

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. 8,245,764

---

**DECLARATION OF GEORGIOS KARAMANIS, PH.D.**

Dated: March 5, 2023

Respectfully submitted,

A handwritten signature in black ink, appearing to be 'G. Karamanis', is written over a light blue rectangular background.

---

Georgios Karamanis, Ph.D.

## TABLE OF CONTENTS

|       |                                                                                                                     |    |
|-------|---------------------------------------------------------------------------------------------------------------------|----|
| I.    | INTRODUCTION AND QUALIFICATIONS.....                                                                                | 1  |
| II.   | MATERIALS CONSIDERED.....                                                                                           | 2  |
| III.  | OVERVIEW AND LEGAL STANDARDS.....                                                                                   | 4  |
| A.    | Priority Date .....                                                                                                 | 4  |
| B.    | Person Having Ordinary Skill in the Art.....                                                                        | 4  |
| C.    | CLAIM CONSTRUCTION .....                                                                                            | 7  |
| 1.    | “reservoir” .....                                                                                                   | 7  |
| 2.    | “chamber” .....                                                                                                     | 7  |
| 3.    | “underside” and “upper side” of the “chassis” .....                                                                 | 7  |
| 4.    | “below” .....                                                                                                       | 8  |
| 5.    | “below ... vertically” .....                                                                                        | 8  |
| 6.    | Other Terms .....                                                                                                   | 9  |
| IV.   | LEGAL STANDARDS .....                                                                                               | 9  |
| V.    | OVERVIEW OF THE '764 PATENT .....                                                                                   | 11 |
| VI.   | OVERVIEW OF PRIOR ART .....                                                                                         | 15 |
| A.    | Duan (Ex-1006).....                                                                                                 | 15 |
| B.    | Duan I (Ex-1007).....                                                                                               | 16 |
| C.    | Batchelder (Ex-1008).....                                                                                           | 16 |
| D.    | Laing (Ex-1015) .....                                                                                               | 16 |
| VII.  | CLAIM ELEMENT NUMBERING KEY .....                                                                                   | 17 |
| VIII. | ANALYSIS.....                                                                                                       | 31 |
| A.    | GROUND 1: Claims 1-19, 21-27, and 29-30 are rendered<br>obvious over Duan by itself or in view of Duan I.....       | 32 |
| 1.    | Duan by itself or in view of Duan I discloses or suggests<br>each limitation of claim 1 and renders it obvious..... | 32 |
| 2.    | Duan by itself or in view of Duan I teaches each<br>limitation of claims 2-9.....                                   | 55 |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

|     |                                                                                                                            |     |
|-----|----------------------------------------------------------------------------------------------------------------------------|-----|
| 3.  | Duan and Duan I disclose or teach each limitation of claim 10 and render it obvious.....                                   | 72  |
| 4.  | Duan teaches each limitation of claims 11-14.....                                                                          | 77  |
| 5.  | Duan and Duan I teach each limitation of claim 15 and render it obvious.....                                               | 80  |
| 6.  | Duan teaches each limitation of claims 16-19, 21-27, and 29.....                                                           | 88  |
| 7.  | Duan by itself or in view of Duan I teaches each limitation of claim 30.....                                               | 97  |
| B.  | GROUND 3 and 4: Claim 8 is obvious over Duan in view of Laing or Duan in view of Duan-I and further in view of Laing. .... | 97  |
| C.  | GROUND 5: Claims 1-30 are rendered obvious over Batchelder in view of Duan.....                                            | 99  |
| 1.  | Batchelder in view of Duan teaches each limitation of claim 1 and renders it obvious. ....                                 | 99  |
| 2.  | Batchelder teaches each limitation of claims 2-9. ....                                                                     | 124 |
| 3.  | Batchelder and Duan teach each limitation of claim 10 and render it obvious.....                                           | 135 |
| 4.  | Batchelder and Duan disclose or teach each limitation of claims 11-14.....                                                 | 140 |
| 5.  | Batchelder and Duan disclose or teach each limitation of claim 15 and render it obvious.....                               | 145 |
| 6.  | Batchelder teaches each limitation of claims 16-29. ....                                                                   | 149 |
| 7.  | Batchelder discloses or teaches each limitation of claim 30.....                                                           | 158 |
| D.  | GROUND 6: Claim 8 is obvious over Batchelder in view of Duan and further in view of Laing.....                             | 159 |
| IX. | CONCLUDING STATEMENT.....                                                                                                  | 160 |

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. 8,245,764 (“’764 patent”). I submit this declaration based on my personal knowledge and in support of CMC’s *inter partes* review Petition against the ’764 patent. I previously submitted a substantively identical declaration in support of Shenzhen Apaltek Co. Ltd.’s *inter partes* review Petition against the ’764 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. 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.

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

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

9. 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**

10. 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 May 6, 2005, I have considered the exhibits to the Petition (Exs. 1001-1015), shown below.

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| Exhibit | Description                                                                                                                                                            |
|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1001    | U.S. Patent No. 8,245,764 (“’764 patent”)                                                                                                                              |
| 1002    | <i>Inter Partes</i> Reexamination Certificate, Reexamination Request 95/002,386, U.S. Patent No. 8,245,764                                                             |
| 1004    | File history of U.S. Patent No. 8,245,764 (“’764-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 Publication No. 2006/0185830 (“Duan”)                                                                                                                      |
| 1007    | U.S. Patent Publication No. 2006/0185829 (“Duan-I”)                                                                                                                    |
| 1008    | U.S. Patent No. 6,019,165 to Batchelder (“Batchelder”)                                                                                                                 |
| 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”)                                                                                     |
| 1012    | File history of Reexamination Request 95/002,386, U.S. Patent No. 8,245,764 (“’764-Rexam-FH”)                                                                          |
| 1013    | Institution Decision, Paper No. 10, IPR2021-01196 (Dec. 28, 2021) (“’196-Institution”)                                                                                 |

| <b>Exhibit</b> | <b>Description</b>                                                                                      |
|----------------|---------------------------------------------------------------------------------------------------------|
| 1014           | Certified Translation of Japanese Unexamined Patent App. Pub. No. 2002-151638 to Takayuki Shin (“Shin”) |
| 1015           | U.S. Patent Publication No. 2004/0052663 (“Laing”)                                                      |

### **III. OVERVIEW AND LEGAL STANDARDS**

#### **A. Priority Date**

11. Counsel has explained to me that I should assume the effective filing date of the ’764 patent is May 6, 2005. I have, therefore, applied this date in considering the prior art and the viewpoint of a person of ordinary skill in the art (“POSITA”).

12. I understand Petitioner may argue that the ’764 patent is not entitled to a 2005 effective filing date. Even if this were true, my opinions would not change.

#### **B. Person Having Ordinary Skill in the Art**

13. I understand that my assessment of the claims of the ’764 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 ’764 patent on its relevant filing date and in light of the specification and file history of the ’764 patent. I will refer to such a person as a “POSITA.”

14. 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 '764 patent.

15. 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.

16. 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.

17. 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, POSITA working in the field of liquid cooling systems for computer systems as of the claimed priority date (May 6, 2005) would have been 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 2-3 years of experience in liquid cooling systems for computer systems or similar systems. (See, e.g., Ex-1001 at 1:11-47 (describing the “Background of the Invention” of the ’764 patent).) A POSITA would be knowledgeable of the concepts, components, and their functions described as “prior art” in the ’764 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.

18. 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 '764 patent.

## **C. CLAIM CONSTRUCTION**

### **1. “reservoir”**

19. I understand that the parties have stipulated, in the pending district court action, to construe the term “reservoir,” as that term is used in the '764 patent claims, to mean “single receptacle defining a fluid flow path.” (Ex-1005 at 2.)

### **2. “chamber”**

20. I further understand that the parties have also stipulated to construe the term “chamber,” as that term is used in the '764 patent claims, to mean “compartment within the reservoir. (Ex-1005 at 2.)

### **3. “underside” and “upper side” of the “chassis”**

21. Claim 1 recites “a double-sided chassis adapted to mount a pump configured to circulate a cooling liquid, the pump comprising a stator and an impeller, the impeller being positioned on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid” (emphasis added). Thus, a POSITA would have understood the “upper side of the chassis” to mean the side isolated from the cooling liquid and the “underside

of the chassis” to mean the other side contacting the cooling liquid.

**4. “below”**

22. The term “below” by itself appears in the following phrase in claim 1: “a pump chamber including the impeller and formed below the chassis[.]” Because the “impeller” is positioned on the underside of the chassis (i.e., the side contacting the cooling liquid) and included in the “pump chamber,” a POSITA would have understood the “pump chamber” to be “formed below the chassis” on the “underside of the chassis” contacting the cooling liquid.

**5. “below ... vertically”**

23. The term “below ... vertically” appears in the following phrase in claim 1: “a thermal exchange chamber formed below the pump chamber and vertically spaced apart from the pump chamber[.]” Petitioner and Patent Owner have stipulated that “vertically spaced apart” means “vertically arranged (with reference to each other and the heat exchanging interface) chambers” (with “chamber” construed as above).” (Ex-1005 at 2.) Thus, a POSITA would have understood “below ... vertically” to mean that the “thermal exchange chamber” is “formed below the pump chamber ... vertically” with reference to each other and the heat exchanging interface.

## **6. Other Terms**

24. As to other terms, a POSITA would have understood the plain and ordinary meaning of the term “double-sided chassis” to be “two-sided frame or base.” To the extent applicable, I have rendered my opinions using these constructions. Although it is my understanding that district court claim construction proceedings are ongoing, for purposes of these IPRs, I believe no additional specific constructions are required; I understand that the other claim terms in these IPRs will be construed according to their ordinary and customary meaning. I further understand that the claims are read in light of the patent’s specification and that claims themselves often provide significant guidance as to the meaning of a particular term.

## **IV. LEGAL STANDARDS**

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

26. 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.

27. 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.

28. 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.

29. 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. OVERVIEW OF THE '764 PATENT**

30. The '764 patent characterizes its field of invention as follows:

“The present invention relates to a cooling system for a central processing unit (CPU) or other processing unit of a computer system. More specifically, the invention relates to a liquid-cooling system for a mainstream computer system such as a PC.” (Ex-1001 at 1:11-15.)

31. The '764 patent relates to a liquid-cooling system for a computer system. The specification purports to disclose embodiments of a liquid-cooling system that is more efficient, easier to use, and more compact with integrated components than prior art cooling systems. (Ex-1001 at 1:11-2:19.)

32. The '764 patent further states that these purported improvements may be achieved by having an integrated element comprising the heat exchange interface,

the reservoir of cooling liquid, and the pump for pumping the cooling liquid. (Id. at 1:51-2:31; claims 1-18.)

33. The following figures capture the main characteristics of the purported invention claimed in the Challenged Claims.

34. FIG. 7 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. 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

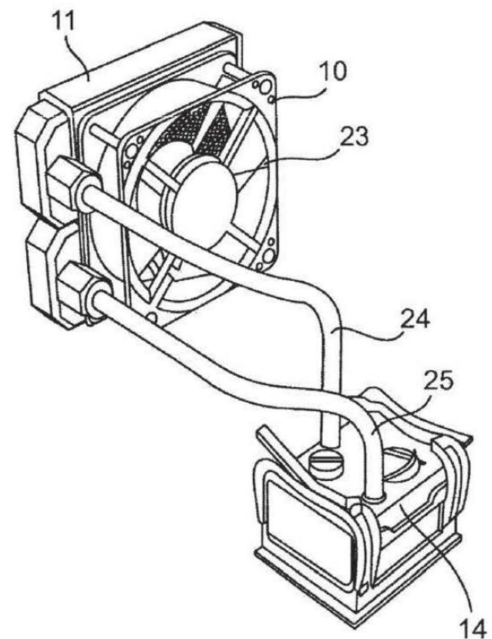


**FIG. 7**

reservoir and the heat radiator, respectively. Within the heat radiator 11, the cooling liquid passes a number of channels for conducting/convecting 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 at 15:61-16:7.)

The internal structures of the claimed reservoir 14 are depicted in FIGS. 17 and 20 reproduced below.

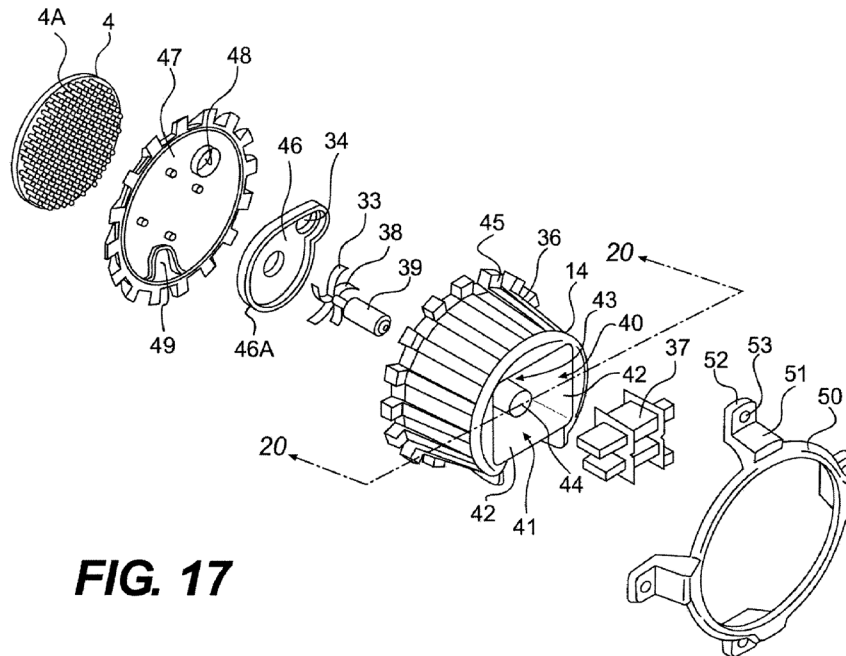


**FIG. 17**

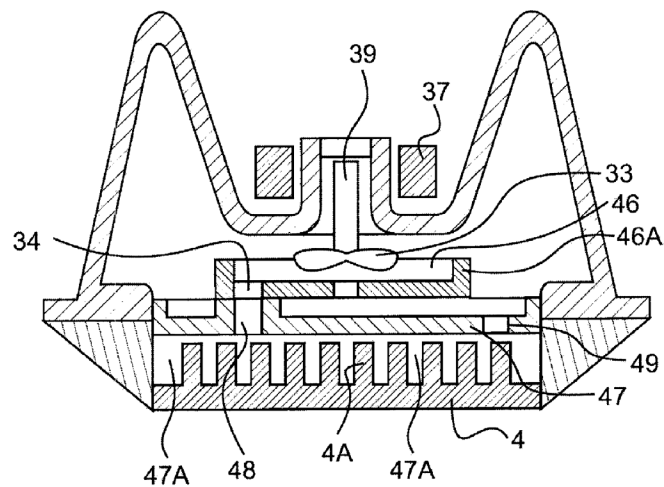
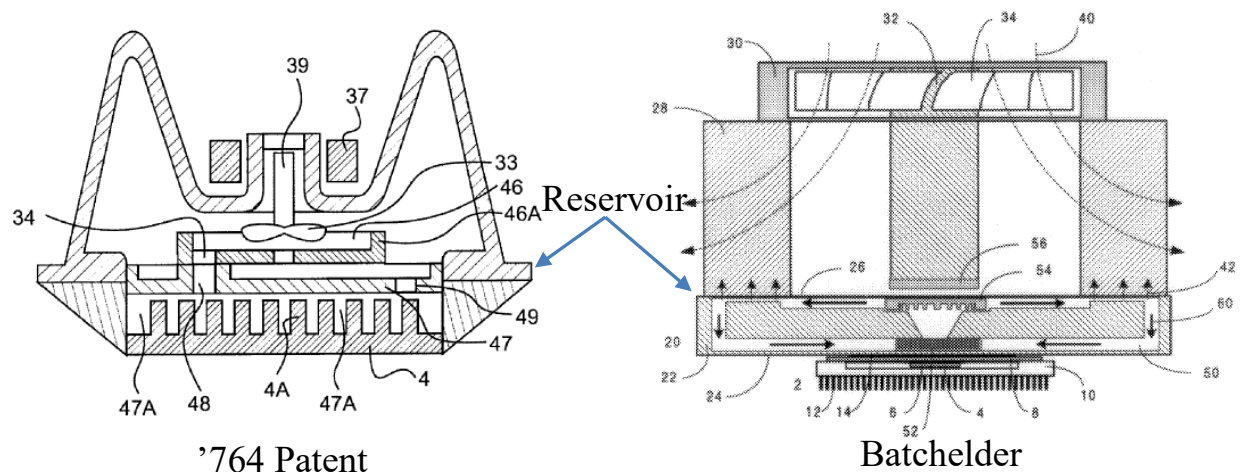


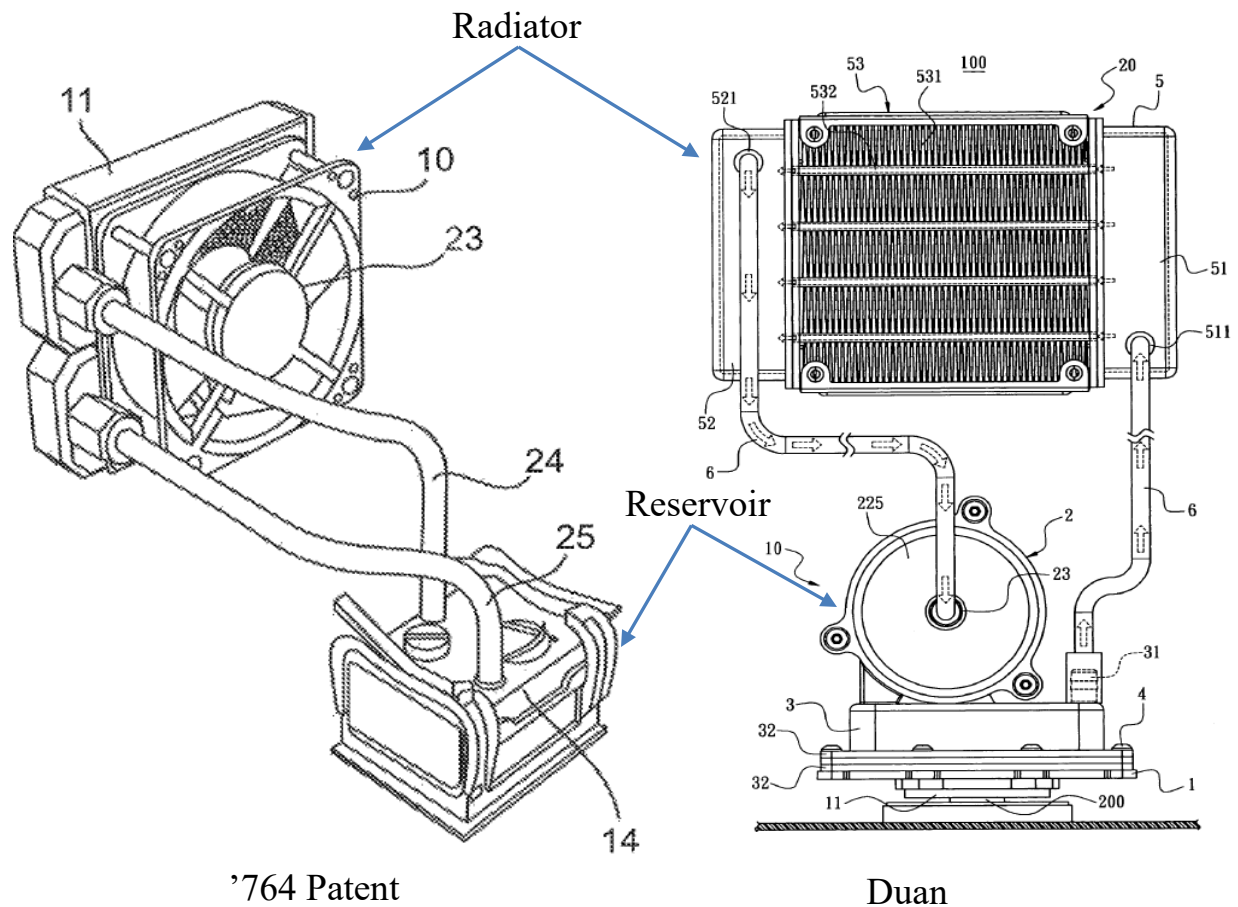
**FIG. 20**

35. The use of liquid cooling with what is sometimes referred to in the industry as an “all-in-one” cooler to cool semiconductor chips in computer systems was generally known to a person of ordinary skill in the art (“POSITA”) long before the claimed May 6, 2005 priority date of the ’764 patent, as evidenced by Batchelder (filed May 18, 1998).

36. The images below compare FIG. 20 of the ’764 patent with FIG. 2 of Batchelder:



37. The use of a closed liquid cooling loop connecting an all-in-one cooler and a radiator with tubes was also generally known to a POSITA before the claimed priority date of the ’764 patent, as evidenced by Duan (Ex-1006) and Duan-I (Ex-1007). The images below compare FIG. 7 of the ’764 patent with FIG. 6 of Duan:



38. The '764 patent only discloses an embodiment of the known “all-in-one” coolers used in closed liquid cooling loops.

## VI. OVERVIEW OF PRIOR ART

### A. Duan (Ex-1006)

39. Duan published as U.S. Patent Publication No. 2006/0185830 on August 24, 2006, from Application No. 11/060,442, which was filed on February

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

18, 2005. My understanding is that Duan qualifies as prior art to the '764 patent for all Challenged Claims.

**B. Duan I (Ex-1007)**

40. Duan I published as U.S. Patent Publication No. 2006/0185829 on August 24, 2006, from Application No. 11/060,419, which was filed on February 18, 2005. My understanding is that Duan I qualifies as prior art to the '764 patent for all Challenged Claims.

**C. Batchelder (Ex-1008)**

41. 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 '764 patent for all Challenged Claims.

**D. Laing (Ex-1015)**

42. Laing published as U.S. Patent Publication No. 2004/0052663 on March 18, 2004, from Application No. 10/434,307, which was filed on May 7, 2003. My understanding is that Laing qualifies as prior art to the '764 patent for all Challenged Claim.

