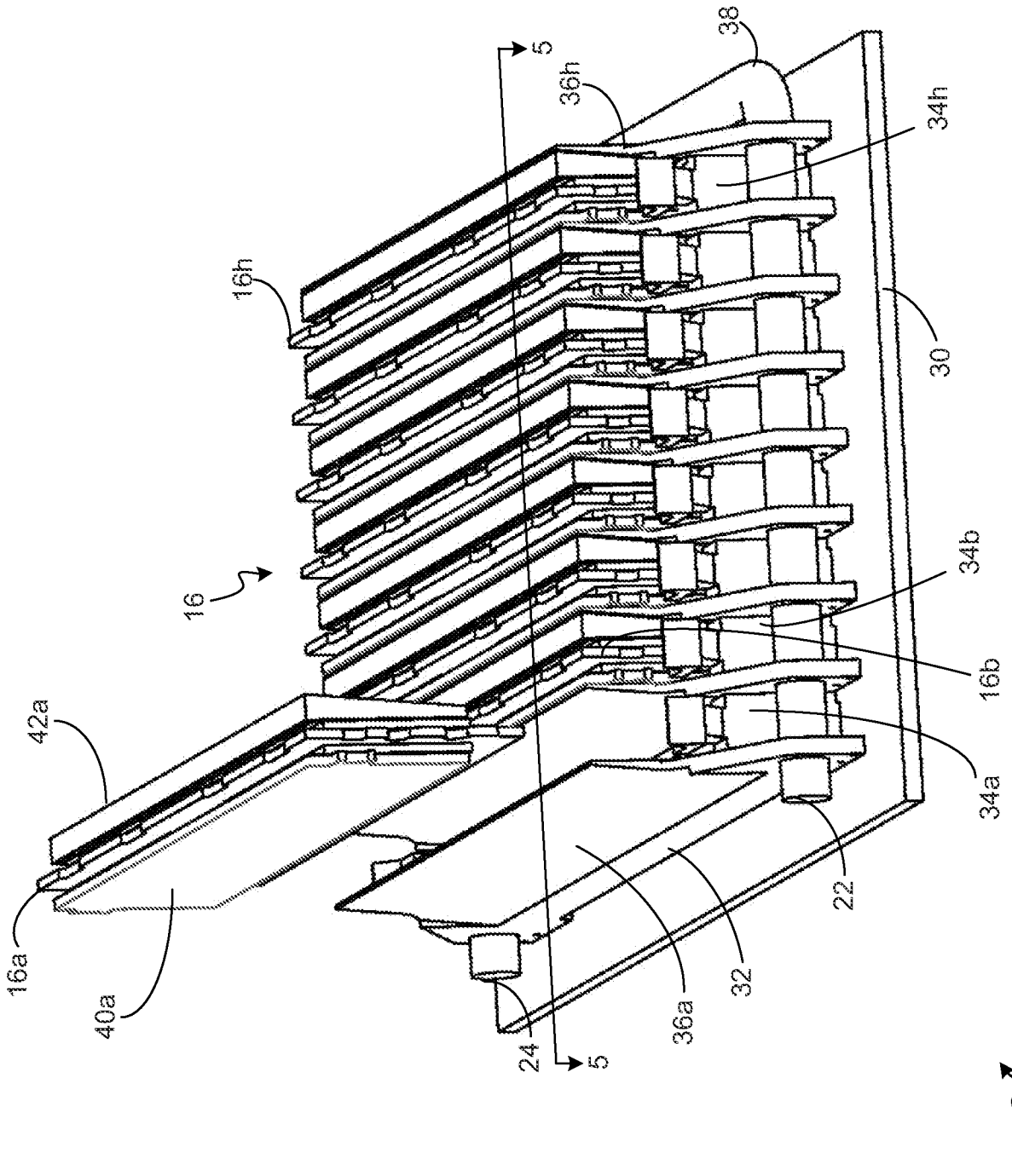

Fig. 4

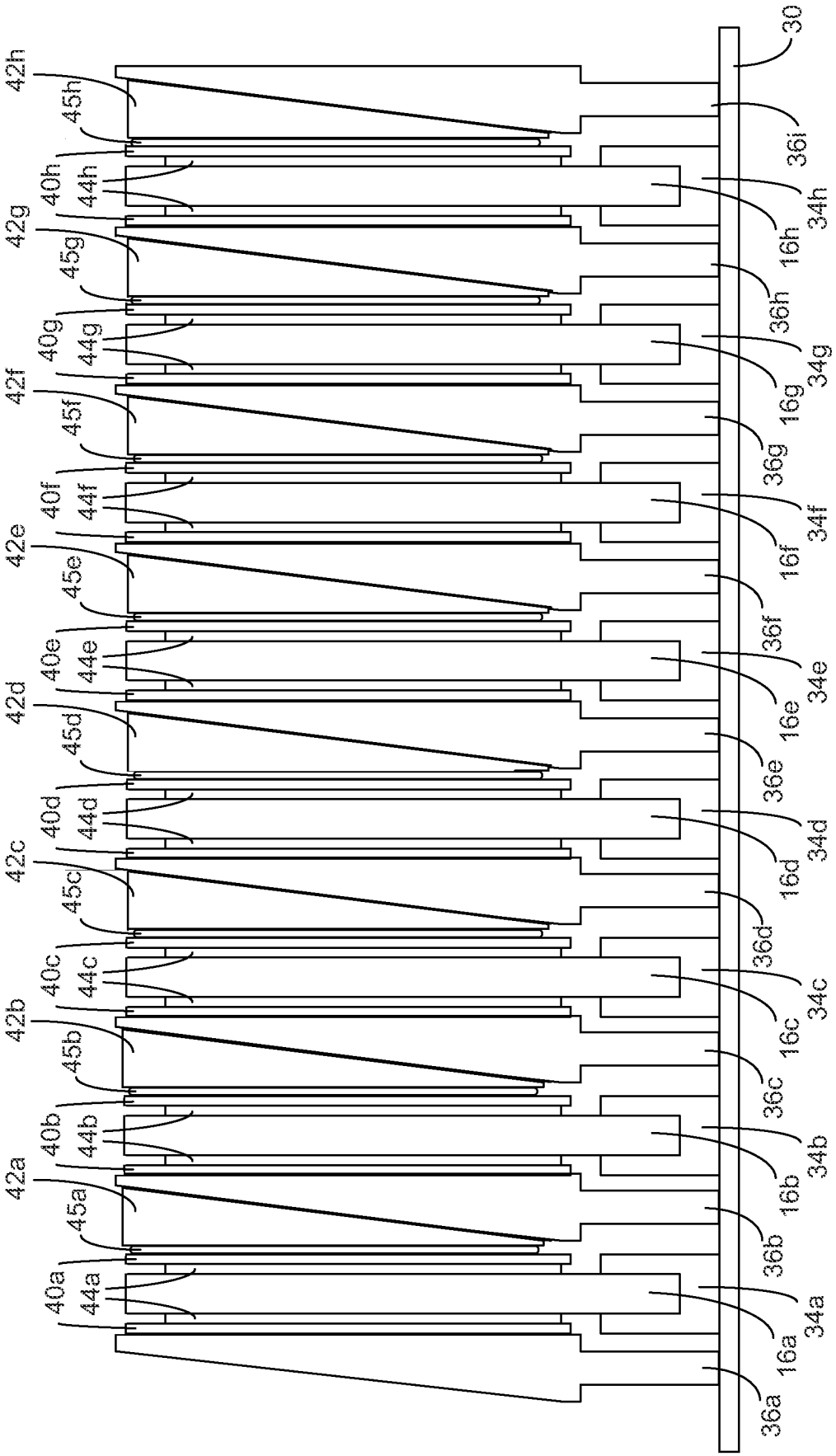
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Fig. 5

