

Petition for Inter Partes Review Of
U.S. Patent No. 8,240,362
Decl. of Georgios Karamanis, Ph.D.

UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE PATENT TRIAL AND APPEAL BOARD

COOLER MASTER CO., LTD.

Petitioner,

v.

ASETEK DANMARK A/S,

Patent Owner

U.S. Patent No. 8,240,362

DECLARATION OF GEORGIOS KARAMANIS, PH.D.

Dated: March 6, 2023

Respectfully submitted,



Georgios Karamanis, Ph.D.

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I, Georgios Karamanis, Ph.D., declare as follows:

I. INTRODUCTION AND QUALIFICATIONS

1. Counsel for Cooler Master Co., Ltd. (“CMC”) has retained me as an expert to offer my opinion regarding the validity of U.S. Patent No. 8,240,362 (“’362 patent”). I submit this declaration based on my personal knowledge and in support of CMC’s *inter partes* review Petition against the ’362 patent. I previously submitted a substantively identical declaration in support of Shenzhen Apaltek Co. Ltd.’s *inter partes* review Petition against the ’362 patent.

2. In 2018, I received my Ph.D. from Tufts University in Mechanical Engineering. My Ph.D. thesis was entitled “Nusselt Numbers for Superhydrophobic Microchannels and Shrouded Longitudinal-Fin Heat Sinks.”

3. In October 2018, I began working at Transport Phenomena Technologies, LLC (TPT) in Medford, MA where I am co-founder and managing member.

4. I am currently a Chief Engineer at TPT and responsible for R&D in the area of thermal management of electronics and heat/mass/momentum transfer modeling.

5. I am the PI on a National Science Foundation Phase I and its successor Phase II SBIR award (#2025882) and before that on a Massachusetts Clean Energy Center Catalyst award (Spring 2019) relevant to development of software and

hardware for thermal management of electronics.

6. In December of 2021, I became part-time Research Assistant Professor in the Department of Mechanical Engineering at Tufts University. My research at Tufts is on heat/mass/momentum transfer and I regularly teach a course on numerical simulations.

7. I have 10 journal publications most of which are related to thermal management of electronics and liquid cooling. A copy of my Curriculum Vitae (“CV”) is submitted herewith as Appendix A, which describes my education, training, and experience in greater detail.

8. My primary consulting client is Apaltek, acting as an expert on thermal management in general, including liquid cooling to cool CPUs.

9. I have not previously testified as an expert witness in any court or administrative proceeding.

10. I am billing my work in this matter at \$200 per hour, with reimbursement for actual expenses. My payment is not contingent upon my testimony or the outcome of the case. I have no personal interest in the outcome of the case.

II. MATERIALS CONSIDERED

11. The analysis provided in this declaration is based on my education as

well as my experience in the field. In addition to relying upon my knowledge based on written materials and other information that was known as of November 7, 2003, I have considered the exhibits to the Petition (Exs. 1001-1011), shown below.

Exhibit	Description
1001	U.S. Patent No. 8,240,362 (“’362 patent”)
1002	File history of U.S. Patent No. 8,240,362 (“’362 FH”)
1005	Defendants’ Reply Claim Construction Brief filed on April 12, 2022 in Asetek Danmark A/S v. Shenzhen Apaltek Co., Ltd., Case No. 6:21-cv-501-ADA (W.D. Tex.) (Doc. 61)
1006	U.S. Patent No. 6,019,165 to Batchelder (“Batchelder”)
1007	Certified Translation of Japanese Unexamined Patent App. Pub. No. 2002-151638 to Takayuki Shin (“Shin”)
1008	U.S. Patent No. 6,915,653 to Nakano et al. (“Nakano”)
1009	Patent Owner’s Response, Paper No. 21 in IPR2020-00523 (Nov. 30, 2020) (“’354-POR”)
1010	U.S. Patent No. 10,078,354 (the “’354 patent”)
1011	Final Written Decision in IPR2020-00523, Paper No. 36 (Aug. 19, 2021) (“’354-FWD”)

III. OVERVIEW AND LEGAL STANDARDS

A. Priority Date

12. Counsel has explained to me that I should assume the effective filing date of the ’362 patent is November 7, 2003. I have, therefore, applied this date in considering the prior art and the viewpoint of a person of ordinary skill in the art

(“POSITA”).

13. I understand Petitioner may argue that the ’362 patent is not entitled to a 2003 effective filing date. Even if this were true, my opinions would not change.

B. Person Having Ordinary Skill in the Art

14. I understand that my assessment of the claims of the ’362 patent must be undertaken from the perspective of what would have been known or understood by a person having ordinary skill in the art, reading the ’362 patent on its relevant filing date and in light of the specification and file history of the ’362 patent. I will refer to such a person as a “POSITA.”

15. I understand that my analysis and opinions expressed in this declaration must be rendered based on the perspective of a POSITA as of the priority date of the Challenged Claims. I also understand that a POSITA is a hypothetical person who is presumed to have known the relevant art at the time of the alleged invention claimed in the ’362 patent.

16. I further understand that in determining the level of ordinary skill in the art, I am to consider factors including:

- a) the type of problems encountered in the art or field of invention,
- b) prior art solutions to those problems,
- c) the rapidity with which innovations are made,

- d) sophistication of the technology, and
- e) the educational level of active workers in the field.

17. I understand that a POSITA is a person of ordinary creativity, but not an automaton, and that a POSITA can often fit multiple patents or prior art references together like pieces of a puzzle as a result of this ordinary creativity. I also understand that I may consider the inferences and creative steps that a POSITA would employ. In addition, I understand that a POSITA would necessarily have been capable of understanding the scientific and engineering principles applicable to the pertinent art. I also understand that when I consider what would have been obvious to a POSITA, I am not considering what would have been obvious to me at the time, nor to the inventors, judges, laymen, those skilled in other arts, or to geniuses in the art.

18. Based on my review and analysis of the Challenged Patent, the prior art cited herein, and the ordinary skill factors described in this section, in my opinion, a POSITA working in the field of liquid cooling systems for computer systems as of the earliest possible effective filing date of November 7, 2003 knowledgeable regarding liquid cooling systems for computer systems, would have had a Bachelor of Science (B.S.) in electrical or mechanical engineering, or similar advanced post-graduate education in this area, or would have possessed at least two or three years

of experience in liquid cooling systems for computer systems or in similar systems. (See, e.g., Ex-1001 at 1:13-49 (describing the “Background of the Invention” of the ’362 patent).) A POSITA would be knowledgeable of the concepts, components, and their functions described as “prior art” in the ’362 patent such as, for example, liquid pumps, heat radiators, air fans, reservoirs, and other techniques of heat dissipation and liquid cooling. (*Id.*) In addition, a POSITA would be knowledgeable about electric motors and their components such as, for example, electromagnetic coils, rotors, stators, AC motors, DC motors, etc.

19. A person with less education but more relevant practical experience, depending on the nature of that experience and degree of exposure to liquid cooling systems for computer systems could also qualify as a POSITA in the field of the ’362 patent.

IV. LEGAL STANDARDS

20. I have been asked to opine on whether certain claims are either anticipated or rendered obvious by the prior art.

21. I have been instructed that anticipation means that a single prior art reference discloses each claim element and discloses the arrangement of each claim element. To disclose a claim element, the prior art does not have to expressly spell out the claim element as long as a POSITA, reading the reference, would at once

envisage the claimed arrangement or combination.

22. I have been instructed that obviousness means that one or more prior art references disclose each claim element of a claim and that there must be an apparent reason to combine the known elements to arrive at the claims. The analysis is a flexible one, accounting for the inferences and creative steps that a person of ordinary skill in the art would employ. The claims must be read as a whole when evaluating whether it is obvious.

23. It is my understanding that a claimed invention is unpatentable under 35 U.S.C. § 103 if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the alleged invention was made to a person of ordinary skill in the art to which the subject matter pertains. This is sometimes described as “obviousness.” I understand that an obviousness analysis considers the level of ordinary skill in the art, the scope and content of the prior art, and the differences between the prior art and the claimed subject matter. The analysis may also consider secondary considerations, such as commercial success, unmet but long felt need and failure of others.

24. It is my understanding that court cases have recognized several rationales for combining references or modifying a reference to show obviousness of the claimed subject matter. Some of these rationales include the following:

combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to obtain predictable results; a predictable use of prior art elements according to their established functions; applying a known technique to a known device to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and some teaching, suggestion, or motivation in the prior art that would have led a POSITA to modify the prior art or combine prior art teachings to arrive at the claimed invention.

V. GROUNDS OF INVALIDITY

In my opinion, the Challenged Claims of the '362 patent should be cancelled based on the following grounds of unpatentability:

Ground of Unpatentability	'362 Patent Claim(s)	Basis for Rejection under 35 U.S.C. §103
Ground 1	1, 3-11, 13, 17-19	Rendered obvious over Batchelder in view of Shin
Ground 2	12, 14-16	Rendered obvious over Batchelder in view of Shin and further in view of Nakano

VI. OVERVIEW OF THE '362 PATENT

25. The '362 patent relates to a liquid-cooling system for a central

processing unit (CPU) or other processing unit of a computer system. (Ex-1001, 1:21-25.) The specification discloses embodiments of a small and compact liquid-cooling solution that it claims are more efficient than existing air-cooling arrangements and that can be produced in high volume and at low cost. (*Id.*, 1:62-65.) The '362 patent discloses that these improvements may be obtained by:

a cooling system for a computer system, said computer system comprising: at least one unit such as a central processing unit (CPU) generating thermal energy and said cooling system intended for cooling the at least one processing unit, a reservoir having an amount of cooling liquid, said cooling liquid intended for accumulating and transferring of thermal energy dissipated from the processing unit to the cooling liquid, a heat exchanging interface for providing thermal contact between the processing unit and the cooling liquid for dissipating heat from the processing unit to the cooling liquid, a pump being provided as part of an integrate element, said integrate element comprising the heat exchanging interface, the reservoir and the pump, said pump intended for pumping the cooling liquid into the reservoir, through the reservoir and from the reservoir to a heat radiating means, said heat radiating means intended for radiating thermal energy from the cooling liquid, dissipated to the cooling liquid, to surroundings of the heat radiating means.

(*Id.*, 2:6-24; *see also id.* claims 1-16.)

26. Liquid cooling systems for use in cooling semiconductor chips in

computing devices were well known in the field prior to the 2003 priority date of the '362 patent. Closed liquid cooling loops having a modular pumping mechanism that pumps the liquid through an array of fins (sometimes described as an “all-in-one” cooler) were also well known as of the 2003 timeframe. The cooling systems of Batchelder and Shin (discussed below) are examples of an all-in-one cooler. The '362 patent discloses and claims a specific embodiment of an all-in-one cooler.

A. Embodiments Claimed in Challenged Claims

27. Figure 8 — annotated on the right with red and blue arrows indicating the direction of coolant flow— captures the main characteristics of the purported invention claimed in the Challenged Claims. “FIG. 8 is a perspective view of the cooling system showing the reservoir housing 14 with the heat exchanging surface (not shown) and the pump (not shown) inside the reservoir.

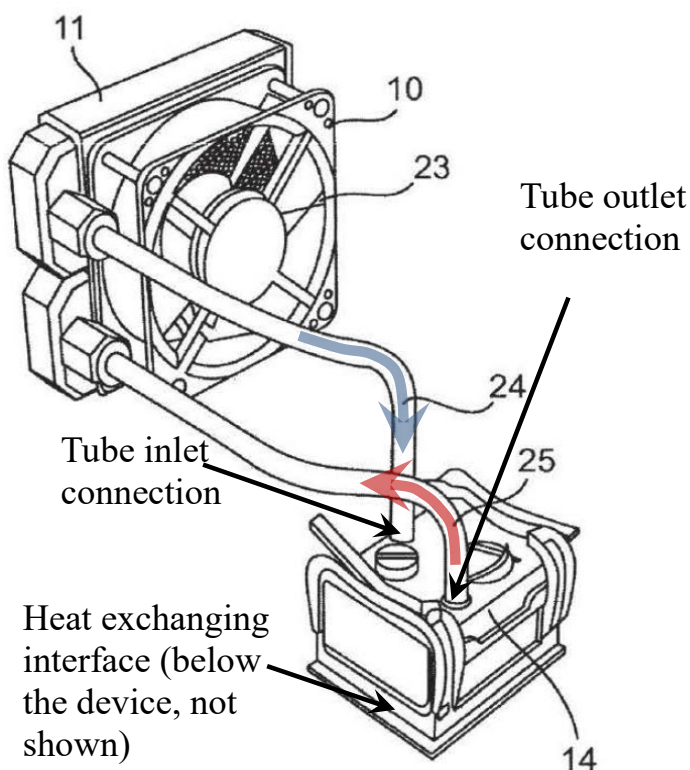


FIG. 8

The tube inlet connection and the tube outlet connection are connected to a heat radiator by means of connecting tubes 24 and 25 through which the cooling liquid flows into and out of the reservoir and the heat radiator, respectively. Within the heat radiator 11, the cooling liquid passes a number of channels for radiating the heat, which has been dissipated into the cooling liquid inside the reservoir, and to the surroundings of the heat exchanger. The air fan 10 blows air past the channels of the heat radiator in order to cool the radiator and thereby cooling the cooling liquid flowing inside the channels through the heat radiator and back into the reservoir.”
(Ex-1001, 13:29-44.)

B. Priority Date

28. The '362 patent issued on August 14, 2012, from Application No. 12/826,768 filed on June 30, 2010, claiming a priority date of November 7, 2003. I do not concede that the '362 patent is entitled to a priority date of November 7, 2003, and reserve the right to challenge such claim of priority, but I assume that this date applies for purposes of the analysis below.

VII. CLAIM CONSTRUCTION

A. “reservoir”

29. It is my understanding that the parties have stipulated to construe the term “reservoir,” as used in the '362 patent claims, to mean “single receptacle

defining a fluid flow path.” (Ex-1005 at 2.) I believe that the claimed “reservoir” should be given such construction.

B. “chamber”

30. It is my understanding that the parties have stipulated to construe the term “chamber,” as used in the ’362 patent claims, to mean “compartment within the reservoir.” (Ex-1005 at 2.) I believe that the claimed “chambers” should be given such construction.

C. “impeller”

31. I believe that the term “impeller” should be given its plain and ordinary meaning. An impeller is a conventional and well-known component of rotary systems. An impeller may refer to a rotor (e.g., a blade, turbine, or rotating arm) that is used to create a pressure difference within a fluid. (*Id.*) The ’362 patent describes “pumping means with an impeller for pumping the cooling liquid through a pumping housing.” (Ex-1001 at 6:24-25.) This is consistent with the plain and ordinary meaning of “impeller.”

D. “radiator”

32. I believe that the term “radiator” should be given its plain and ordinary meaning. A radiator is a conventional and well-known component included in systems that require cooling. In its plain meaning radiators are understood by a

POSITA as a system that transfers thermal energy (i.e., heat) from one medium to another medium. (*Id.*) This is consistent with the '362 patent, which states that a radiator may serve “as a means for removing the heat from the liquid by means of the air fan 10 blowing air through the heat radiator.” (Ex-1001 at 8:14-16 and FIG.

3.) Radiators may include structures such as pipes or fins to transfer heat.

E. Other Terms

33. I do not believe any additional constructions are required at this time. Accordingly, all other terms of the '362 patent have been given their ordinary and customary meaning in this Petition. I reserve the right to respond to claim construction positions raised by the Board or Patent Owner.

VIII. OVERVIEW OF PRIOR ART

A. Batchelder (Ex-1006)

34. Batchelder issued as U.S. Patent No. 6,019,165 on February 1, 2000. (Ex-1006 at [11], [45].) My understanding is that Batchelder qualifies as prior art to the '362 patent for all Challenged Claims.

B. Shin (Ex-1007)

35. Shin was filed as Japanese Patent Application 2000-345470 on November 8, 2000, and published on May 24, 2002, as Japanese Unexamined Patent Application Publication No. 2002-151638 to Takayuki Shin. (Ex-1007 at (21), (22),

(11), (43).) My understanding is that Shin qualifies as prior art to the '362 patent.

C. Nakano (Ex-1008)

36. Nakano issued as U.S. Patent No. 6,915,653 on July 12, 2005. (Ex-1008 at [11], [45].) Nakano, filed on April 8, 2004, published on December 16, 2004, as U.S. Patent Publication No. 2004/0250558. My understanding is that Nakano qualifies as prior art to the '362 patent.

IX. CLAIM ELEMENT NUMBERING KEY

37. Because the Challenged Claims have similar claim elements, they are numbered as follows for the element-by-element invalidity analyses of the Challenged Claims in Section VIII *infra*.

'362 Claim Limitations		
[1-PRE] 1. A cooling system for a computer system processing unit, comprising: (Claim 1)	[14-PRE] 14. A cooling system for a processing unit positioned on a motherboard of a computer, comprising: [14-a] a reservoir configured to be coupled to the	[17-PRE] 17. A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising: [17-a]

'362 Claim Limitations		
[1-a] an integrated element including a heat exchanging interface, a reservoir, and a pump, (Claim 1)	processing unit positioned on the motherboard at a first location, [14-b] the reservoir being adapted to pass a cooling liquid therethrough, (Claim 14)	separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard, (Claim 17)
[1-b] wherein the reservoir is configured to receive a cooling liquid from outside the reservoir through an inlet and pass the cooling liquid to the outside through an outlet, (Claim 1)		
See [1-f] below		

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'362 Claim Limitations		
[1-c] the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being vertically displaced chambers (Claim 1)	[14-c] wherein the reservoir includes an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers containing cooling liquid that are (Claim 14)	[17-b] the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart (Claim 17)

'362 Claim Limitations		
[1-d] [the upper chamber and the lower chamber being vertically displaced chambers that are] separated from each other by at least a horizontal wall and fluidly coupled together by a plurality of substantially circular passages, at least one of the plurality of substantially circular passages being positioned on the horizontal wall, (Claim 1)	[14-d] [the upper chamber and the lower chamber being separate chambers containing cooling liquid that are] separated by at least a horizontal wall and fluidly coupled together by one or more passageways, at least one of the one or more passageways being a substantially circular passageway positioned on the horizontal wall, (Claim 14)	[17-c] [the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and] separated by at least a horizontal wall, the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall, (Claim 17)
See [1-e] below	[14-e] the reservoir further including a heat exchanging interface (Claim 14)	

'362 Claim Limitations		
See [1-f] below	[14-f] [a heat exchanging interface] configured to be placed in separable thermal contact with the processing unit, (Claim 14)	
See claim 6 below	[14-g] the heat exchanging interface being removably attached to the reservoir (Claim 14)	[17-d] the heat exchanging interface being removably coupled to the reservoir (Claim 17)

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'362 Claim Limitations		
[1-e] a boundary wall of the lower chamber being formed by the heat exchanging interface; (Claim 1)	[14-h] [the heat exchanging interface being removably attached to the reservoir] such that the heat exchanging interface forms a boundary wall of the lower chamber of the reservoir; (Claim 14)	

'362 Claim Limitations		
[1-f] the heat exchanging interface is adapted to provide separable thermal contact between the processing unit and the cooling liquid such that heat is dissipated from the processing unit to the cooling liquid as the cooling liquid passes through the lower chamber of the reservoir; and (Claim 1)	See [14-f] above	

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'362 Claim Limitations		
[1-g] the pump is adapted to direct the cooling liquid through the upper chamber and the lower chamber of the reservoir, the pump including a motor having a rotor, a stator and an impeller having a plurality of curved blades, the impeller being positioned within the reservoir; (Claim 1)		

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'362 Claim Limitations		
		[17-e] [the heat exchanging interface being removably coupled to the reservoir such that] an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir; (Claim 17)

'362 Claim Limitations		
[1-h] a heat radiator spaced apart from the integrated element, the heat radiator being fluidly coupled to the outlet and the inlet of the reservoir, the heat radiator being configured to circulate the cooling liquid therethrough and exhaust heat from the cooling liquid; and (Claim 1)	[14-i] a heat radiator configured to be positioned at a second location horizontally spaced apart from the first location when the reservoir is coupled to the processing unit; (Claim 14)	[17-f] positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location; (Claim 17)
[1-i] a fan configured to direct air through the heat radiator, the fan being driven by a motor separate from the motor of the pump. (Claim 1)	[14-j] a fan adapted to direct air to the heat radiator to dissipate heat from the cooling liquid to surrounding atmosphere; (Claim 14)	

'362 Claim Limitations		
See [1-g] above	[14-k] a pump configured to circulate the cooling liquid between the reservoir and the heat radiator, the pump including a motor having a rotor, a stator, and an impeller having curved blades, the impeller being mechanically coupled to the rotor and at least partially submerged in the cooling liquid in the reservoir, (Claim 14)	[17-g] activating a pump to a circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and (Claim 17)
	[14-l] wherein a speed of the impeller is configured to be varied independent of the speed of the fan. (Claim 14)	

'362 Claim Limitations		
See [1-i] above	See [14-j] above	[17-h] activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump. (Claim 17)
3. The cooling system of claim 1, further including a plurality of channels in the lower chamber of the reservoir. (Claim 3)		
6. The cooling system of claim 1, wherein the heat exchanging interface is removably coupled to the reservoir. (Claim 6)		

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'362 Claim Limitations		
7. The cooling system of claim 1, wherein a surface of the heat exchanging interface exposed to the lower chamber includes features to enhance heat dissipation. (Claim 7)		
8. The cooling system of claim 7, wherein the plurality of passages includes only two passages. (Claim 8)		

'362 Claim Limitations		
9. The cooling system of claim 1, wherein the lower chamber of the reservoir includes one or more features that are configured to increase an amount of time the cooling liquid takes to flow through the lower chamber. (Claim 9)	15. The cooling system of claim 14, wherein the lower chamber of the reservoir includes one or more features that are configured to increase an amount of time the cooling liquid takes to flow through the lower chamber. (Claim 15)	
11. The cooling system of claim 1, wherein the motor of the pump is a DC motor. (Claim 11)		

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'362 Claim Limitations		
12. The cooling system of claim 1, wherein a speed of the fan is configured to be varied independent of a speed of the impeller of the pump. (Claim 12)		

'362 Claim Limitations		
13. The cooling system of claim 1, wherein the integrated element is separate from the heat radiator and the integrated element and the heat radiator are fluidly coupled together by tubing such that the heat radiator can be positioned at a location away from the integrated element when the heat exchanging interface is in thermal contact with the processing unit. (Claim 13)		

In the below disclosures of where in the prior art references each element of the asserted claims are found, any reference to a claim element applies to all other elements in the same row or rows in accordance with the numbering key above.