## VII. CLAIM ELEMENT NUMBERING KEY

43. Because the Challenged Claims have similar claim elements, they are numbered as follows for the element-by-element invalidity analyses of the Challenged Claims that follows below.

| '764 Claim Limitations                                                             |                                                                            |                                                                                      |
|------------------------------------------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| <b>[1-PRE]</b><br>1. A cooling system for a heat-generating component, comprising: | <b>[10-PRE]</b><br>10. A cooling system for a computer system, comprising: | <b>[15-PRE]</b><br>15. A cooling system for a heat-generating component, comprising: |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| <b>'764 Claim Limitations</b>                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                              |                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>[1-a]</b><br/> a double-sided chassis adapted to mount a pump configured to circulate a cooling liquid, the pump comprising a stator and an impeller, the impeller being positioned on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid;<br/> (Claim 1)</p> | <p><b>[10-a]</b><br/> a centrifugal pump adapted to circulate a cooling liquid, the pump including: an impeller exposed to the cooling liquid; and a stator isolated from the cooling liquid; (Claim 10)</p> | <p><b>[15-a]</b><br/> a pump adapted to circulate a cooling liquid, the pump including: an impeller exposed to the cooling liquid; and a stator isolated from the cooling liquid;<br/> (Claim 15)</p> |
| <p><b>[1-b]</b><br/> a reservoir adapted to pass the cooling liquid therethrough, the reservoir including:<br/> (Claim 1)</p>                                                                                                                                                                                                                       | <p><b>[10-b]</b><br/> a reservoir configured to be thermally coupled to a heat-generating component of the computer system, the reservoir including:<br/> (Claim 10)</p>                                     | <p><b>[15-b]</b><br/> a reservoir including<br/> (Claim 15)</p>                                                                                                                                       |
|                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                              | <p><b>[15-c]</b><br/> an impeller cover, an intermediate member and<br/> (Claim 15)</p>                                                                                                               |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| <b>'764 Claim Limitations</b>                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>See [1-d] and [1-e] below</b>                                                                                                                                                                                                  | <b>[10-c]</b><br>a thermal exchange chamber adapted to be positioned in thermal contact with the heat-generating component;<br>(Claim 10)                                                                                                                                      |                                                                                                                                                                                                                                     |
| <b>[1-c]</b><br>a pump chamber including the impeller and formed below the chassis, the pump chamber being defined by at least an impeller cover having one or more passages for the cooling liquid to pass through;<br>(Claim 1) | <b>[10-d]</b><br>a separate pump chamber vertically spaced part from the thermal exchange chamber and coupled with the thermal exchange chamber through one or more passages configured for fluid communication between the pump chamber and the thermal exchange chamber, and | <b>[15-e]</b><br>wherein a top wall of the reservoir and the impeller cover define a pump chamber for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber, the pump |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| '764 Claim Limitations                                                                                                                                                                                                                                                                           |                                                                                                                                     |                                                                                                                                                              |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>[1-d]</b><br/> a thermal exchange chamber formed below the pump chamber and vertically spaced apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages; and<br/> (Claim 1)</p> | <p>(Claim 10)</p>                                                                                                                   | <p>chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together; and<br/> (Claim 15)</p> |
| <p><b>See Claim 6 below</b></p>                                                                                                                                                                                                                                                                  | <p><b>[10-e]</b><br/> wherein at least one of the one or more passages is offset from a center of the impeller.<br/> (Claim 10)</p> |                                                                                                                                                              |
|                                                                                                                                                                                                                                                                                                  |                                                                                                                                     |                                                                                                                                                              |
| <p><b>See [1-a] above</b></p>                                                                                                                                                                                                                                                                    | <p>11. The cooling system of claim 10, wherein a top wall of the reservoir physically separates the impeller from the stator.</p>   |                                                                                                                                                              |
|                                                                                                                                                                                                                                                                                                  |                                                                                                                                     |                                                                                                                                                              |

| <b>'764 Claim Limitations</b>                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>[1-e]</b><br/> a heat-exchanging interface, the heat-exchanging interface forming a boundary wall of the thermal exchange chamber, and configured to be placed in thermal contact with a surface of the heat-generating component; and<br/> (Claim 1)</p> | <p>12. The cooling system of claim 10, wherein the thermal exchange chamber includes a heat-exchange interface configured to be placed in thermal contact with the heat-generating component.</p>                                                          | <p><b>[15-d]</b><br/> wherein a first side of the heat-exchanging interface is in contact with a cooling liquid in the thermal exchange chamber and a second side of the heat-exchanging interface opposite the first side is configured to be placed in thermal contact with a surface of the heat-generating component; and<br/> (Claim 15)</p> |
| <p><b>[1-f]</b><br/> a heat radiator fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid.<br/> (Claim 1)</p>                                                                                                              | <p>13. The cooling system of claim 10, further including a heat radiator fluidly coupled to the reservoir using flexible conduits, wherein the heat radiator is configured to be positioned remote from the reservoir.</p> <p><b>See Claim 9 below</b></p> | <p><b>[15-f]</b><br/> a liquid-to-air heat exchanger fluidly coupled to the reservoir using flexible conduits, the heat exchanger being configured to be positioned remote from the reservoir.<br/> (Claim 15)</p>                                                                                                                                |
|                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                   |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| '764 Claim Limitations                                                                                                                                                                                                                                                                                                                                                                                          |  |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| 2. The cooling system of claim 1, wherein the chassis shields the stator from the cooling liquid in the reservoir.<br><br><b>See [1-a] above</b>                                                                                                                                                                                                                                                                |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |
| 3. The cooling system of claim 1, wherein the heat-exchanging interface includes a first side and a second side opposite the first side, and wherein the heat-exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side and the heat-exchanging interface is configured to be in thermal contact with the surface of the heat-generating component on the second side. |  |  |
|                                                                                                                                                                                                                                                                                                                                                                                                                 |  |  |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| '764 Claim Limitations                                                                                                                                                                                                                           |                                                                                                                                                                               |                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| 4. The cooling system of claim 3, wherein the first side of the heat-exchanging interface includes features that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber. |                                                                                                                                                                               |                                                                                                                                    |
|                                                                                                                                                                                                                                                  |                                                                                                                                                                               |                                                                                                                                    |
| 5. The cooling system of claim 4, wherein the features include at least one of pins or fins.                                                                                                                                                     |                                                                                                                                                                               | 17. The cooling system of claim 15, wherein the first side of the heat-exchanging interface includes at least one of pins or fins. |
|                                                                                                                                                                                                                                                  |                                                                                                                                                                               |                                                                                                                                    |
| 6. The cooling system of claim 1, wherein a passage of the one or more passages that fluidly couple the pump chamber and the thermal exchange chamber is offset from a center of the impeller.                                                   | 14. The cooling system of claim 10, wherein the fluid passage that is offset from the center of the impeller is positioned tangentially to the circumference of the impeller. |                                                                                                                                    |
|                                                                                                                                                                                                                                                  |                                                                                                                                                                               |                                                                                                                                    |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| '764 Claim Limitations                                                                                                                                                                                   |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| 7. The cooling system of claim 1, wherein the impeller includes a plurality of curved blades.                                                                                                            |  |  |
|                                                                                                                                                                                                          |  |  |
| 8. The cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum.                                                                                             |  |  |
|                                                                                                                                                                                                          |  |  |
| 9. The cooling system of claim 1, wherein the heat radiator is fluidly coupled to the reservoir using flexible conduits, and the heat radiator is configured to be positioned remote from the reservoir. |  |  |
|                                                                                                                                                                                                          |  |  |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| <b>'764 Claim Limitations</b>       |                     |                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| See [1-c] above.                    | See Claim 14 above. | 16. The cooling system of claim 15, wherein the impeller cover includes a first opening radially offset from a center of the impeller and the intermediate member includes a second passage that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber.<br><b>See [15-c] &amp; [15-e] above.</b> |
|                                     |                     |                                                                                                                                                                                                                                                                                                                                                                                                                      |
| See [1-a], [1-b], and Claim 2 above |                     | 18. The cooling system of claim 15, wherein the top wall of the reservoir extends between the stator and the impeller and shields the stator from the cooling liquid in the reservoir.                                                                                                                                                                                                                               |
|                                     |                     |                                                                                                                                                                                                                                                                                                                                                                                                                      |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| '764 Claim Limitations |  |                                                                                                                                                                                                            |
|------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| See [1-d] above        |  | 19. The cooling system of claim 1, wherein the one or more passages include a passage configured to direct cooling liquid from the pump chamber directly into the thermal exchange chamber.                |
|                        |  |                                                                                                                                                                                                            |
| See [1-e] above        |  | 21. The cooling system of claim 1, wherein an entire surface of the heat exchanging interface in contact with the cooling liquid in the reservoir forms the boundary wall of the thermal exchange chamber. |
|                        |  |                                                                                                                                                                                                            |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| '764 Claim Limitations |  |                                                                                                                                                                                                                            |
|------------------------|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        |  | 22. The cooling system of claim 1, wherein the reservoir further includes an inlet configured to direct the cooling liquid into the reservoir and an outlet configured to discharge the cooling liquid from the reservoir. |
|                        |  |                                                                                                                                                                                                                            |
| See [1-d] above        |  | 23. The cooling system of claim 10, wherein the one or more passages include a passage configured to direct cooling liquid from the pump chamber directly into the thermal exchange chamber.                               |
|                        |  |                                                                                                                                                                                                                            |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| '764 Claim Limitations |  |                                                                                                                                                                                                                                                              |
|------------------------|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| See [1-e] above        |  | 25. The cooling system of claim 12, wherein an entire surface of the heat-exchange interface in contact with the cooling liquid in the reservoir forms a boundary wall of the thermal exchange chamber.                                                      |
|                        |  |                                                                                                                                                                                                                                                              |
|                        |  | 26. The cooling system of claim 10, wherein the reservoir further includes an inlet configured to direct the cooling liquid into the reservoir and an outlet configured to discharge the cooling liquid from the reservoir.<br><br><b>See Claim 22 above</b> |
|                        |  |                                                                                                                                                                                                                                                              |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| '764 Claim Limitations |  |                                                                                                                                                                                                                                                                                                                                                |
|------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        |  | <p>27. The cooling system of claim 15, wherein the pump chamber and the thermal exchange chamber are fluidly coupled together by one or more passages, the one or more passages including a passage configured to direct cooling liquid from the pump chamber directly into the thermal exchange chamber.</p> <p><b>See Claim 19 above</b></p> |
|                        |  |                                                                                                                                                                                                                                                                                                                                                |
|                        |  | <p>28. The cooling system of claim 15, wherein the pump chamber and the thermal exchange chamber are fluidly coupled together by a plurality of passages positions within the reservoir that open into the thermal exchange chamber.</p>                                                                                                       |
|                        |  |                                                                                                                                                                                                                                                                                                                                                |

Petition for Inter Partes Review Of  
U.S. Patent No. 8,245,764  
Decl. of Georgios Karamanis, Ph.D.

| <b>'764 Claim Limitations</b> |  |                                                                                                                                                                                                           |
|-------------------------------|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| See [1-e] above               |  | 29. The cooling system of claim 15, wherein an entire surface of the heat exchanging interface in contact with the cooling liquid in the reservoir forms a boundary wall of the thermal exchange chamber. |
|                               |  |                                                                                                                                                                                                           |
| See [1-c] and [1-d] above     |  | <b>[30-a]</b><br>30. The cooling system of claim 15, wherein the pump chamber and thermal exchange chamber are fluidly coupled together by one or more passages, and                                      |

| '764 Claim Limitations |  |                                                                                                                                                                                                                                             |
|------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        |  | <b>[30-b]</b><br>the reservoir further includes an inlet configured to direct the cooling liquid into the reservoir and an outlet configured to discharge the cooling liquid from the reservoir.<br>(Claim 30)<br><b>See Claim 22 above</b> |

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(s) in accordance with the numbering key above.

## VIII. ANALYSIS

44. I have been asked to assess the validity of claims 1-30 of the '764 patent ("the Challenged Claims") from the perspective of a POSITA as of the claimed priority date of May 6, 2005. The following are my opinions concerning the validity of the Challenged Claims.

**A. GROUND 1: Claims 1-19, 21-27, and 29-30 are rendered obvious over Duan by itself or in view of Duan I.**

45. As discussed below, it is my opinion that Duan by itself, or combined with Duan I, renders claims 1-19, 21-27, and 29-30 of the '764 patent obvious. Due to the significant overlap between these separate but related grounds, I discuss them together.

**1. Duan by itself or in view of Duan I discloses or suggests each limitation of claim 1 and renders it obvious.**

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

46. This limitation is disclosed or suggested by Duan. Duan discloses that “[t]he present invention relates to a cooling plate module, and more particularly to a cooling plate module used for heat emitting device such as a CPU.” (Duan, [0002]).

47. Duan further discloses:

A cooling plate module includes a cooling plate and a liquid driving module. The liquid driving module includes an accommodation chamber and a liquid driving unit used to driving cooling liquid. The liquid driving module includes a liquid inlet communicated to the accommodation chamber and a first liquid outlet is communicated to the bottom of the accommodation chamber. A cap encloses the first liquid outlet and a second liquid outlet is defined on the cap. The cooling plate is assembled with the cap to define a closed space therein and the first liquid outlet is corresponding to the heat-dissipating plates.

Therefore, there is no duct connecting between the cooling plate and the liquid driving module, the stagnant problem caused by pressure difference can be prevented and the cool liquid can directly flush the heat-dissipating plates for enhancing heat dissipation efficiency.

(Duan, [Abstract].)

48. Similarly, claim 1 of Duan reads: “A cooling plate module used in a liquid cooling cyclic mechanism for removing heat from a heat source, comprising...”

**[1-a] “a double-sided chassis adapted to mount a pump configured to circulate a cooling liquid, the pump comprising a stator and an impeller, the impeller being positioned on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid;”**

49. Duan by itself or in view of Duan I teaches limitation [1-a] obvious.

50. Duan teaches a double-sided chassis (accommodation chamber 21) adapted to mount a pump (liquid driving unit 22) configured to circulate a cooling liquid, the pump comprising a stator (coil stage 221) and an impeller (impeller stage 223), as shown in the figures below:

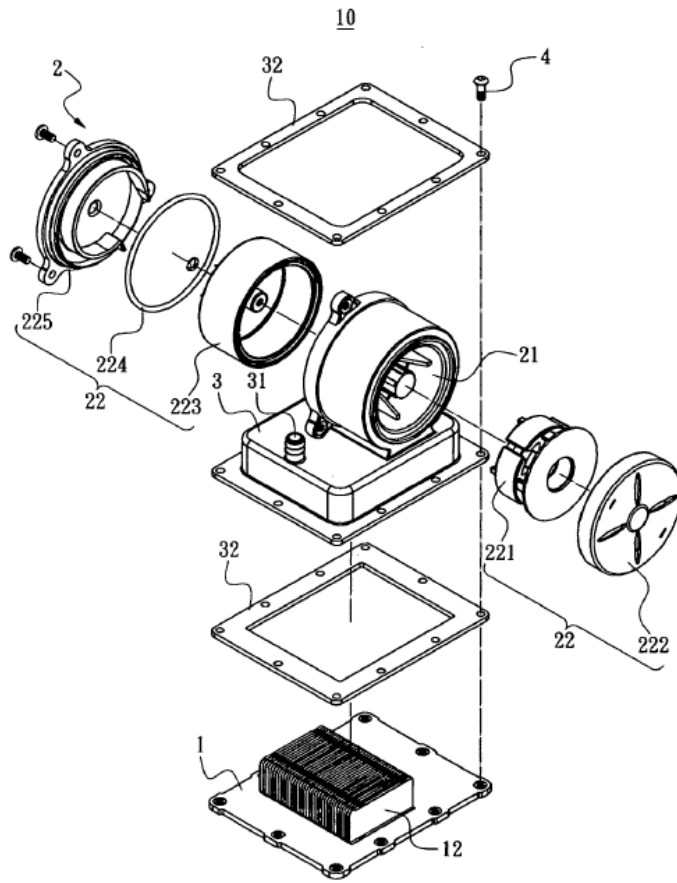


FIG. 2

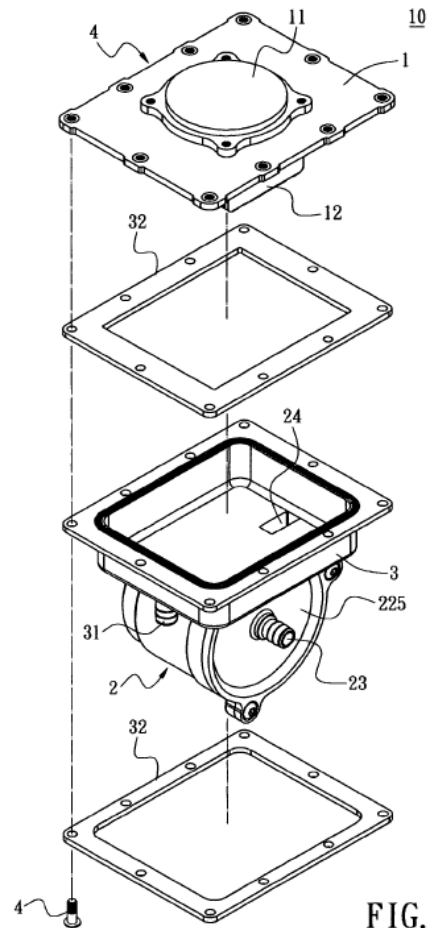
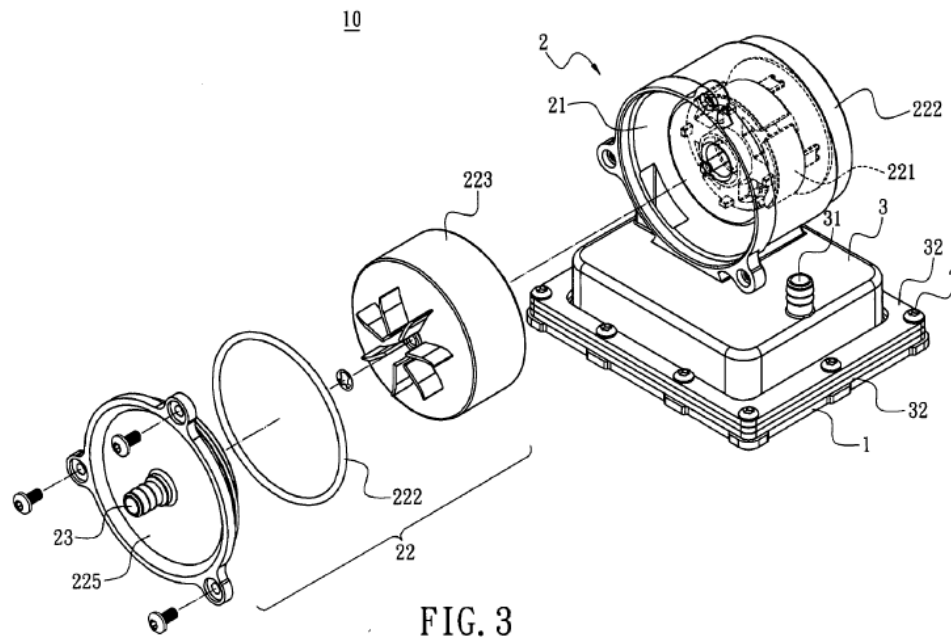


FIG. 4



(Duan, FIGS. 2-4.)

51. Duan describes those figures as follows:

With reference to FIGS. 2, 3 and 4, the liquid driving module 2 comprises an accommodation chamber 21 and a liquid driving unit 22 located in the accommodation chamber 21 and used to driving the cool liquid. The liquid driving unit 22 comprises a coil stage 221, an upper cover 222, an impeller stage 223, a sealing washer 224 and a lower cover 225. The lower cover 225 comprises a liquid inlet 23 communicated with the accommodation chamber 21. A first liquid outlet 24 is communicated to the bottom of the accommodation chamber 21 and is enclosed by a cap 3. A second liquid outlet 31 is defined on the cap 3. The cooling plate 1 is assembled with the cap 3 to

define a closed space therein and the first liquid outlet 24 is corresponding to the heat-dissipating plates 12. **In the present invention, the liquid driving module 2 can be reciprocating pump, centrifugal pump or axial-flow pump.**

(Duan, [0023].)

52. Duan also discloses that the impeller (223) is positioned on one side of the chassis (accommodation chamber 21) contacting the cooling liquid and the stator (221) is positioned on the chassis' other side isolated from the cooling liquid:

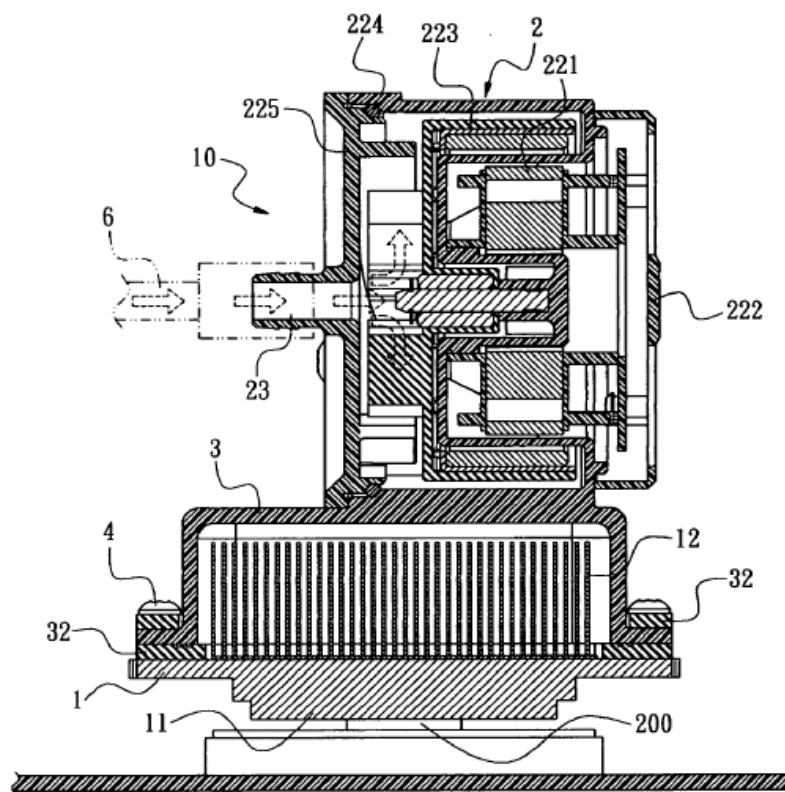


FIG. 7

(Ex-1006, FIG. 7.)

53. Duan in view of Duan I also teaches limitation [1-a]. Duan I discloses a cooling system in which the pump is oriented vertically, with the stator (coil stage 21) positioned on the “upper side” of the chassis (casing 1) isolated from the liquid and the impeller (23) positioned on the “underside” of the chassis (casing 1) contacting the liquid, as shown in the figures below:

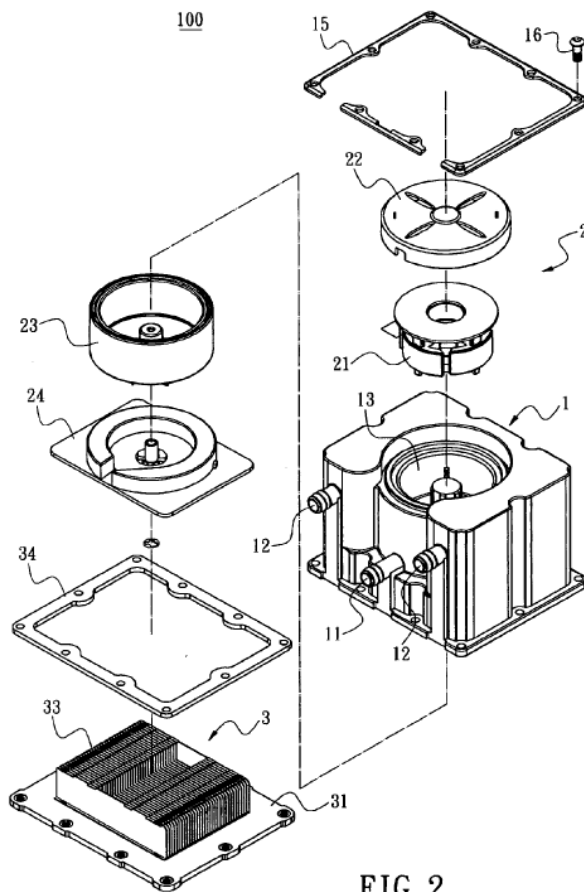


FIG. 2

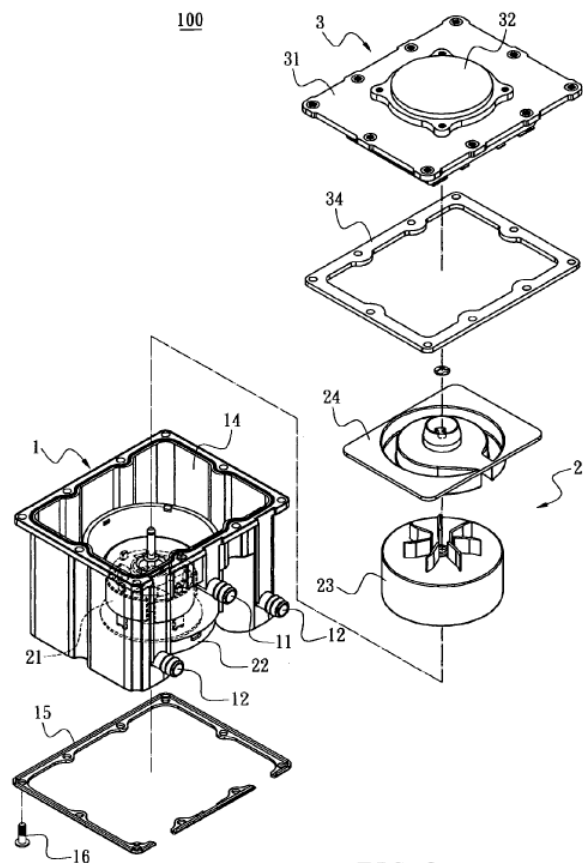


FIG. 3

(Duan I, FIGS. 2-3; [0021] (“the liquid driving unit 2 comprises a coil stage 21...an impeller stage 23....”).) As shown above, Duan I’s liquid driving unit 2 is oriented

in a direction 90° from that of Duan's liquid driving unit 22.

54. A POSITA would have recognized that, as currently configured, Duan's liquid driving module 22 is oriented in a way such that the overall device is taller than Duan I, as shown below:

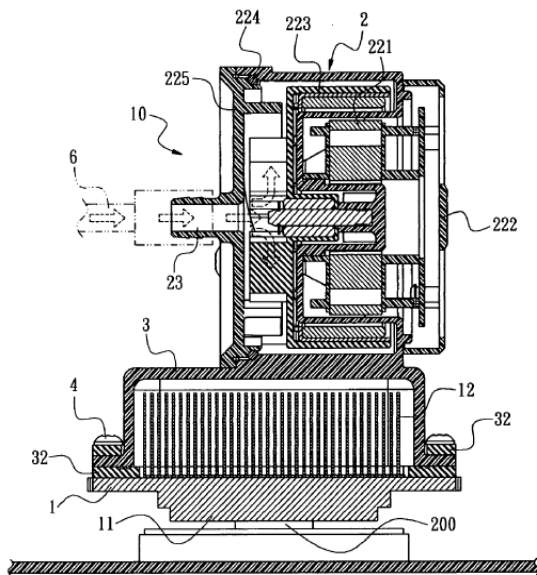


FIG. 7

Duan

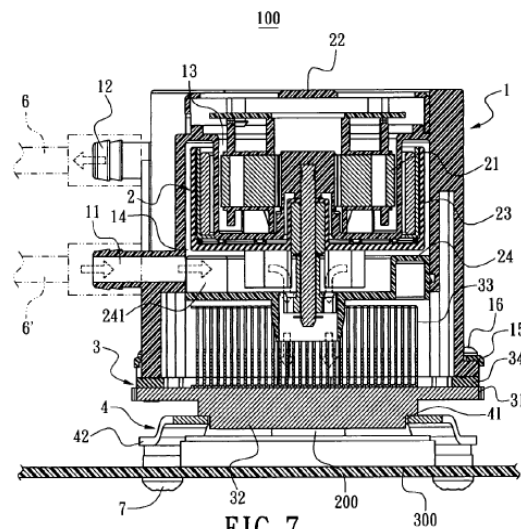


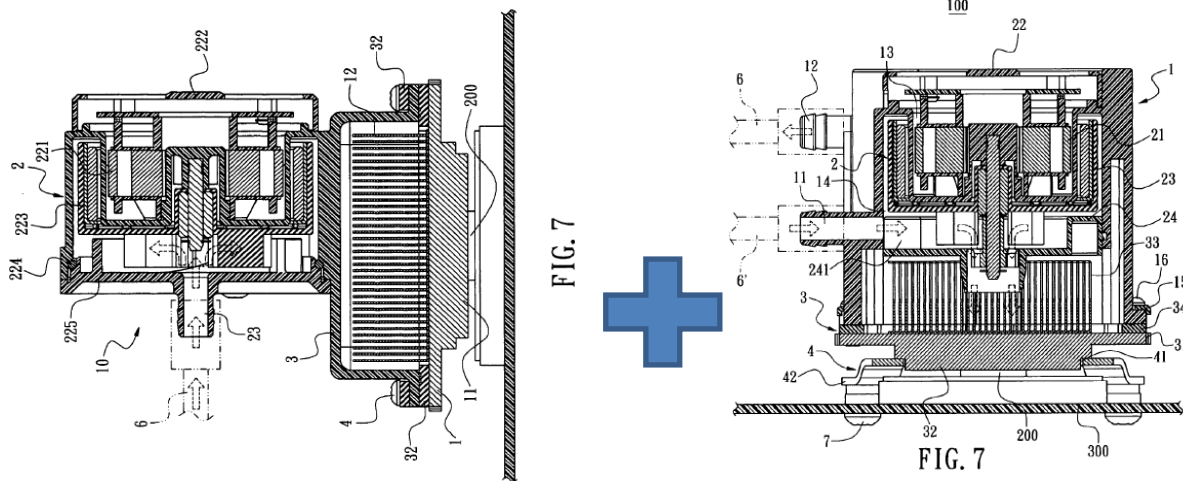
FIG. 7

Duan I

55. Duan recognized a “compact trend of computer[s].” (Duan, [0006].) To save space, a POSITA would have been motivated to rotate Duan's liquid driving module 2 (pump) counterclockwise by 90 degrees in Figure 7 to reduce the system's overall height in view of Duan I.