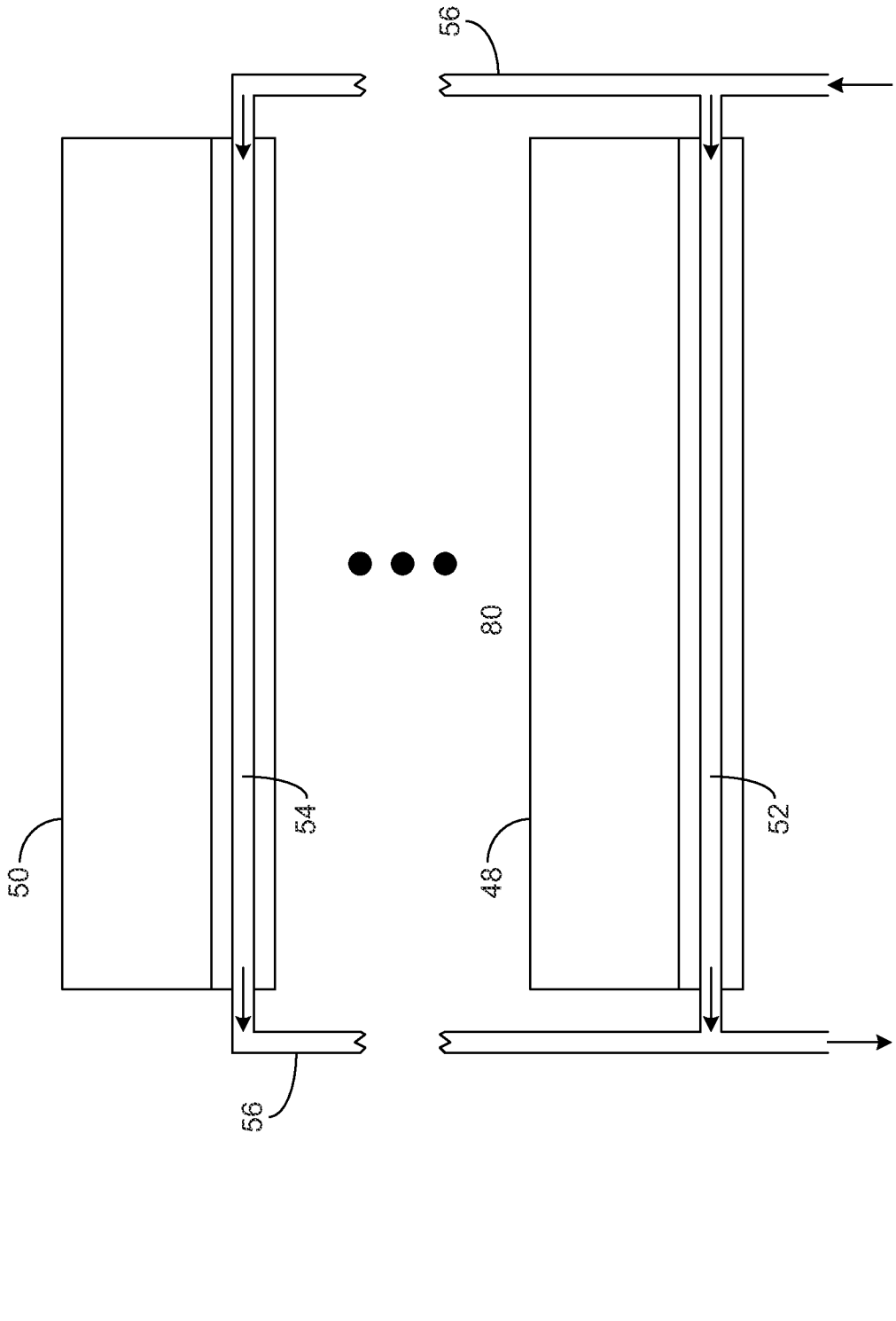
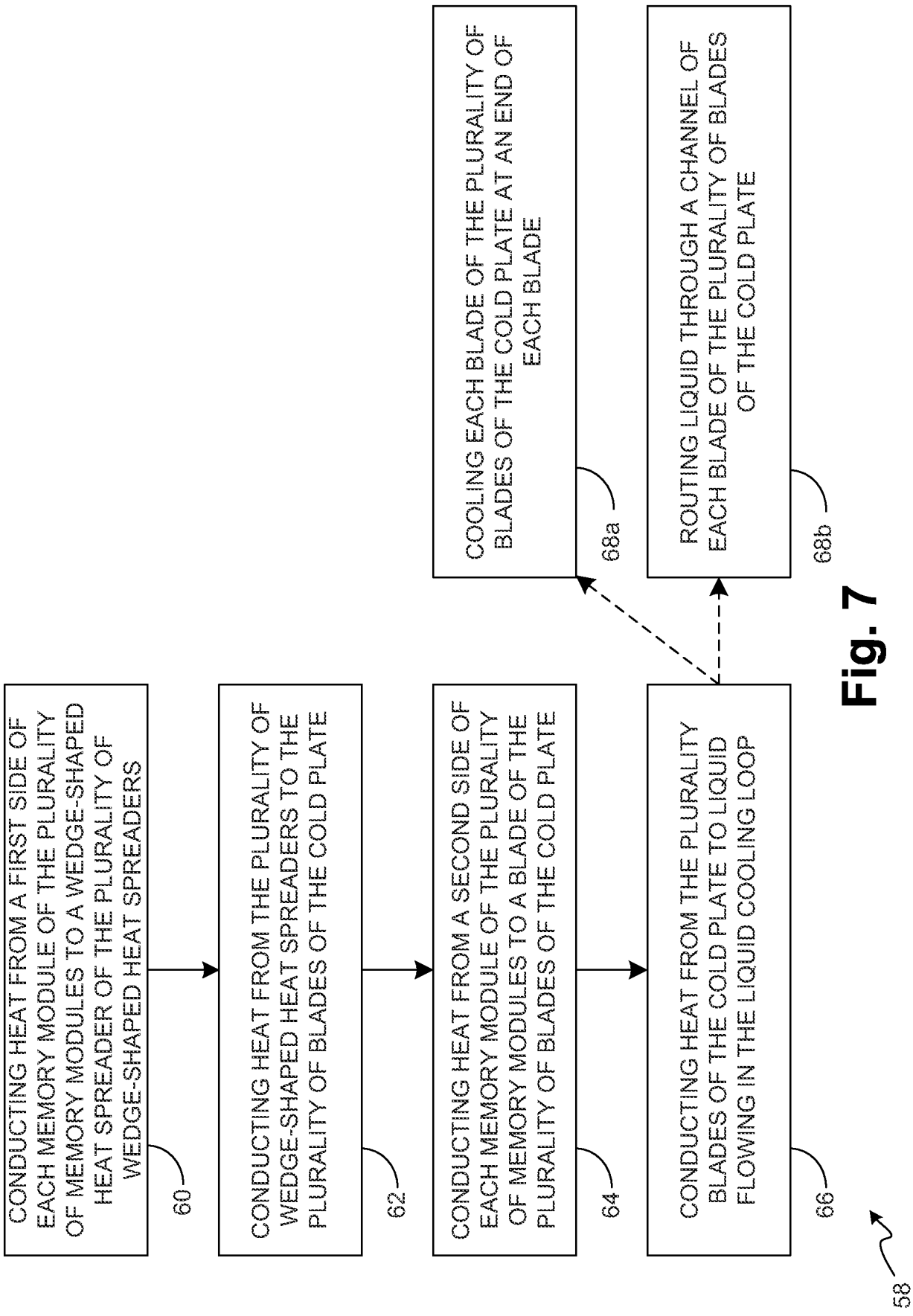