X. ANALYSIS

38. I have been asked to assess the validity of claims 1 and 3-19 of the '362 patent (“the Challenged Claims”) from the perspective of a POSITA as of the claimed priority date of November 7, 2003. The following are my opinions concerning the validity of the Challenged Claims.

A. GROUND 1: Claims 1, 3-11, 13, and 17-19 are rendered obvious over the combination of Batchelder and Shin.

1. Batchelder in view of Shin discloses or teaches each limitation of claim 1.

[1-PRE] “A cooling system for a computer system processing unit, comprising:”

39. Batchelder discloses or teaches that “[t]he primary objective of this invention is to provide a low-cost high reliability heat exchange apparatus that incorporates a composite substrate containing flow channels and a heat transfer fluid, providing low thermal resistance cooling to high density sources.” (Batchelder, 2:40-45; *see also id.* at 1:5-10 (discussing “our ability to get that waste heat out of semiconductor circuits and into the room”).) Shin similarly discloses or teaches that “[t]he heat generating element 1, such as an LSI chip, is installed on a wiring board 2, which is a motherboard” in a computer system. (Shin, [0024].) Thus, Batchelder and Shin each alone or in view of each other teach the preamble.

[1-a] “an integrated element including a heat exchanging interface, a reservoir, and a pump,”

40. Batchelder discloses or teaches “an integrated element including a heat exchanging interface, a reservoir, and a pump.” Batchelder’s heat sink assembly 240 (Batchelder, 8:4-12, FIG. 7) discloses or teaches this limitation, as shown below:

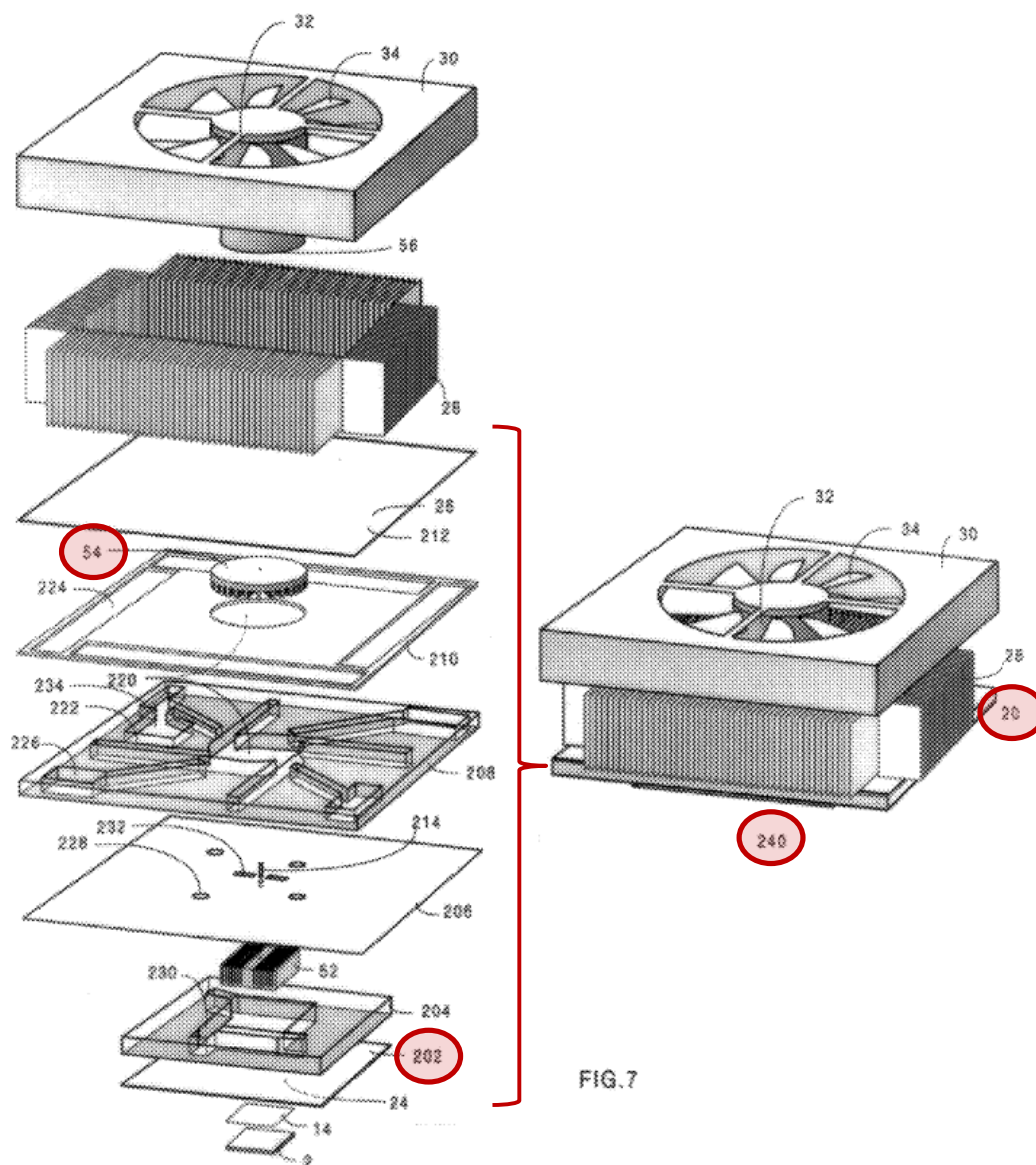
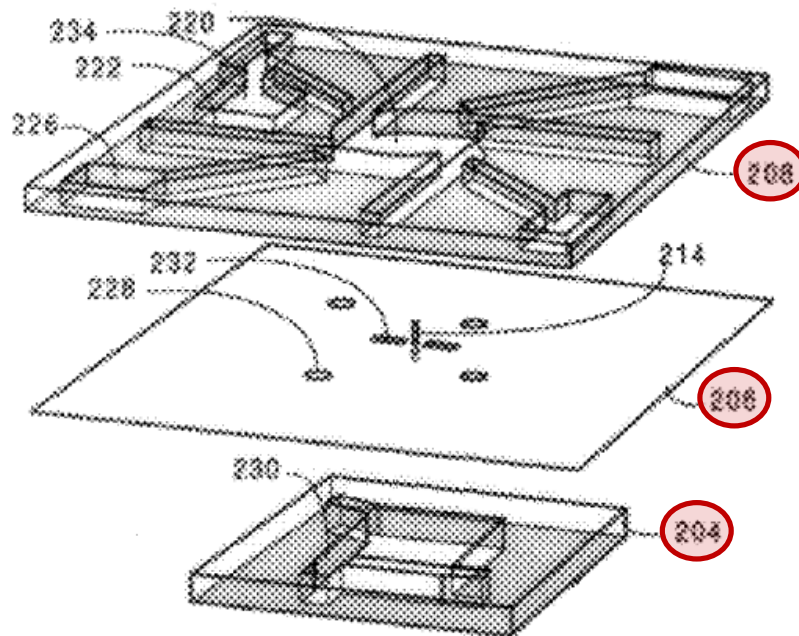


FIG. 7 of Batchelder is reproduced above. As can be seen in FIG. 7, the “integrated element” (heat sink assembly 240) includes a heat exchanging interface (the “bottom sheet (202)” to which “[a] heat source is attached” (Batchelder, 7:24-26)), a pump (the “rotatable impeller 54” (*id.* 7:48-51, 8:14-67, FIG. 9)), and a reservoir (the “active spreader plate” 20 (*id.* 7:23-24, FIG. 2). Batchelder describes its active spreader plate as a “geometry” (*id.*, 1:65) that can take various shapes such as, for example, “a large hemispherical shell” (*id.*, at 3:49-51). A POSITA would understand Batchelder’s active spreader plate 20 is a single, unitary receptacle that defines a fluid flow path (60), *i.e.*, a “reservoir” as claimed by the ’362 patent. To elaborate, Batchelder discloses that “[t]he lower stamped plate (204), the medial sheet (206), the upper stamped plate (208), the channel forming sheet (210), and the top sheet (212) [in FIG. 7] are preferably formed from plastic” and “assembled with ... ultrasonic bonding, solvent bonding, or welding.” (Batchelder, 7:52-55, 8:4-8.) A POSITA would have understood that these plastic components, once combined together using “ultrasonic bonding, solvent bonding, or welding [,]” are fused together into a continuous, seamless “single receptacle defining a fluid flow path” that is a permanently unitary structure. Batchelder further discloses that “those skilled in the art will recognize that the individual components of the active spreader plate could be molded, and that several of the described components can be

functionally combined if the components are molded.” (*Id.*, 8:8-12.) A POSITA would have understood that the lower stamped plate (204), the medial sheet (206), and the upper stamped plate (208) can be combined into a unitary “single receptacle” structure with injection molding, as shown below (*id.*, 8:8-12):



(Batchelder, FIG. 7 (excerpt) (shaded red circles added).) After the impeller 54 is placed in the coaxial cavities (220) (Ex-1006, 7:46-48), the channel forming sheet (210) and the top sheet (212) in FIG. 7 can be further combined with this “single receptacle” using “ultrasonic bonding, solvent bonding, or welding” to fuse all of

them together into a continuous, seamless, and permanently unitary structure that, as a whole, can be the “reservoir.” (Batchelder, 8:8-12.)

41. The following annotated version of FIG. 2 illustrates another embodiment of the “active spreader plate” 20 that is different from the “active spreader plate” 20 embodiment– in FIG. 7. In the version of FIG. 2 below, the reservoir has been outlined by a red box.

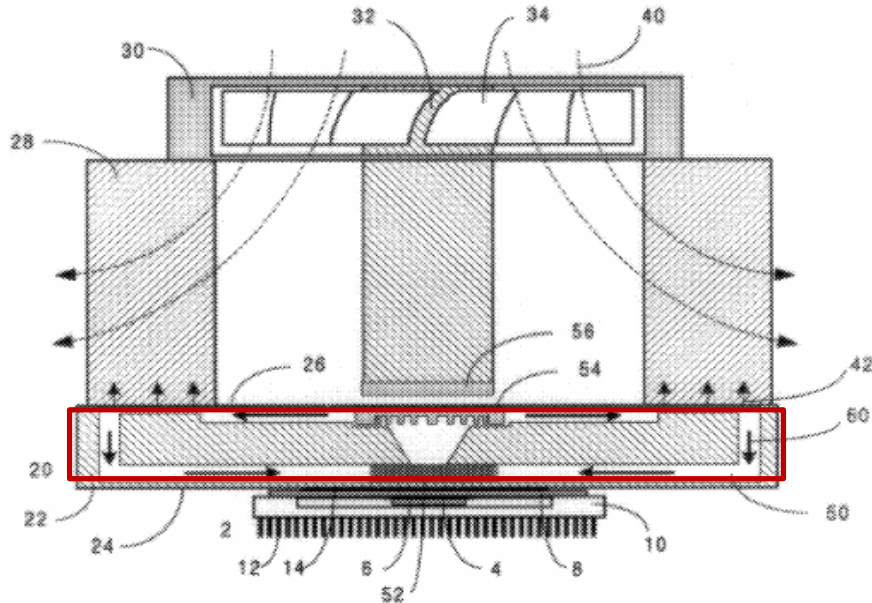


FIG.2

A POSITA would have understood that the portion of the active spreader plate 20 outlined by the read box above can be made into a unitary, one-piece “single receptacle” structure with injection molding, analogous to the lower stamped plate

(204), the medial sheet (206), and the upper stamped plate (208) that can be “functionally combined” in FIG. 7 discussed above (Batchelder, 8:8-12), as shown below:

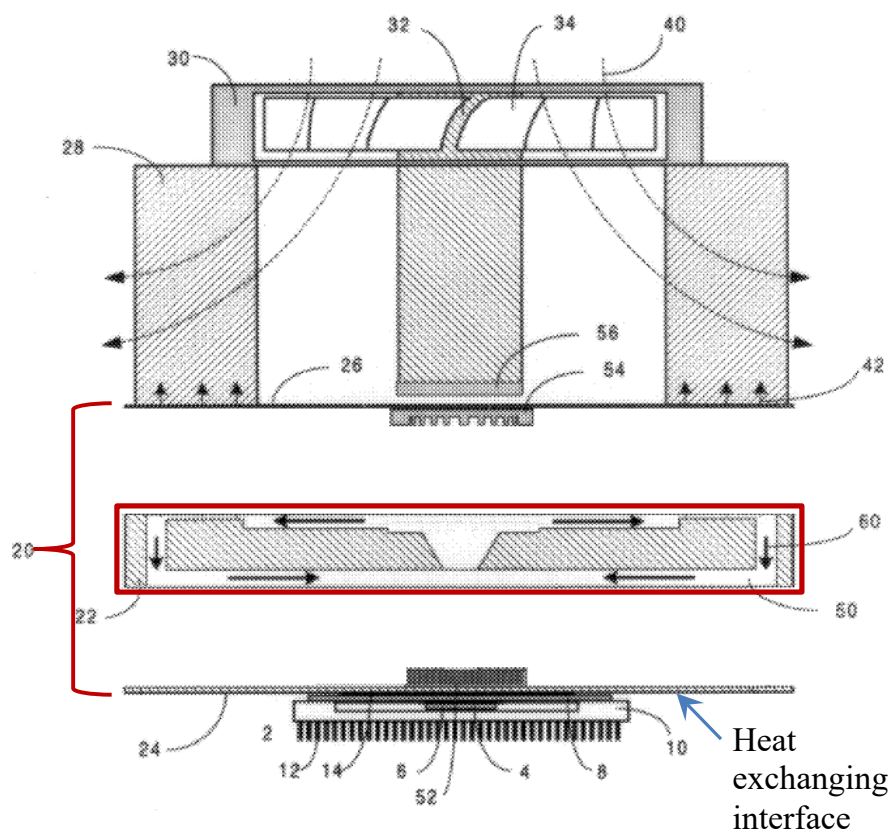


FIG.2

(Batchelder, FIG. 2 (modified).) Like FIG. 7, the top sheet having a top surface 26 in FIG. 2 can be further combined with this “single receptacle” using “ultrasonic

bonding, solvent bonding, or welding” to fuse them together into a continuous, seamless, and permanently unitary structure that, as a whole, can be the “reservoir.”

The lower sheet having a bottom surface 24, *e.g.*, can be a heat exchanging interface.

[1-b] “wherein the reservoir is configured to receive a cooling liquid from outside the reservoir through an inlet and pass the cooling liquid to the outside through an outlet,”

42. This limitation relates to two other limitations in claim 1 below, which are addressed here together:

- [1-h] “a heat radiator spaced apart from the integrated element, the heat radiator being fluidly coupled to the outlet and the inlet of the reservoir, the heat radiator being configured to circulate the cooling liquid therethrough and exhaust heat from the cooling liquid;” and
- [1-i] “a fan configured to direct air through the heat radiator, the fan being driven by a motor separate from the motor of the pump.”

43. Shin discloses or teaches a radiator (heat exchange section comprising heat exchanger 27 as shown in FIG. 3) horizontally spaced apart from and fluidly coupled to an “integral structure”¹ via hoses 13 and 16 as shown below:

¹ Shin discloses or teaches a “pump [that] is secured to the top part of [a] liquid cooled heat sink, forming a structure that allows the pump and liquid cooled heat sink to be handled as *an integral structure*” horizontally situated relative to the orientation of the heat generating element 1. (Shin, [0008], [0012], FIGS. 1, 3.)

FIG. 1

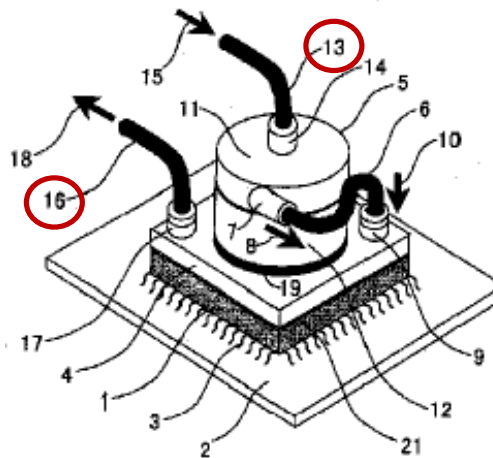
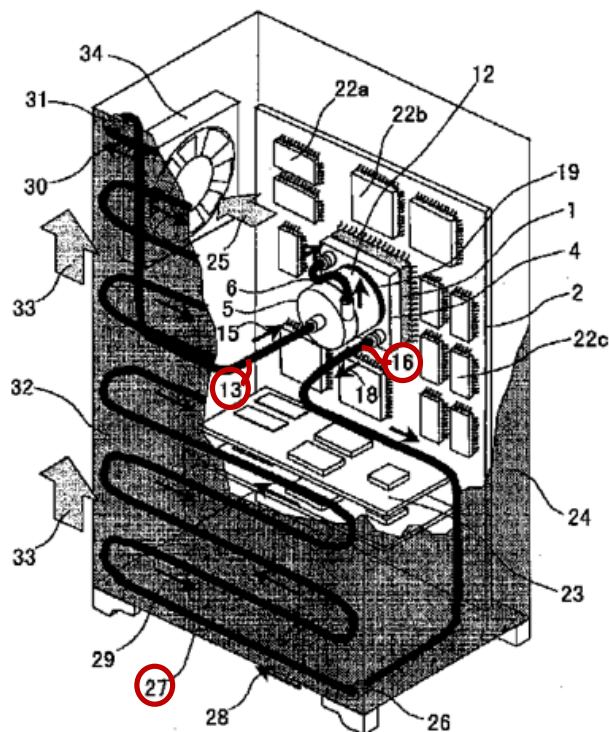


FIG. 3

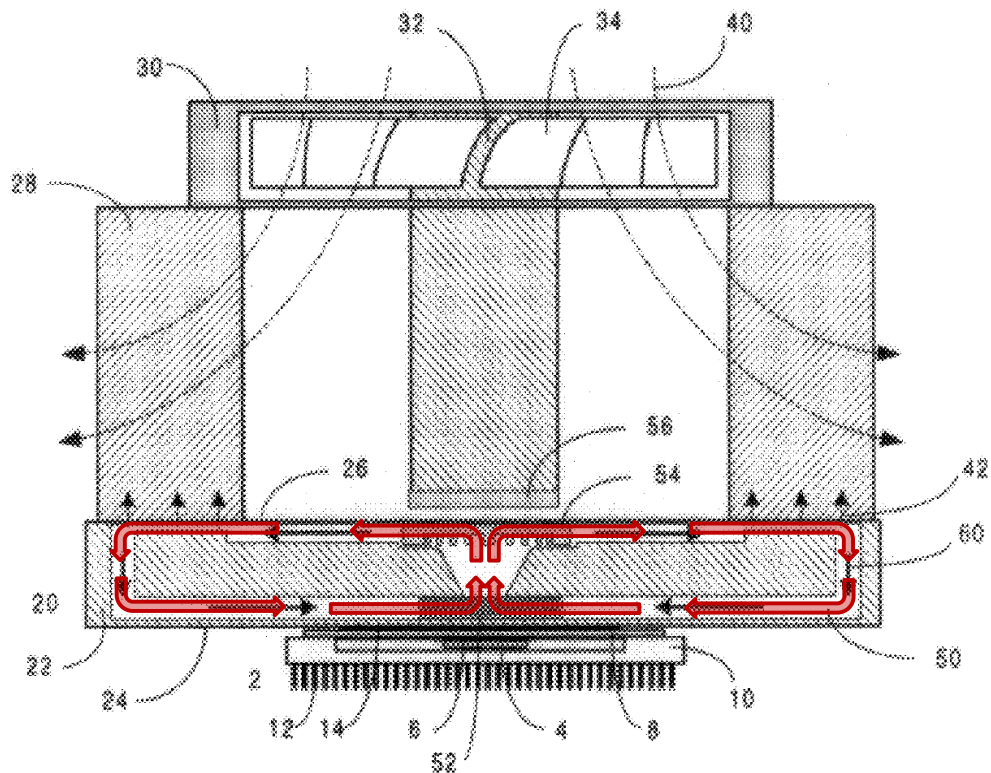


(Shin, FIGS. 1 and 3.) Shin states:

“Liquid coolant which has been heated in the liquid cooled heat sink 4 flows through hose 16, as shown by 18, which is connected via a connecting coupler 26 to a heat exchanger 27 installed on a side panel 32 of the case. In the present embodiment example, the pipes of the heat exchanger 27 are installed in thermal contact with the side panel 32, and the liquid coolant flows upward while snaking through the inside of the heat exchanger as shown by 28 and 29. The heat of the liquid coolant spreads through thermal conduction to the entirety of the side panel 32 and is then released with the aid of the cooling air 25 provided by the fan 34 and air flow 33 provided by natural convection around the electronic equipment case.”