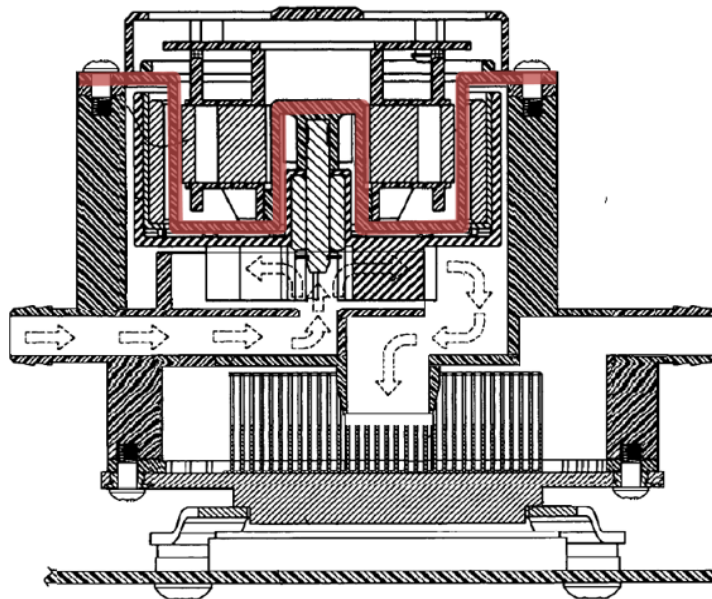
56. Although modifying Duan to rotate the pump by 90 degrees would require some minor reconstruction, those modifications would have been well within

a POSITA's technical grasp. Reconfiguring Duan by rotating the pump 90 degrees would have predictably resulted in a modified system like the one below (in which the double-sided chassis is highlighted in red):



Duan (rotated 90° CCW)

Duan-I



57. Duan, as modified above in view of Duan I, teaches or suggests a double-sided chassis (accommodation chamber 21) adapted to mount a pump (liquid driving unit 22) configured to circulate a cooling liquid, the pump comprising a stator (coil stage 221) and an impeller (impeller stage 223), the impeller (223) being positioned on the underside of the chassis (21) and the stator (221) being positioned on the upper side of the chassis (21) and isolated from the cooling liquid.

**[1-b] “a reservoir adapted to pass the cooling liquid therethrough, the reservoir including:”**

58. Duan teaches limitation [1-b] as discussed below.

59. Duan discloses a “liquid cooling cyclic mechanism 100, which is used for the heat dissipation of a CPU 200 and composed of the cooling plate module 10 and a water tank module 20 connected with the cooling plate module 10 through ducts.” (Duan, [0022], FIG. 6.)

60. Duan’s “reservoir” is illustrated in the figures below:

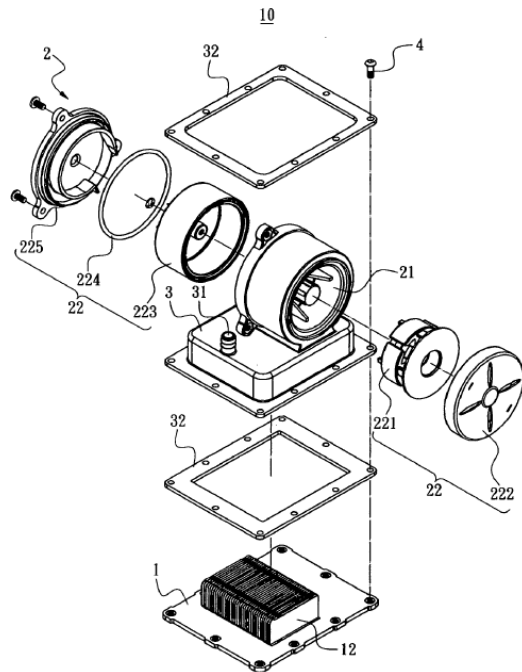


FIG. 2

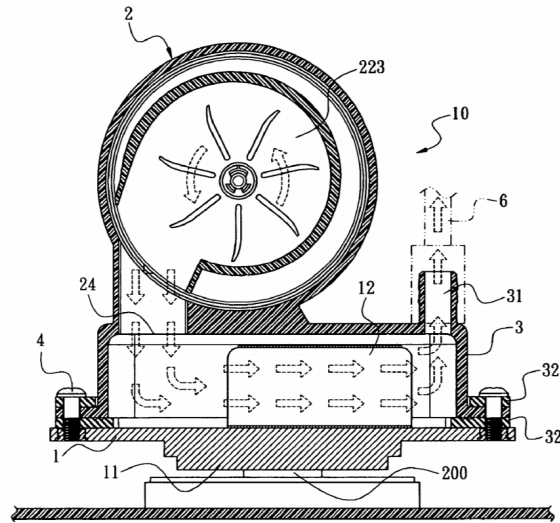


FIG. 8

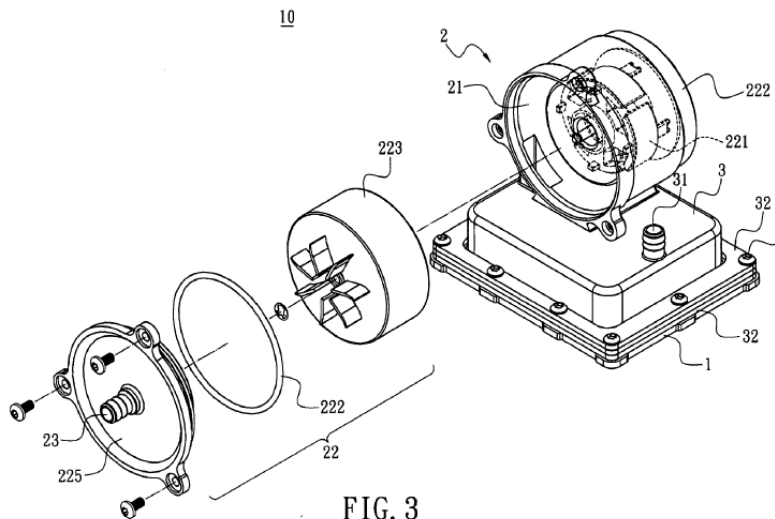


FIG. 3

(Duan, FIGS. 2, 3, 8.)

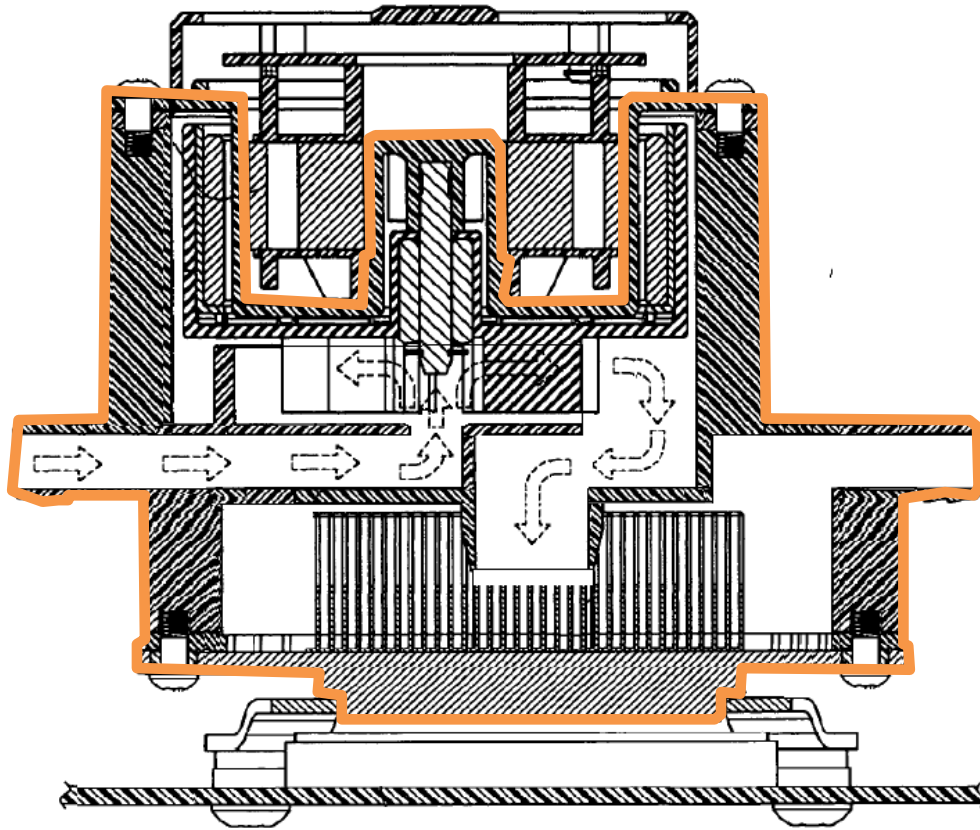
61. As shown above, cooling plate module 10 includes a “reservoir” (a

single receptacle defining a fluid flow path) in which the cooling fluid enters accommodation chamber 21” of the module via inlet 23, flows through outlet 24 into the closed space defined by cap 3 and cooling plate 1, and exits at second liquid outlet 31. These features are also discussed in Duan. (*See, e.g.*, Duan [0023] (“The lower cover 225 comprises a liquid inlet 23 communicated with the accommodation chamber 21. A first liquid outlet 24 is communicated to the bottom of the accommodation chamber 21 and is enclosed by a cap 3. A second liquid outlet 31 is defined on the cap 3. The cooling plate 1 is assembled with the cap 3 to define a closed space therein...”); [0024] (“[S]ealing pads 32 are provided between the cap 3 and the cooling plate 1 and provided atop the cap 3... The cooling plate 1 is fixed to bottom of the cap 3...”); [0027] (“[T]he cool liquid in the water tank 20 is conveyed to the accommodation chamber 21 through...the liquid inlet 23 of the cooling plate module 10 and driven by the liquid driving unit 22. The cool liquid then flows to the cap 3 through the first liquid outlet 24 for heat dissipating the heat-dissipating plates 12 in the cap 3...The hot liquid then flows to the liquid entrance region 51 of the water tank 20 through the second liquid outlet 31...”).)

62. Thus, Duan teaches a reservoir (accommodation chamber 21, cap 3, and cooling plate 1) adapted to pass the cooling liquid therethrough.

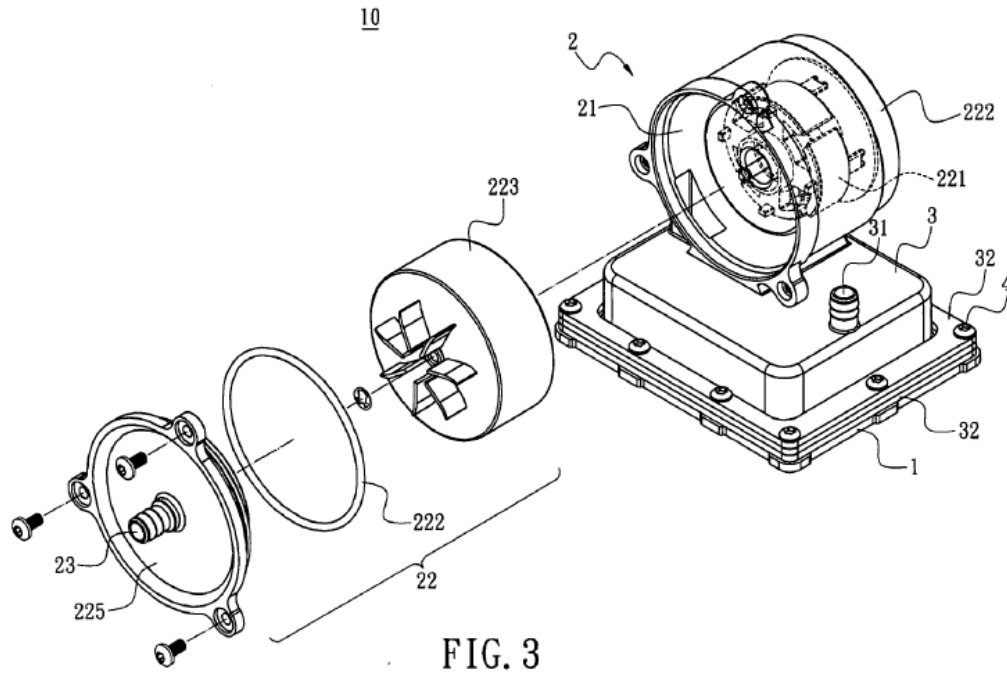
63. In the modified Duan system in which the pump is rotated 90 degrees

(as discussed above in [1-a]), the modified system also satisfies this limitation, as shown in the modified figure below (with the reservoir outlined in orange):



**[1-c] “a pump chamber including the impeller and formed below the chassis, the pump chamber being defined by at least an impeller cover having one or more passages for the cooling liquid to pass through”**

64. Duan teaches this limitation, as discussed below.



(Duan, FIG. 3.)

65. As shown, Duan discloses a pump chamber (at the near end of accommodation chamber 21 in FIG. 3) including the impeller (223), the pump chamber being defined by at least an impeller cover (the cylindrical wall surrounding accommodation chamber 21 plus lower cover 225 that together cover the impeller stage 223) having one or more passages (liquid inlet 23) for the cooling liquid to pass through.

66. Duan's impeller cover (*e.g.*, lower cover 225) has another passage (colored in orange below) for the cooling liquid to pass through:

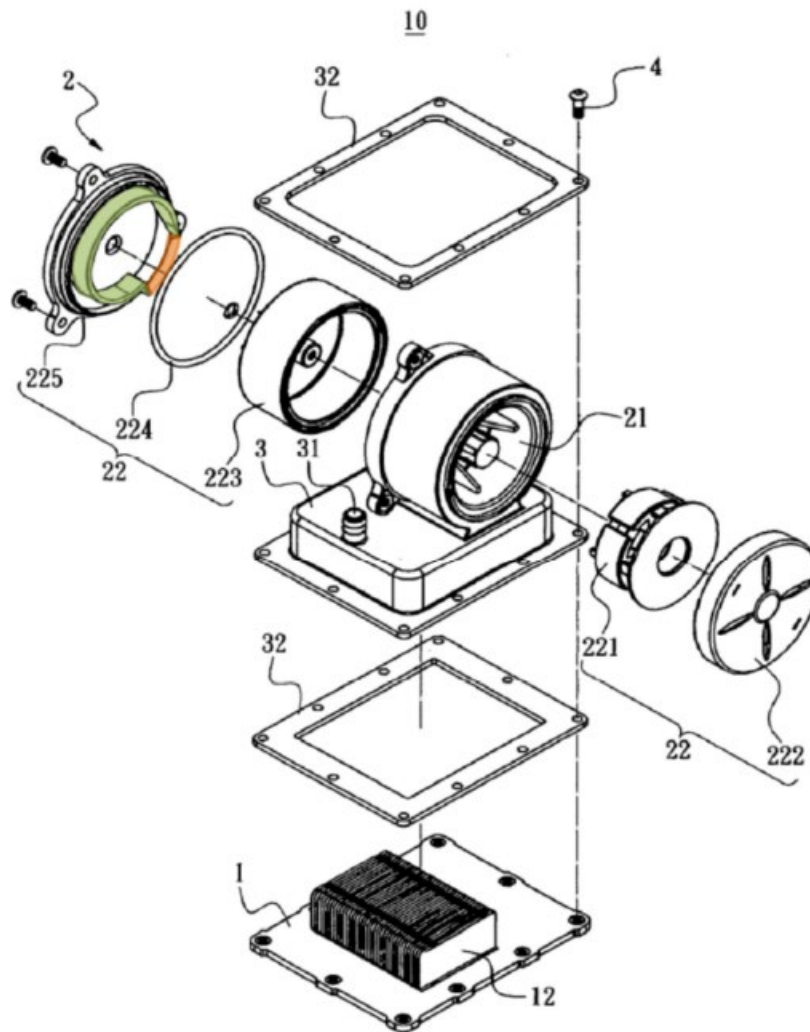
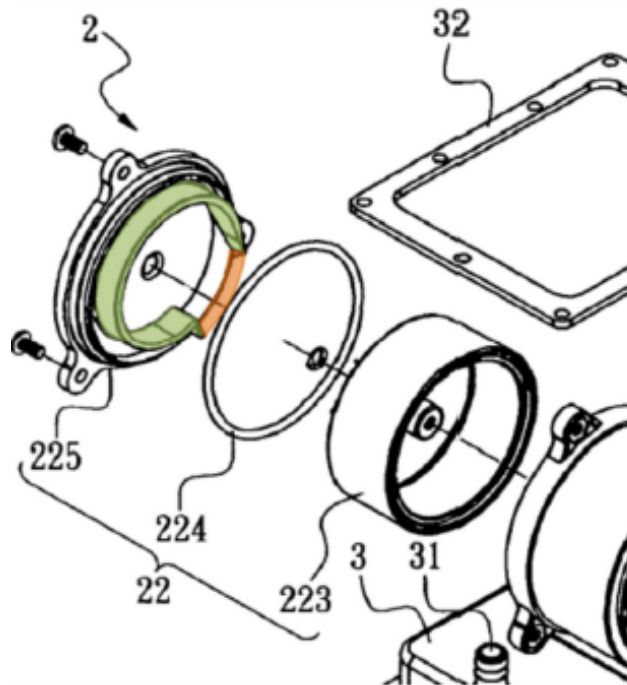


FIG. 2

(Duan, FIG. 2 (annotated).)



(Duan, FIG. 2 (excerpt) (annotated).)

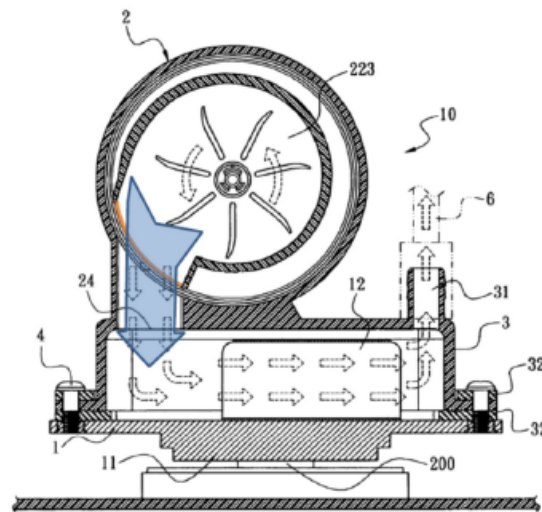
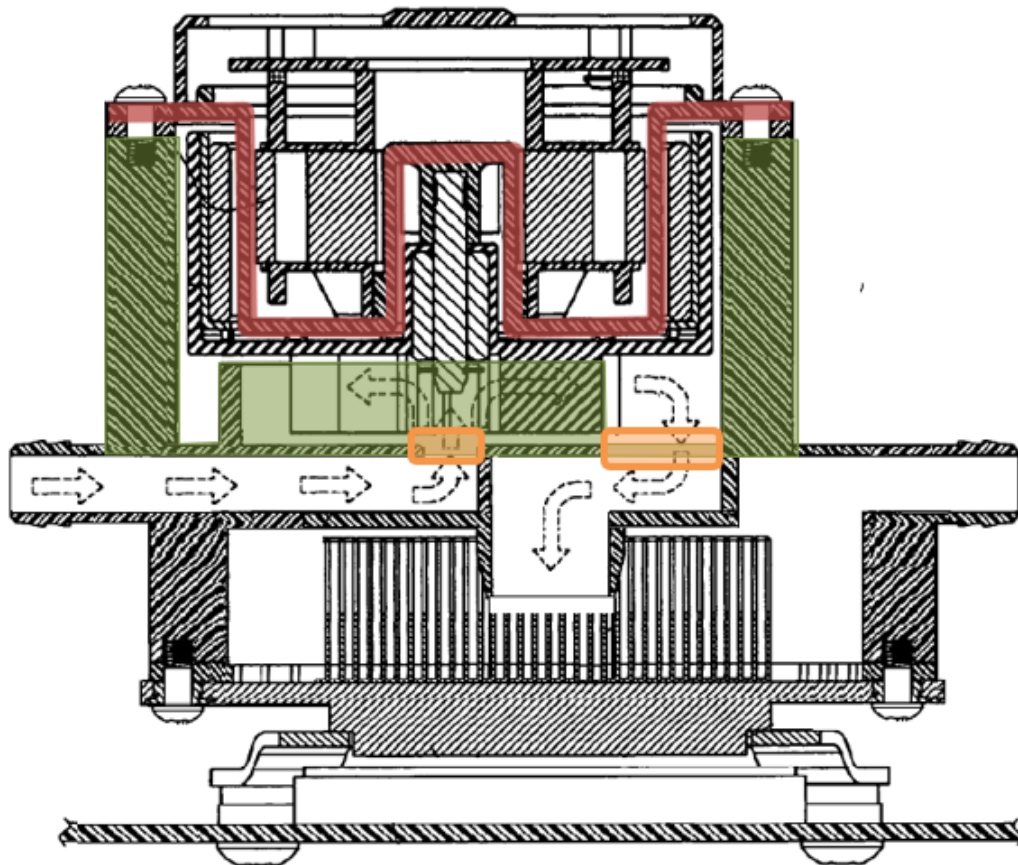


FIG. 8

(Duan, FIG. 8 (annotated).)

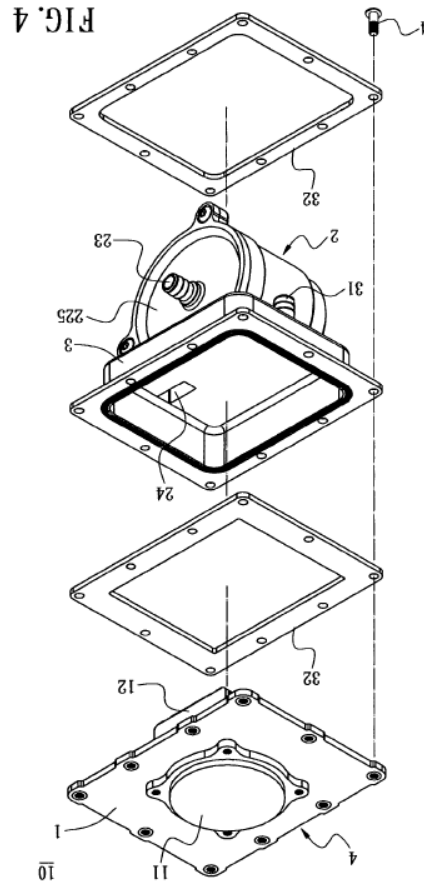
67. When Duan is modified in view of Duan I by rotating the pump (*see* limitation [1-a] above), this limitation is also satisfied, as shown in the modified figure below (with the chassis in red, impeller cover in green, and impeller within the pump chamber — i.e., the space surrounded by the impeller cover (green) and under the chassis (red)):



68. As illustrated above, the impeller cover (green) has two passages (orange) for the cooling liquid to pass through.

**[1-d] “a thermal exchange chamber formed below the pump chamber and vertically spaced apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages; and”**

69. Duan teaches limitation [1-d].

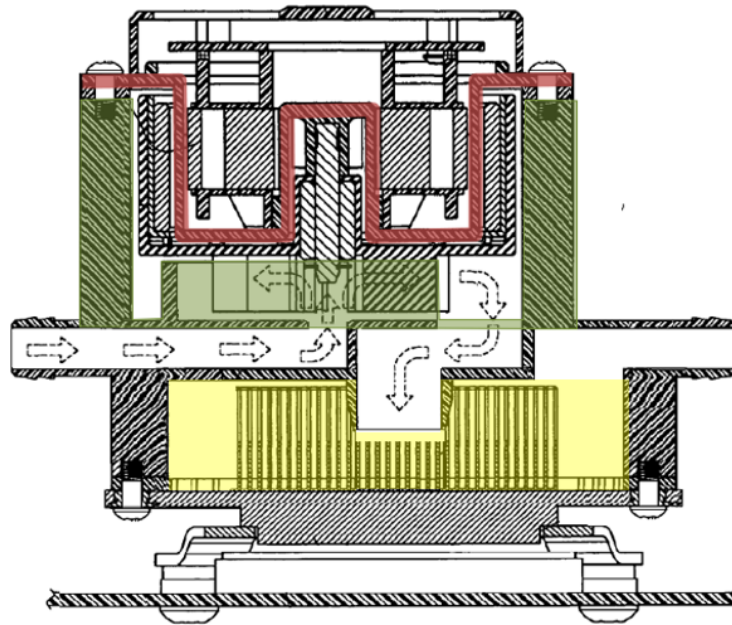


(Duan, FIG. 4 (rotated upside-down).)