Fig. 6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CONDUCTING HEAT FROM A SECOND SIDE OF EACH MEMORY MODULE OF THE PLURALITY OF MEMORY MODULES TO A BLADE OF THE PLURALITY OF BLADES OF THE COLD PLATE
64
CONDUCTING HEAT FROM THE PLURALITY BLADES OF THE COLD PLATE TO LIQUID FLOWING IN THE LIQUID COOLING LOOP
66
COOLING EACH BLADE OF THE PLURALITY OF BLADES OF THE COLD PLATE AT AN END OF EACH BLADE
68a
ROUTING LIQUID THROUGH A CHANNEL OF EACH BLADE OF THE PLURALITY OF BLADES OF THE COLD PLATE
68b
58

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/062770

A. CLASSIFICATION OF SUBJECT MATTER

G06F 1/20(2006.01)i, H05K 7/20(2006.01)i, G06F 1/16(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06F 1/20; F28F 7/00; H05K 7/20

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: memory module, cold plate, wedge-shaped heat spreader

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2008-0084668 A1 (CAMPBELL et al.) 10 April 2008 See abstract; figures 3, 6a-6b; paragraphs [0011], [0035], [0036], [0048].	1-15
Y	US 7342797 B2 (KAMATH et al.) 11 March 2008 See abstract; figures 3-8; column 3, line 31-42; column 5, line 41-52.	1-15
Y	US 2008-0264613 A1 (CHU HUANG-CHENG) 30 October 2008 See abstract; figures 2-7; paragraph [0015].	3,9,15
A	US 2009-0122481 A1 (CHANG CHIH-I et al.) 14 May 2009 See abstract; figures 1-3; paragraphs [0012], [0028].	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 JULY 2010 (19.07.2010)	**22 JULY 2010 (22.07.2010)**

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2009/062770

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 7408776 B2	05.08.2008
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		US 7289331 B2	30.10.2007
		US 7339793 B2	04.03.2008
US 2008-0264613 A1	30.10.2008	None	
US 2009-0122481 A1	14.05.2009	None	