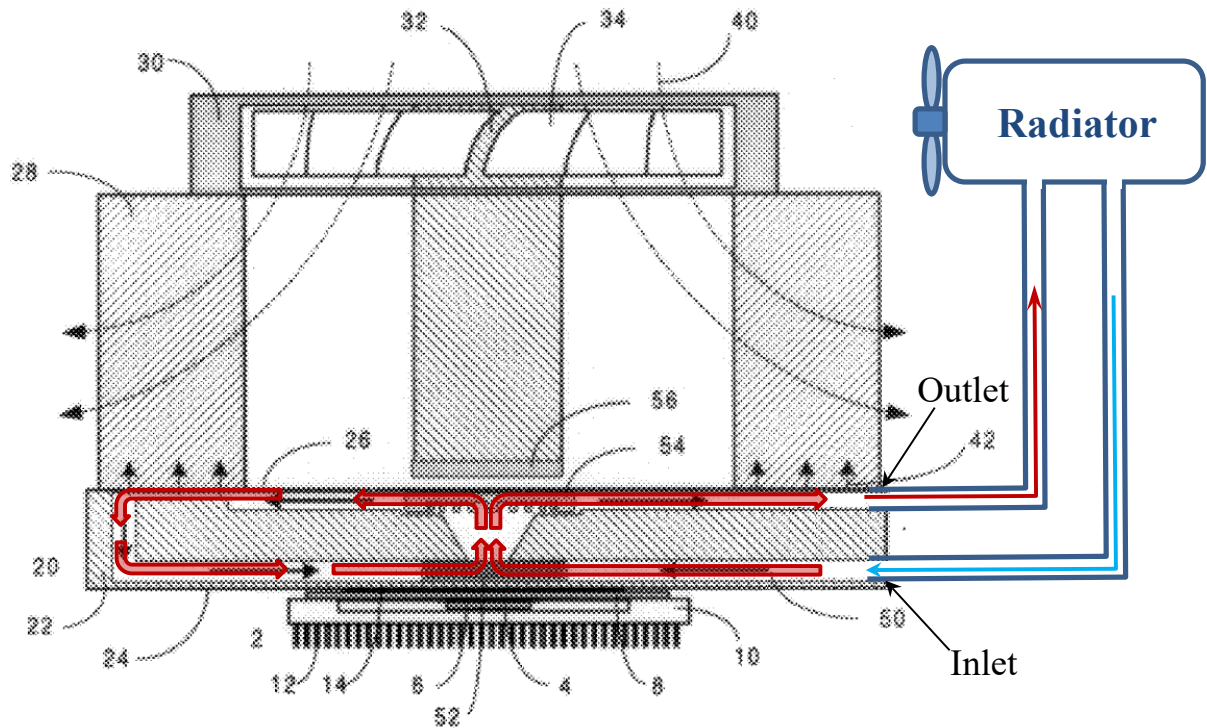
(Shin, [0025]; *see also id.* at [0023].) “The cooled liquid coolant flows as shown by 30, and is connected to the return side hose 13 via connecting coupler 31 and returns to the pump 5 as shown by 15, and is again pressurized and supplied to the liquid cooled heat sink 4.” (*Id.* at [0026]; *see also id.* at [0027] (“As an example of the method of constructing the side panel 32 and heat exchanger 27, there is the method whereby the side panel 32 is fashioned from a metal material such as aluminum, magnesium or steel, the pipes of the heat exchanger are also fashioned from metal material, and the two are connected through metal joining, such as brazing or soldering, or by using a thermally conductive adhesive, or the like. In this case, the thermal conductivity can be improved ...”).)

44. It would have been obvious to connect Batchelder's heat spreader plate 20 to a radiator, a well-known component used in the field of liquid cooling to transfer thermal energy (i.e., heat) from one medium to another, like the one taught in Shin. As the cooling liquid in the lower chamber heats up, a POSITA would have been motivated to use an external radiator to cool the heated cooling liquid, which is a conventional technique known to a POSITA, before the cooling liquid returns to the pump. (*Id.*) In particular, the spreader plate in FIG. 2 of Batchelder has two looped flow paths, as illustrated below (red arrows):



45. A POSITA would have known how to, and been motivated to, modify

one of the two looped flow paths to connect Batchelder's "reservoir" to an external radiator and a fan horizontally spaced apart from the reservoir, as taught by Shin:



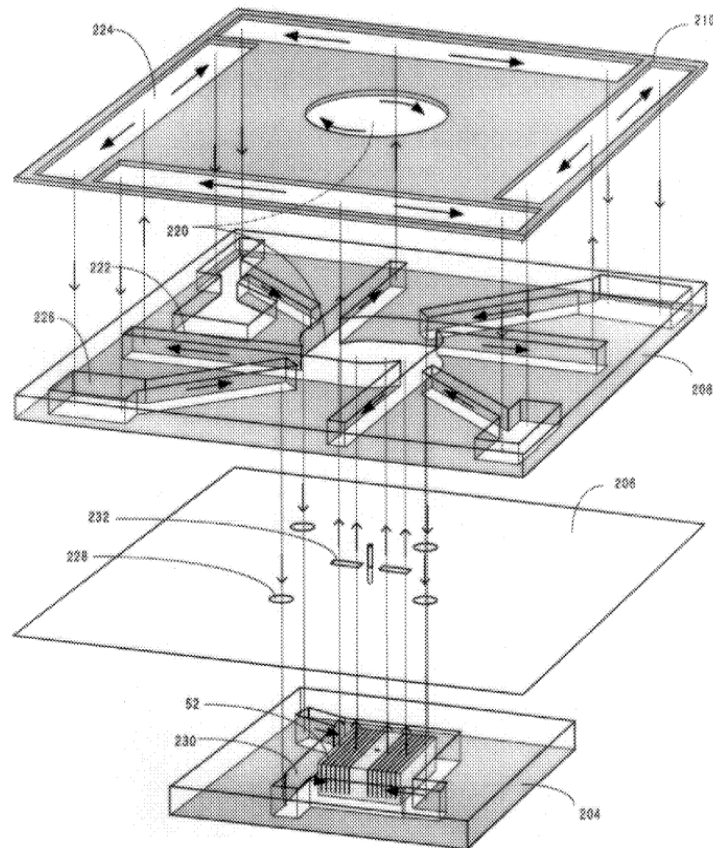
46. A POSITA would have understood that the heat spreader plate 20 in Batchelder and the "integrated structure" in Shin are analogous to each other. For the reasons discussed above, a POSITA would have been motivated to connect Shin's external radiator with a fan to Batchelder's heat spreader plate 20. The modified Batchelder device, with an external radiator as disclosed in Shin, teaches "the reservoir is configured to receive a cooling liquid from outside the reservoir through an inlet and pass the cooling liquid to the outside through an outlet."

47. A POSITA would have been motivated to combine Shin with Batchelder to further increase heat management efficiency by using an external radiator that cools the heated cooling liquid after “snaking through the inside of the heat exchanger as shown by 28 and 29.” (Shin, [0025].) This technique increases the heat transfer efficiency of the system. In addition, Shin teaches coupling the radiator to the reservoir to circulate liquid away, spacing it apart from the reservoir to divert heat away from the reservoir, and then circulating the *cooled* cooling liquid back to the reservoir. Adding a radiator to Batchelder would have been an obvious modification to improve Batchelder’s objective of cooling electronic components. (Batchelder, 2:41-45.)

48. A POSITA would have been further motivated to modify Batchelder in view of Shin to add an external radiator when the heat load is too high for Batchelder’s existing heat spreader plate. Batchelder recognized that heat-generating components will continue to advance and produce more heat. (Batchelder, 1:34-38 (“The thermal power density emerging from the chip will be so high in ten years than even copper or silver spreader plates will not be adequate.”)). In additional, Batchelder discloses that top sheet (212) in Batchelder is “preferably formed from plastic” to be “assembled with [the rest of the active heat spreader plate’s plastic structure with] ultrasonic bonding, solvent bonding, or

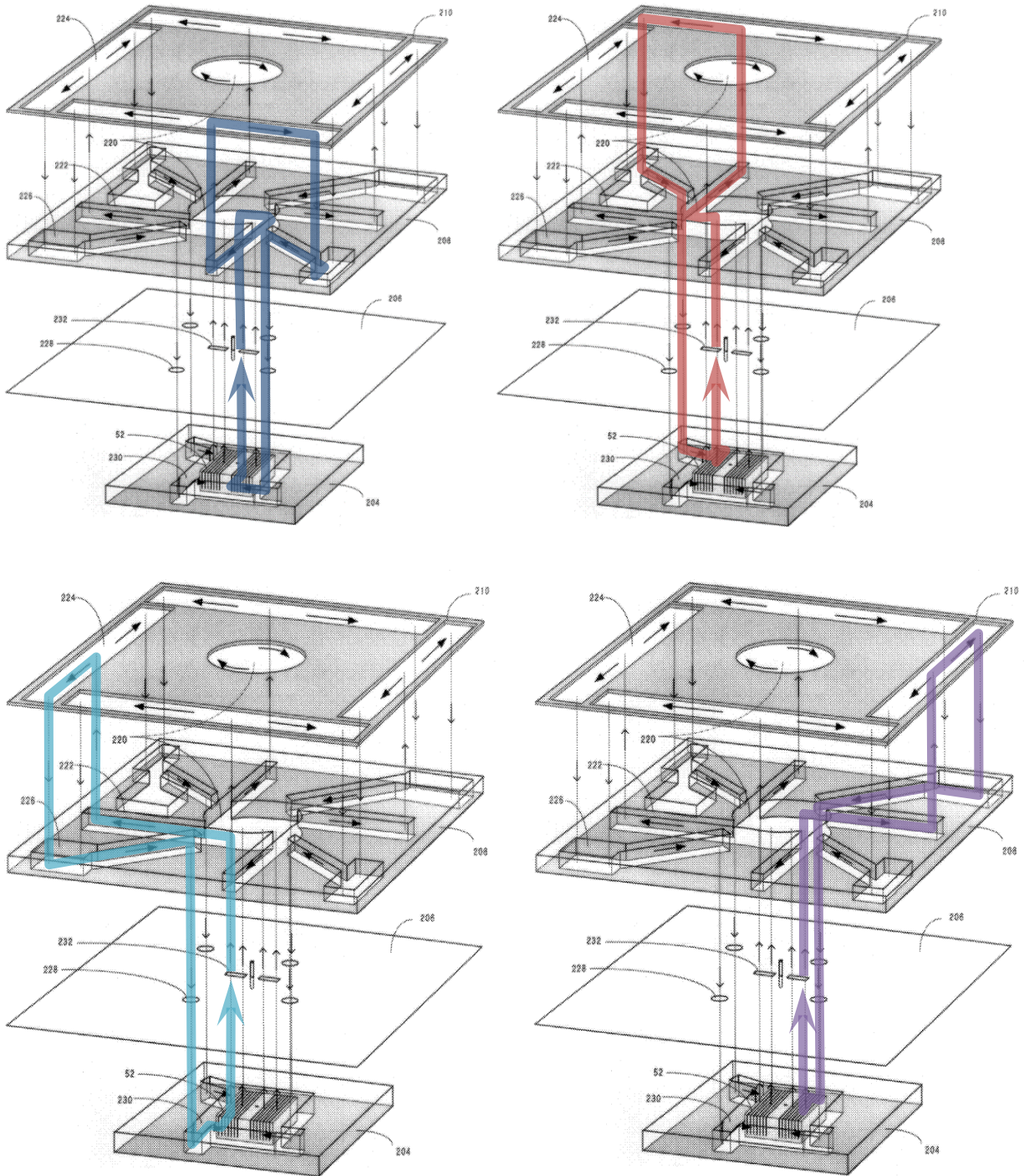
welding.” (Batchelder, 7:52-55, 8:4-8.) A POSITA would have understood that the heat dissipation through the plastic top sheet would eventually be insufficient, which is a further motivation to add an external radiator with a fan such as those in Shin to add heat dissipation in FIGS. 2, 7, and 8 of Batchelder.

49. FIG. 8 shows the flow paths of the embodiment in FIG. 7 in detail, as follows:

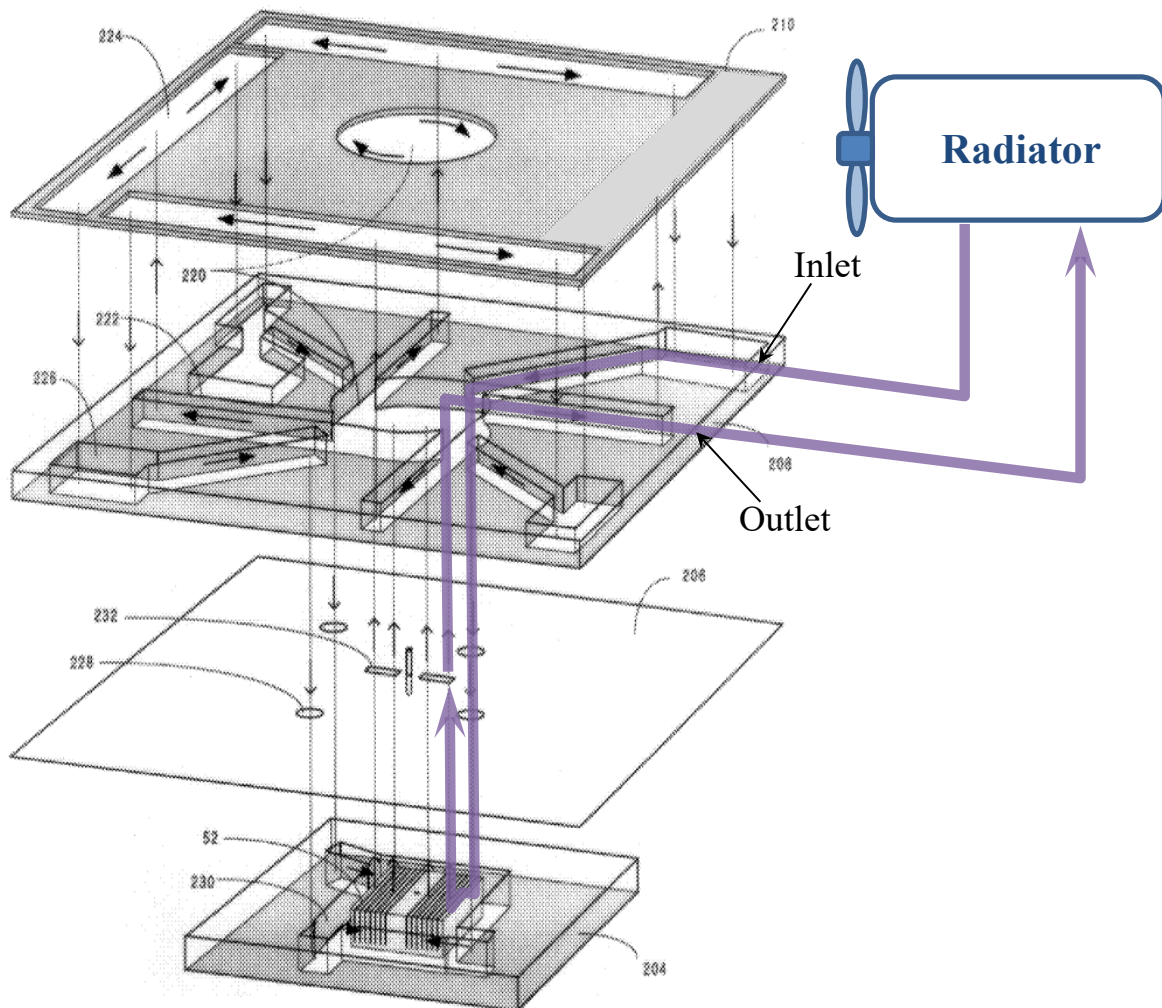


(Batchelder, FIG. 8.) A POSITA would have understood that there are at least four exemplary looped flow paths in FIG. 8 above, as shown below:

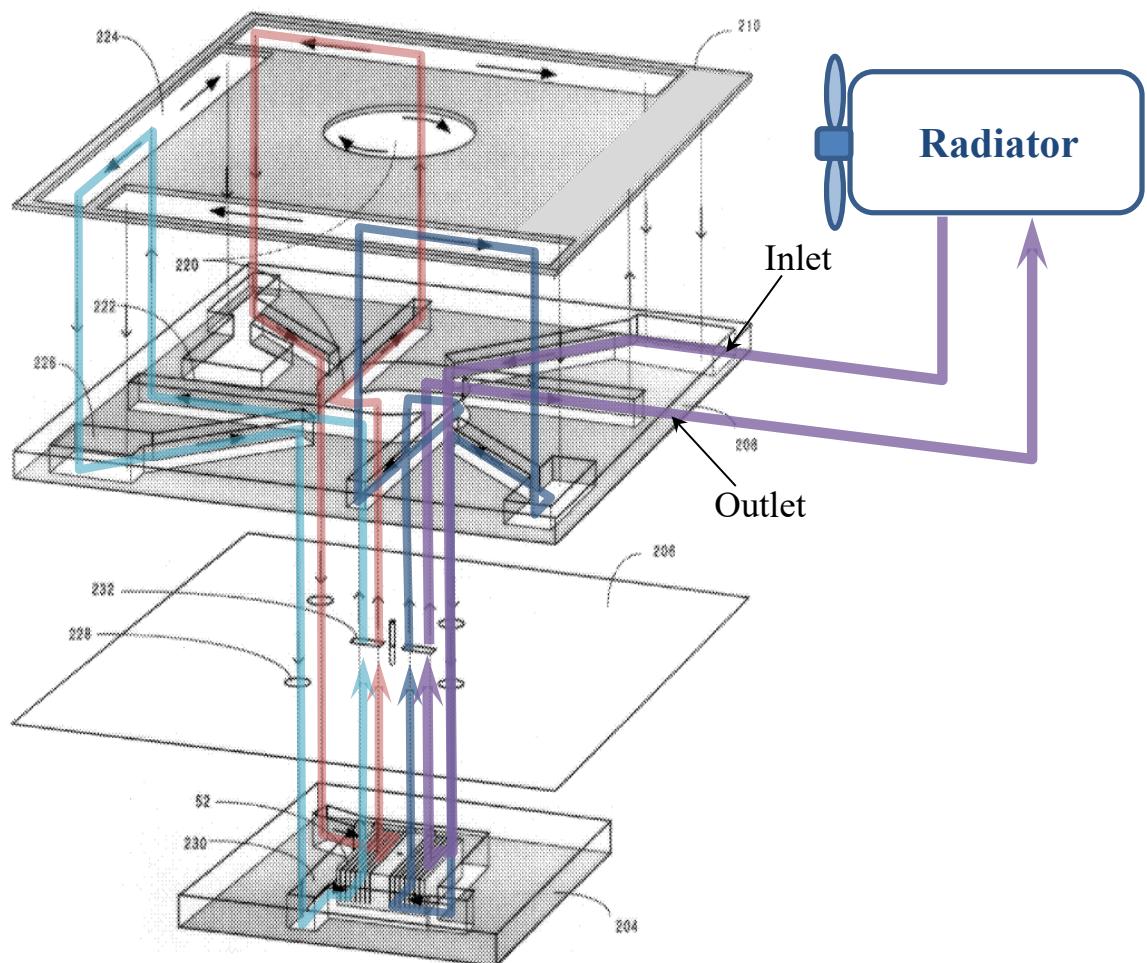
Petition for Inter Partes Review Of
U.S. Patent No. 8,240,362
Decl. of Georgios Karamanis, Ph.D.



50. As discussed above with respect to Batchelder FIG. 2, a POSITA would have known how to, and would have been motivated to, modify one of the four exemplary looped flow paths in Batchelder's FIG. 8 to connect Batchelder's "reservoir" to an external radiator and a fan horizontally spaced apart from the reservoir (as those in Shin), as follows, with a reasonable expectation of success:



51. Adding the other three exemplary looped flow paths back, a POSITA would have understood the embodiment in FIG. 8 of Batchelder, as modified in view of Shin, to become the following system:



52. Accordingly, a POSITA would have been motivated to modify Batchelder in view of Shin to incorporate a radiator into the embodiments in FIG. 2 and the embodiment in FIGS. 7 and 8, and would have had a reasonable expectation

of success in doing so.

53. For the reasons discussed above, Batchelder in view of Shin renders limitations [1-b], [1-h], and [1-i] obvious.

54. I understand that Patent Owner previously argued (Ex-1009, 354-POR at 40-41) that Batchelder “teaches away” from adding a radiator with a fan because of (1) higher cost due to the added fan and radiator; or (2) lower reliability due to the need for hoses and couplings to connect the heat spreader plate to the radiator. I disagree. I understand that to “teach away” from doing something, a prior art reference must clearly discourage that feature. Batchelder does not *clearly discourage* use of an external radiator.

55. Batchelder contrasts its “monolithic assembly” from “heat transfer systems that use an external source of energy to pump a recirculating heat transfer fluid.” (Batchelder, 1:61-2:10.) It is in that context that Batchelder describes hoses and couplings as a “disadvantage.” Batchelder never discourages use of an external radiator, let alone indicates that one should be avoid because it would require hoses or couplings. Even in the context of describing an external pump, Batchelder merely describes hoses and couplings as a “disadvantage,” it does not state or suggest that they should be avoided.

56. In designing a device, a POSITA would recognize that most design

changes have advantages and disadvantages. With respect to this particular design change, the potential disadvantage of not using an external radiator (the potential failure of the computing device due to overheating if the existing Batchelder device could not handle the heat load) would outweigh any cost of adding a remote radiator with a fan (which can often be an existing case fan that does not cost extra) or reliability concerns associated with hoses or couplings.)