70. As shown, Duan discloses a thermal exchange chamber (the space bounded by inside of cap 3 and top of cooling plate 1) formed below the pump chamber (accommodation chamber 21) and vertically spaced apart from the pump

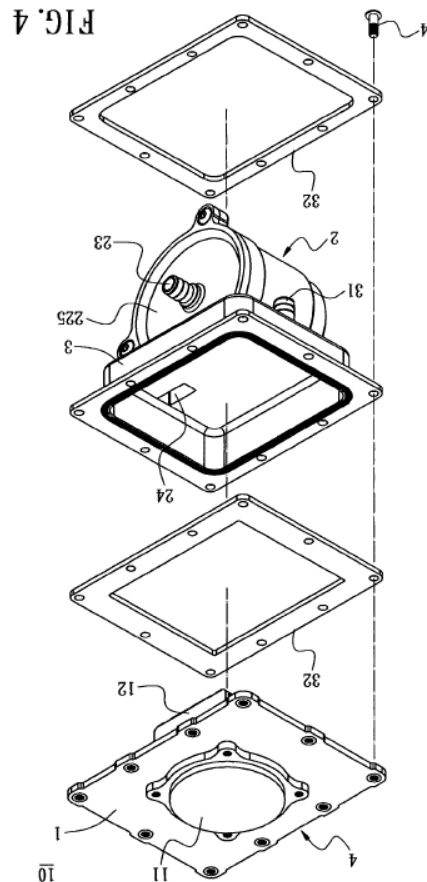
chamber (with reference to each other and the heat exchanging interface), the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages (liquid inlet 24).

71. When Duan is modified in view of Duan I by rotating the pump 90 degrees (*see* limitation [1-a] above), the modified system also satisfies this limitation, as shown in the modified figure below (with the thermal exchange chamber shaded yellow and formed below and vertically spaced from the pump chamber — i.e., the space inside the impeller cover and under the chassis):



**[1-e] “a heat-exchanging interface, the heat-exchanging interface forming a boundary wall of the thermal exchange chamber, and configured to be placed in thermal contact with a surface of the heat-generating component; and”**

72. Duan teaches limitation [1-e].



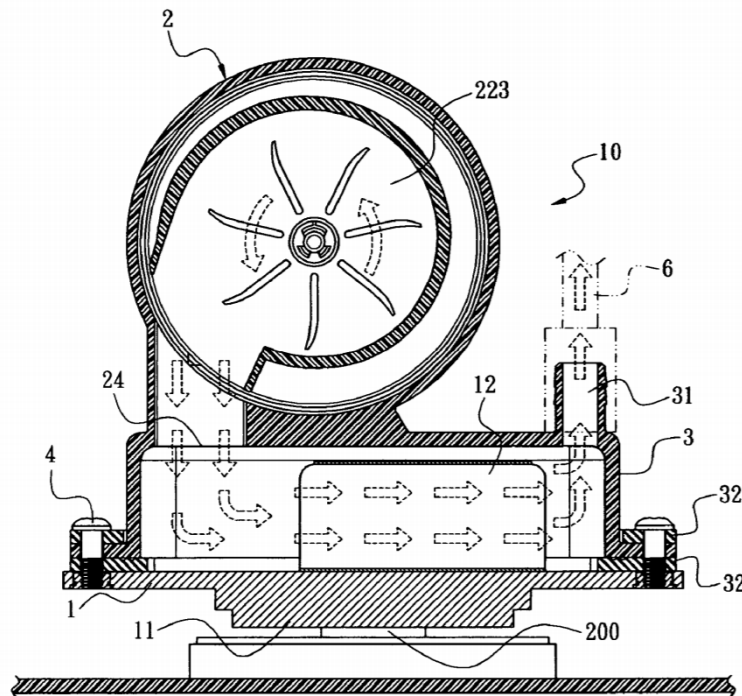


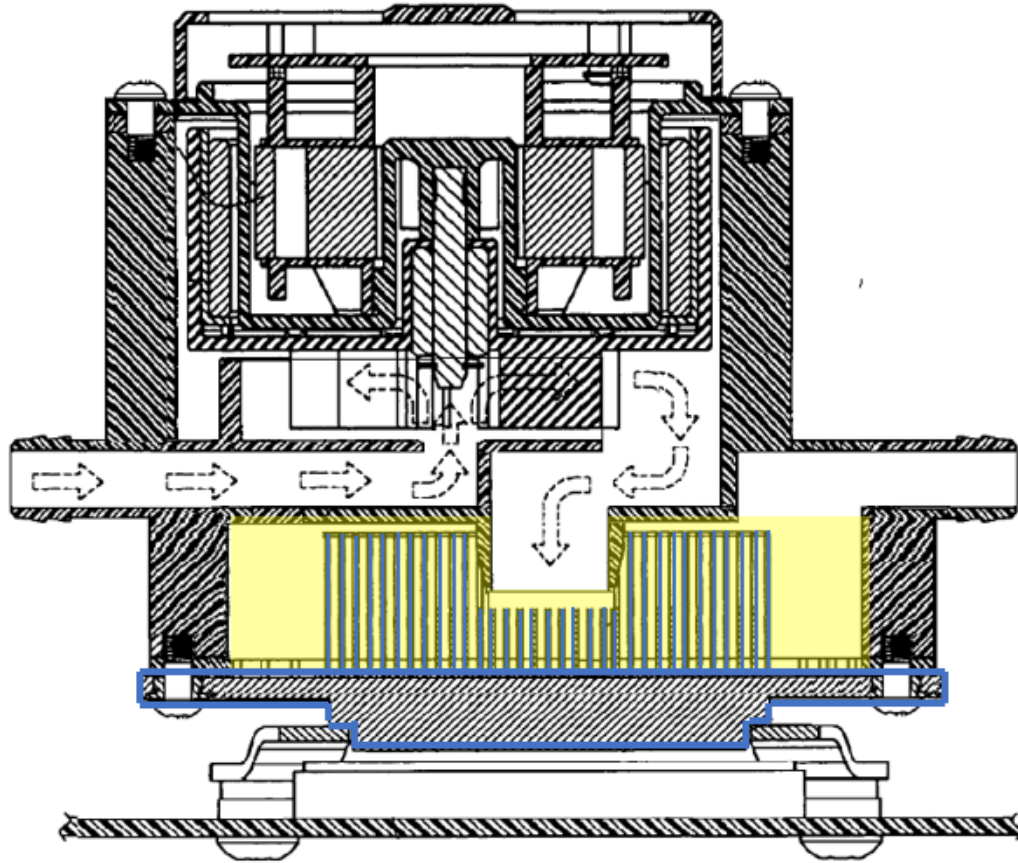
FIG. 8

(Duan, FIGS. 4 (upside down), 8.)

73. Duan states that “cooling plate 1” that includes “a heat absorbing face 11 on bottom thereof...in contact with a heat source.” (Duan, [0022].) Accordingly, Duan discloses a heat-exchanging interface (cooling plate 1 and heat absorbing face 11), the heat-exchanging interface forming a boundary wall of the thermal exchange chamber (cap 3 and cooling plate 1), and configured to be placed in thermal contact with a surface of the heat-generating component (CPU 200).

74. When Duan is modified in view of Duan I by rotating the pump 90 degrees (*see* limitation [1-a] above), the modified system also satisfies this

limitation, as shown in the modified figure below (with the heat-exchanging interface outlined in blue and the thermal exchange chamber shaded yellow):



**[1-f] “a heat radiator fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid.”**

75. Duan teaches limitation [1-f].

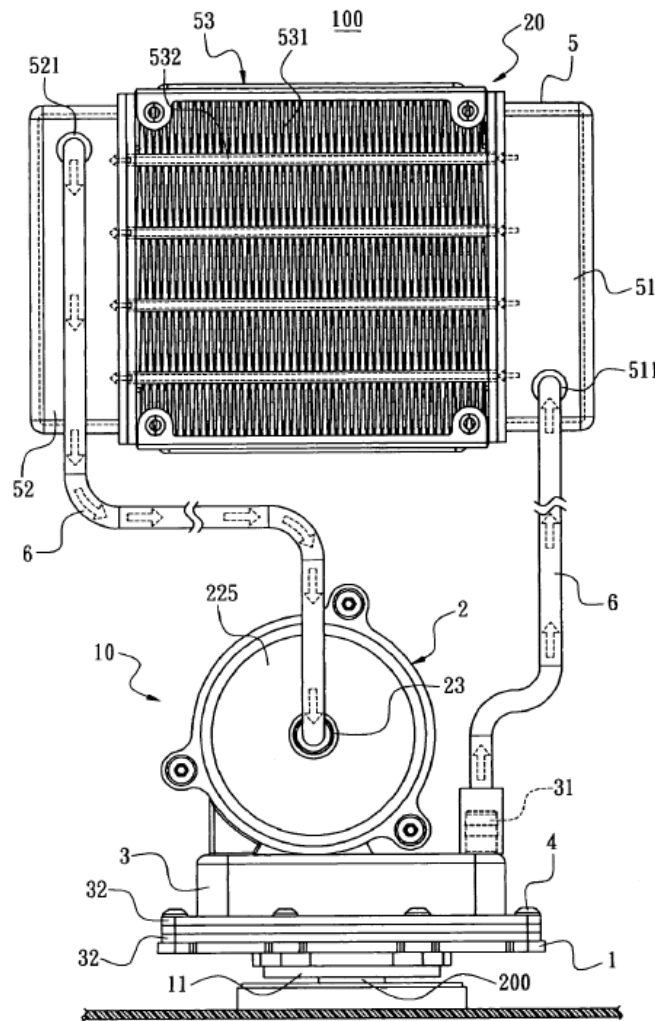


FIG. 6

(Duan, FIG. 6.).

76. Duan discloses that:

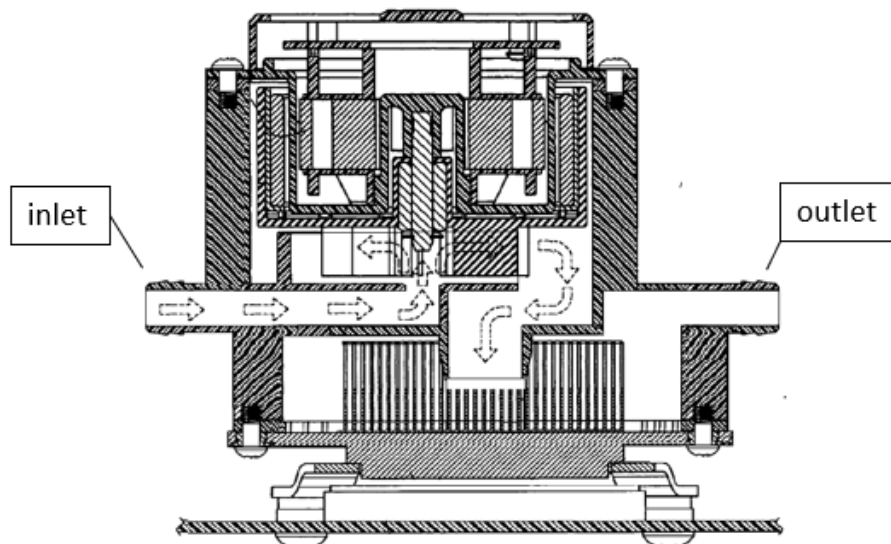
[T]he water tank 20 of the liquid cooling cyclic mechanism 100 comprises a box 5 with a liquid entrance region 51 and a liquid exit region 52 provided on both sides of the water tank 20, respectively. The box 5 comprises a cooling stage 53 at center thereof and composed of a plurality of stacked heat-dissipating fins 531 arranged in rows.

Runners 532 are defined between rows of the heat-dissipating fins 531;  
both ends of the runner 532 are communicated with the liquid entrance  
region 51 and the liquid exit region 52.”

(Duan, [0025].)

77. For the reasons discussed above, Duan discloses a heat radiator (cooling stage 53, heat-dissipating fins 531, and runners 532) fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid (duct 6, liquid inlet 511, and liquid outlet 521).

78. When Duan is modified in view of Duan I by rotating the pump 90 degrees (*see* limitation [1-a] above), in the modified system, the heat radiator would still be fluidly coupled to the reservoir at the inlet and outlet at either end of the device, shown below:



79. For at least the reasons stated above, Duan by itself or in view of Duan I teaches each limitation of claim 1 and renders it obvious.

**2. Duan by itself or in view of Duan I teaches each limitation of claims 2-9.**

**[Claim 2] “The cooling system of claim 1, wherein the chassis shields the stator from the cooling liquid in the reservoir.”**

80. Duan teaches the limitations of claim 2.

81. In the Duan system, the double-sided chassis (accommodation chamber 21 - red) shields the stator (coil stage 221 - yellow) from the cooling liquid contained inside the pump chamber defined by impeller cover (lower cover 225 - green) and the double-sided chassis (accommodation chamber 21):

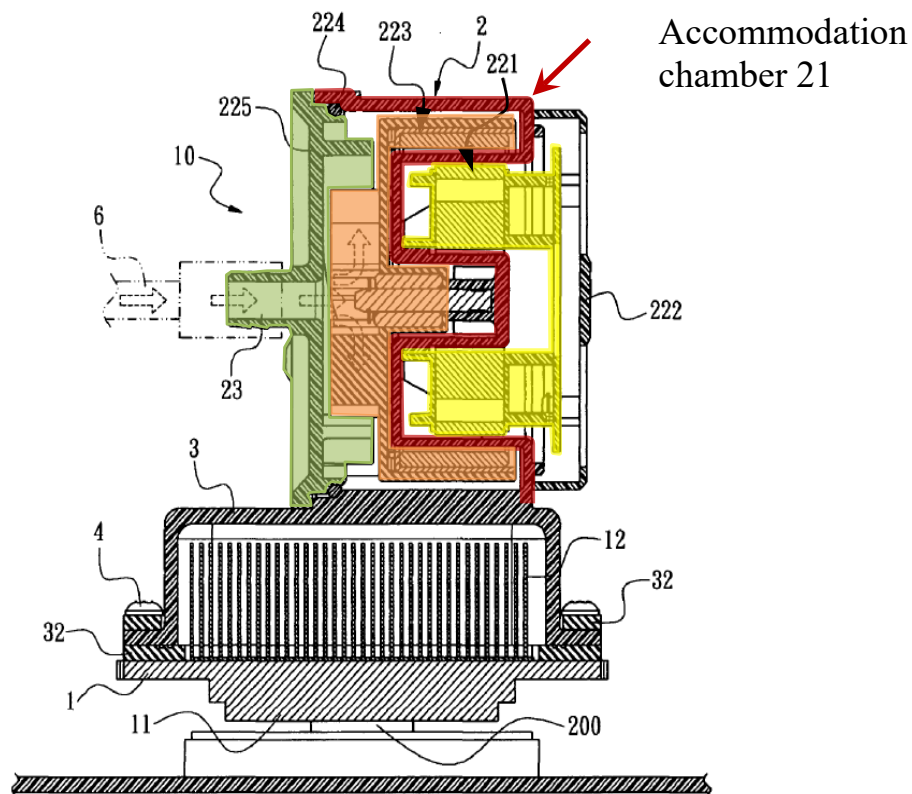
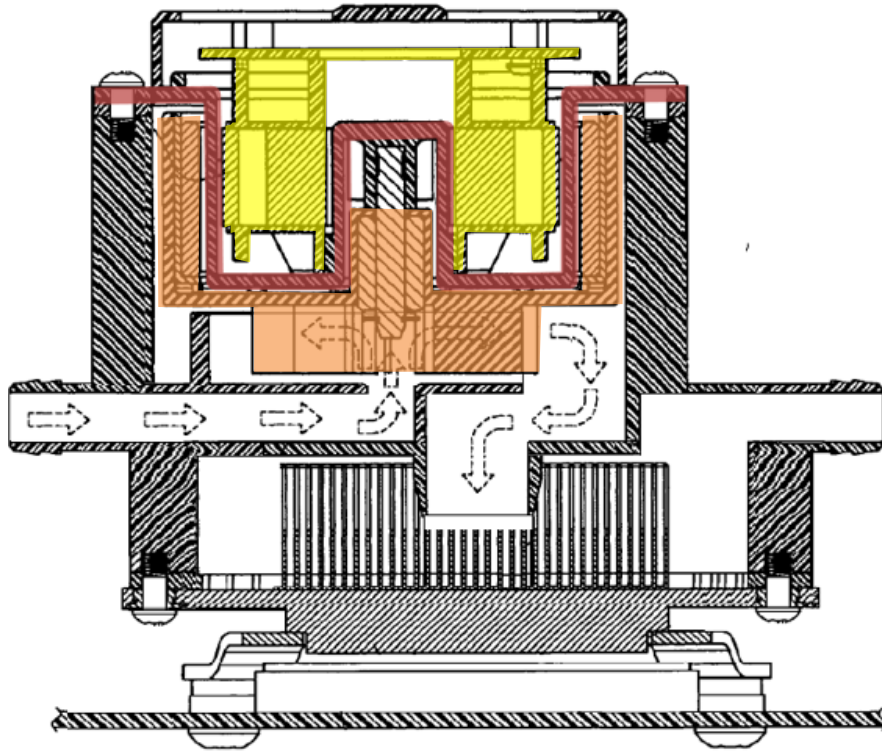


FIG. 7

(Duan, FIG. 7 (annotated).)

82. Similarly, in the modified Duan system, the double-sided chassis (red) also shields the stator (yellow, located on the upper side of the chassis) from the cooling liquid (which, as shown by the arrows, circulates on the underside of the chassis):



**[Claim 3] “The cooling system of claim 1, wherein the heat-exchanging interface includes a first side and a second side opposite the first side, and wherein the heat-exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side and the heat-exchanging interface is configured to be in thermal contact with the surface of the heat-generating component on the second side.”**

83. Duan teaches the limitations of claim 3.

84. As discussed, (*see* limitation [1-e] above), Duan discloses a heat-exchanging interface (cooling plate 1 and heat absorbing face 11):

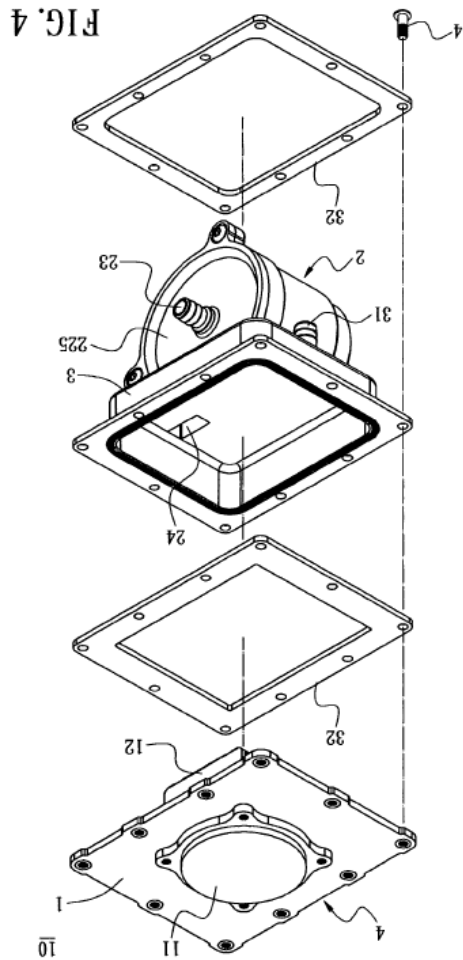
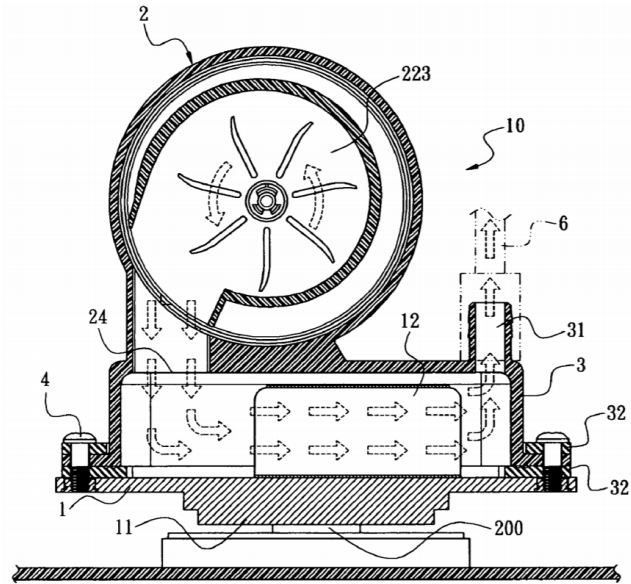


FIG. 8

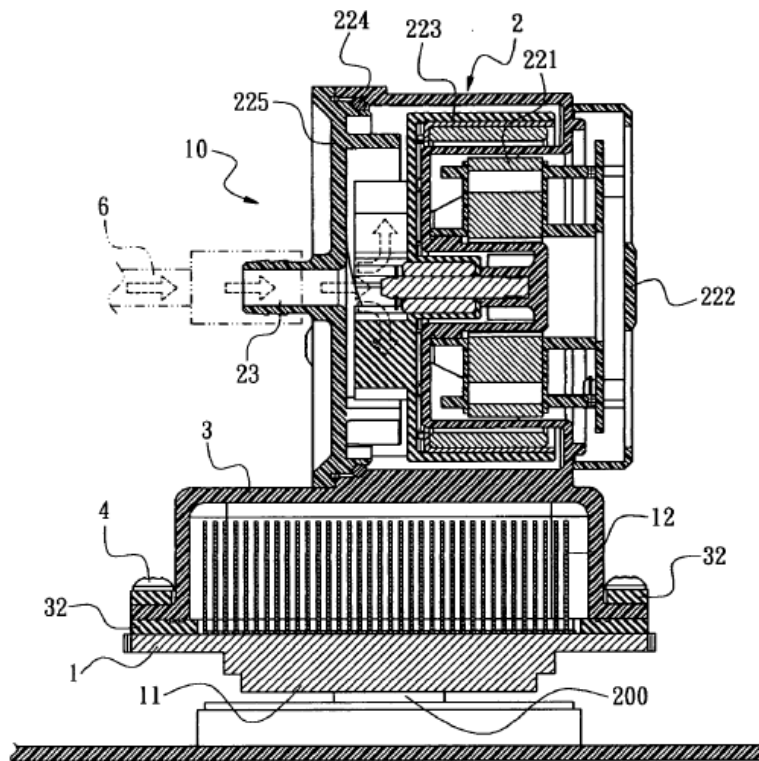


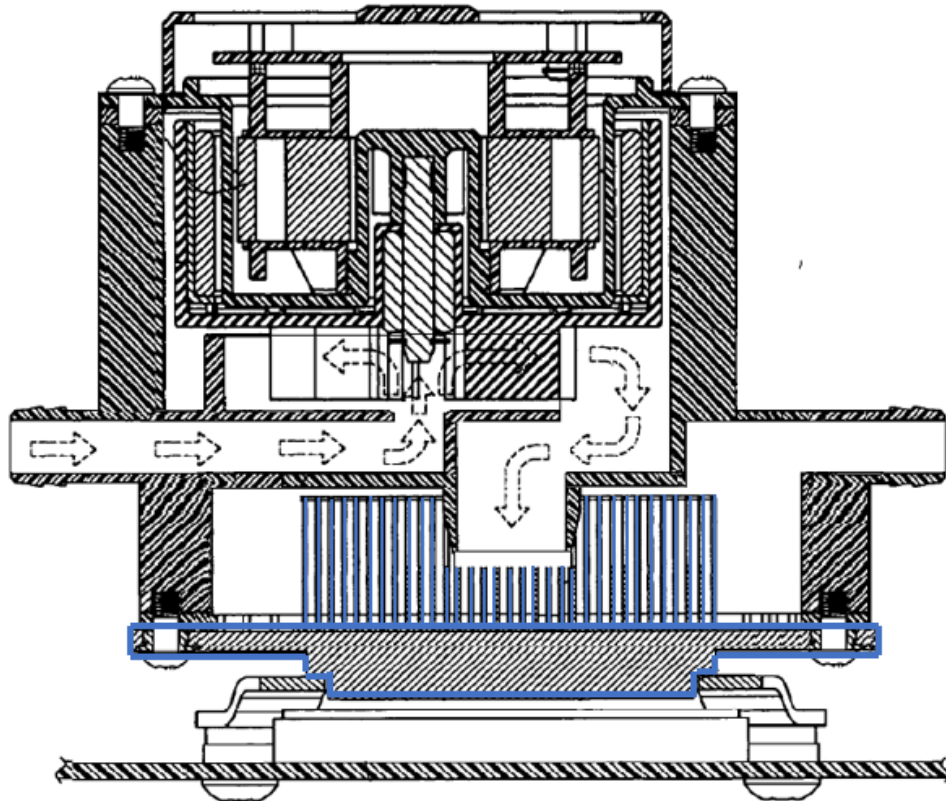
FIG. 7

(Duan, FIGS. 4 (upside down), 7-8.)

85. Duan's heat-exchanging interface has a first side (the top surface of cooling plate 1 and heat-dissipating plates 12), which contacts the cooling liquid in the thermal exchange chamber, and a second side opposite the first side (heat absorbing face 11) in thermal contact with the surface of the heat-generating component (CPU 200). For example, Duan discloses that "cooling plate 1 comprises a heat absorbing face 11 on bottom thereof and being in contact with a heat source." (Duan, [0022]; *see also* Duan at [0026] ("the heat absorbing face 11 being in contact

with the CPU 200 for heat dissipating....”); [0022] (“A plurality of heat-dissipating plates 12 are formed on top face of the cooling plate 1....”); [0031] (“the cool liquid can directly flush the heat-dissipating plates 12 for enhancing heat dissipation efficiency”).)

86. When Duan is modified in view of Duan I (*see* limitation [1-a] above), the modified system has a heat-exchanging interface with the same features (outlined in blue), and therefore it also teaches the claim 3 limitation:



**[Claim 4] “The cooling system of claim 3, wherein the first side of the heat-exchanging interface includes features that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber.”**

87. Duan teaches the limitations of claim 4.

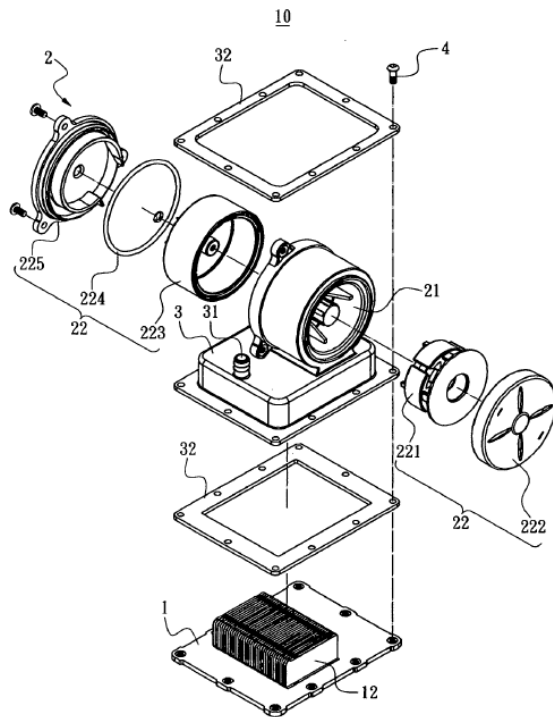


FIG. 2

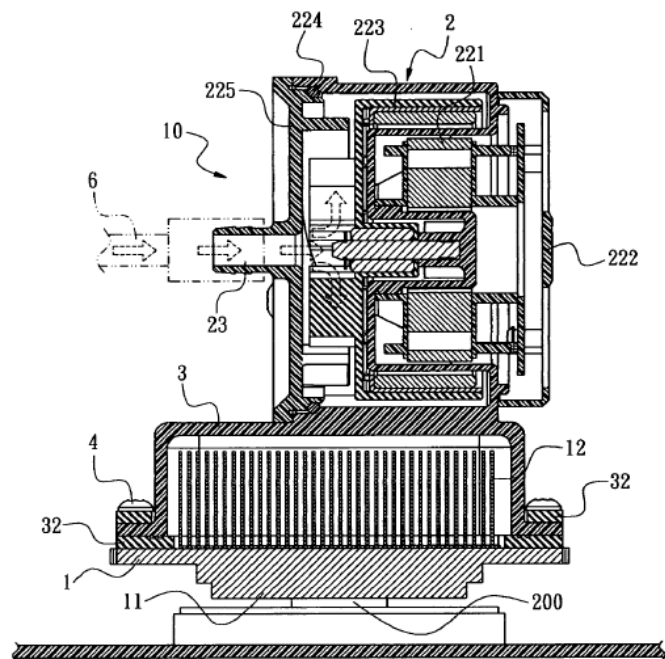


FIG. 7

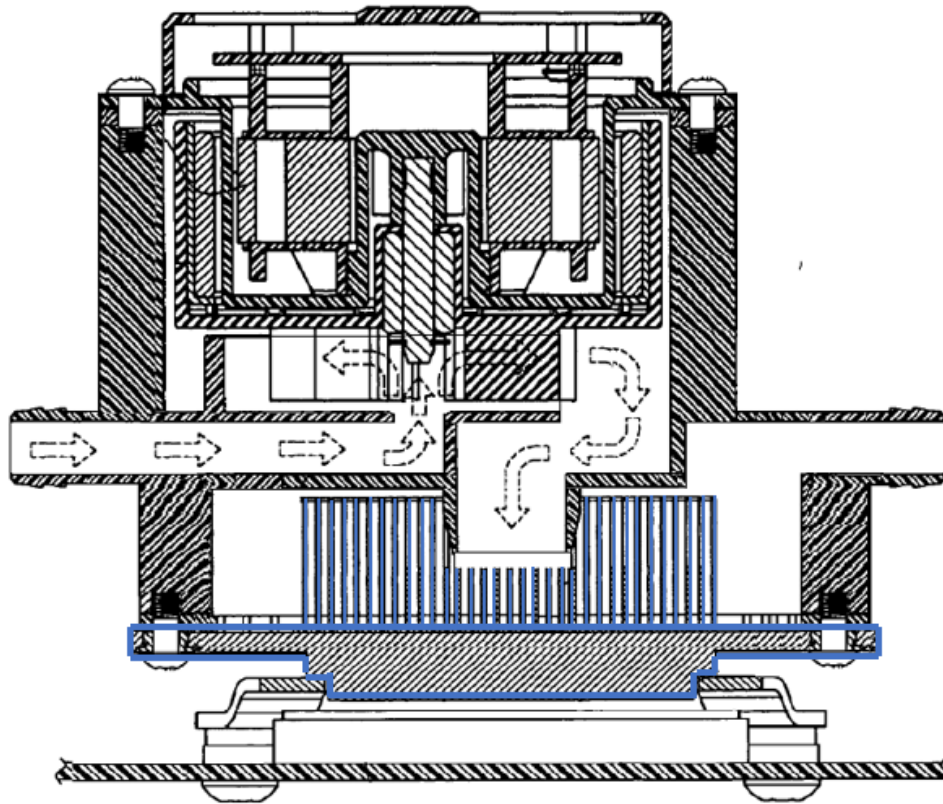
(Duan, FIGS, 2, 7.)

88. Duan discloses “[a] plurality of heat-dissipating plates 12 are formed on top face of the cooling plate 1” and that “cool liquid can directly flush the heat-dissipating plates 12 for enhancing heat dissipation efficiency.” (Duan, [0022], [0031].)

89. Accordingly, Duan discloses a first side (the top side of cooling plate

1) of the heat-exchanging interface that includes features (heat-dissipating plates 12) that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber (cap 3 and cooling plate 1).

90. When Duan is modified in view of Duan I (*see* limitation [1-a] above), the modified system has a heat-exchanging interface with the same features (outlined in blue), and therefore it also teaches the claim 4 limitation:



**[Claim 5] “The cooling system of claim 4, wherein the features include at least one of pins or fins.”**

91. Duan teaches the limitations of claim 5.

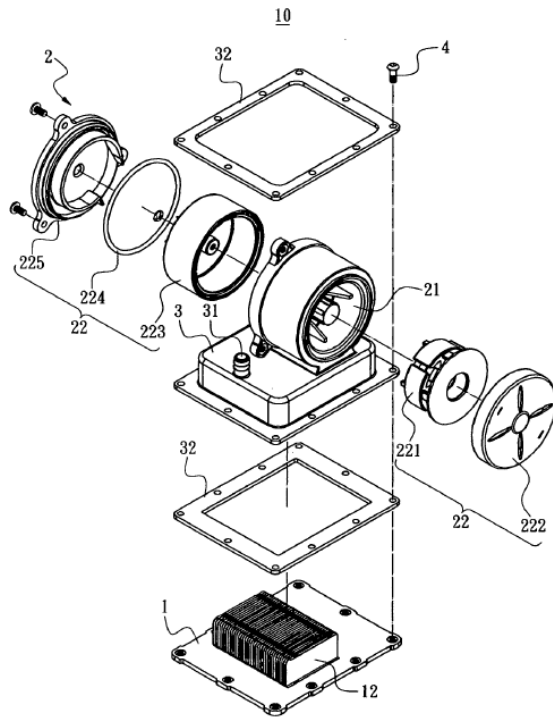


FIG. 2

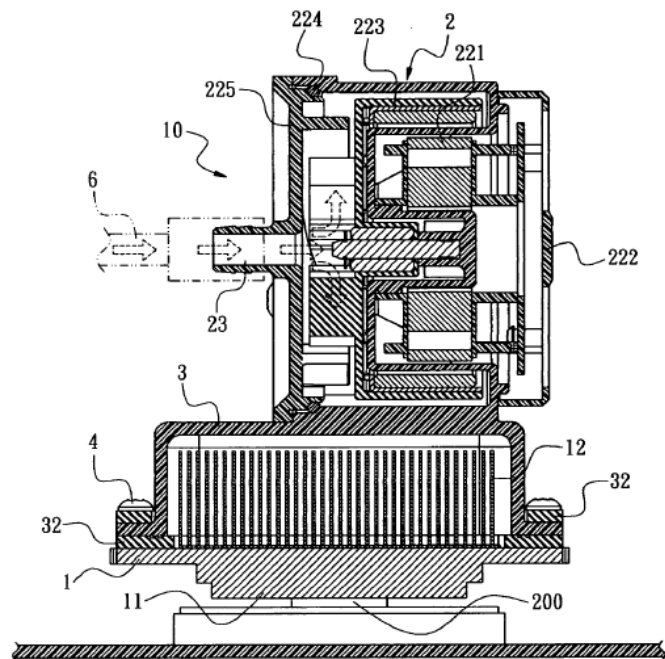


FIG. 7

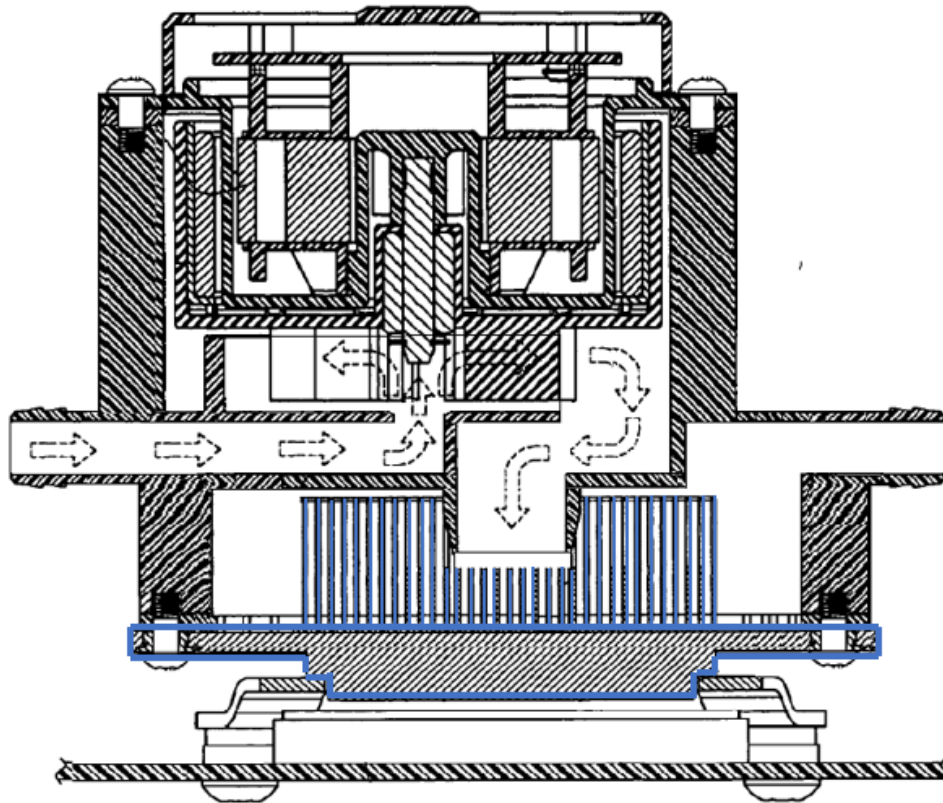
(Duan, FIGS. 2, 7.)

92. Duan discloses that cooling plate 1 includes “heat-dissipating plates 12,” and that “[t]he cool liquid then flows to the cap 3 through the first liquid outlet 24 for heat dissipating the heat-dissipating plates 12 in the cap 3.” (Duan, [0023], [0027].)

93. Accordingly, Duan discloses the limitation of claim 5 that the features include at least one of pins or fins (heat-dissipating plates 12). It would have been

obvious to a POSITA to substitute pins instead of fins for embodiments where the flow in the thermal exchange chamber is not along a single direction.

94. When Duan is modified in view of Duan I (*see* limitation [1-a] above), the modified system has a heat-exchanging interface with the same features (outlined in blue), and therefore it also teaches the claim 5 limitation:



**[Claim 6] “The cooling system of claim 1, wherein a passage of the one or more passages that fluidly couple the pump chamber and the thermal exchange chamber is offset from a center of the impeller.”**

95. Duan teaches the limitations of claim 6.

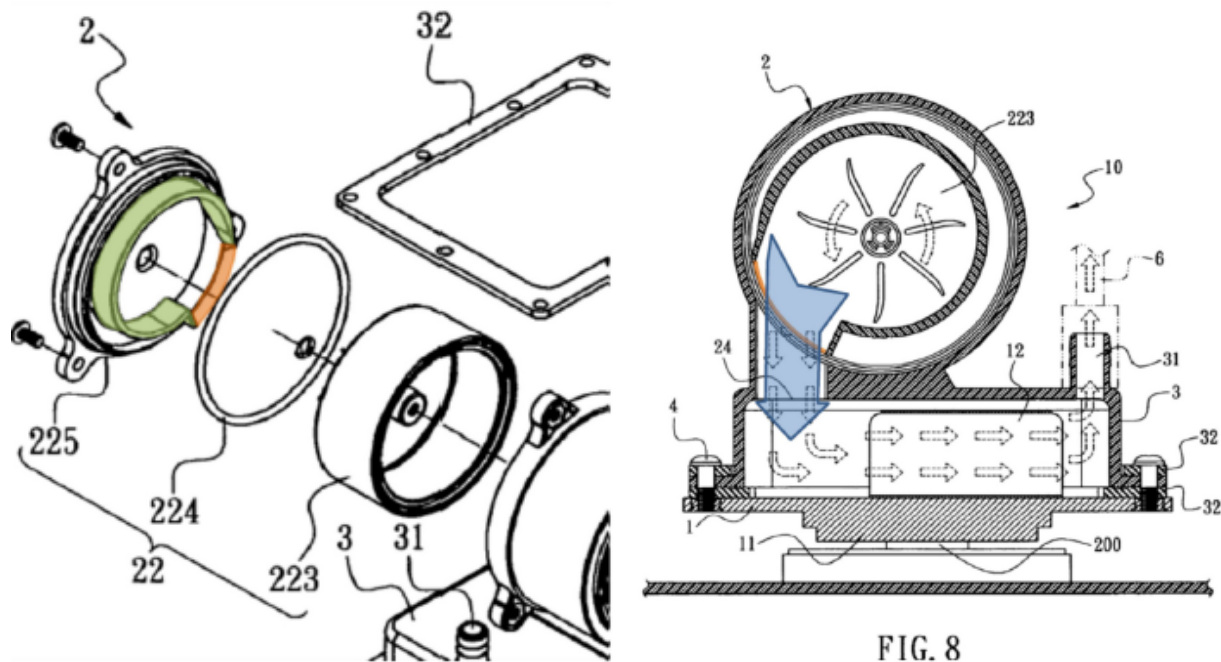
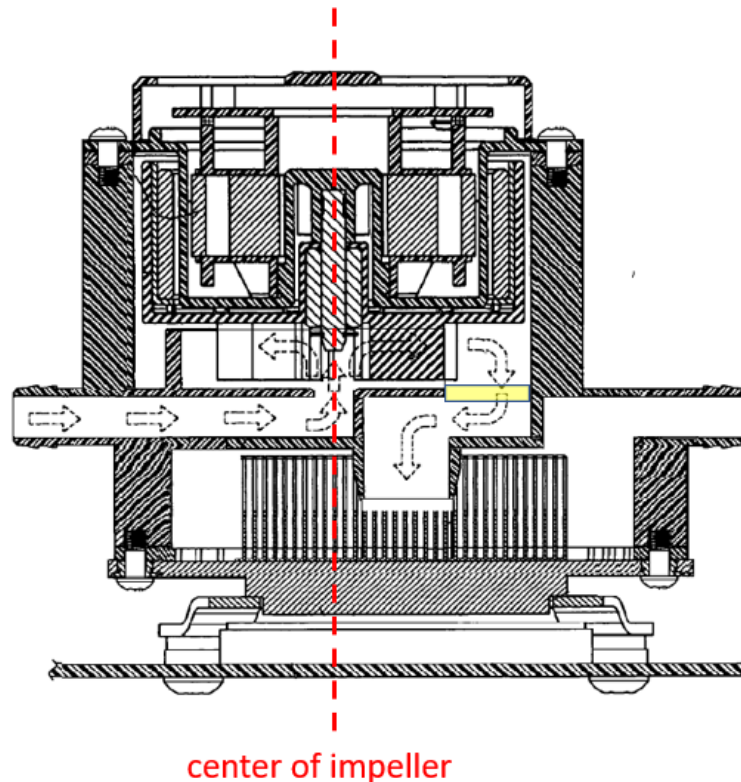


FIG. 8

96. (Duan, FIGS. 2 (excerpt), 8.) Duan discloses a passage (first liquid outlet 24) of the one or more passages that fluidly couple the pump chamber (accommodation chamber 21 plus lower cover 225) and the thermal exchange chamber (cap 3 and cooling plate 1) that is offset from a center of the impeller (223).

97. Although first liquid outlet 24 would have to be relocated in the modified Duan system, it would have been obvious for one of the outlet passages that couples the pump chamber and thermal exchange chamber to be offset from a

center of the impeller because when using centrifugal pumps, like the one in Duan, fluid enters at the center and exits at the perimeter, as shown below (with the passage highlighted yellow):

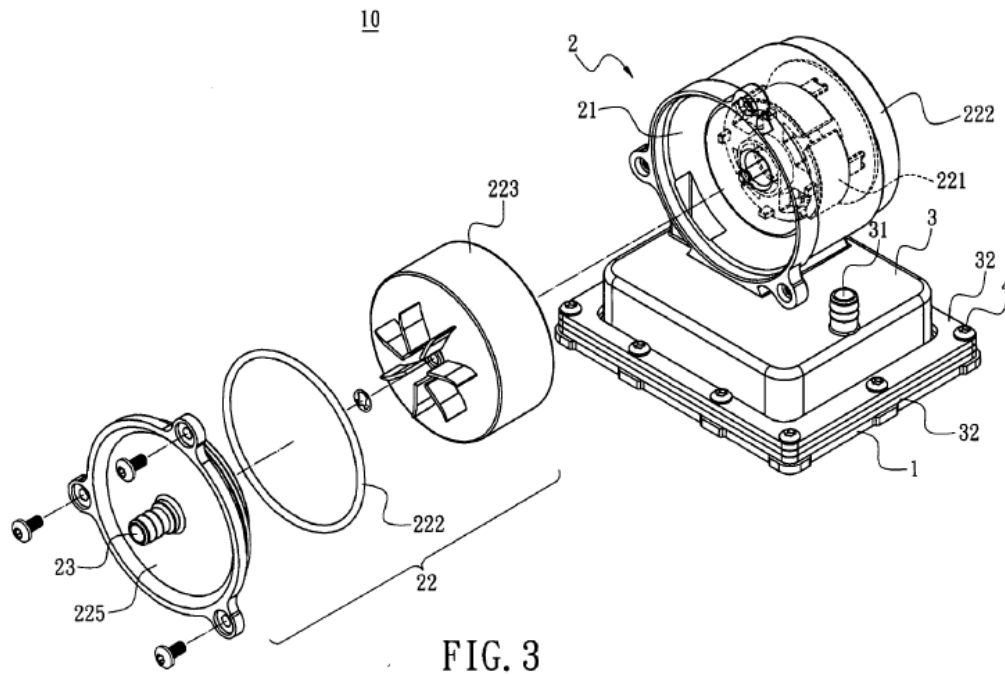


98. It would have been obvious to position the outlet passage offset from the center of the impeller. Locating the outlet in line with the center of the impeller is just one of limitless locations where the outlet could be located. Aside from the fact that it makes sense to locate the outlet at the periphery of the impeller because that is where fluid exits the pump, there is no requirement that the outlet passage be centered with the impeller. It would have been obvious to try an offset location, as

disclosed in Duan, when relocating the outlet passage in the modified Duan system, as one of only two finite options for the passage location (the other being centered).

**[Claim 7] “The cooling system of claim 1, wherein the impeller includes a plurality of curved blades.”**

99. Duan disclosed or suggested the limitations of claim 7.



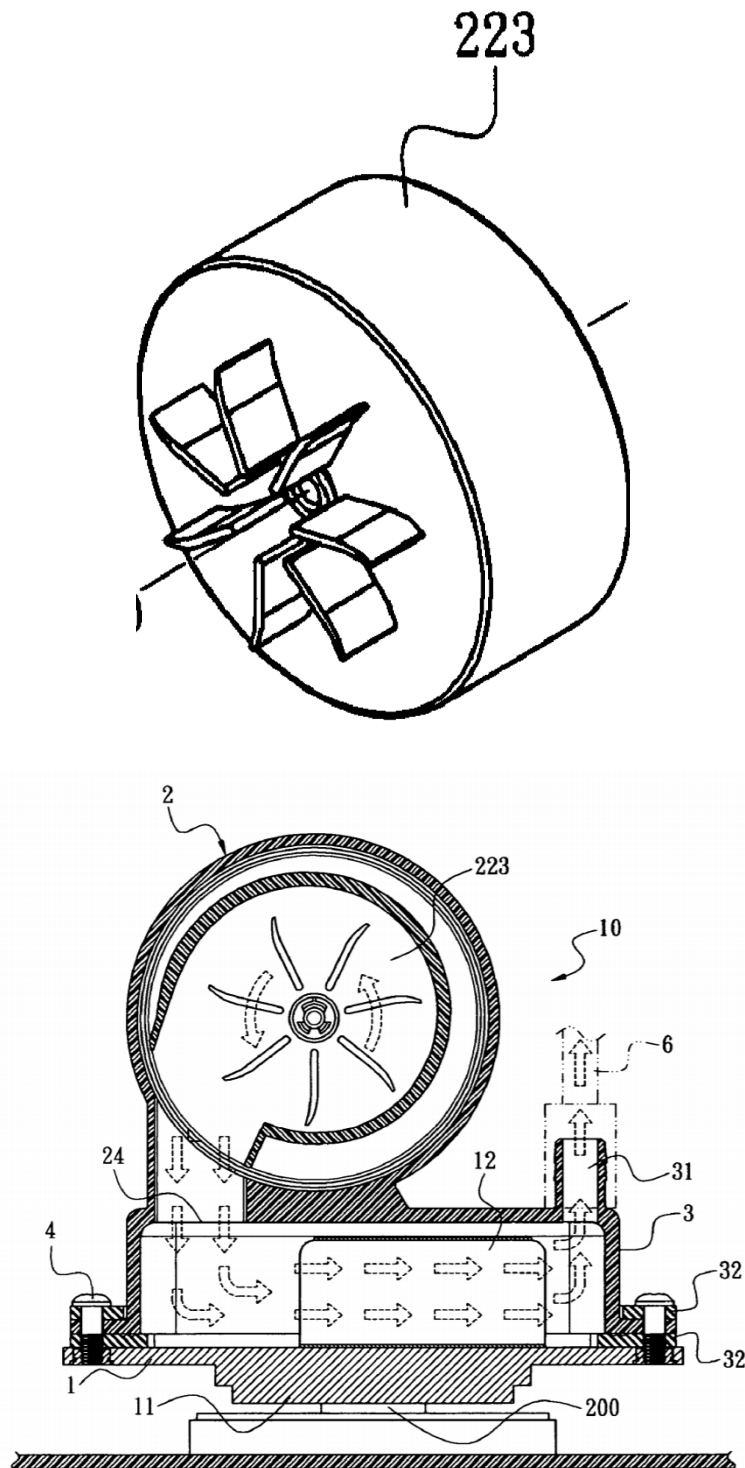
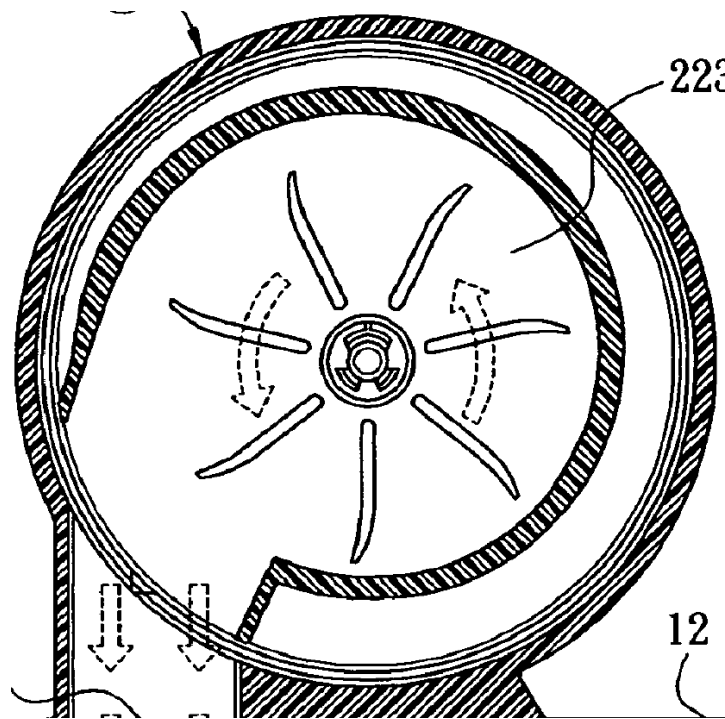


FIG. 8



(Duan, FIGS. 3, 8.)