[1-c] “the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being vertically displaced chambers”

57. Batchelder discloses or teaches this limitation as shown below:

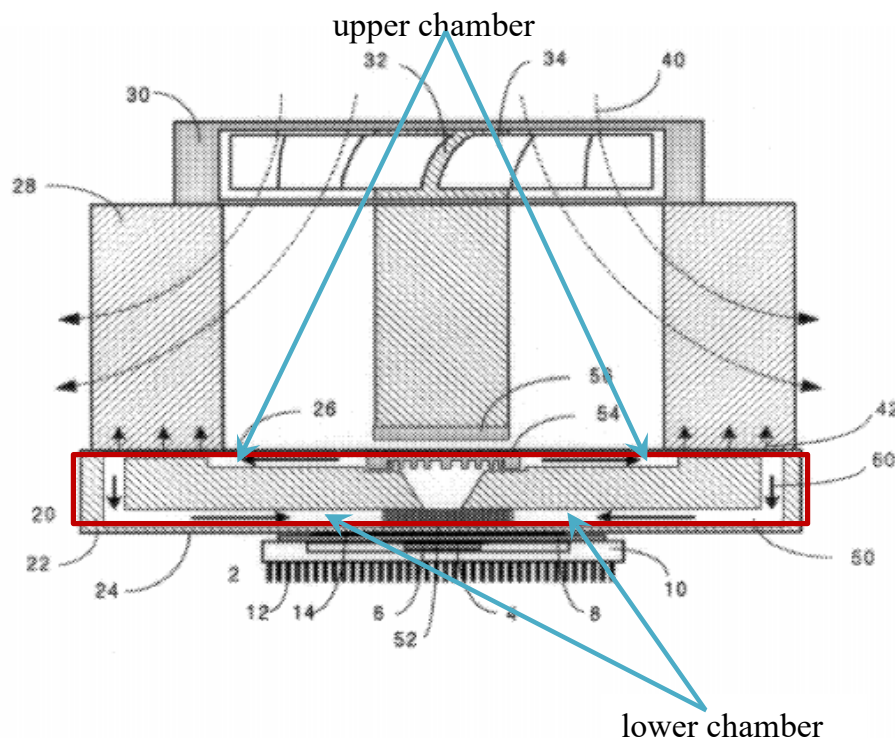
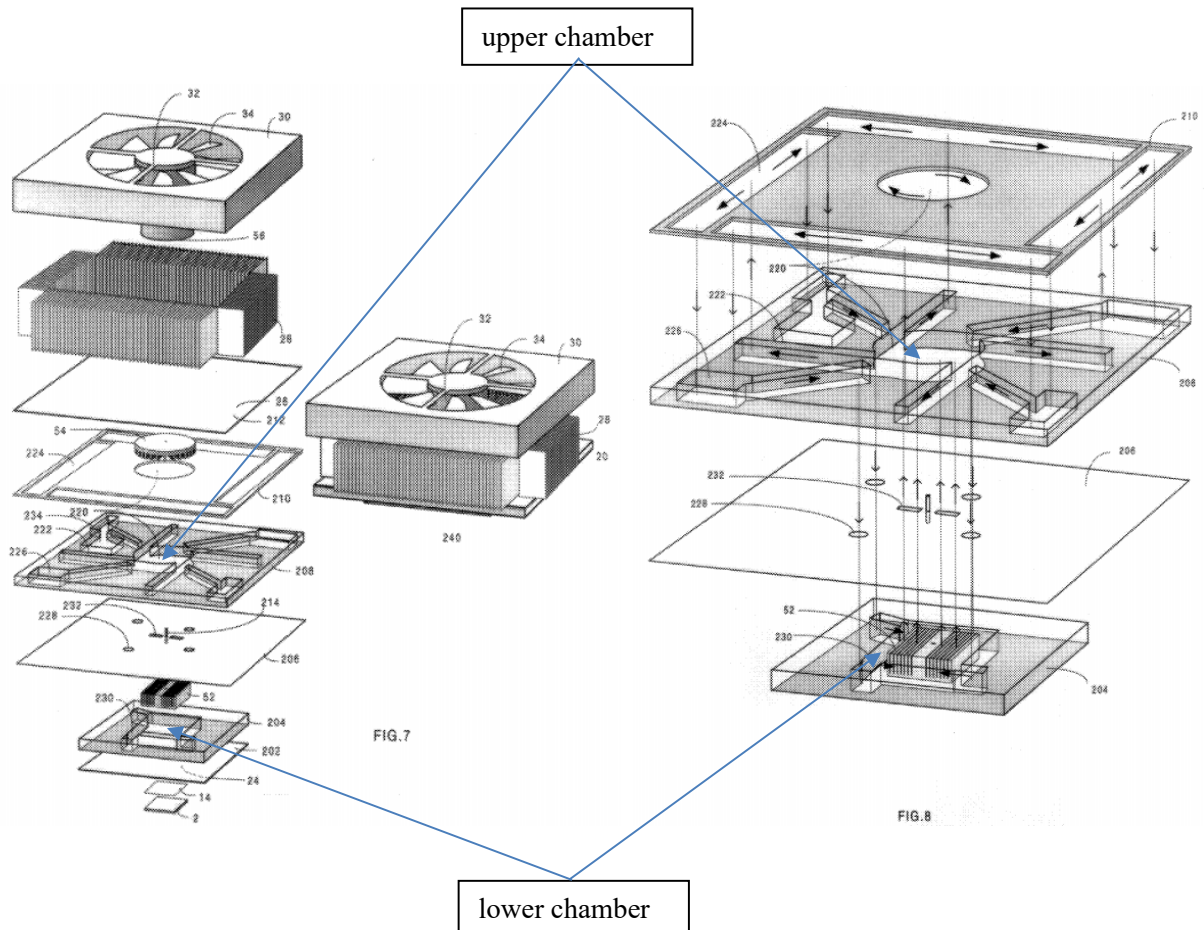


FIG. 2

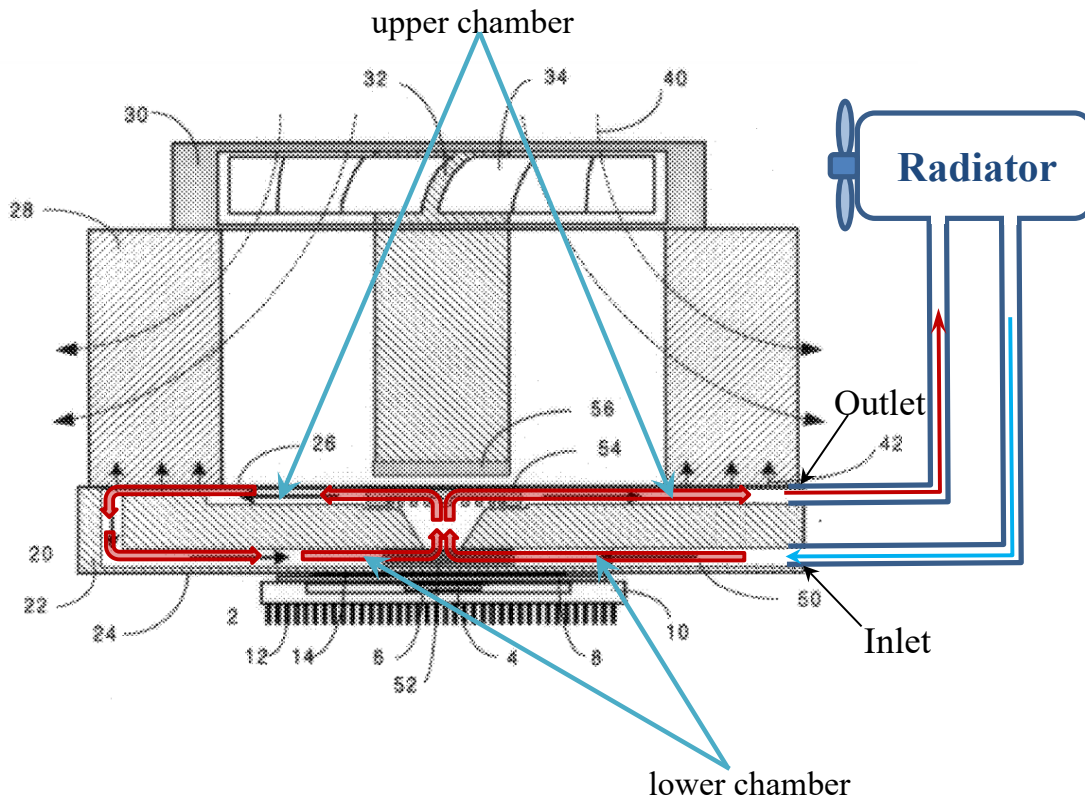


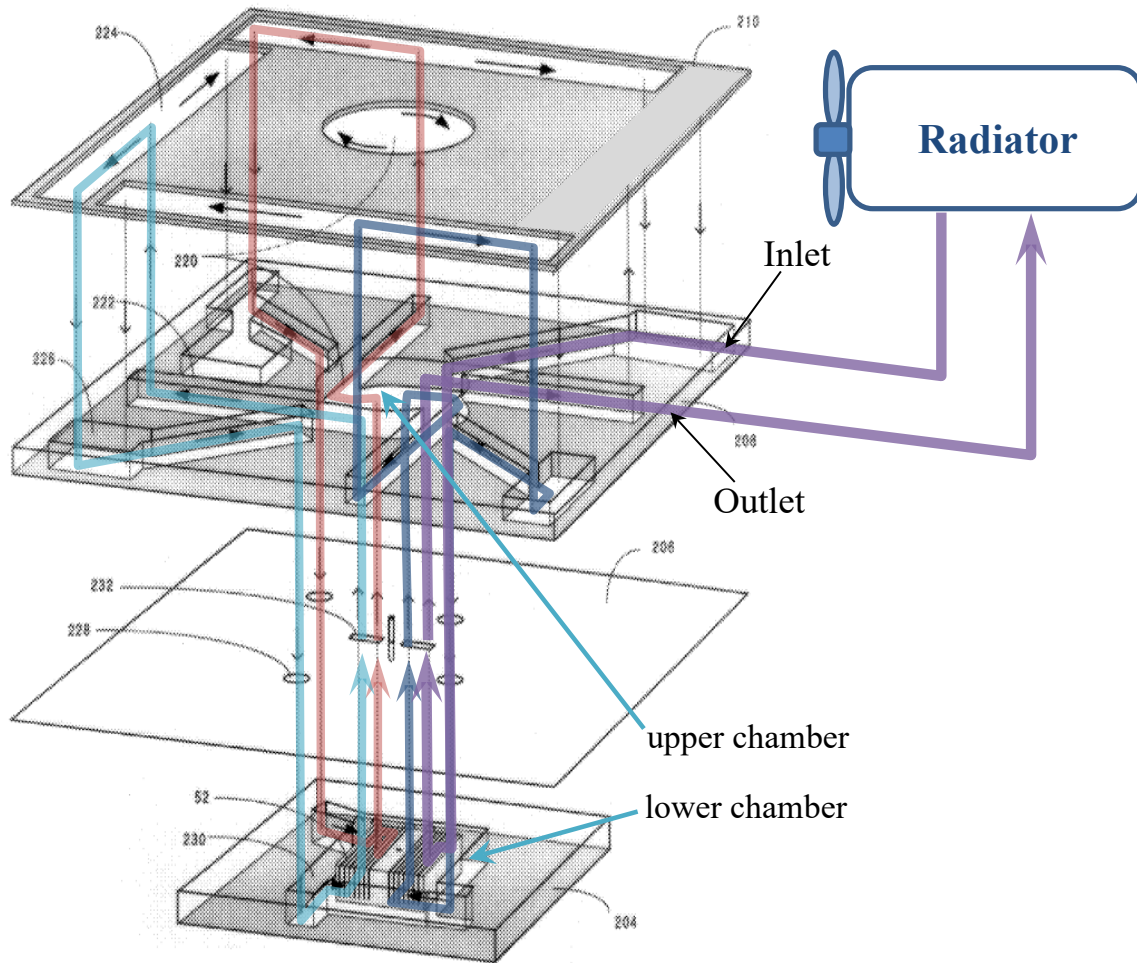
(Batchelder, FIGS. 2, 7, 8.)

58. As discussed above, Batchelder discloses or teaches a reservoir (spreader plate 20), which includes an upper chamber. In the FIG. 2 embodiment, the upper chamber is below the top surface 26. In the embodiment shown in FIGS. 7 and 8, the upper chamber is formed by the internal stamped features of the upper stamped plate 208.

59. Batchelder also discloses or teaches a lower chamber. In the

embodiment in FIG. 2, the lower chamber is formed as the flow channels 50, above lower surface 24. In the embodiment in FIGS. 7 and 8, the lower chamber is formed by the internal stamped features of the lower stamped plate 204. The upper and lower chambers are vertically displaced and separated from each other by boundary walls, shown as the shaded region between lower surface 24 and top surface 26 in FIG. 2 and as the medial sheet 206 in FIGS. 7 and 8. After the modification of Batchelder in view of Shin (reproduced again below), the teachings by Batchelder of this limitation do not change.



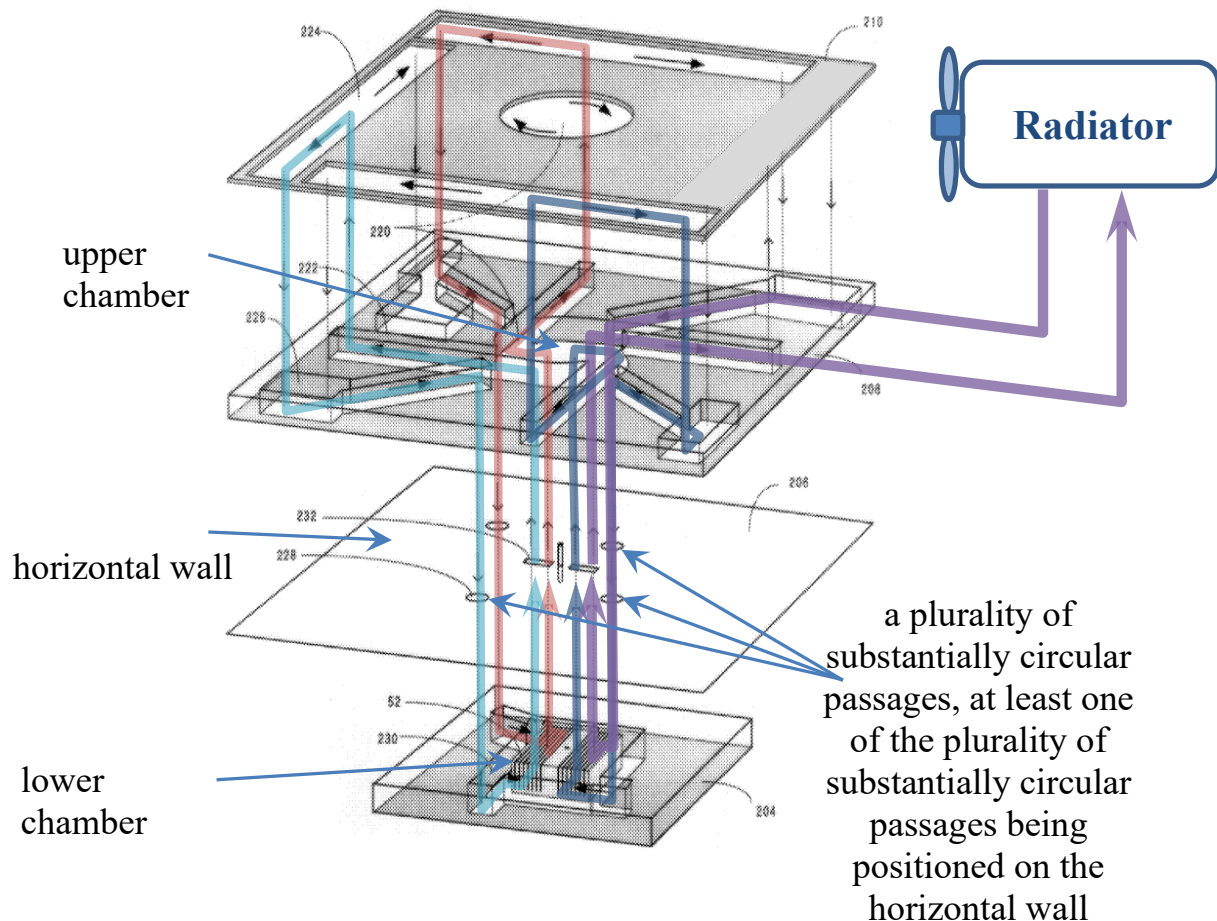


60. For the reasons discussed above, Batchelder in view of Shin renders limitation [1-c] obvious.

[1-d] “[the upper chamber and the lower chamber being vertically displaced chambers that are] separated from each other by at least a horizontal wall and fluidly coupled together by a plurality of substantially circular passages, at least one of the plurality of substantially circular passages being positioned on the horizontal wall,”

61. Batchelder discloses or teaches this limitation, as shown in the

annotated figure below:

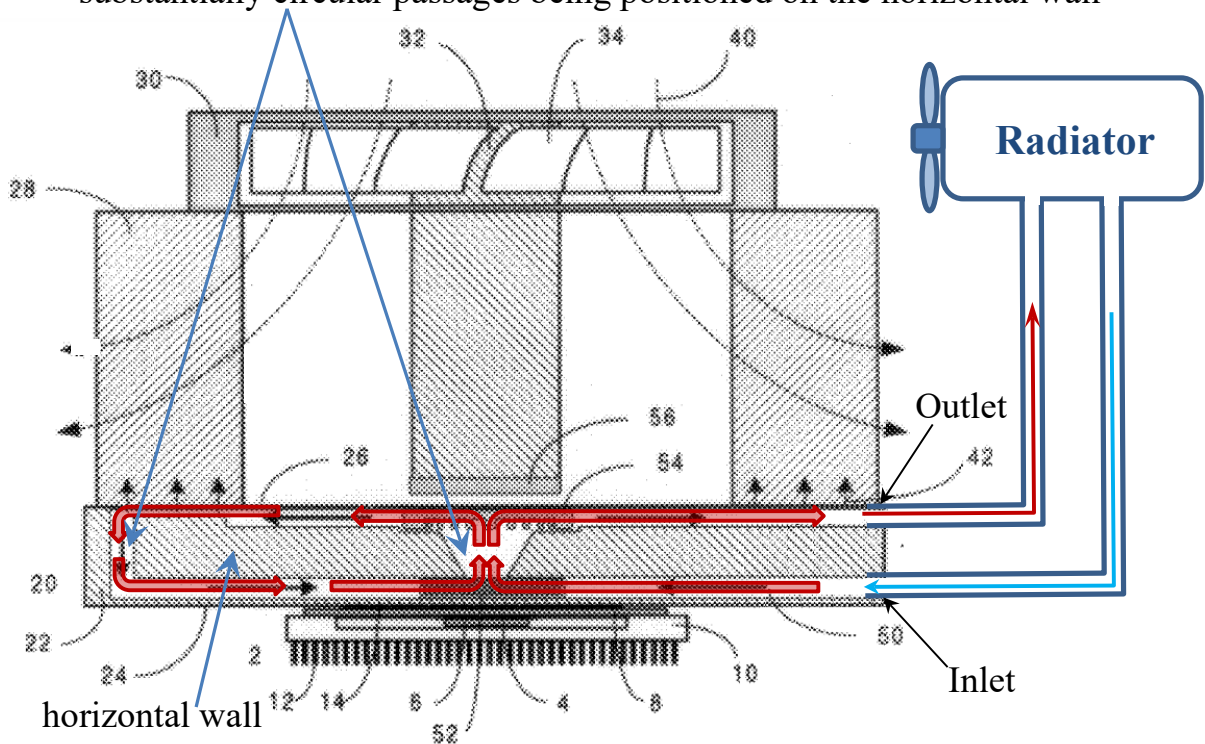


62. As illustrated in annotated and modified version of Figure 8 above, the upper chamber and the lower chamber are separated by a horizontal wall (medial sheet 206) that includes a plurality of substantially circular passages (holes 228). The upper and lower chambers are fluidly coupled together through these substantially circular passages, at least one of which is located on the horizontal wall.

As shown above, the upper chamber and the lower chamber of the modified Batchelder device in view of Shin are vertically displaced chambers that are separated from each other by at least a horizontal wall and fluidly coupled together by a plurality of substantially circular passages, at least one of the plurality of substantially circular passages being positioned on the horizontal wall.

63. When modified in view of Shin, the modified system in FIG. 2 of Batchelder similarly discloses a horizontal wall:

a plurality of substantially circular passages, at least one of the plurality of substantially circular passages being positioned on the horizontal wall



64. A POSITA would have understood the two passages in the modified

FIG. 2 of Batchelder (above) are substantially circular, with the one on the left

shaped like a cylinder () and the one in the middle shaped like an upside-down,

flat-headed cone (). This is because they can be effectively made with drills,

as a POSITA would have understood. Thus, the upper chamber and the lower chamber of the modified Batchelder FIG. 2 embodiment are vertically displaced chambers that are separated from each other by at least a horizontal wall and fluidly coupled together by a plurality of substantially circular passages, at least one of the plurality of substantially circular passages being positioned on the horizontal wall.