100. As can be seen in Figures 3 and 8 above, Duan discloses multiple impeller blades that are curved. Accordingly, Duan discloses the cooling system of claim 1, wherein the impeller (impeller 223) includes a plurality of curved blades.

**[Claim 8] “The cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum.”**

101. As discussed above with respect to limitation [1-e], Duan teaches a heat-exchanging interface, but it does not explicitly disclose what material the heat-exchanging interface is made of. It would have been obvious to a POSITA, however, to use copper or aluminum because they are used extensively in electronics cooling

applications due to their high thermal conductivity (especially copper). (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.”).) Due to their high thermal conductivity, a POSITA would have been motivated to use a copper or aluminum for the heat-exchanging interface to increase heat transfer between the cooling liquid and the heat-generating component. Moreover, use of copper or aluminum would have been obvious to try.

**[Claim 9] “The cooling system of claim 1, wherein the heat radiator is fluidly coupled to the reservoir using flexible conduits, and the heat radiator is configured to be positioned remote from the reservoir.”**

102. Duan teaches the limitations of claim 9.

103. As discussed, (*see* limitation [1-f] above) and shown below, Duan discloses a heat radiator fluidly coupled to the reservoir via ducts (6).

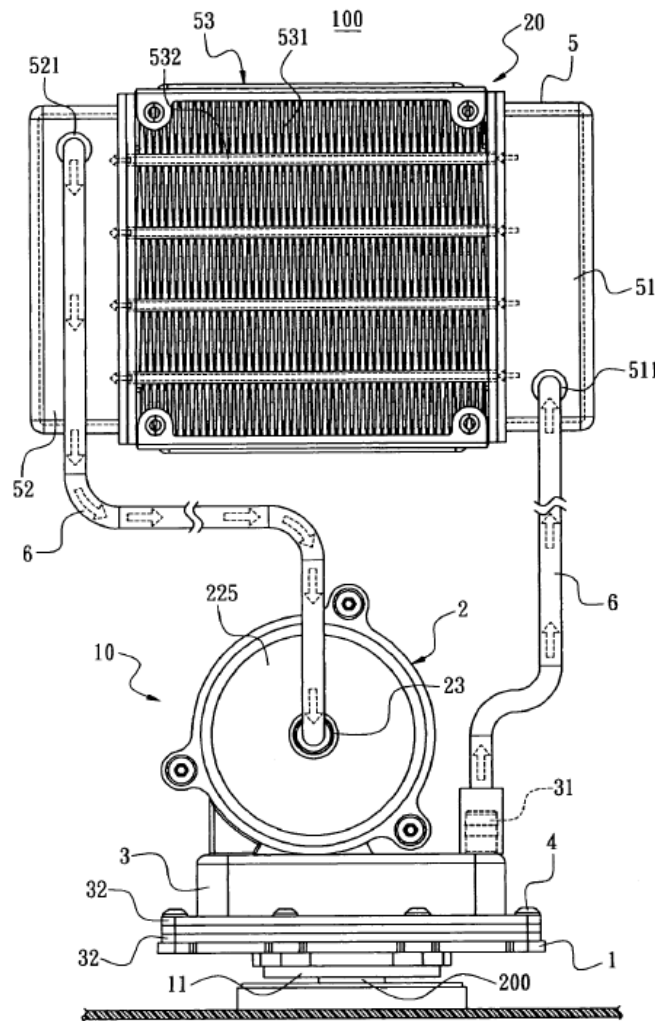


FIG. 6

(Duan, FIG. 6.)

104. Duan also discloses that

[T]he liquid inlet 23 of the cooling plate module 10 is communicated to the liquid outlet 521 of the liquid exit region 52 of the water tank 20 through duct 6. Moreover, the second liquid outlet 31 of the cooling plate module 10 is communicated to the liquid inlet 511 of the liquid entrance region 51 of the water tank 20 through duct 6, thus forming

the liquid cooling cyclic mechanism 100 with continuous cycles.  
(Duan, [0026].)

105. Although Duan does not appear to disclose whether or not duct 6 is flexible, a POSITA would have been motivated to use flexible tubing such as rubber tubing, which was commonly used in cooling systems, to make assembly easier.

106. Accordingly, Duan discloses the cooling system of claim 1, wherein the heat radiator (cooling stage 53, heat-dissipating fins 531, and runners 532) is fluidly coupled to the reservoir using flexible conduits (duct 6), and the heat radiator is configured to be positioned remote from the reservoir (accommodation chamber 21, cap 3, and cooling plate 1).

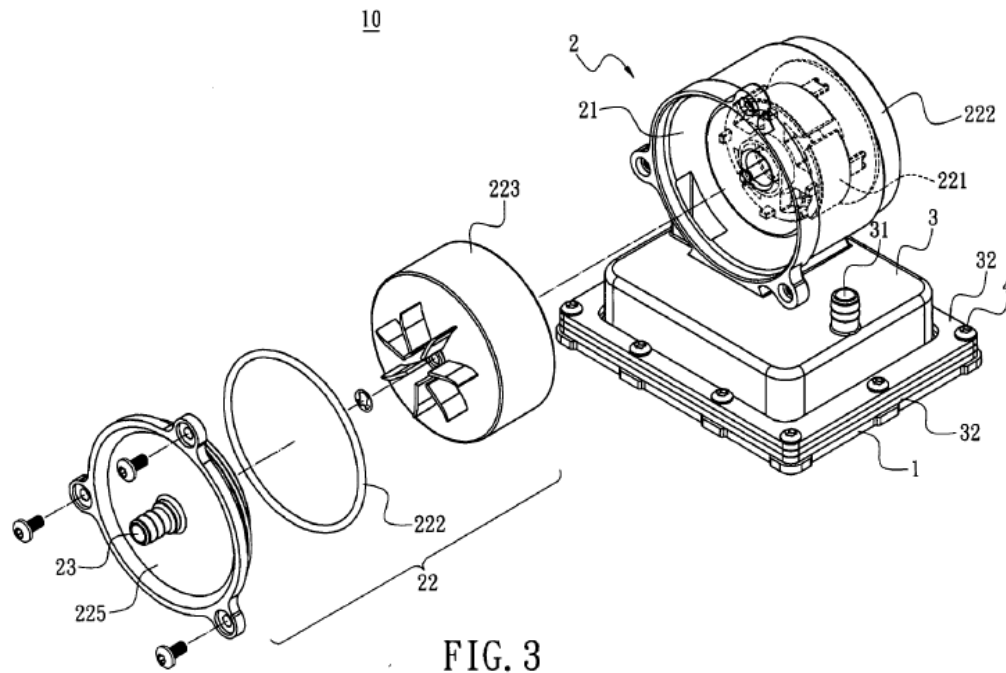
**3. Duan and Duan I disclose or teach each limitation of claim 10 and render it obvious.**

**[10-PRE] “A cooling system for a computer system, comprising:”**

107. Duan by itself or in view of Duan I teaches limitation [10-PRE] for the same reasons discussed above for [1-PRE], hereby incorporated by reference.

**[10-a] “a centrifugal pump adapted to circulate a cooling liquid, the pump including: an impeller exposed to the cooling liquid; and a stator isolated from the cooling liquid:”**

108. Duan by itself or in view of Duan I teaches limitation [10-a] for the same reasons discussed above for [1-a], hereby incorporated by reference.



(Duan, FIG. 3.)

109. Duan explicitly discloses that “the liquid driving module 2 can be” a “centrifugal pump” (Duan, [0023].) Accordingly, Duan teaches a centrifugal pump (liquid driving unit 2) adapted to circulate a cooling liquid.

**[10-b] “a reservoir configured to be thermally coupled to a heat-generating component of the computer system, the reservoir including:”**

110. Duan by itself or in view of Duan I teaches limitation [10-b] for the same reasons discussed above for [1-b], hereby incorporated by reference.

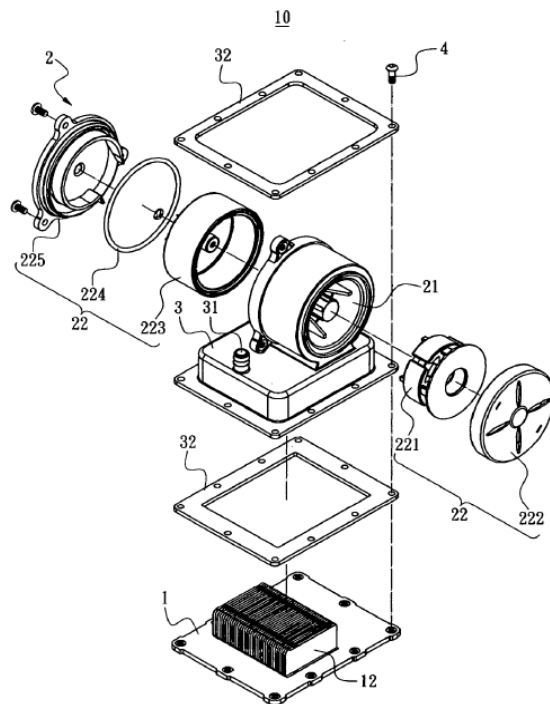


FIG. 2

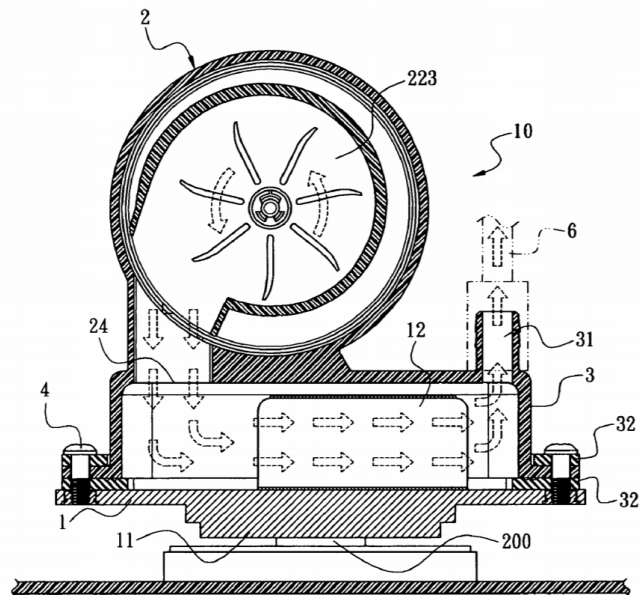


FIG. 8

111. Duan by itself or in view of Duan I teaches a reservoir situated above the heat-generating element (200) so that heat may be transferred into the reservoir's thermal exchange chamber. Accordingly, Duan by itself or in view of Duan I teaches a reservoir (accommodation chamber 21, cap 3, and cooling plate 1) configured to be thermally coupled to a heat-generating component (CPU 200) of the computer system.

**[10-c] “a thermal exchange chamber adapted to be positioned in thermal contact with the heat-generating component;”**

112. Duan by itself or in view of Duan I teaches a thermal exchange chamber

for the same reasons discussed above for [1-d], hereby incorporated by reference.

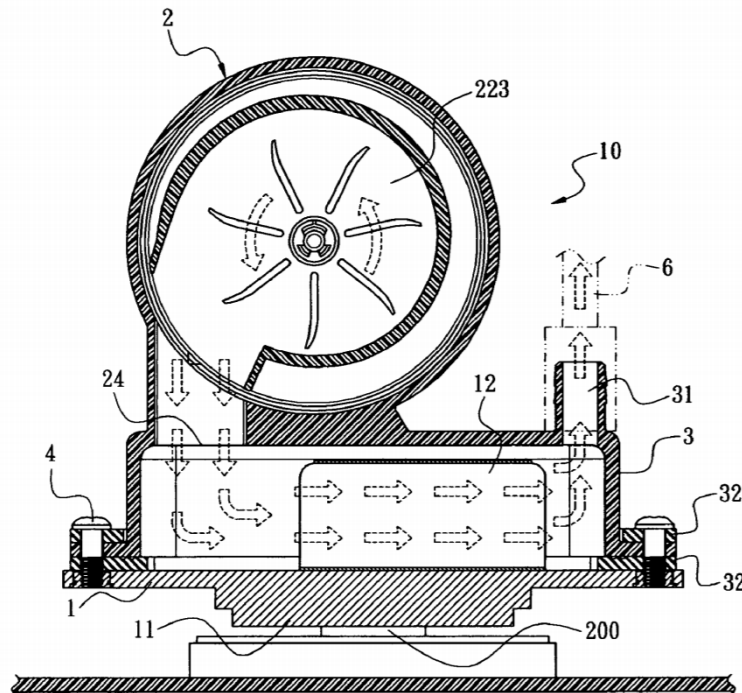


FIG. 8

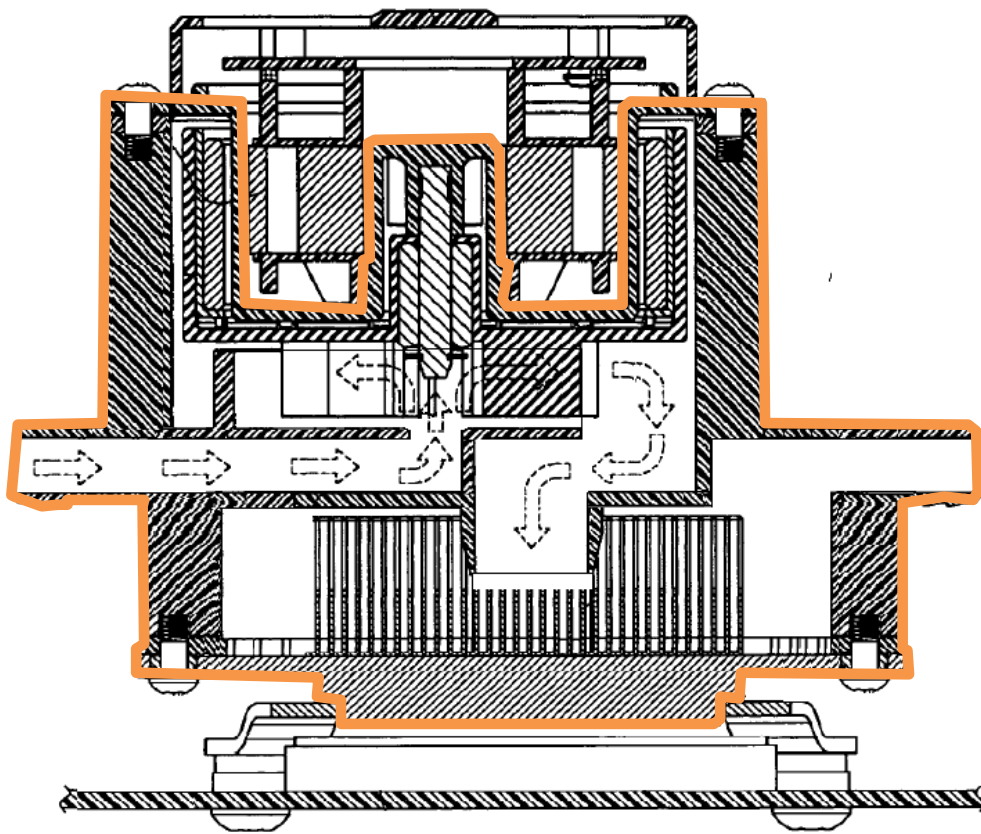
(Duan, FIG. 8)

113. Duan describes, and a POSITA would understand, that Duan's thermal exchange chamber is in thermal contact with the heat source. (See Duan, [0022] ("The cooling plate 1 comprises a heat absorbing face 11 on bottom thereof and being in contact with a heat source. A plurality of heat-dissipating plates 12 are formed on top face of the cooling plate 1..."); [0026] ("heat absorbing face 11 being in contact with the CPU 200 for heat dissipating the CPU 200"); [0027] ("The cool liquid then flows to the cap 3...for heat dissipating the heat-dissipating plates 12 in

the cap 3).

114. Accordingly, Duan discloses a thermal exchange chamber (cap 3 and cooling plate 1) adapted to be positioned in thermal contact with the heat-generating component (CPU 200).

115. The modified system of Duan in view of Duan I teaches the same:



**[10-d] “a separate pump chamber vertically spaced apart from the thermal exchange chamber and coupled with the thermal exchange chamber through one or more passages configured for fluid communication between the pump chamber and the thermal exchange chamber, and wherein at least one of the one or more passages is offset from a center of the impeller.”**

116. Duan by itself or in view of Duan-I teaches limitation [10-d] for the same reasons discussed above for [1-c], and [1-d], hereby incorporated by reference.

**[10-e] “wherein at least one of the one or more passages is offset from a center of the impeller.”**

117. Duan by itself or in view of Duan-I teaches limitation [10-e] for the same reasons discussed above for [claim 6], hereby incorporated by reference.

118. For at least the reasons stated above, Duan either by itself or in view of Duan I teaches all of the limitations of claim 10 and renders it obvious.

#### **4. Duan teaches each limitation of claims 11-14.**

**[Claim 11] “The cooling system of claim 10, wherein a top wall of the reservoir physically separates the impeller from the stator:”**

119. Duan discloses or teaches (1) a reservoir and (2) an impeller and stator that are physically separated, as discussed above for [1-a] and [1-b], hereby incorporated by reference. A “top wall” of the reservoir physically separating the impeller (orange) from the stator (yellow) is indicated below:

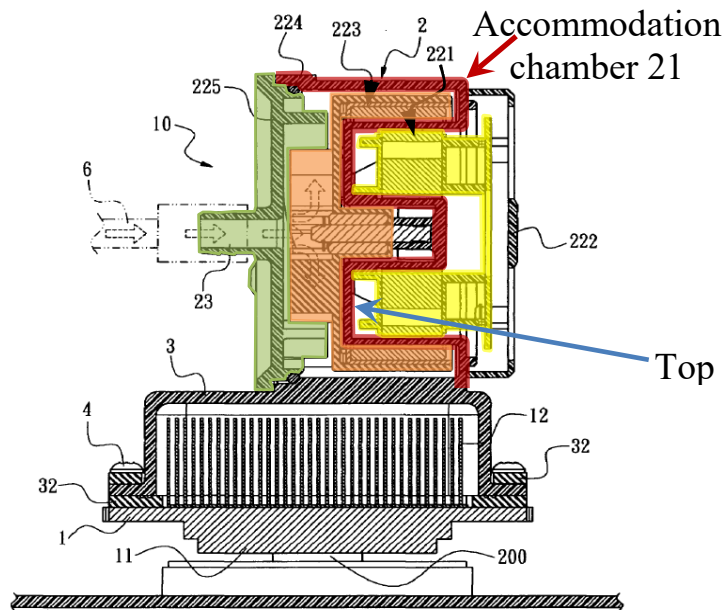
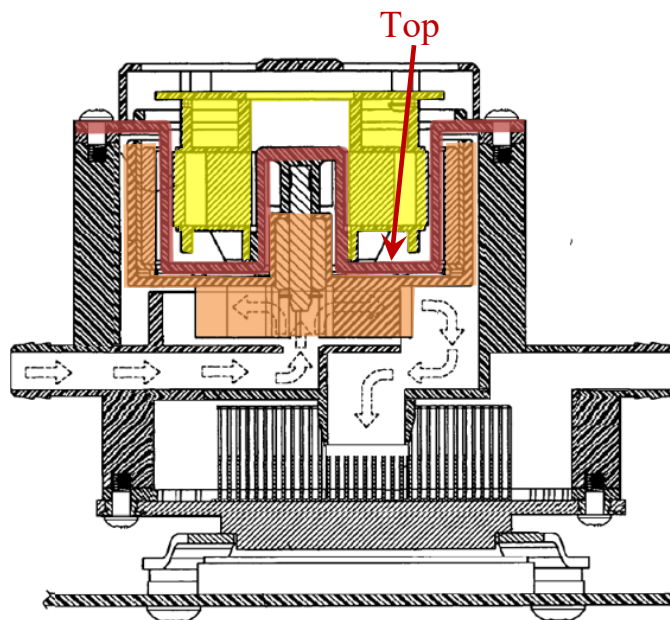


FIG. 7

120. In the modified Duan system, the “top wall” of the reservoir physically separates the impeller from the stator, as shown below:



**[Claim 12] “The cooling system of claim 10, wherein the thermal exchange chamber includes a heat-exchange interface configured to be placed in thermal contact with the heat-generating component.”**

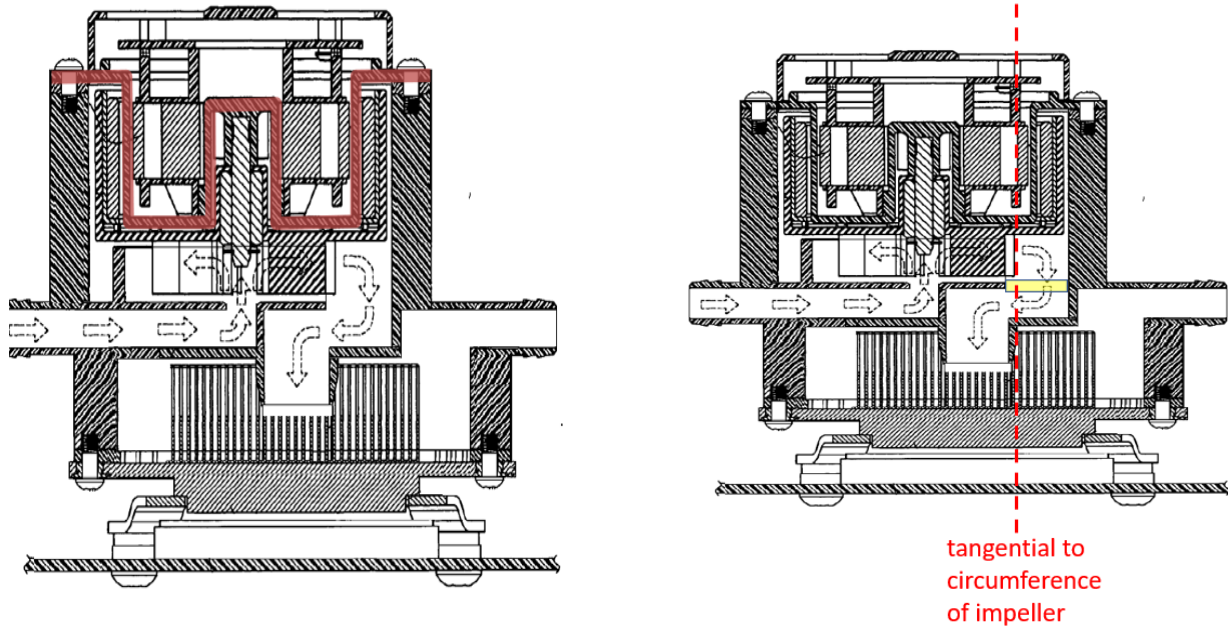
121. Duan by itself or Duan in view of Duan I teaches Claim 12 for the same reasons discussed above for [1-e], hereby incorporated by reference.

**[Claim 13] “The cooling system of claim 10, further including a heat radiator fluidly coupled to the reservoir using flexible conduits, wherein the heat radiator is configured to be positioned remote from the reservoir.”**

122. Duan by itself or Duan in view of Duan I teaches Claim 13 is disclosed or taught or the same reasons discussed above for [1-f] and claim 9, hereby incorporated by reference.

**[Claim 14] “The cooling system of claim 10, wherein the fluid passage that is offset from the center of the impeller is positioned tangentially to the circumference of the impeller.”**

123. Duan by itself or Duan in view of Duan I teaches Claim 14 for the same reasons discussed above for claim 6, hereby incorporated by reference. As shown below, the offset passage is positioned tangentially to the circumference of the impeller in both Duan (first liquid outlet 24) and the modified Duan system in view of Duan I (yellow passage):



(Duan, FIG. 8.)

**5. Duan and Duan I teach each limitation of claim 15 and render it obvious.**

**[15-PRE] “A cooling system for a heat-generating component, comprising:”**

124. Duan by itself or Duan in view of Duan I teaches limitation [15-PRE] for the same reasons discussed above for [1-PRE], hereby incorporated by reference.

**[15-a] “a pump adapted to circulate a cooling liquid, the pump including: an impeller exposed to the cooling liquid; and a stator isolated from the cooling liquid;”**

125. Duan by itself or Duan in view of Duan-I teaches limitation [15-a] for the same reasons discussed above for limitation [1-a], hereby incorporated by reference.