65. For the reasons discussed above, Batchelder in view of Shin renders this limitation [1-d] obvious.

[1-e] “a boundary wall of the lower chamber being formed by the heat exchanging interface;”

66. In FIG. 2 of Batchelder, the heat-exchanging interface with the lower surface 24 (which a POSITA would have understood is analogous to the bottom sheet 202 in FIG. 7) forms a boundary wall of the lower chamber, as can be seen below:

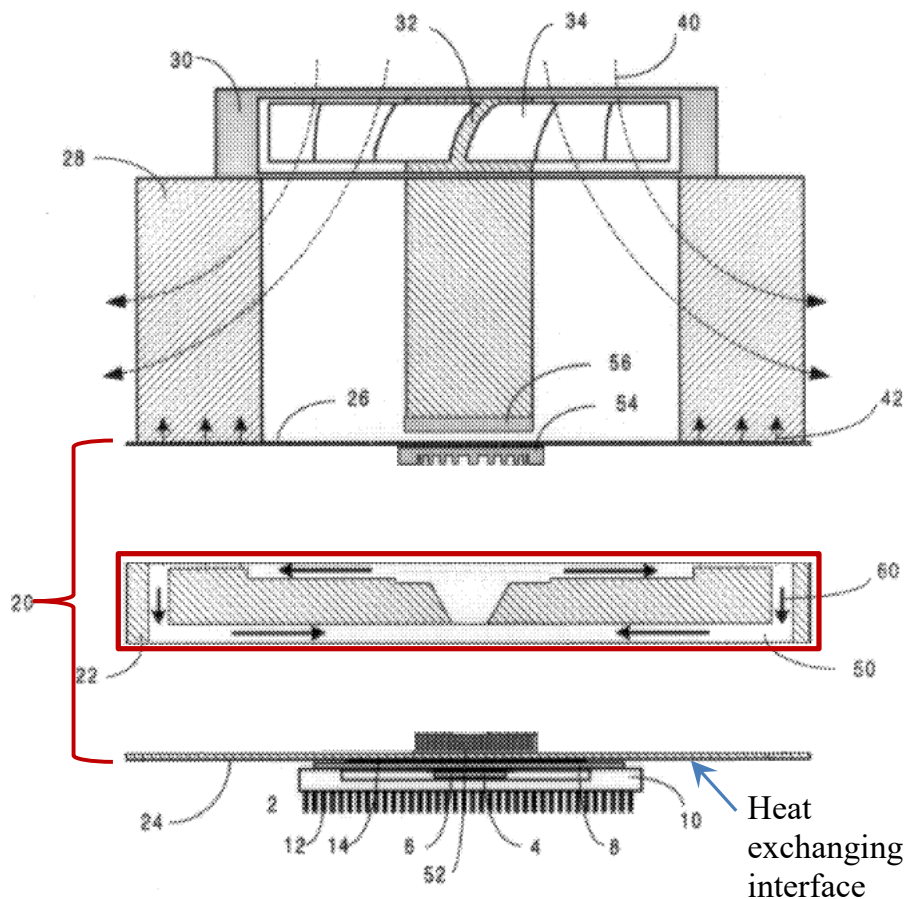
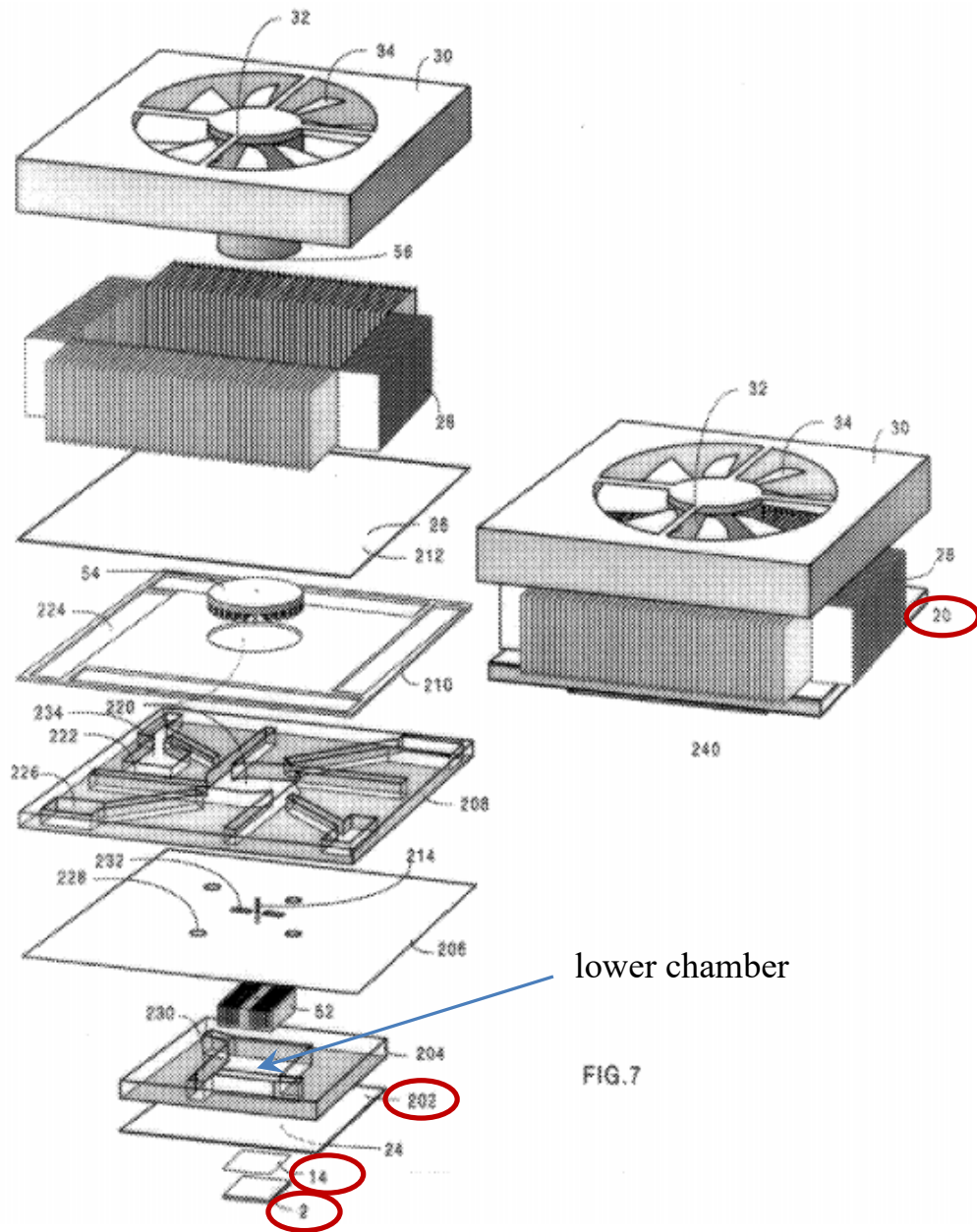


FIG.2

(Batchelder, FIG. 2 (modified and annotated).). In modifying Batchelder's FIG. 2 device in view of Shin (to add an external radiator) this feature would not change.

67. This limitation can also be illustrated in annotated FIG. 7 below, which also does not change in Batchelder's FIG. 8 device, when modified in view of Shin.



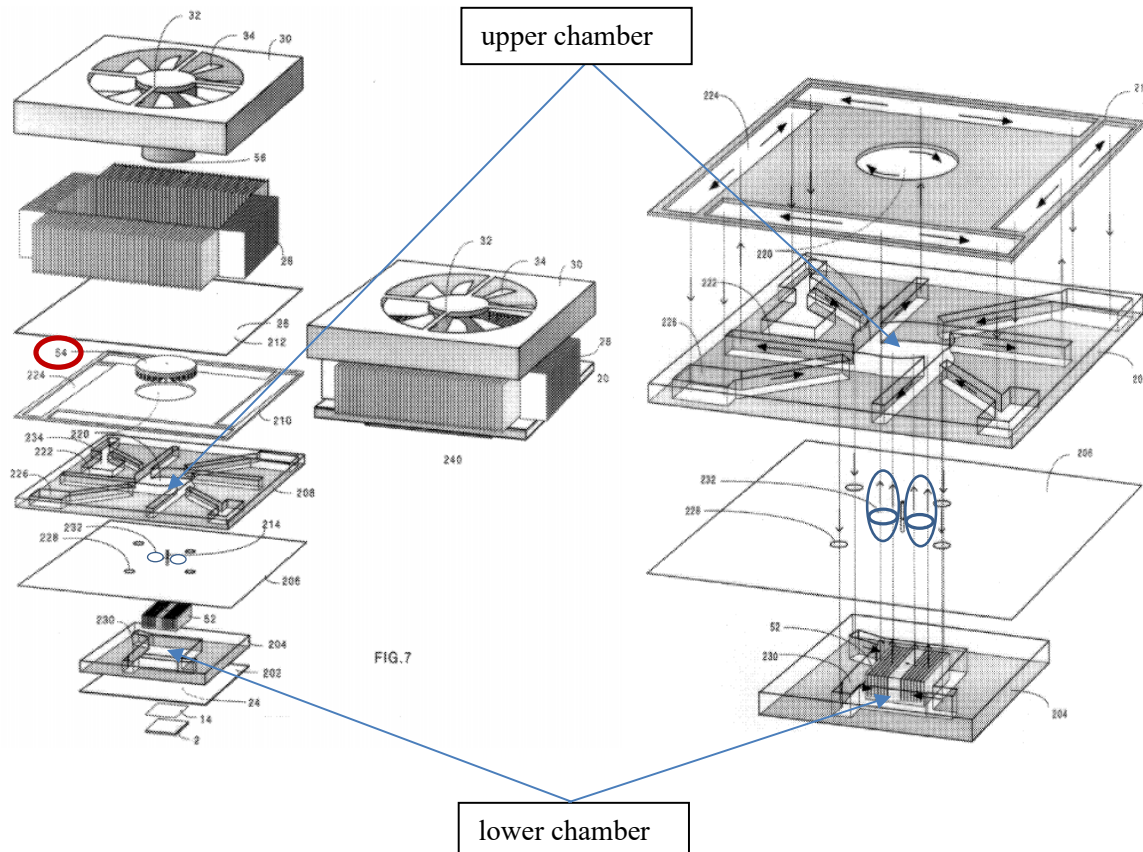
68. For the reasons discussed above, Batchelder in view of Shin renders limitation [1-e] obvious.

[1-f] “the heat exchanging interface is adapted to provide separable thermal contact between the processing unit and the cooling liquid such that heat is dissipated from the processing unit to the cooling liquid as the cooling liquid passes through the lower chamber of the reservoir; and”

69. As illustrated in the annotated FIG. 7 of Batchelder above, the heat exchanging interface (bottom sheet 202) is adapted to provide separable thermal contact (via the compliant thermal conductor and electrical insulator 14 that conducts heat from the heat source 2 to the heat spreader plate 20 (Batchelder, 4:35-37)) between the processing unit (heat source 2) and the cooling liquid in the lower chamber such that heat is dissipated from the processing unit to the cooling liquid as the cooling liquid passes through the lower chamber of the reservoir (within heat spreader plate 20). A POSITA would have understood that the compliant thermal conductor and electrical insulator 14 between the heat exchanging interface 202 and the processing unit 2 would be a common type of thermal interface material such as thermally conductive paste or elastomeric pad which in general have no bonding properties. As such, the compliant thermal conductor and electrical insulator 14 disclose or teach that the thermal contact between the processing unit and the cooling liquid in the lower chamber is “separable.” For these reasons, Batchelder discloses or teaches limitation [1-f], and Batchelder in view of Shin renders limitation [1-f] obvious.

[1-g] the pump is adapted to direct the cooling liquid through the upper chamber and the lower chamber of the reservoir, the pump including a motor having a rotor, a stator and an impeller having a plurality of curved blades, the impeller being positioned within the reservoir;

70. Batchelder discloses or teaches limitation [1-g]. As illustrated in FIGS. 7 and 8 of Batchelder below, the pump (fluid impeller 54, circled in red on the left in FIG. 7) directs the cooling liquid through the upper chamber and the lower chamber of the reservoir (heat spreader plate 20), as shown in the modified FIG. 8 on the right (*see* [1-d] *above*, explaining that openings 232 are substantially circular passages). A POSITA would have understood that impeller 54 is part of a pump with a motor that includes a rotor and a stator. (*See, e.g.*, Batchelder, 3:20-23, 4:53-55, 5:11-13, 6:5-7, 9:22-10:53, FIG. 10.)



71. Batchelder discloses that different pumps can be used as the impeller 54 in the active spreader plate 20 in Figure 2. In the Batchelder’s FIG. 2 embodiment, “impeller 54 is a centripetal or centrifugal pump[.]” (Batchelder, 5:26-32.) Batchelder also discloses that the “centripetal or centrifugal pump 300,” in the lower left corner of FIG. 9 below, is one of “several examples of fluid impellers that can effectively be used in an active spreader plate” (item 20 of FIG. 2) (Batchelder, 8:14-15, 8:36-47):

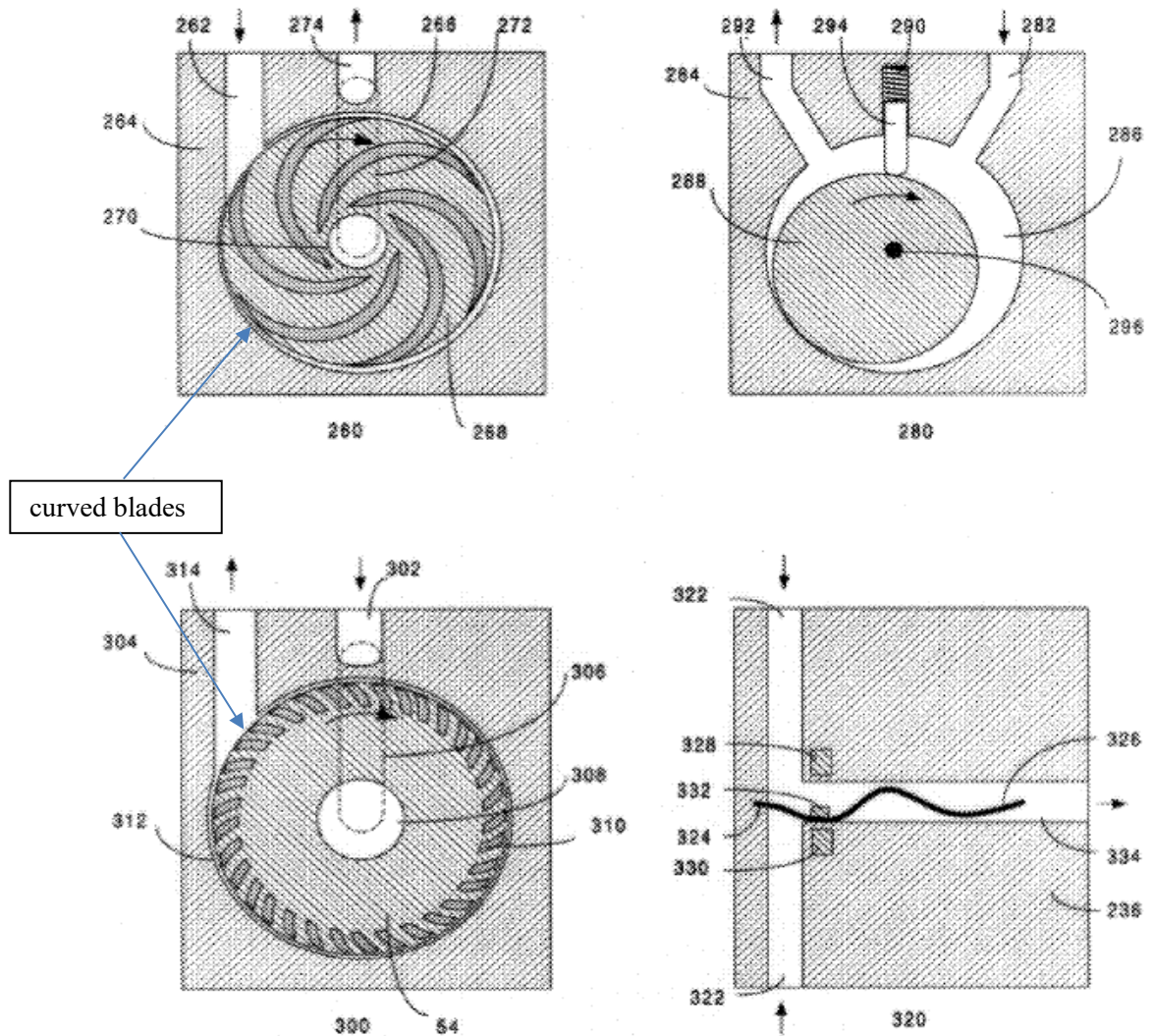
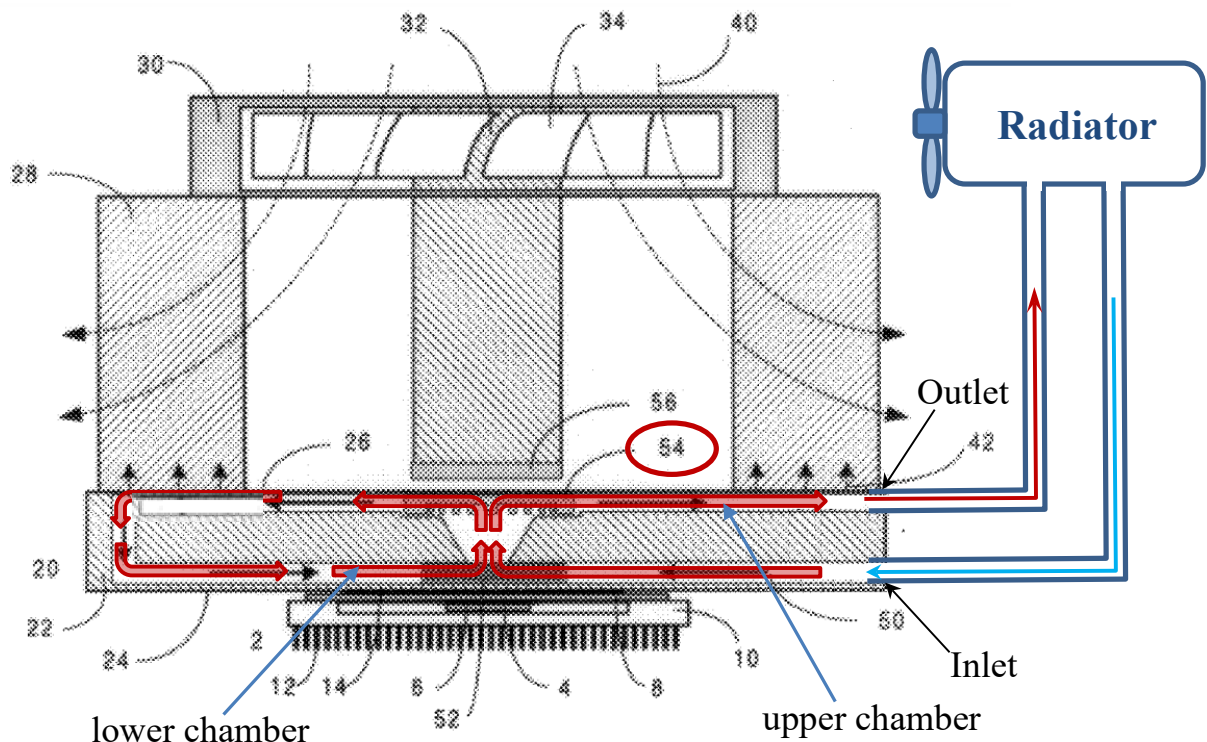
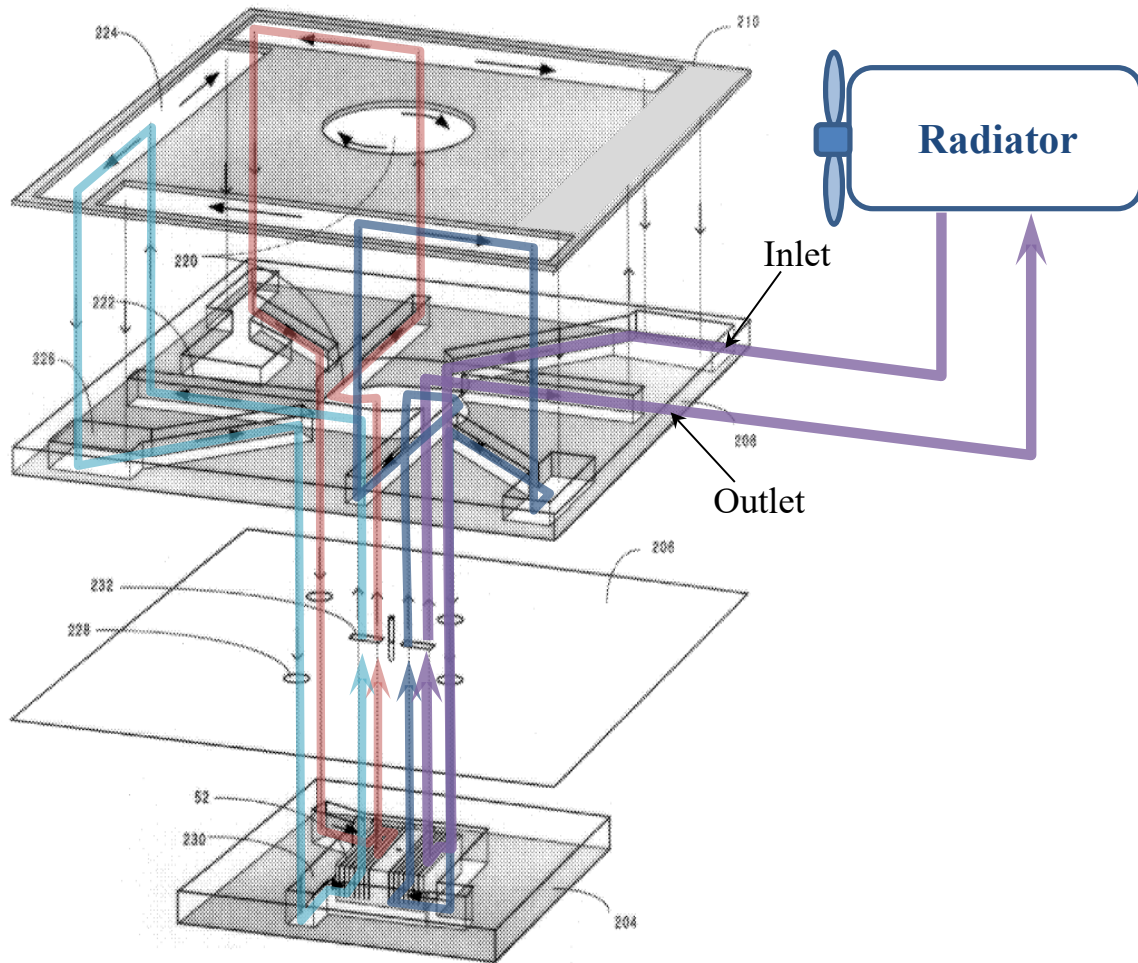


FIG. 9

72. When either the “viscosity pump 260” (top left) or the “centripetal or centrifugal pump 300” (bottom left) is adopted for impeller 54 in the modified Batcheler device, the “rotatable impeller 54” has curved blades as claimed by the ’362 patent. (Batchelder, 8:14-27, 8:36-47.) Batchelder discloses or teaches a rotor

268 in the viscosity pump 260 and a rotor 54 in the centripetal or centrifugal pump 300. (*Id.*) A POSITA would have understood that the rotatable impeller 54 is driven by the magnetic field emanated from the permanent magnet 56 mounted on the rotor 32 (5:16-20) that is part of a motor. (*Id.*, 6:5-18.) A POSITA would have also understood that the motor includes a stator as well, which is the motor's stationary part that must be present for the motor to work.





73. Batcheler in view of Shin teaches that the pump is adapted to direct the cooling liquid through the upper chamber and the lower chamber of the reservoir, with the pump including a motor having a rotor, a stator and an impeller having a plurality of curved blades, further with the impeller being positioned within the reservoir. For the reasons discussed above, Batchelder in view of Shin renders limitation [1-g] obvious.

[1-h] a heat radiator spaced apart from the integrated element, the heat radiator being fluidly coupled to the outlet and the inlet of the reservoir, the heat radiator being configured to circulate the cooling liquid therethrough and exhaust heat from the cooling liquid; and

74. Batchelder in view of Shin teaches this limitation, as discussed above in [1-b], which is incorporated herein by reference.

[1-i] a fan configured to direct air through the heat radiator, the fan being driven by a motor separate from the motor of the pump.

75. Batchelder in view of Shin teaches this limitation, as discussed above in [1-b], which is incorporated herein by reference.

* * *

76. For at least the reasons stated above, Batchelder in view of Shin discloses or teaches each limitation of claim 1 and renders it obvious.

2. Batchelder in view of Shin discloses or teaches each limitation of claims 3-11 and 13.

[Claim 3] “The cooling system of claim 1, further including a plurality of channels in the lower chamber of the reservoir.”

77. Batchelder discloses or teaches the limitations of claim 3. For example, Batchelder discloses that: “Heat enters the active spreader plate (20) on its lower surface (24), and is conducted into a metallic fin array (52). Instead of the heat primarily being conducted by the solid bulk material of the active spreader plate (22), it is transfer from the fin array (52) into a heat transfer fluid sealed in flow

channels (50) inside the active spreader plate (20).” (Batchelder, 4:63-5:6.)

Batchelder’s fin array is described in FIG. 6, in which at least embodiments 110 and 120 disclose or teach such “channels”:

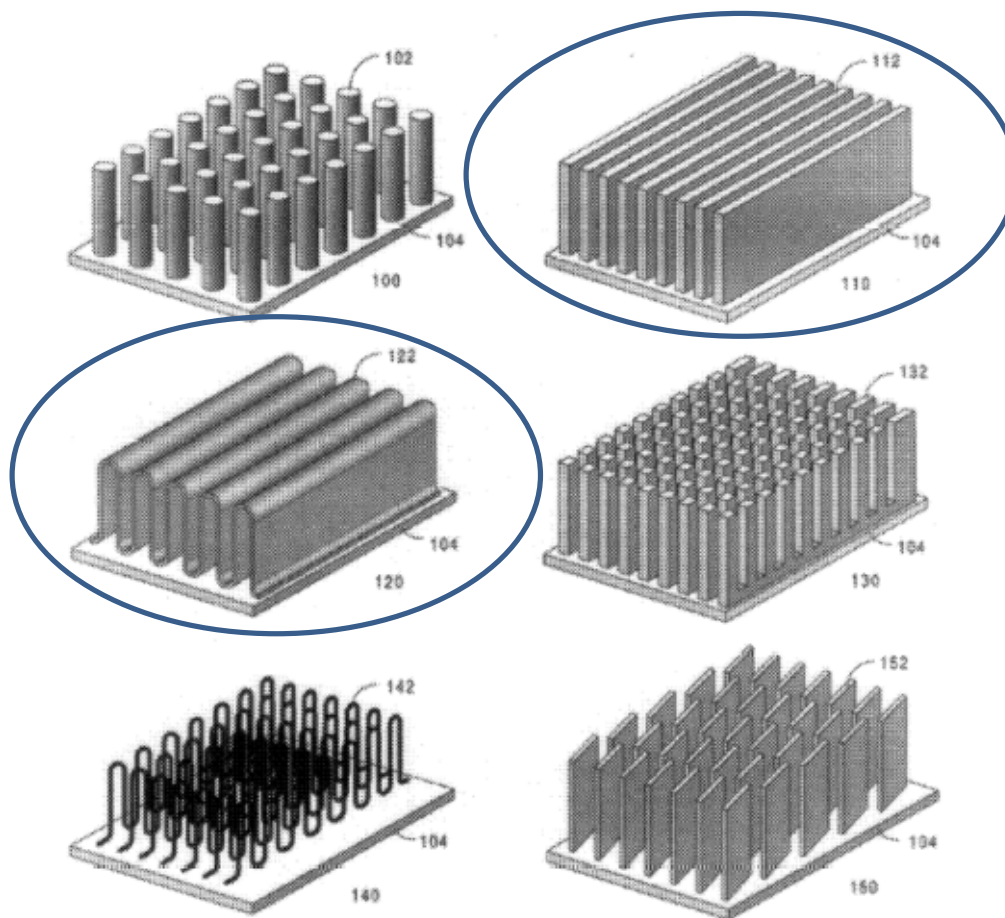
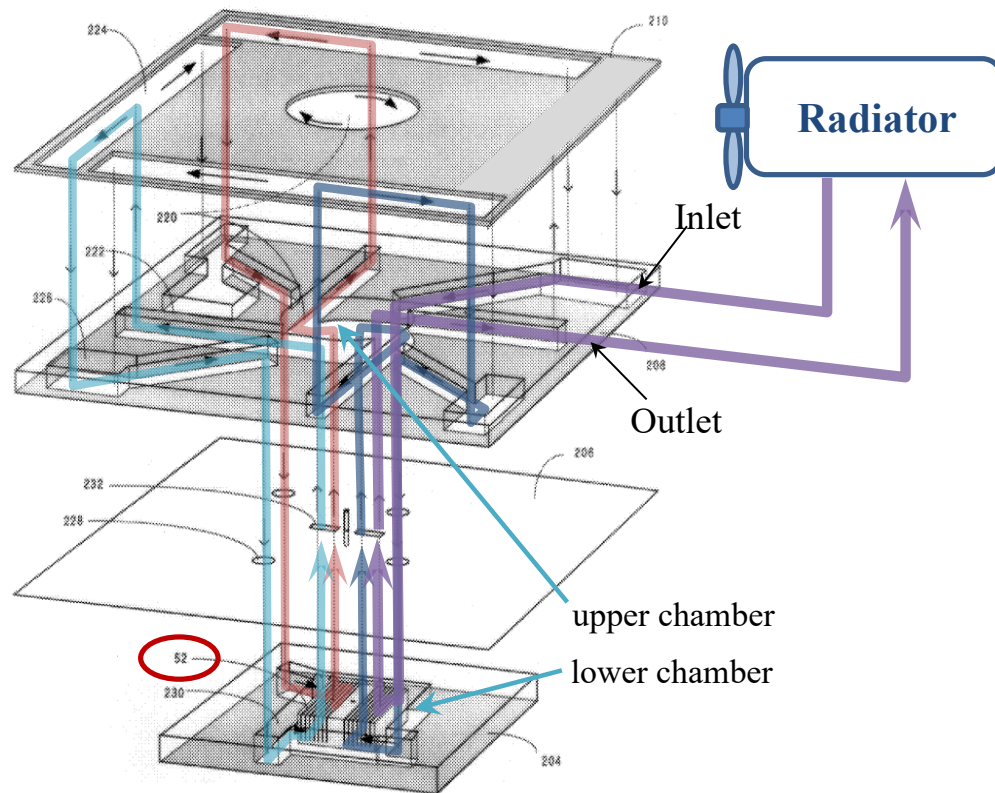


FIG. 6



79. For the reasons discussed above, Batchelder in view of Shin renders claim 3 obvious.

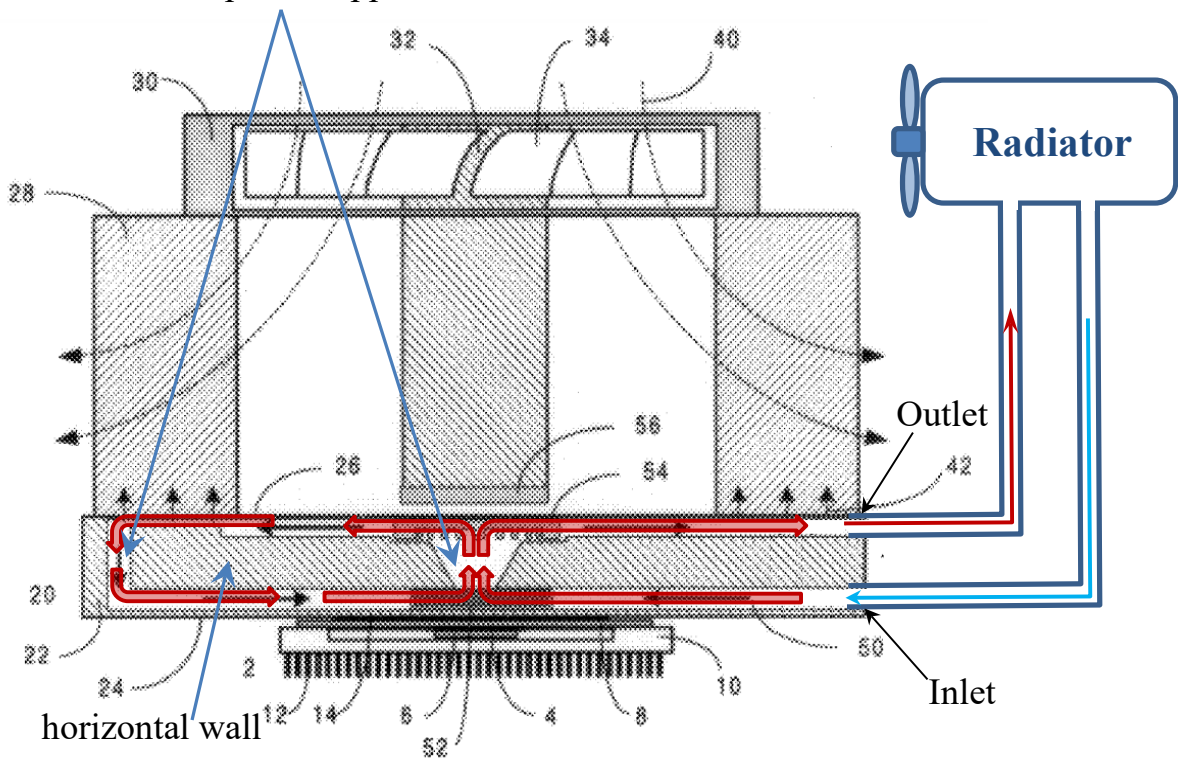
[Claim 4] “The cooling system of claim 1, wherein the pump is positioned in the upper chamber of the reservoir.”

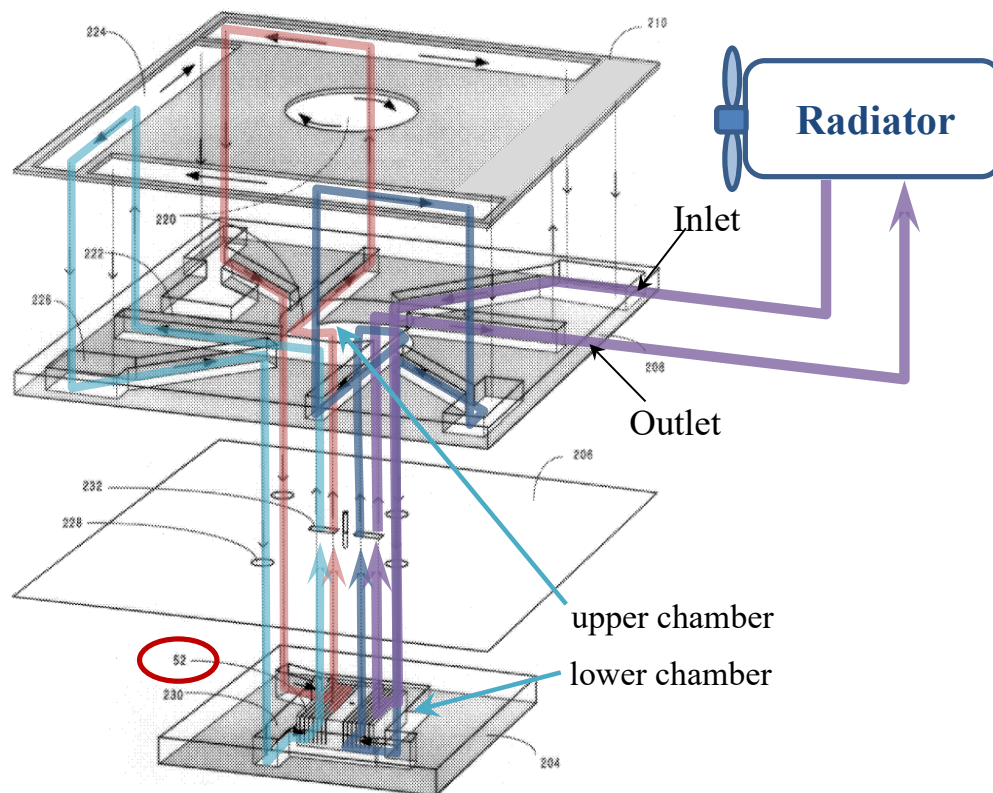
80. As illustrated above, the pump (liquid impeller 54) in the modified Batchelder device is positioned in the upper chamber of the reservoir (heat spreader plate 20). Thus, Batchelder in view of Shin renders claim 4 obvious.

[Claim 5] “The cooling system of claim 1, wherein the cooling liquid is transferred between the upper chamber and the lower chamber of the reservoir only through the plurality of passages that fluidly couple the upper chamber and the lower chamber.”

81. Batchelder in view of Shin teaches this limitation, as discussed above in [1-d], which is incorporated by reference. As shown below, in the modified Batchelder device, the cooling liquid is transferred between the upper chamber and the lower chamber of the reservoir only through the passages 232 that fluidly couple the upper and the lower chamber.

the cooling liquid is transferred between the upper chamber and the lower chamber of the reservoir only through the plurality of passages that fluidly couple the upper chamber and the lower chamber





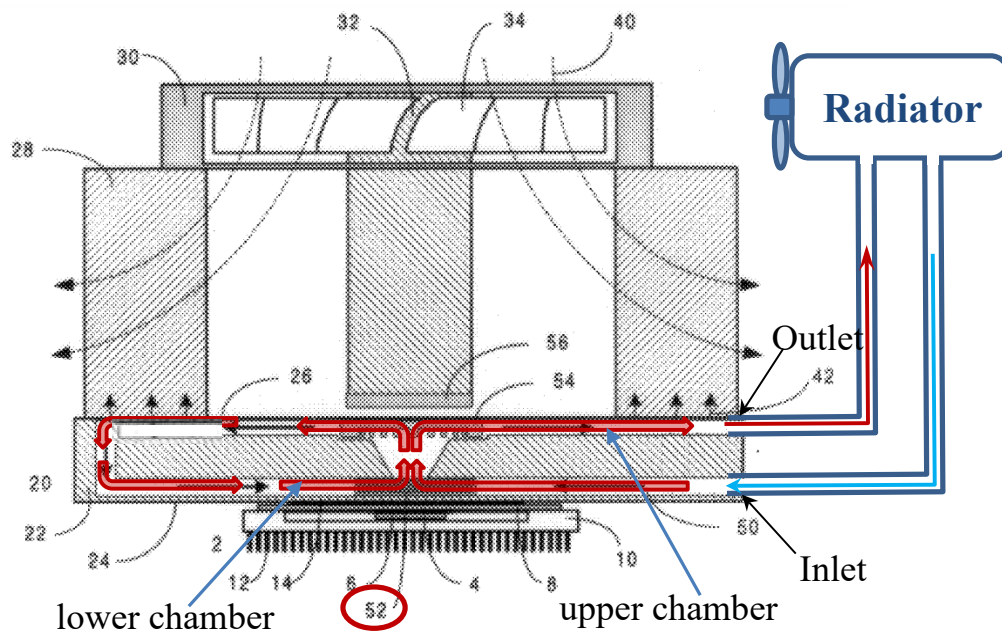
82. For the reasons discussed above, Batchelder in view of Shin renders claim 5 obvious.

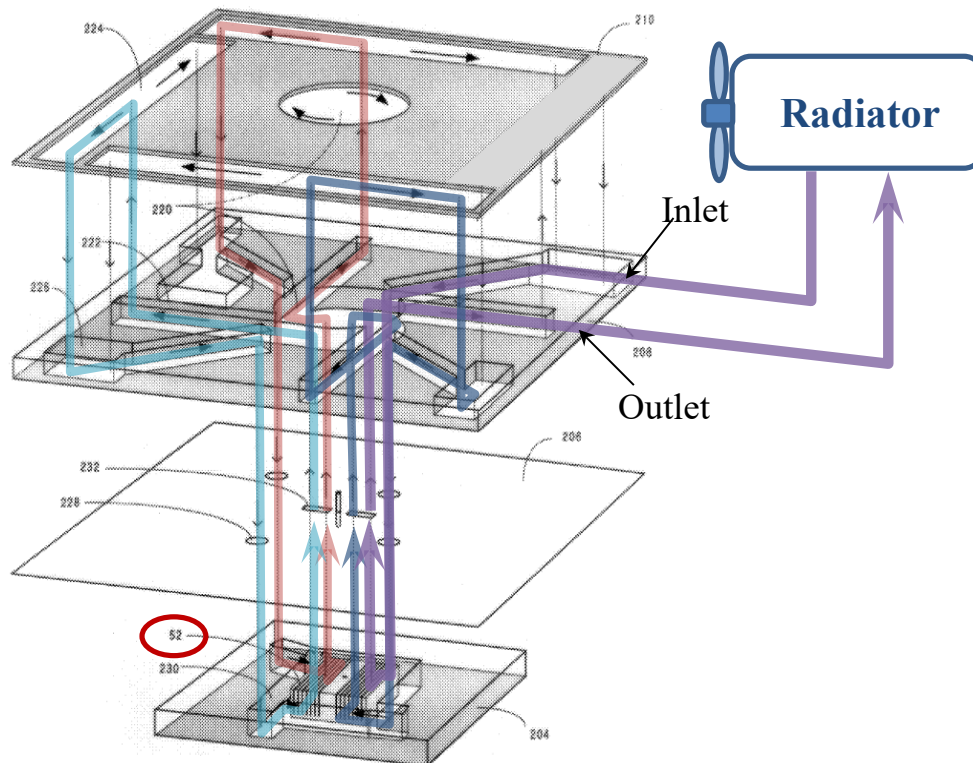
[Claim 6] “The cooling system of claim 1, wherein the heat exchanging interface is removably coupled to the reservoir.”

83. Batchelder discloses or teaches a heat exchanging interface (bottom sheet 202 in FIG. 7) removably coupled to the reservoir (item 20), as illustrated by the yellow annotations in the excerpt of FIG. 7 below:

heat dissipation by increasing the contact area of the cooling liquid.

85. The same applies to the lower chamber of the modified Batchelder device:

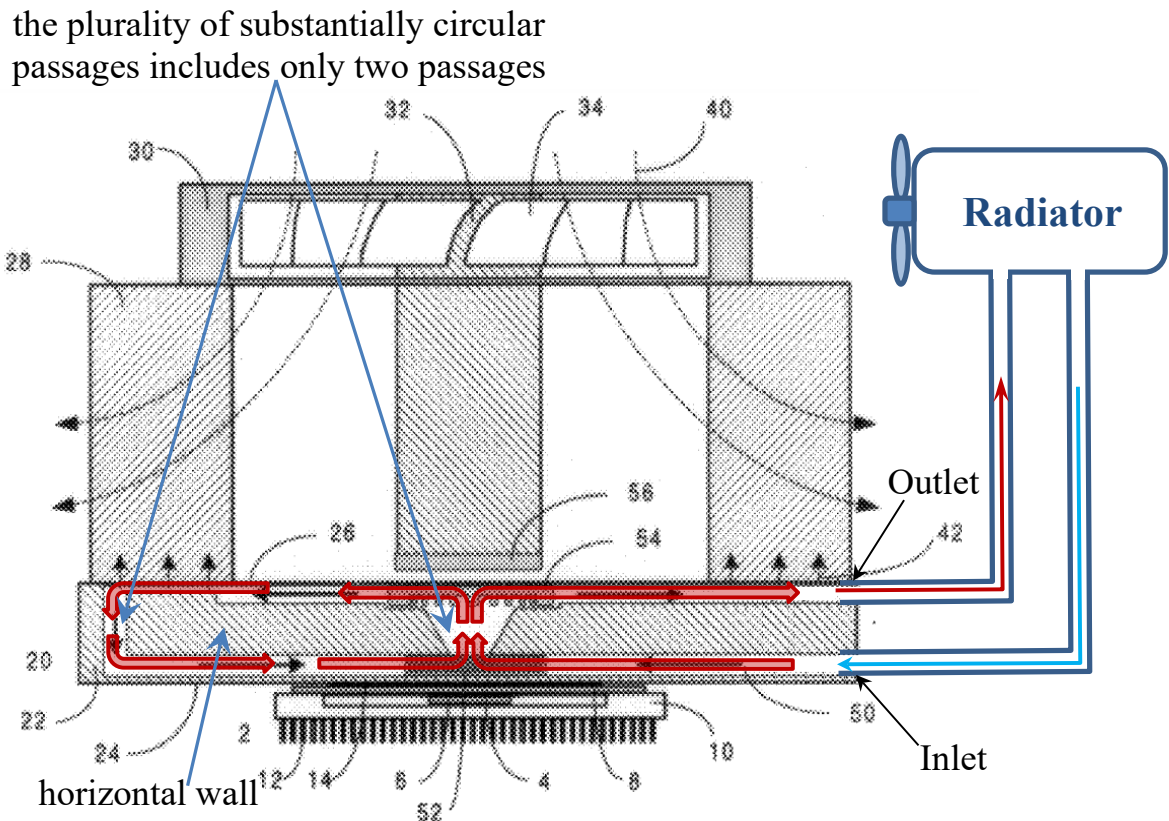




86. For the reasons discussed above, Batchelder in view of Shin renders claim 7 obvious.

[Claim 8] “The cooling system of claim 7, wherein the plurality of passages includes only two passages.”

87. As shown below, when Batchelder’s FIG. 2 device is modified in view of Shin, the device includes only two passages 232.