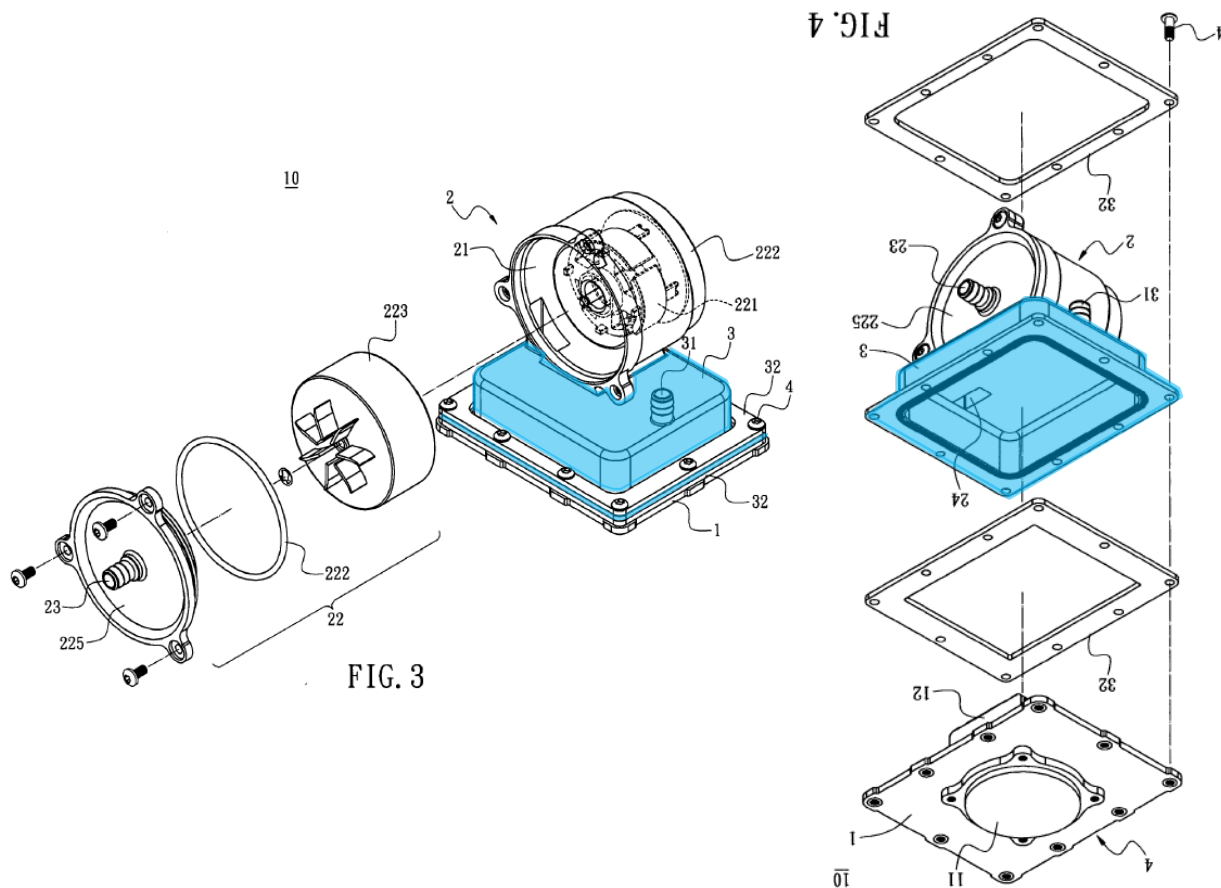
**[15-b] “a reservoir including”**

126. Duan by itself or Duan in view of Duan-I teaches limitation [15-b] for the same reasons discussed above for limitation [1-b], hereby incorporated by reference.

**[15-c] “an impeller cover, an intermediate member and”**

127. Duan and the modified Duan system in view of Duan I teaches an “impeller cover” as discussed above for limitation [1-c], hereby incorporated by reference.

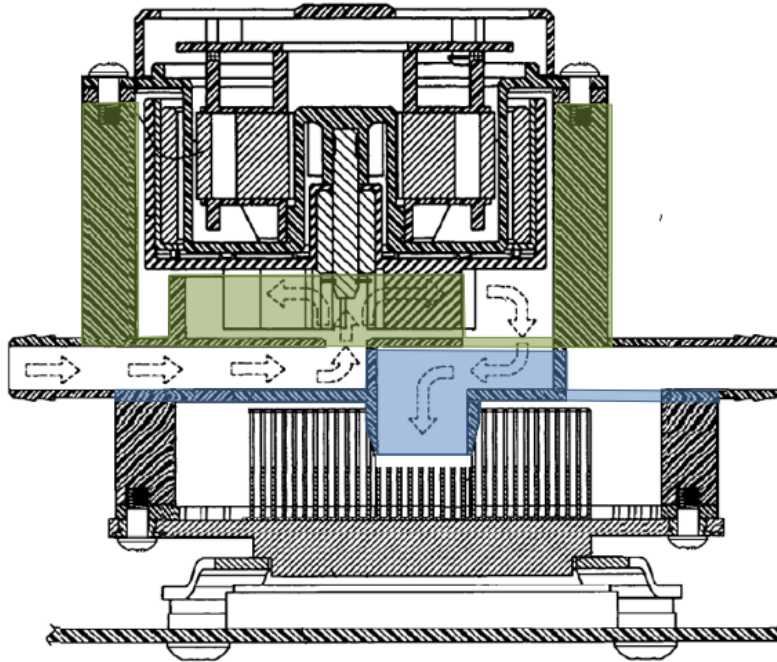
128. Duan by itself or the modified Duan system in view of Duan I also teaches an intermediate member.



(Duan, FIGS. 3, 4 (upside down).)

129. As shown, Duan discloses an intermediate member (cap 3, colored in blue).

130. The modified Duan system includes both an impeller cover (green) and intermediate member blue, as shown below:



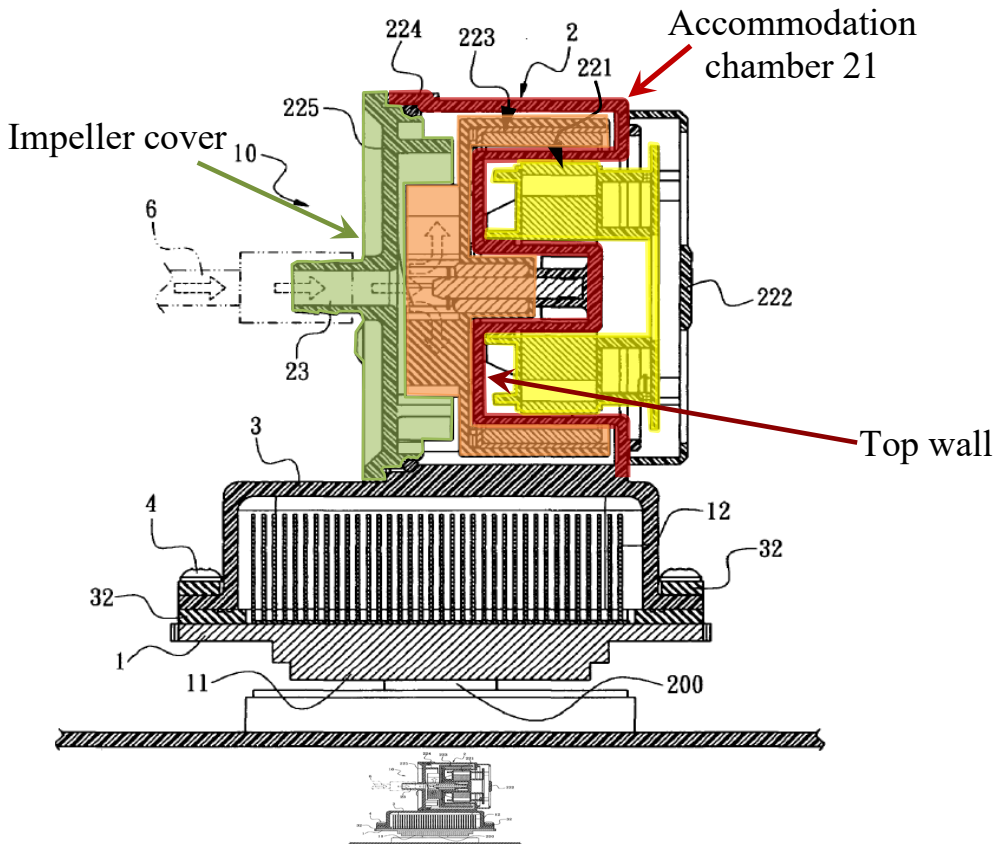
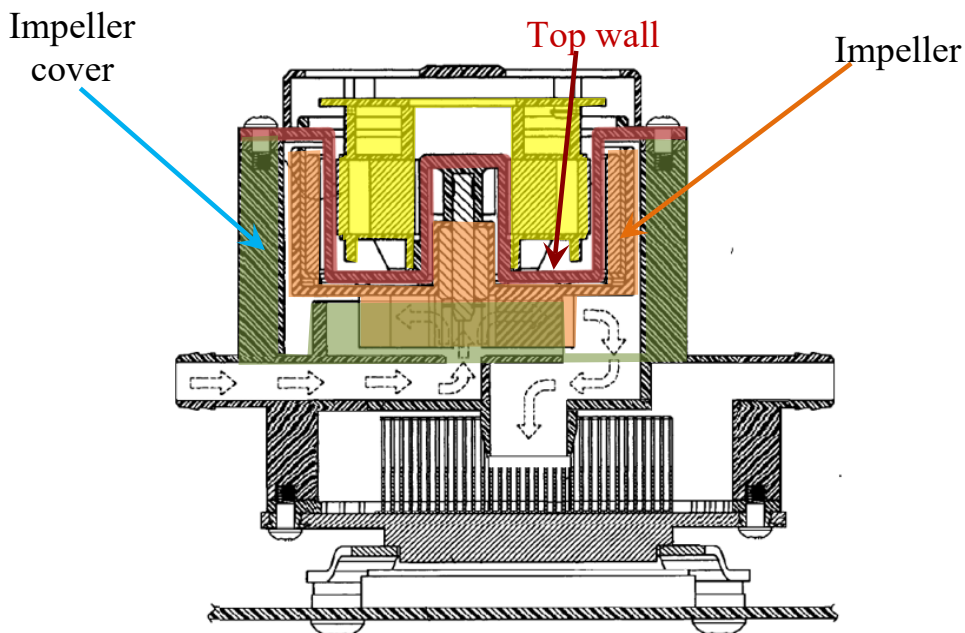
**[15-d] “a heat exchange interface...wherein a first side of the heat-exchanging interface is in contact with a cooling liquid in the thermal exchange chamber and a second side of the heat-exchanging interface opposite the first side is configured to be placed in thermal contact with a surface of the heat-generating component; and”**

131. Duan by itself or Duan in view of Duan-I teaches limitation [15-d] for the same reasons discussed above for limitation [1-e] and claim 3, hereby incorporated by reference.

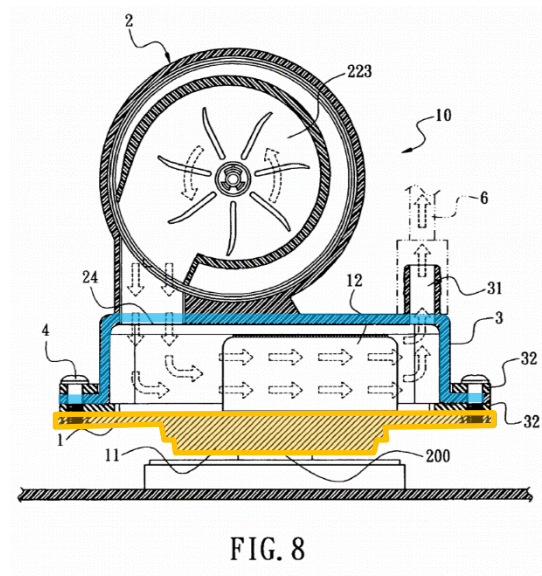
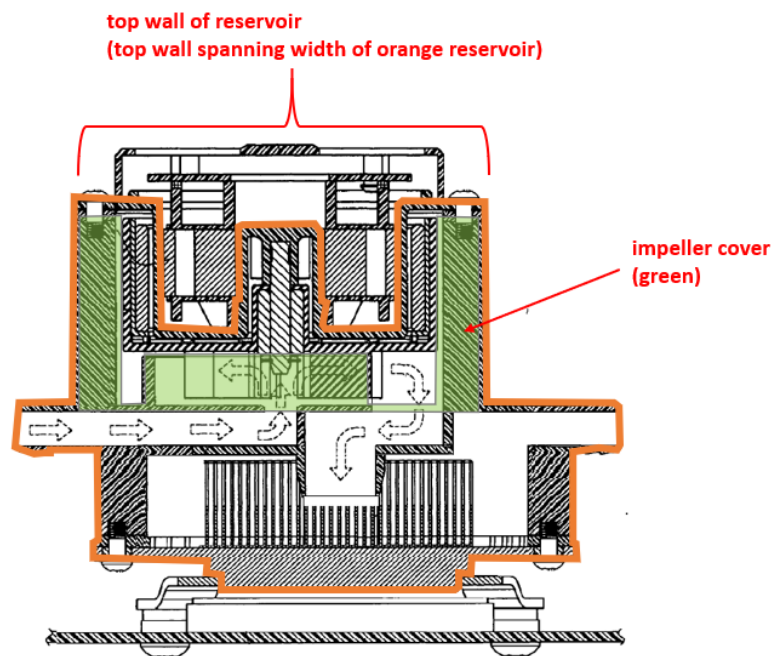
**[15-e] “wherein a top wall of the reservoir and the impeller cover define a pump chamber for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber, the pump chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together; and”**

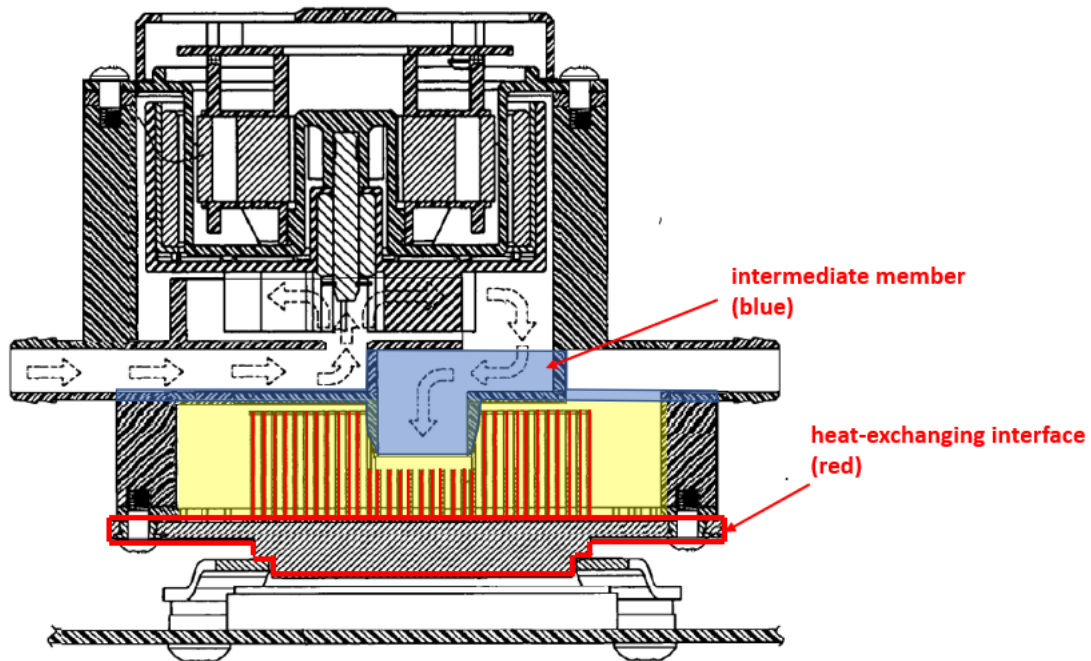
132. Duan or the modified Duan system in view of Duan I renders obvious all of the elements of [15-e] for the reasons discussed above with respect to [1-a] through [1-e] and [15-c], hereby incorporated by reference.

133. As shown below, in both Duan and the modified Duan system in view of Duan I, a top wall of the reservoir (accommodation chamber 21) and the impeller cover (green) define a pump chamber for housing impeller (223).



134. In Duan, the intermediate member (cap 3 (blue)) and the heat-exchanging interface (cooling plate 1 and heat absorbing face 11 (gold)) define a thermal exchange chamber, as illustrated below:





(Duan, FIG. 8)

135. As reflected in the figures above, the pump chamber and the thermal exchange chamber are spaced apart from each other in a vertical direction and fluidly coupled together.

**[15-f] “a liquid-to-air heat exchanger fluidly coupled to the reservoir using flexible conduits, the heat exchanger being configured to be positioned remote from the reservoir.”**

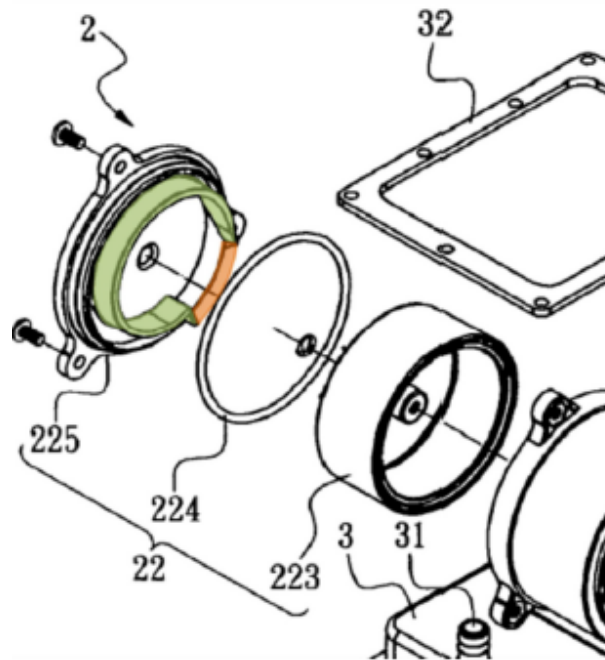
136. A POSITA would understand Duan’s heat radiator to be “a liquid-to-air heat exchanger.” Accordingly, limitation [15-f] is disclosed or taught for the same reasons discussed above for limitation [1-f] and claim 9, hereby incorporated

by reference.

**6. Duan teaches each limitation of claims 16-19, 21-27, and 29.**

**[Claim 16] “The cooling system of claim 15, wherein the impeller cover includes a first opening radially offset from a center of the impeller and the intermediate member includes a second passage that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber.”**

137. Duan or the modified Duan system in view of Duan I teaches an impeller cover an intermediate member, as discussed above for limitations [1-c] and [15-c], hereby incorporated by reference.



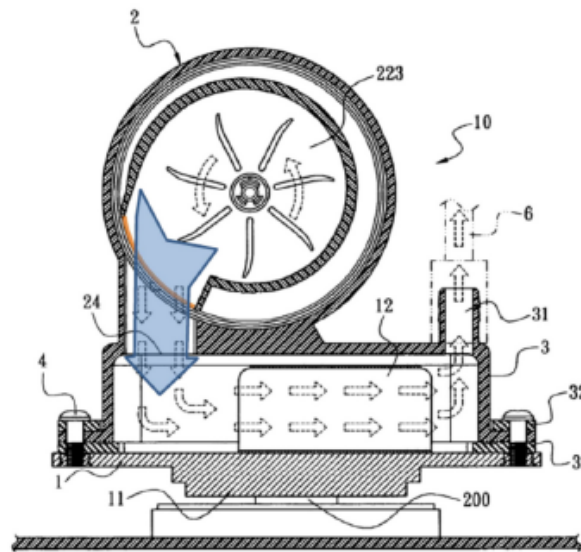


FIG. 8

138. Duan's impeller cover has a first opening (orange) radially offset from a center of the impeller and the intermediate member includes a second passage (blue below) that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber (white arrows).

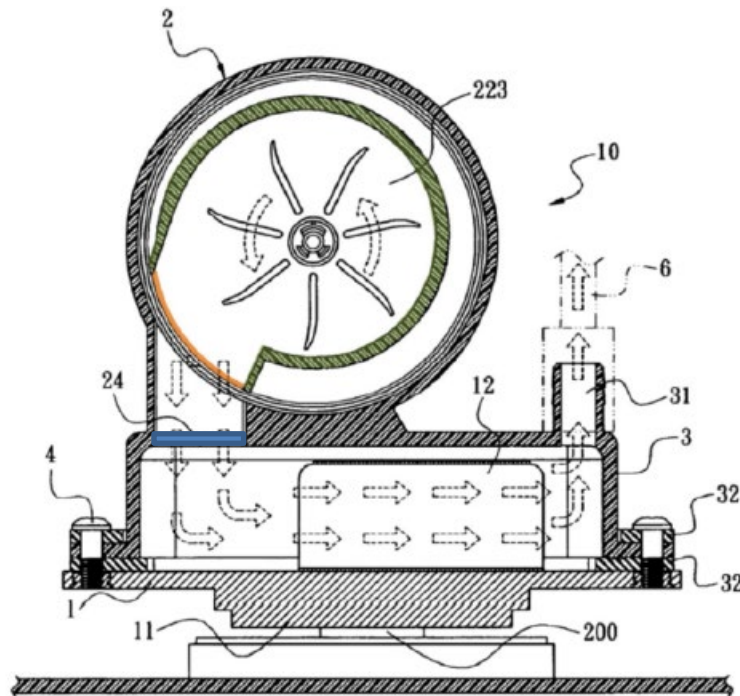
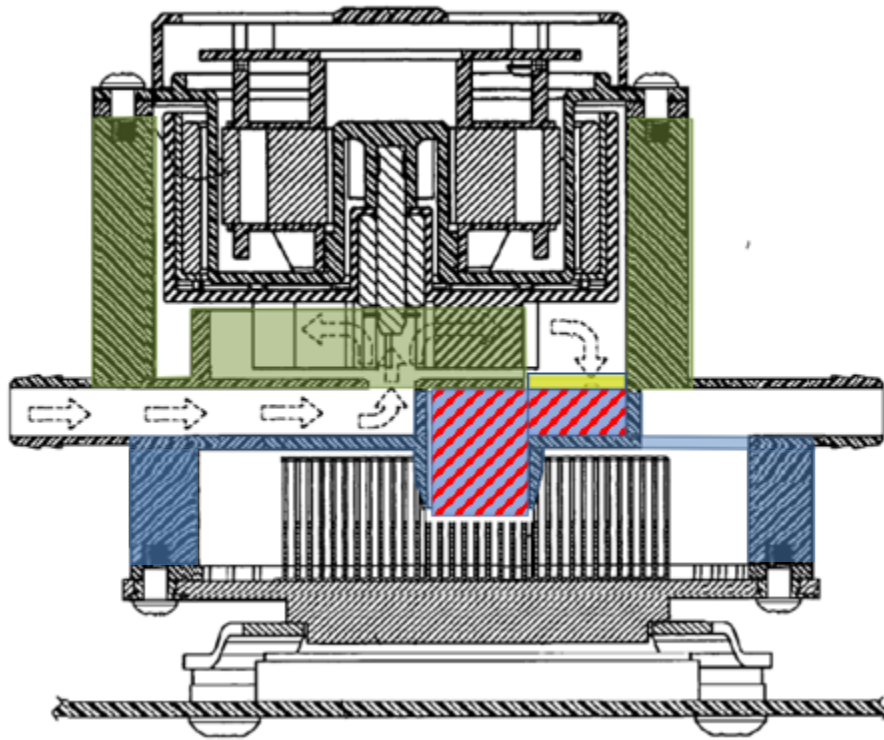


FIG. 8

139. The modified Duan system also teaches this limitation, as shown below, with the impeller cover's first opening (yellow) radially offset from a center of the impeller and the intermediate member (blue) includes a second passage (red cross hatching) that is aligned with the first opening:



**[Claim 17] “The cooling system of claim 15, wherein the first side of the heat-exchanging interface includes at least one of pins or fins.”**

140. Claim 17 is disclosed or taught for the same reasons discussed above for claim 5, hereby incorporated by reference.

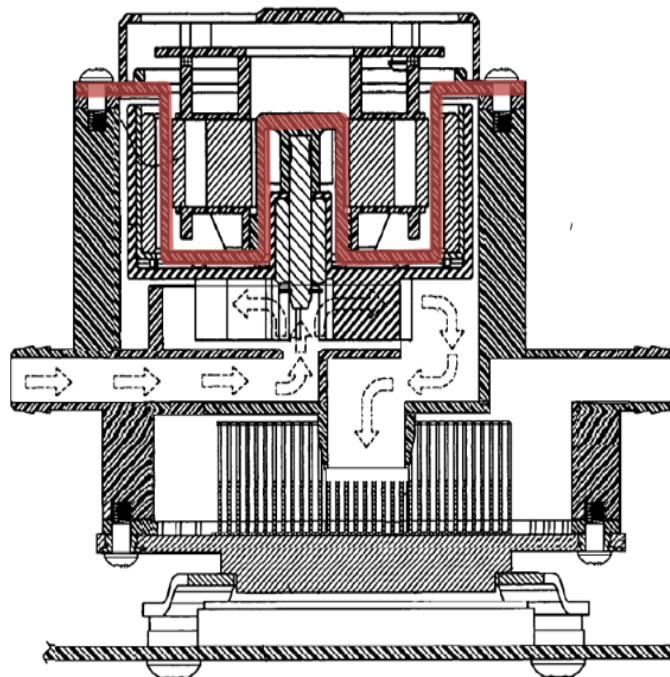
**[Claim 18] “The cooling system of claim 15, wherein the top wall of the reservoir extends between the stator and the impeller and shields the stator from the cooling liquid in the reservoir.”**

141. Claim 18 is disclosed or taught for the same reasons discussed above for limitation [1-a], limitation [1-b] and claim 2, hereby incorporated by reference.