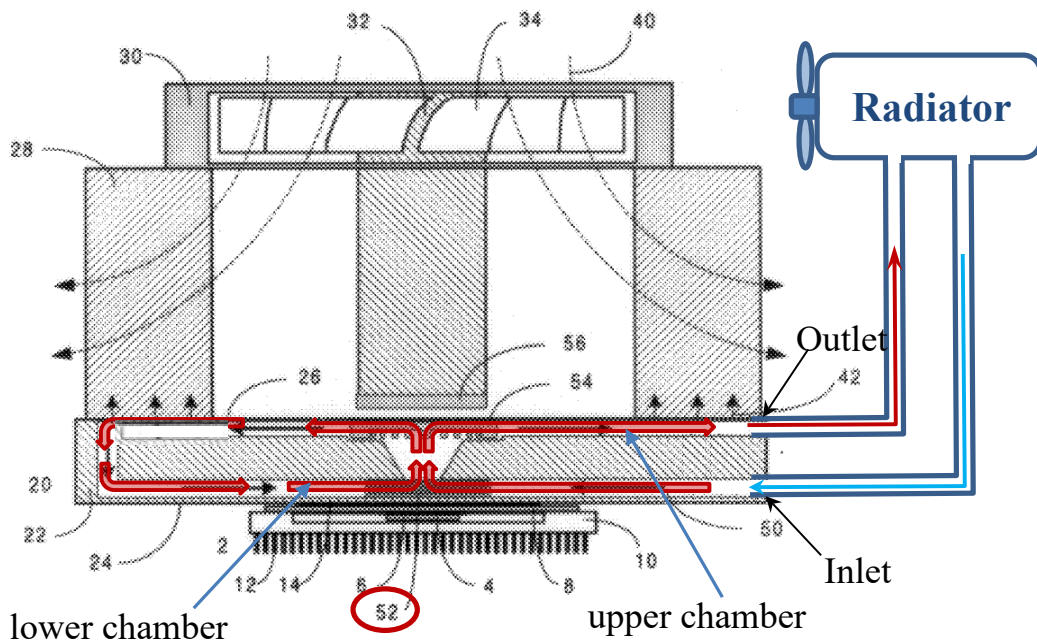
88. Batchelder in view of Shin therefore renders claim 8 obvious.

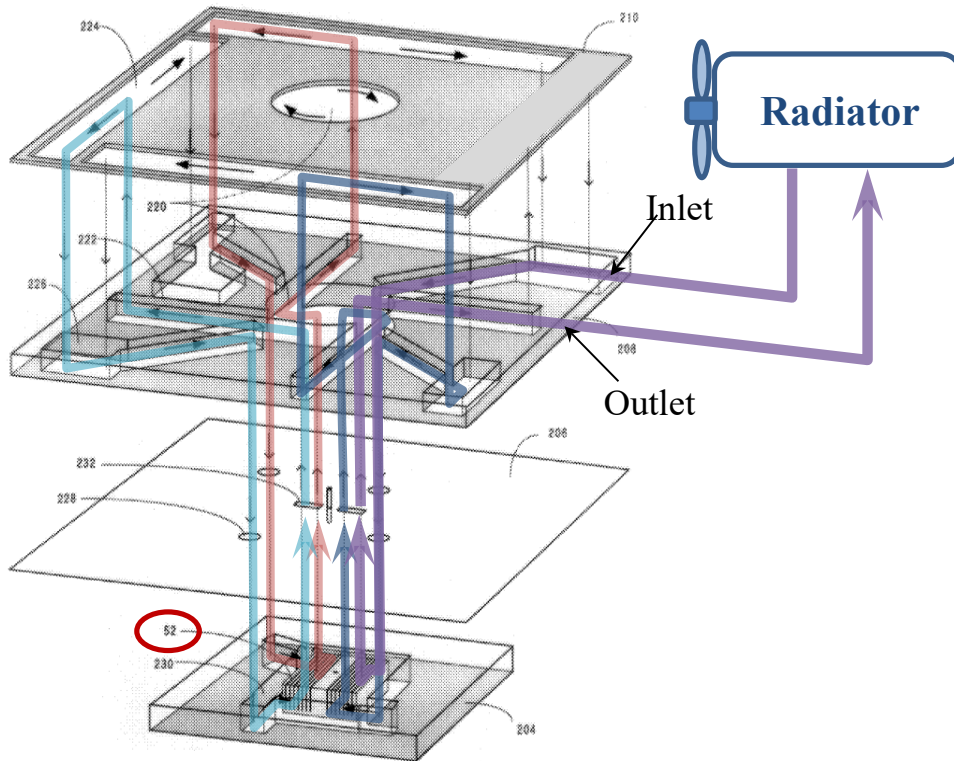
[Claim 9] “The cooling system of claim 1, wherein the lower chamber of the reservoir includes one or more features that are configured to increase an amount of time the cooling liquid takes to flow through the lower chamber.”

89. For the same reasons as described above in claim 3, which are incorporated by reference, Batchelder in view of Shin renders the limitations of claim 9 obvious. A POSITA would have understood that the fin array 52 included in the lower chamber of the reservoir (heat spreader plate 20) increases the flow resistance and thus slows down the flow. As such, the fin array creates features

configured to increase an amount of time the cooling liquid takes to flow through the lower chamber.

90. The same applies to the lower chamber of the modified Batchelder device in view of Shin:





91. For the reasons discuss above, Batchelder in view of Shin renders claim 9 obvious.

[Claim 10] “The cooling system of claim 1, wherein the motor of the pump is an AC motor.”

92. Batchelder does not expressly disclose or teach whether the motor of the pump uses alternating current (“AC”) or direct current (“DC”), but Shin does. Specifically, Shin states that “the present invention does not necessarily limit the motor 12 to a DC motor, and an AC motor driven by alternating current of, for example, 100 (V) or 200 (V) may be used as well.” (Shin, [0020].) AC motors were commonly used in cooling systems (as evidenced by Shin) and would have been to

try as one of a finite number of design choices. Batchelder in view of Shin therefore renders claim 10 obvious.

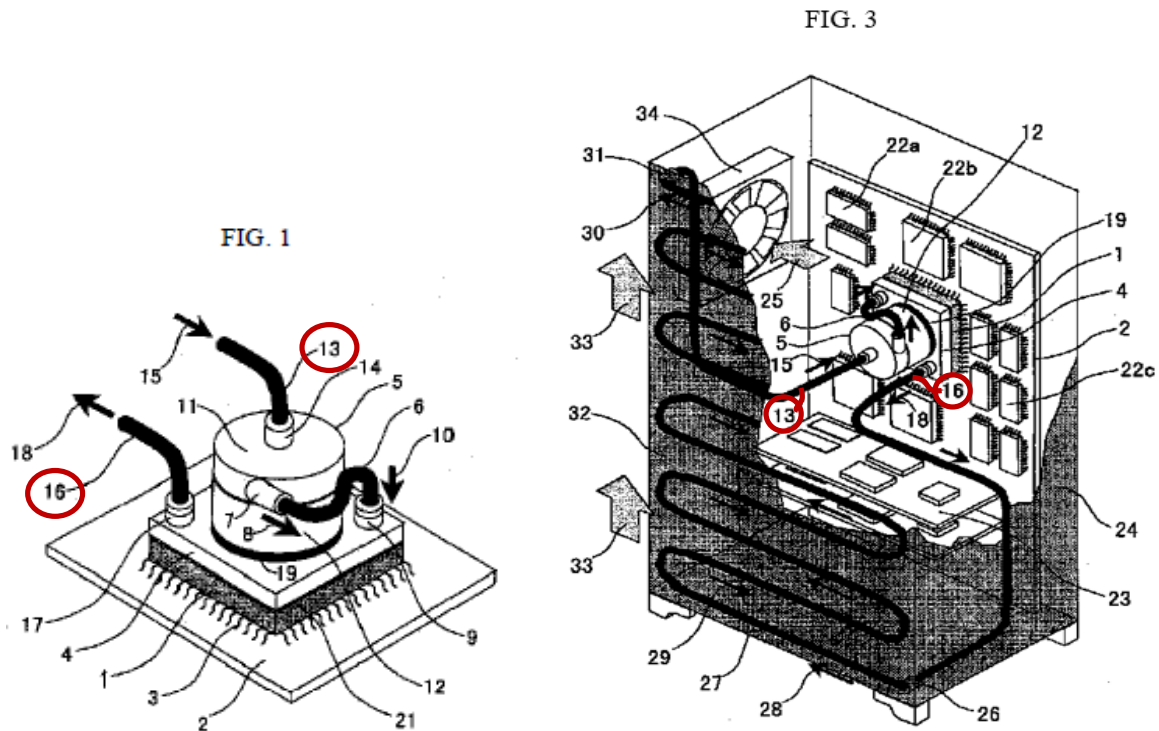
[Claim 11] “The cooling system of claim 1, wherein the motor of the pump is a DC motor.”

93. Batchelder does not expressly disclose or teach whether the motor of the pump uses alternating current (“AC”) or direct current (“DC”), but Shin does. Specifically, Shin states: “The motor 12 [for the pump] is a DC motor driven by a direct current power supply.” (Shin, [0019].) DC motors were commonly used in cooling systems (as evidenced by Shin) and would have been to try as one of a finite number of design choices. Batchelder in view of Shin therefore renders claim 11 obvious.

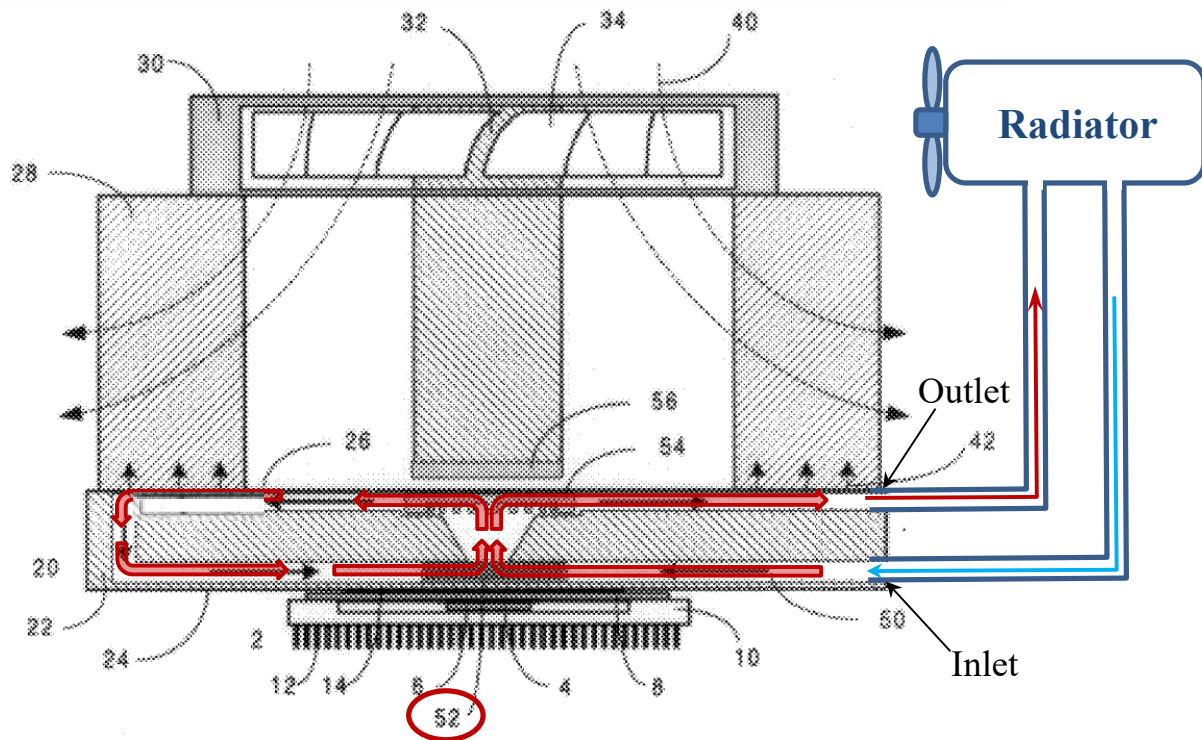
[Claim 13] “The cooling system of claim 1, wherein the integrated element is separate from the heat radiator and the integrated element and the heat radiator are fluidly coupled together by tubing such that the heat radiator can be positioned at a location away from the integrated element when the heat exchanging interface is in thermal contact with the processing unit.”

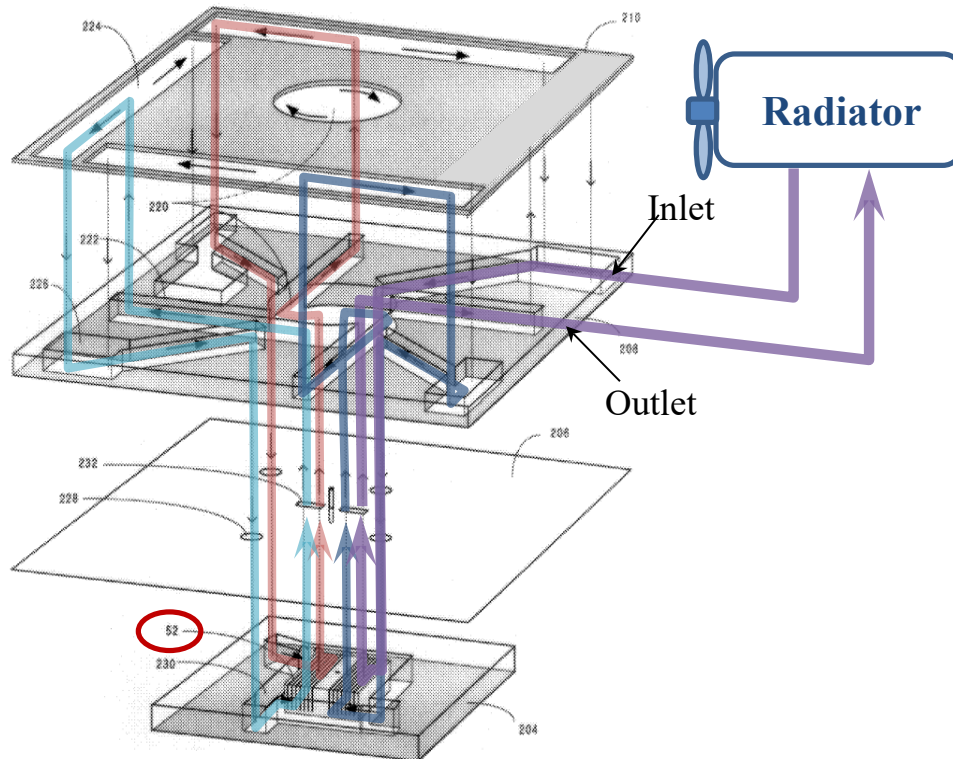
94. For the same reasons discussed above with respect to limitation [1-b], which are incorporated by reference, Batchelder in view of Shin discloses or teaches these limitations. As illustrated below, Shin discloses or teaches a “radiator” (heat exchange section comprising heat exchanger 27 as shown in FIG. 3) that is “separate from” and “fluidly coupled” to the “integrated element” (“integral structure” [0008])

by “tubing” (the hoses 13 and 16, which are the inlet and outlet of the integrated structure, respectively):



(Shin, FIGS. 1 and 3.) When the Batchelder device is modified in view of Shin, the radiator and the integrated element 20 are arranged such that the heat radiator can be positioned at a location away from the integrated element 20 when the heat exchanging interface 24 is in thermal contact with the processing unit 2, as shown below:





95. For the reasons discussed above, Batchelder in view of Shin renders claim 13 obvious.

3. Batchelder in view of Shin discloses or teaches each limitation of claim 17.

[17-PRE] “A method of operating a liquid cooling system for an electronic component positioned on a motherboard of a computer system, comprising:”

96. For the same reasons as stated in [1-PRE], [1-a], and [1-b], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this preamble. Thus, Batchelder in view of Shin renders this preamble obvious.

[17-a] “separably thermally coupling a heat exchanging interface of a reservoir with the electronic component positioned at a first location on the motherboard,”

97. For the same reasons as stated in [1-f], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. Thus, Batchelder in view of Shin renders this limitation obvious.

[17-b] “the reservoir including an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers that are vertically spaced apart”

98. For the same reasons as stated in [1-c], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. Thus, Batchelder in view of Shin renders this limitation obvious.

[17-c] “[the upper chamber and the lower chamber being separate chambers that are vertically spaced apart and] separated by at least a horizontal wall, the upper chamber and the lower chamber being fluidly coupled by one or more passageways, at least one of the one or more passageways being positioned on the horizontal wall,”

99. For the same reasons as stated in [1-d], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. Thus, Batchelder in view of Shin renders this limitation obvious.

[17-d] “the heat exchanging interface being removably coupled to the reservoir”

100. For the same reasons as stated in [Claim 6], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. Thus,

Batchelder in view of Shin renders this limitation obvious.

[17-e] “[the heat exchanging interface being removably coupled to the reservoir such that] an inside surface of the heat exchanging interface is exposed to the lower chamber of the reservoir;”

101. For the same reasons as stated in [Claim 7], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. Thus, Batchelder in view of Shin renders this limitation obvious.

[17-f] “positioning a heat radiator at a second location horizontally spaced apart from the first location, the heat radiator and the reservoir being fluidly coupled together by tubing that extends from the first location to the second location;”

102. For the same reasons as stated in [1-h] and [Claim 13], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. Thus, Batchelder in view of Shin renders this limitation obvious.

[17-g] “activating a pump to a circulate a cooling liquid through the reservoir and the heat radiator, the pump including a motor and an impeller having curved blades, the impeller being positioned in the reservoir; and”

103. For the same reasons as stated in [1-g] and [1-h], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. Thus, Batchelder in view of Shin renders this limitation obvious.

[17-h] “activating a fan to direct air through the heat radiator, the fan being operated by a motor separate from the motor of the pump.”

104. For the same reasons as stated in [1-i], which are incorporated by

reference, Batchelder in view of Shin discloses or teaches this limitation. Thus, Batchelder in view of Shin renders this limitation obvious.

4. Batchelder in view of Shin discloses or teaches each limitation of claims 18 and 19.

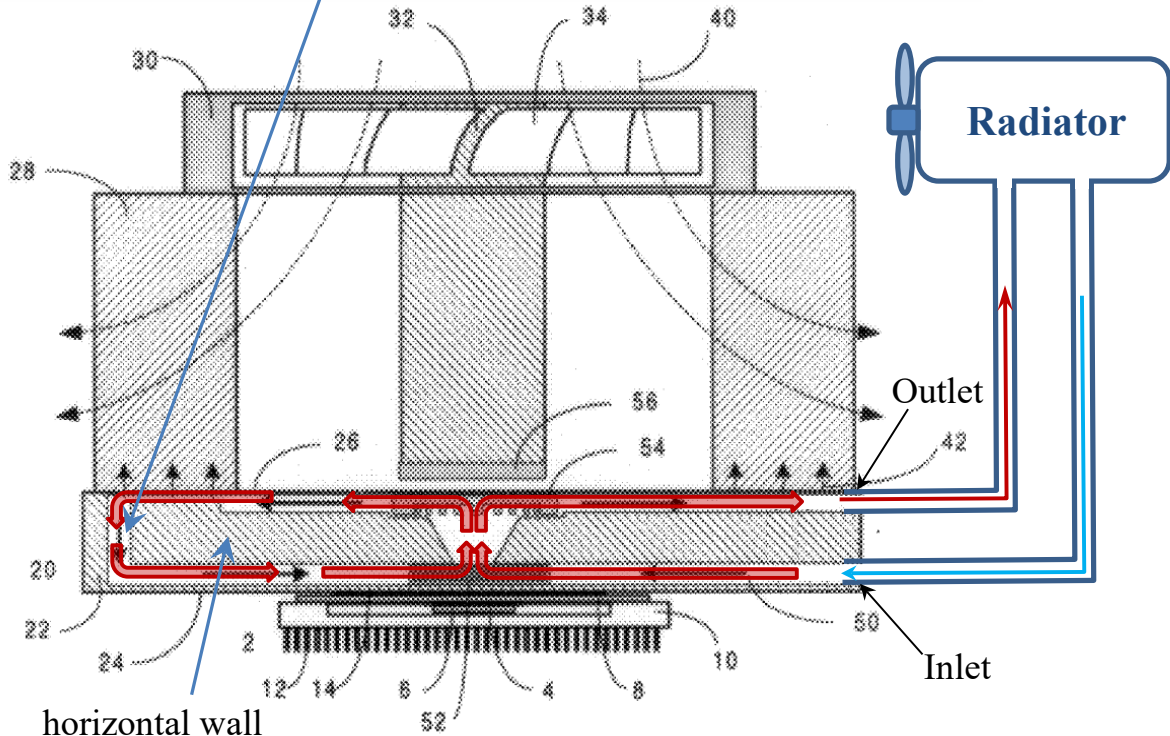
[Claim 18] “The method of claim 17, wherein activating the pump includes circulating the cooling liquid between the upper and the lower chambers of the reservoir.”

105. For the same reasons as stated in [Claim 5], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. Thus, Batchelder in view of Shin renders claim 18 obvious.

[Claim 19] “The method of claim 18, wherein circulating the cooling liquid between the upper and the lower chambers includes passing the cooling liquid from the upper chamber to the lower chamber through a single passageway of the one or more passageways.”

106. For the same reasons as stated in [Claim 8], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. When Batchelder’s Figure 2 device is modified in view of Shin, the upper chamber and the lower chamber are fluidly coupled by only two passageways, and only a single passageway of those two passes the cooling liquid from the upper chamber to the lower chamber, as shown below.

passing the cooling liquid from the upper chamber to the lower chamber
through a single passageway of the one or more passageways



107. For the reasons discussed above, Batchelder in view of Shin renders claim 19 obvious.

B. GROUND 2: Claims 12 and 14 to 16 are rendered obvious over the combination of Batchelder and Shin in view of Nakano.

1. Batchelder in view of Shin and further in view of Nakano discloses or teaches each limitation of claim 12.

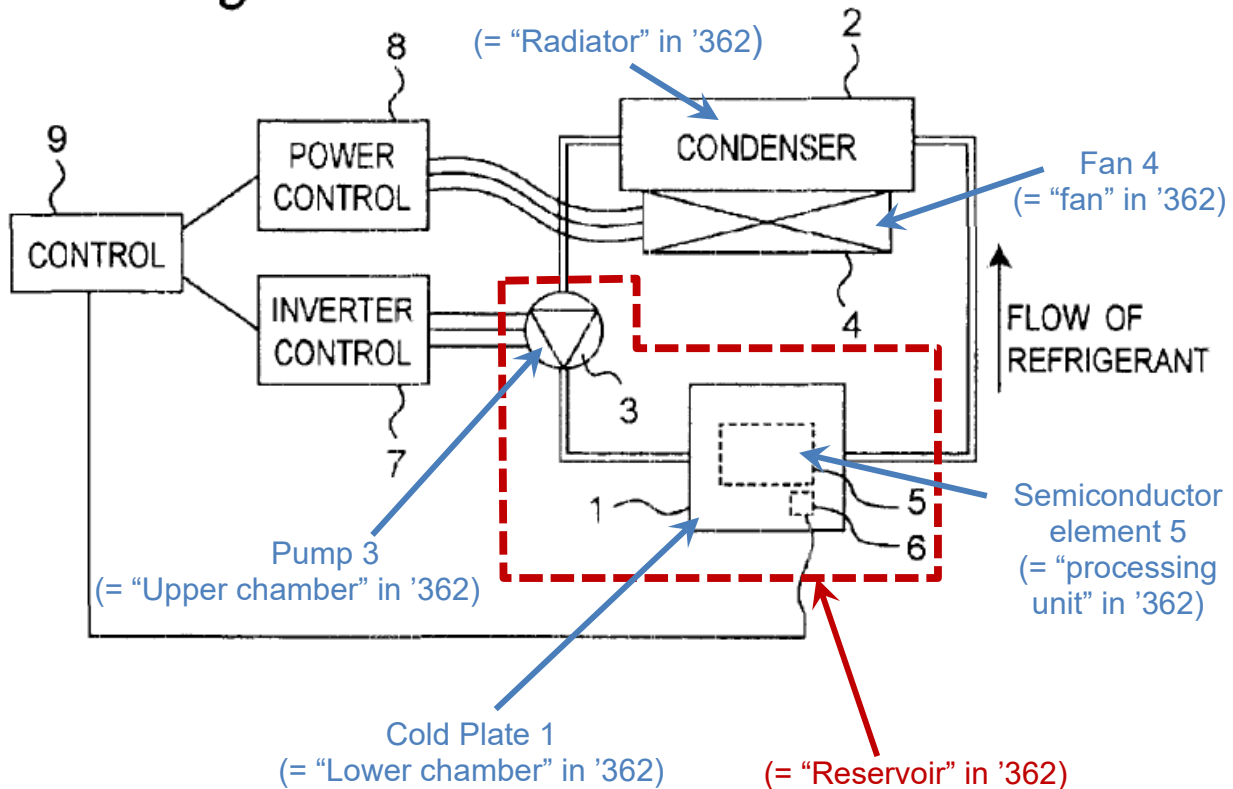
[Claim 12] “The cooling system of claim 1, wherein a speed of the fan is configured to be varied independent of a speed of the impeller of the pump.”

108. Batchelder and Shin do not appear to expressly disclose or teach this

limitation, but Nakano does. Nakano discloses or teaches a system similar to that claimed by the '362 patent. For example, Nakano discloses that: “The semiconductor cooling device shown in FIG. 2 includes a cold plate **1** for cooling a highly exothermic semiconductor element **5** that tends to emit a substantial amount of heat when in operation, a condenser **2**, and an inverter-controlled refrigerant pump **3**, all connected in series with each other to define a refrigerating cycle. A refrigerant is filled in this refrigerating cycle. The condenser **2** is adapted to be cooled by a fan **4**.” (Nakano, 2:38-45.)

109. A POSITA would have understood Nakano’s cooling system to be similar to that of the '362 patent, as demonstrated by the followed annotated version of Nakano FIG. 2:

Fig. 2



110. Nakano also states that “the cold plate 1 is provided with a temperature sensor 6 mounted thereon in proximity to the semiconductor element 5, and the temperature sensor 6 is electrically connected to a controller 9.” (Nakano, 2:57-60.)

Nakano further states:

In accomplishing the above and other objectives, the semiconductor cooling device according to the present invention includes a cold plate for cooling a semiconductor element, a condenser, and an inverter-controlled refrigerant pump, all of which are fluid connected in series with each other to define a refrigerating cycle. The semiconductor

cooling device also includes a fan for cooling the condenser, a temperature detector disposed in proximity to the semiconductor element, and a controller for controlling the refrigerant pump and the fan. **The controller controls the number of revolutions of the refrigerant pump and that of the fan depending on a value measured by the temperature detector.** The temperature detector may be accommodated in the semiconductor element.

(Nakano, 1:42-55.) Nakano also discloses or teaches “adjust[ing] the pump speed” as follows:

When the value measured by the temperature sensor 6 increases more than a predetermined value within a predetermined period of time, **the controller 9 first maximizes the number of revolutions of the fan 4 and then increases the number of revolutions of the refrigerant pump 3** step by step while comparing the measured value by the temperature sensor 6 with a value set in the controller 9.

(Nakano, 3:7-13.)

The controller 9 appropriately controls the number of revolutions of the refrigerant pump 3 and that of the fan 4 based on a value measured by the temperature sensor 6. **The controller 9 is designed so as to preferentially reduce, when the amount of heat emitted from the semiconductor element 5 is less than a predetermined level, the number of revolutions of the fan 4 before that of the refrigerant**

pump 3, making it possible to provide a cooling device that is low in noise level.

(Nakano, 2:65-3:6.)

111. A POSITA would have understood that the controller is capable of adjusting the speed of the pump independent of the fan speed. Nakano therefore discloses or teaches “a speed of the fan is configured to be varied independent of a speed of the impeller of the pump.”

112. For the reasons discussed above, Batchelder in view of Shin and further in view of Nakano renders claim 12 obvious.

2. The motivation to combine Nakano with Batchelder and Shin.

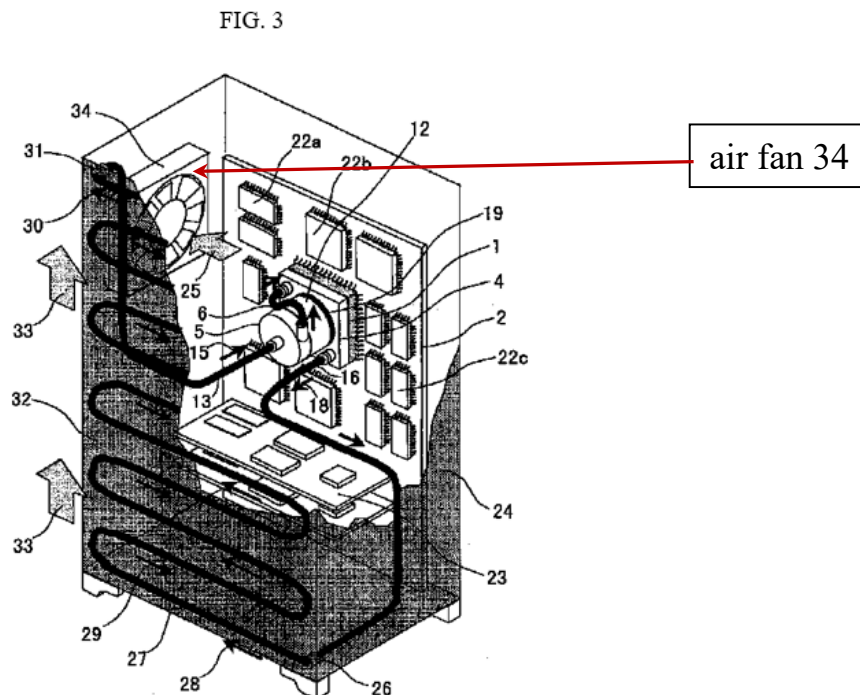
113. A POSITA would have been motivated to modify the combination of Batchelder and Shin to incorporate the control system of Nakano. Shin discloses that: “Using a DC motor *allows the motor speed to be easily changed by changing the DC voltage, thus enabling control of cooling power*. Moreover, *making the motor into a DC brushless motor makes it possible to implement a pump of low noise and long service life*.” (Shin, [0019]; *see also id.* at [0006] (“It is an object of the present invention to *provide a cooling structure for electronic devices which is compact, has low noise, superior cooling performance* and high reliability.”).) Shin

also discloses, with respect to the embodiment in FIG. 3, that:

Besides the heat generating element 1, heat generating elements 22a, 22b, 22c, such as memory LSI and driver LSI chips, *which can be cooled by air cooling*, as well as an IO card, memory card, hard disk or other card mounting board 23 are also installed on the wiring board 2. The wiring board 2 is housed inside case 24, which is an electronic equipment case. *An air cooling fan 34 is installed in the case 24, and the aforementioned multiple air cooled components are air-cooled by cooling air 25.*

(*Id.* at [0024].)

114. These elements are also shown in FIG. 3:



(*Id.* at FIG. 3.)

115. A POSITA would have been motivated to incorporate Nakano's control system into the Batchelder/Shin system in order to adjust the fan speed and the pump speed to reduce noise and meet the needed cooling capacity. The POSITA would have had a reasonable expectation of success because a pump, a fan, and a control system are familiar elements that can be readily combined with predictable results.

3. Batchelder in view of Shin and further in view of Nakano discloses or teaches each limitation of claim 14.

[14-PRE] "A cooling system for a processing unit positioned on a motherboard of a computer, comprising:"

116. For the same reasons as stated in [1-PRE], [1-a], and [1-b], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this preamble. In turn, Batchelder in view of Shin and further in view of Nakano renders this preamble obvious.

[14-a] "a reservoir configured to be coupled to the processing unit positioned on the motherboard at a first location,"

117. For the same reasons as stated in [1-PRE], [1-a], and [1-b], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-b] “the reservoir being adapted to pass a cooling liquid therethrough,”

118. For the same reasons as stated in [1-b] which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-c] “wherein the reservoir includes an upper chamber and a lower chamber, the upper chamber and the lower chamber being separate chambers containing cooling liquid that are”

119. For the same reasons as stated in [1-c], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-d] “[the upper chamber and the lower chamber being separate chambers containing cooling liquid that are] separated by at least a horizontal wall and fluidly coupled together by one or more passageways, at least one of the one or more passageways being a substantially circular passageway positioned on the horizontal wall,”

120. For the same reasons as stated in [1-d], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-e] the reservoir further including a heat exchanging interface

121. For the same reasons as stated in [1-a], [1-c], and [1-e], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. The reservoir in Batchelder (heat spreading plate 20) includes the heat exchanging interface (metal sheet 202) that forms a boundary wall of the reservoir's lower chamber. Accordingly, Batchelder's reservoir includes a heat exchanging interface. Thus, Batchelder in view of Shin discloses or teaches limitation [14-e], and Batchelder in view of Shin and further in view of Nakano renders limitation [14-e] obvious.

[14-f] “[a heat exchanging interface] configured to be placed in separable thermal contact with the processing unit,”

122. For the same reasons as stated in [1-f], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-g] “the heat exchanging interface being removably attached to the reservoir”

123. For the same reasons as stated in [Claim 6], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this

limitation obvious.

[14-h] “[the heat exchanging interface being removably attached to the reservoir] such that the heat exchanging interface forms a boundary wall of the lower chamber of the reservoir;”

124. For the same reasons as stated in [1-e], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-i] “a heat radiator configured to be positioned at a second location horizontally spaced apart from the first location when the reservoir is coupled to the processing unit;”

125. For the same reasons as stated in [1-h], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-j] “a fan adapted to direct air to the heat radiator to dissipate heat from the cooling liquid to surrounding atmosphere;”

126. For the same reasons as stated in [1-h] and [1-i], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-k] a pump configured to circulate the cooling liquid between the reservoir and the heat radiator, the pump including a motor having a rotor, a stator, and an impeller having curved blades, the impeller being mechanically coupled to the rotor and at least partially submerged in the cooling liquid in the reservoir,

127. For the same reasons as stated in [1-g] and [1-h], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[14-l] “wherein a speed of the impeller is configured to be varied independent of the speed of the fan.”

128. For the same reasons as stated in [Claim 12], which are incorporated by reference, Batchelder in view of Shin and further in view of Nakano discloses or teaches this limitation and in turn renders this limitation obvious.

4. Batchelder in view of Shin and further in view of Nakano discloses or teaches each limitation of claims 15 and 16.

[Claim 15] The cooling system of claim 14, wherein the lower chamber of the reservoir includes one or more features that are configured to increase an amount of time the cooling liquid takes to flow through the lower chamber.

129. For the same reasons as stated in [Claim 3], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. In turn, Batchelder in view of Shin and further in view of Nakano renders this limitation obvious.

[Claim 16] The cooling system of claim 14, wherein at least one of a location of the pump or a configuration of the reservoir is selected to create a turbulence of cooling liquid flow proximate the heat exchanging interface.

130. For the same reasons as stated in [1-PRE], [1-a], and [1-b], which are incorporated by reference, Batchelder in view of Shin discloses or teaches this limitation. A POSITA would have understood that the location of the pump (impeller 54) or the configuration of the reservoir (heat spreader plate 20) in Batchelder is selected to create a turbulence of cooling liquid flow in the proximity of the heat exchanging interface, because the turbulence of the cooling liquid flow enhances its absorption of heat from the heat exchanging interface. Accordingly, a POSITA would have been motivated to position the pump or to configure the reservoir in Batchelder so that the turbulence of the cooling liquid is increased near the heat exchanging interface. Thus, Batchelder in view of Shin and further in view of Nakano renders claim 16 obvious.

XI. CONCLUDING STATEMENT

131. In signing this Declaration, I recognize that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in this proceeding. If required, I will appear for cross-examination at the appropriate time.

132. I reserve the right to amend, supplement, or otherwise modify my opinions, whether in a further written declaration or otherwise. I also reserve the right to reply to positions taken by Patent Owner's experts.

133. I hereby declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

Appendix A

GEORGIOS KARAMANIS

CO-FOUNDER AND SENIOR ENGINEER

TRANSPORT PHENOMENA TECHNOLOGIES, LLC

Phone: (781) 363-5528 | E-mail: Georgios.Karamanis@tptechcorp.com | 444 Somerville Ave, Somerville, MA 02143

<https://www.tptechcorp.com/>

AREAS OF INTEREST

- Thermal management of electronics; air and liquid cooling applications.
- Fluid flow and heat transfer modeling.
- Electromechanical and electronic devices.

EDUCATION

Tufts University **Medford, MA**
PhD Mechanical Engineering 2018

Tufts University **Medford, MA**
MS Mechanical Engineering 2015

Aristotle University of Thessaloniki **Thessaloniki, Greece**
BS Mechanical Engineering 2012

EXPERIENCE

Transport Phenomena Technologies, LLC **Medford, MA**
Co-Founder and Senior Engineer October 2017–present

- Technical and business activities related to development of hardware and software for thermal management of electronics and optimization of heat sinks and cold plates.
- Consulting on transport phenomena, including legal consulting.
- Design of custom electromechanical devices.

Tufts University **Medford, MA**
Research Assistant Professor (Part-Time) December 2021–Present

- Modeling and experimental techniques pertaining to mass, momentum, and heat transfer, and supercritical drying of silica aerogels.
- ME193 Simulation for Mechanical Engineers: Structural, thermal, and fluid flow analysis using commercial software packages (SOLIDWORKS, COMSOL, ANSYS Workbench, MATLAB).

Consultant August 2018–December 2021
 • Modeling of supercritical drying of silica aerogels.

Instructor Spring Semester 2020
 • ME193 Simulation for Mechanical Engineers: Structural, thermal, and fluid flow analysis using commercial software packages (SOLIDWORKS, COMSOL, ANSYS Workbench, MATLAB).

Imperial College **London, UK**
Invited Researcher September 2016–December 2016

- Modeling of the extended Graetz–Nusselt problem for liquid flow over isothermal parallel ridges; Microchannel liquid cooling in the presence of apparent slip.

FUNDING

- PI on National Science Foundation Phase II SBIR award (\$986,321, #2025882):
- PI on Massachusetts Clean Energy Center Catalyst award (\$65,000, Spring 2019):

PATENTS

- [1] Karamanis, G., Hodes, M., 2021, “Compliant Thermal Management Devices, Systems, and Methods of Fabrication Thereof.” WO2021178722A1. (Filed)

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Published

- [1] Kirk, T., **Karamanis, G.**, Crowdy, D., Hodes, M., 2020, "Thermocapillary stress and meniscus curvature effects on slip lengths in ridged microchannels." *Journal of Fluid Mechanics*, 894.
- [2] **Karamanis, G.**, Hodes, M., 2019, "Simultaneous Optimization of an Array of Heat Sinks." *ASME J. Electronic Packaging*, **141**(2).
- [3] **Karamanis, G.**, Hodes, M., 2019, "Conjugate Nusselt Numbers for Simultaneously-Developing Flow through Rectangular Ducts." *ASME J. Heat Transfer*, **141**.
- [4] Luca, E., Marshall, J., **Karamanis, G.**, 2018, "Longitudinal shear flow over a bubble mattress with curved menisci: Arbitrary protrusion angle and solid fraction." *IMA Journal of Applied Mathematics*, **83**(6), p.917–941.
- [5] **Karamanis, G.**, Hodes, M., Kirk, T., Papageorgiou, D., 2017, "Solution of the Extended Graetz–Nusselt Problem for Liquid Flow Over Isothermal Parallel Ridges." *ASME J. Heat Transfer*, **140**(6), p. 061703.
- [6] **Karamanis, G.**, Hodes, M., Kirk, T., Papageorgiou, D., 2017. "Solution of the Graetz-Nusselt problem for liquid flow over isothermal parallel ridges." *ASME Journal of Heat Transfer*, **139**(9), p. 091702.
- [7] Hodes, M., Kirk, T. L., **Karamanis, G.**, MacLachlan, S., 2017. "Effect of thermocapillary stress on slip length for a channel textured with parallel ridges." *Journal of Fluid Mechanics*, 814, pp. 301-324.
- [8] Kadoko, J., **Karamanis, G.**, Kirk, T., Hodes, M., 2017. "One-dimensional analysis of gas diffusion-induced Cassie to Wenzel state transition." *ASME Journal of Heat Transfer*, **139**(12), p. 122006.
- [9] **Karamanis, G.**, Hodes, M., 2016. "Longitudinal-fin heat sink optimization capturing conjugate effects under fully developed conditions." *Journal of Thermal Science and Engineering Applications*, **8**(4), p. 041011.
- [10] Lam, L. S., Hodes, M., **Karamanis, G.**, Kirk, T., MacLachlan, S., 2016. "Effect of meniscus curvature on apparent thermal slip." *ASME Journal of Heat Transfer*, **138**(12), p. 122004.

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- [1] Karamanis, G., Hodes, M., "Algorithm for simultaneous optimization of an array of heat sinks." *ITHERM 2018*, Paper #P225.
- [2] Karamanis, G., Dinh, H., Waisbord, N., Hodes, M., "Effects of suction and spillage on supercritical carbon dioxide-based drying of aerogels." *IHTC16*, Paper #24239.
- [3] Karamanis, G., Hodes, M. "Optimal design of longitudinal-fin heat sinks accounting for simultaneously developing flow and conjugate effects." *TFEC-IWHT2017*, Paper #17556.
- [4] Karamanis, G., Hodes, M., Kirk, T., Papageorgiou, D., "Extended Graetz-Nusselt problem for liquid flow in Cassie state over isothermal parallel ridges." *FACM 2017*.
- [5] Karamanis, G., Hodes, M., Kirk, T., Papageorgiou, D., 2016. "Nusselt numbers for fully-developed flow between parallel plates with one plate textured with isothermal parallel ridges." *ASME 2016 HTSC*, pp. V001T05A004.
- [6] Kadoko, J., Karamanis, G., Kirk, T., Hodes, M., 2016. "Analysis of gas diffusion-induced Cassie to Wenzel state transition on a structured surface." *ASME 2016 HTSC*, pp. V002T11A005.
- [7] Karamanis, G. Hodes, M., "Optimal Fin Thickness and Spacing in Fully-Developed Flow Accounting for Non-Uniform Heat Transfer Coefficient." *ASTFE 2015*, Paper #12925.
- [8] Hodes, M., Lam, L., Karamanis, G., MacLachlan, S., "Effect of thermocapillary stress on slip length for poiseuille flow over parallel ridges." *ASTFE 2015*, Paper #12930.
- [9] Hodes, M., Karamanis, G., Steigerwalt Lam, L., MacLachlan, S., Kirk, T., Papageorgiou, D., 2015. "Conformal map and asymptotic solutions for apparent slip lengths in the presence of thermocapillary stress." *23rd ISHMT-ASTFE*, pp. 17-20.

INVITED PRESENTATIONS AND SHORT COURSES

- [1] "Design and Optimization of Heat Sinks." SEMI-THERM 35, San Jose, CA, 2019.
- [2] "Design and Optimization of Heat Sinks." Co-located IEEE Electronic Components & Technology Conference and Intersociety Thermal & Thermomechanical in Electronic Systems Conference, San Diego, CA, 2018. (with Marc Hodes)
- [3] "Evaporation driven flow over parallel ridges." Workshop on Micro & Nano Liquid Flows, University of Warwick, 2016.
- [4] "Nusselt Numbers for Poiseuille Flow over Isothermal Parallel Ridges." Imperial College London-Tufts University Workshop on Microchannel Liquid Cooling in the presence of Apparent Slip, Imperial College London, 2016.

AWARDS

- [1] SoE Award for Outstanding Academic Scholarship, Tufts University, 2018.
- [2] Award for Outstanding Performance in the Graduate Program, Department of Mechanical Engineering, Tufts University, 2018.