**[Claim 19 / Claim 23] “The cooling system of claim [1 / 10 / 15], wherein the one or more passages include a passage configured to direct cooling liquid from the pump chamber directly into the thermal exchange chamber.”**

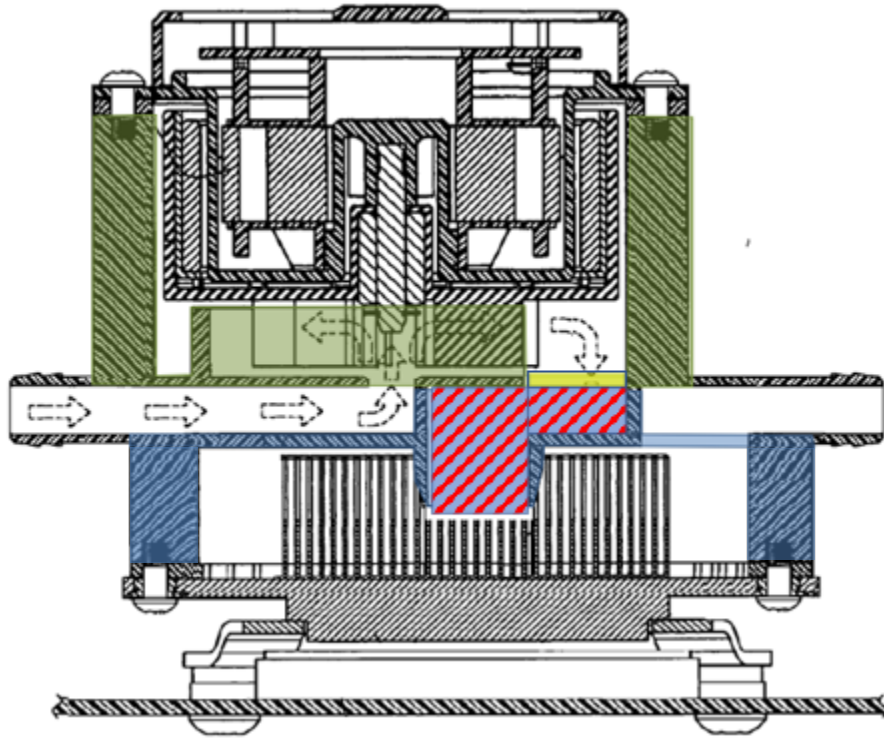
142. Duan or the modified Duan system in view of Duan I teaches a passage configured to direct cooling liquid from the pump chamber into the thermal exchange chamber, as discussed above for [1-d], hereby incorporated by reference.

143. Duan also disclosed or suggested that the passage direct the cooling fluid from the pump chamber (accommodation chamber 21) “directly” into the thermal exchange chamber (the cap 3 and cooling plate 1):



(Duan, FIG. 8.)

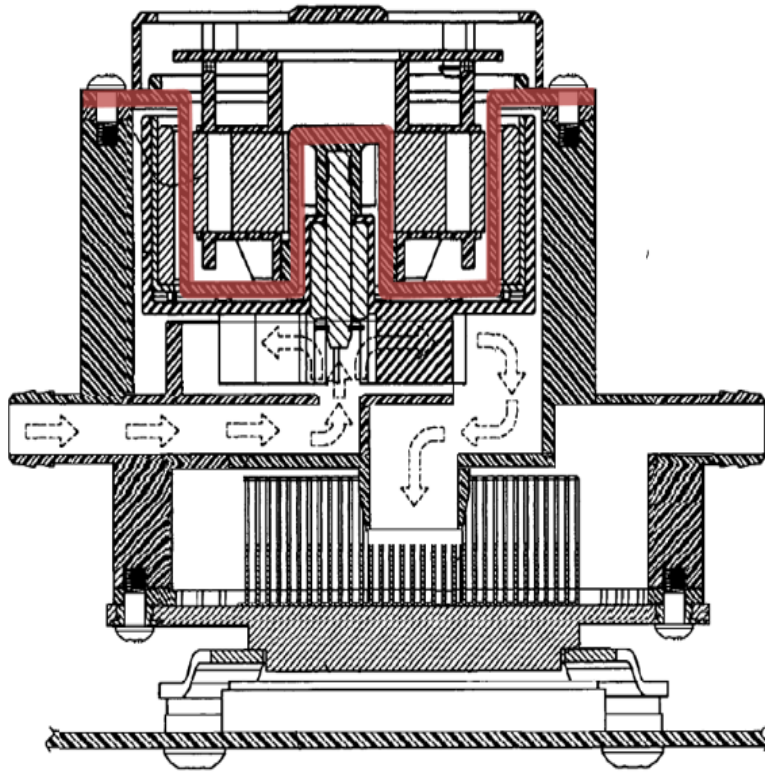
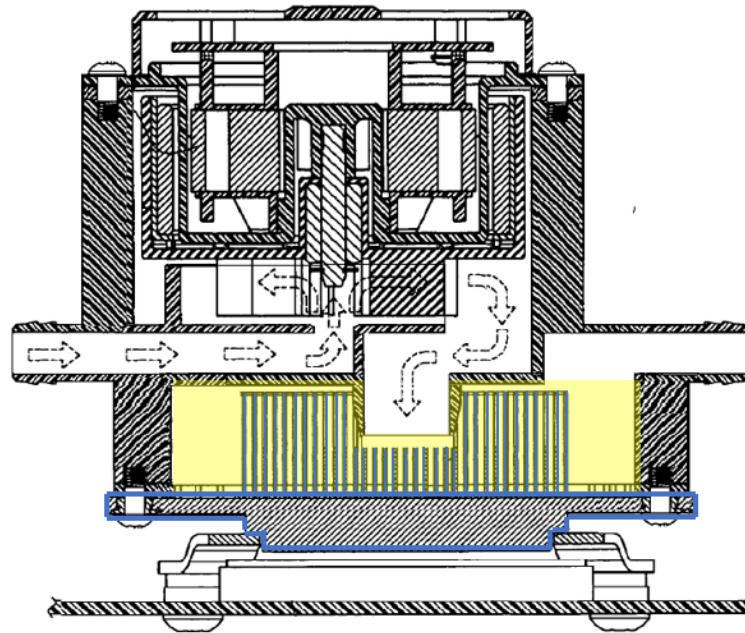
144. The modified Duan system also discloses that the limitation that the passage (red cross hatching) direct cooling fluid from the pump chamber (accommodation chamber 21) “directly” into the thermal exchange chamber:



**[Claim 21 / Claim 25 / Claim 29] “The cooling system of claim [1 / 10 / 15], wherein an entire surface of the heat-exchanging interface in contact with the cooling liquid in the reservoir forms the boundary wall of the thermal exchange chamber.”**

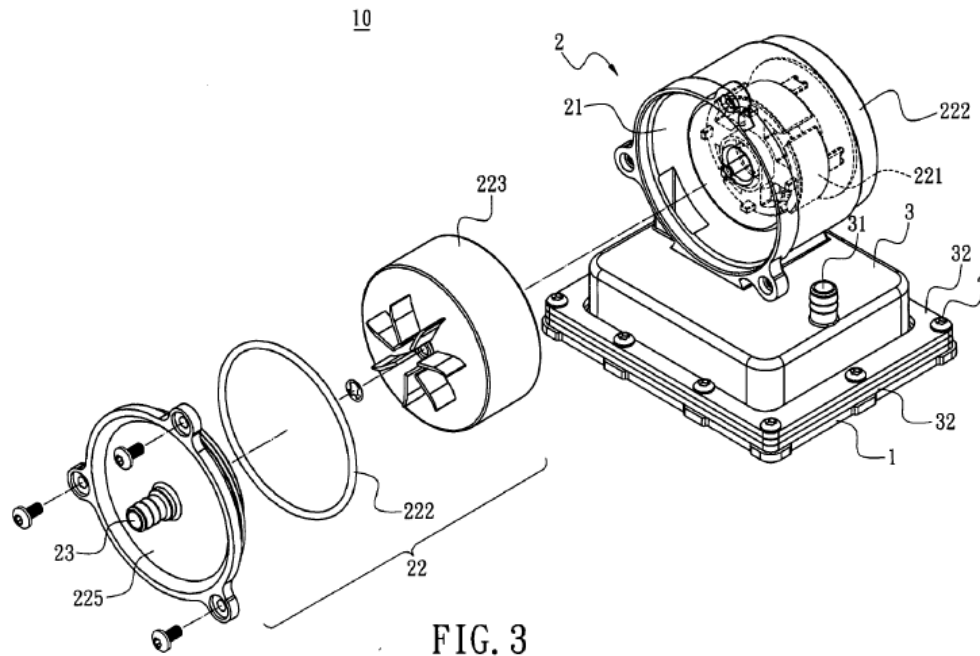
145. Duan by itself or in view of Duan-I teaches claim 21, claim 25, and claim 29, which all add the same limitation, are disclosed, or taught for the same reasons discussed above for limitation [1-e], hereby incorporated by reference.

146. As shown below, the “entire surface of the heat-exchanging interface in contact with the cooling liquid” (i.e., the entire portion of cooling plate 1 in contact with the cooling liquid) forms the boundary wall of the thermal exchange chamber in the Duan and modified Duan systems:



**[Claim 22 / Claim 26] “The cooling system of claim [1 / 10], wherein the reservoir further includes an inlet configured to direct the cooling liquid into the reservoir and an outlet configured to discharge the cooling liquid from the reservoir.”**

147. Duan or the modified Duan system in view of Duan I teaches a reservoir adapted to pass the cooling liquid therethrough, as discussed above for limitation [1-b], hereby incorporated by reference. To facilitate the flow of cooling fluid into and out of the reservoir, Duan's reservoir includes inlet 23 and outlet 31:

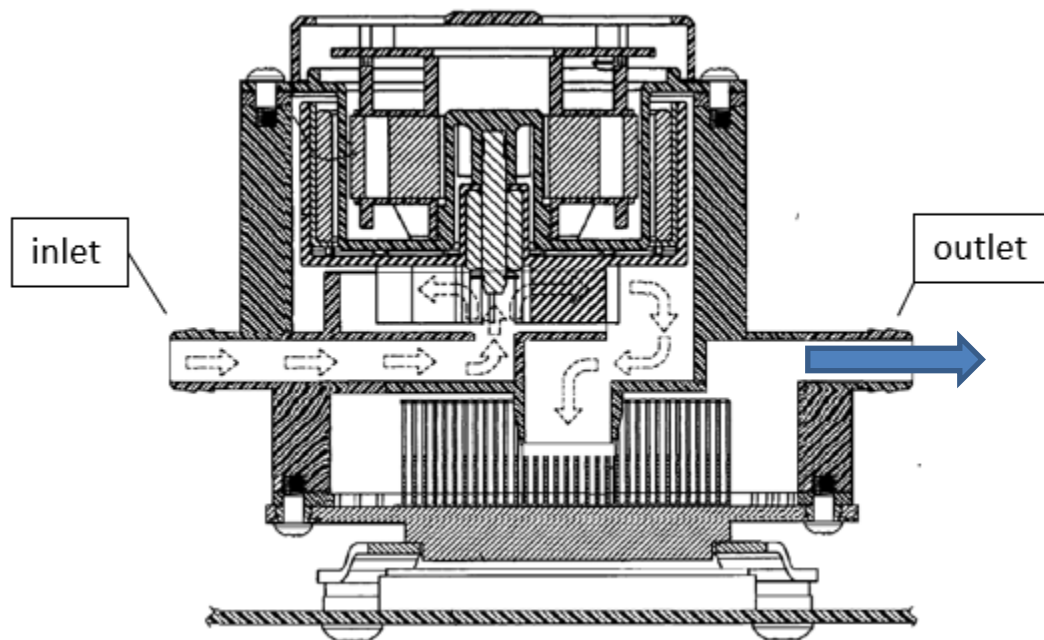


(Duan, FIG. 3.)

148. Duan discloses that “A first liquid outlet 24 is communicated to the bottom of the accommodation chamber 21 and is enclosed by a cap 3. A second

liquid outlet 31 is defined on the cap 3.” (Duan, [0023].)

149. In reconstructing the modified Duan system, a POSITA would have had to move inlet (23), but a POSITA would have continued to maintain an inlet and outlet into and out of the reservoir (e.g., like below) to facilitate flow through the reservoir:



**[Claim 27] “The cooling system of claim 15, wherein the pump chamber and the thermal exchange chamber are fluidly coupled together by one or more passages, the one or more passages including a passage configured to direct cooling liquid from the pump chamber directly into the thermal exchange chamber.”**

150. Duan by itself or in view of Duan I teaches claim 27 for the same

reasons discussed above for limitation [1-d], claim 19, and claim 23, hereby incorporated by reference.

**7. Duan by itself or in view of Duan I teaches each limitation of claim 30.**

**[30-a] “30. The cooling system of claim 15, wherein the pump chamber and thermal exchange chamber are fluidly coupled together by one or more passages, and”**

151. Duan by itself or in view of Duan I teaches limitation [30-a] for the same reasons discussed above for limitations [1-c] and [1-d], hereby incorporated by reference.

**[30-b] “the reservoir further includes an inlet configured to direct the cooling liquid into the reservoir and an outlet configured to discharge the cooling liquid from the reservoir.”**

152. Duan by itself or in view of Duan I teaches limitation [30-b] for the same reasons discussed above for claim 19 and claim 23, hereby incorporated by reference.

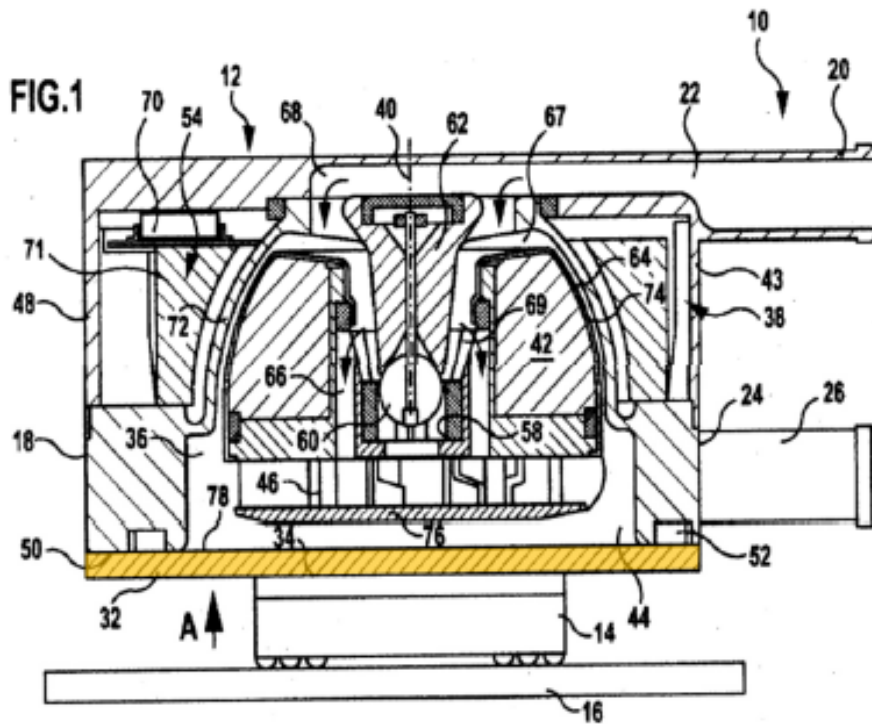
**B. GROUNDS 3 and 4: Claim 8 is obvious over Duan in view of Laing or Duan in view of Duan-I and further in view of Laing.**

**[Claim 8] “The cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum.”**

153. Duan in view of Laing or Duan in view of Duan I and further in view of Laing renders obvious the limitations of claim 8.

154. Laing teaches a “heat-exchanging interface formed of copper,” as

shown in Figure 1 (gold coloring added):



(Laing, FIG. 1.)

155. As shown above, Laing discloses that “[i]n the exemplary embodiment shown in FIG. 1, the thermal contact element 32 is formed as a rigid plate which is made from a material with a good thermal conductivity, such as **copper**.” (Laing [0081] (emphasis added)).

156. A POSITA would have been motivated to combine Laing with Duan and/or Duan I. Like Duan and Duan-I, Laing attempts to solve similar issues — how to cool, with liquids, the increasing temperature of increasingly powerful

semiconductor devices (Laing, [0002]-[0004]), which would motivate a POSITA to combine the teachings of these two references.

157. A POSITA also would further be motivated to combine the teachings of these references in light of their specific disclosures. Laing discloses that “the thermal contact element is made from a metallic material, such as copper, in order to achieve a high thermal conductivity, in order, in turn, to allow optimum dissipation of heat from an object[.]” (Laing, [0015].) A POSITA would have been motivated to apply Laing’s copper “heat exchange interface” to Duan and/or Duan-I “to achieve a high thermal conductivity ... to allow optimum dissipation of heat from” the heat generating component. A POSITA would know that copper is normally used in electronic cooling applications when the thermal conductivity of the aluminum is not sufficiently high and/or corrosion from water needs to be prevented and a coating is not used.

**C. GROUND 5: Claims 1-30 are rendered obvious over Batchelder in view of Duan.**

**1. Batchelder in view of Duan teaches each limitation of claim 1 and renders it obvious.**

**[1-PRE] “A cooling system for a heat-generating component, comprising:”**

158. Batchelder in view of Duan teaches limitation [1-PRE].

159. Batchelder 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”).)

160. For the reasons discussed above, Batchelder teaches [1-PRE].

**[1-a] “a double-sided chassis adapted to mount a pump configured to circulate a cooling liquid, the pump comprising a stator and an impeller, the impeller being positioned on the underside of the chassis and the stator being positioned on the upper side of the chassis and isolated from the cooling liquid;”**

161. Batchelder in view of Duan renders this limitation [1-a] obvious.

162. Batchelder teaches a double-sided chassis (top sheet 212) adapted to mount a pump configured to circulate cooling liquid, the pump having an impeller (54) positioned on the underside of the chassis (212):

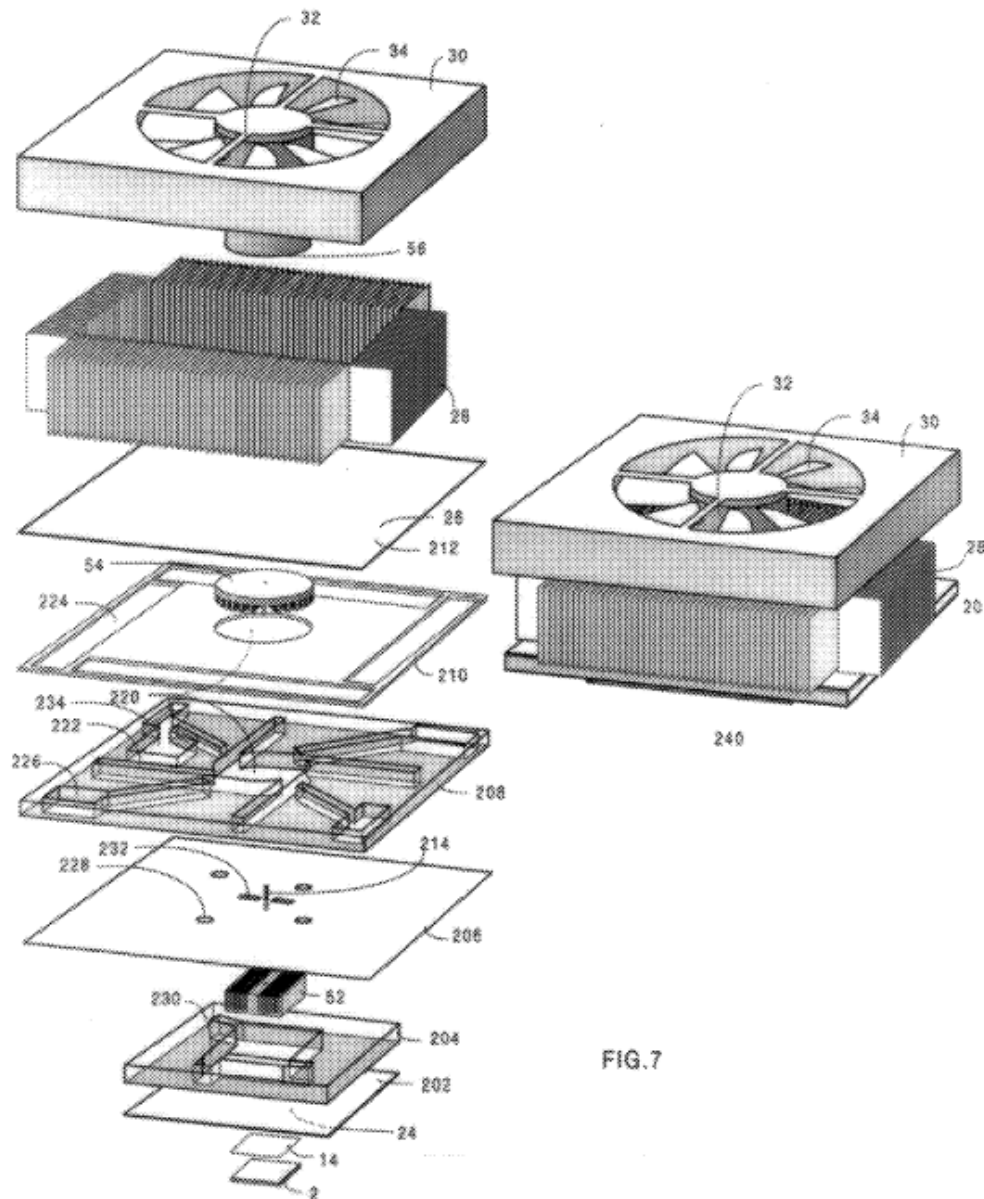


FIG. 7

(Batchelder, FIG. 7.)

163. Batchelder discloses a pump with an impeller. (Batchelder, 5:26-28 (“In the most preferred embodiment the impeller (54) is a centripetal or centrifugal pump that impels the heat transfer fluid to circulate as indicated (60).”), 3:17-19

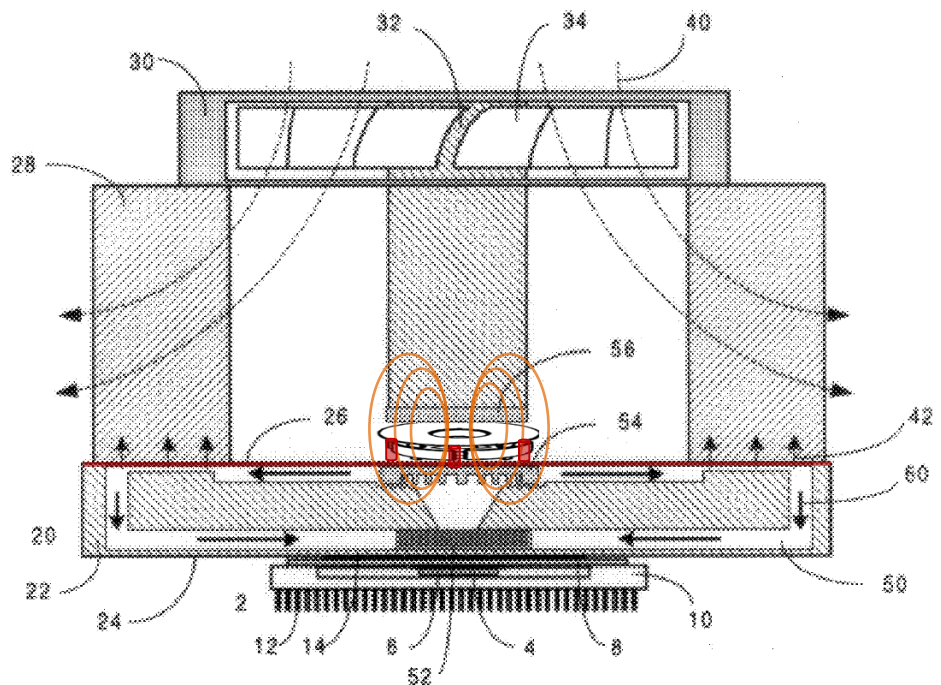
(“FIG. 9 shows various impeller designs, including a centrifugal pump, a displacement pump, a viscosity pump, and a flexure pump.”)

164. Batchelder further discloses “Fin means (28) attaches to the upper surface (26) of the top sheet (212). A fan housing (30), rotor (32), and fan blades (34) are attached to the top of the fin means, rotatably suspending a permanent magnet (56) adjacent to the impeller (54).” (Batchelder, 7:55-59.)

A POSITA would have understood that the rotatable impeller 54 is driven by the magnetic field emanated from the permanent magnet 56 attached to the rotor 32 that is part of the fan motor. (*Id.*, 6:5-18.) A POSITA would have also understood that the fan motor includes inside the fan housing 30 a stator (not shown), which is the fan motor’s stationary part that drives the rotor 32. A POSITA would have understood that the fan motor’s stator in the fan housing drives the rotor 32, which in turn drives the permanent magnet 56, which in turn drives the impeller 54. (Batchelder, 6:12-14.) That is, in Batchelder, the impeller 54 is not directly driven by the stator. Rather, the impeller is indirectly driven by the stator, which a POSITA would have understood can be improved upon. This is at least because the control over the impeller is better if driven directly by the stator, which can also provide a stronger, more effective rotating magnetic field. Thus, reading both Batchelder and Duan, a POSITA would have been motivated to adopt the location of Duan’s stator

(i.e., coil stage 221) by relocating Duan's stator to the top of the top sheet 212 and use the stator to drive both the impeller 54 and the permanent magnet 56 attached to the rotor 32. The magnet 56 can be adapted to be a mirror image of the permanent magnet in 54. The stator can then drive both of them directly. The magnet 56 will now drive the rotor 32 to operate the fan. The modified mechanism can still achieve the goal in Batchelder to drive the impeller and fan using the same motor, but can now drive both the impeller 54 and the fan's magnet 56 attached to the rotor 32 directly with the stator.

A POSITA would have had a reasonable expectation of success because it is just a straightforward exercise of rearranging the motor components



that requires only a few simple modifications, such as shortening the rotor 32 to allow space for the stator and adapting the permanent magnet 56 to be directly driven by the rotating magnetic field, as shown above-right. The magnetic field (orange) generated by the stator can be shared by both 54 and 56. Also, see below:

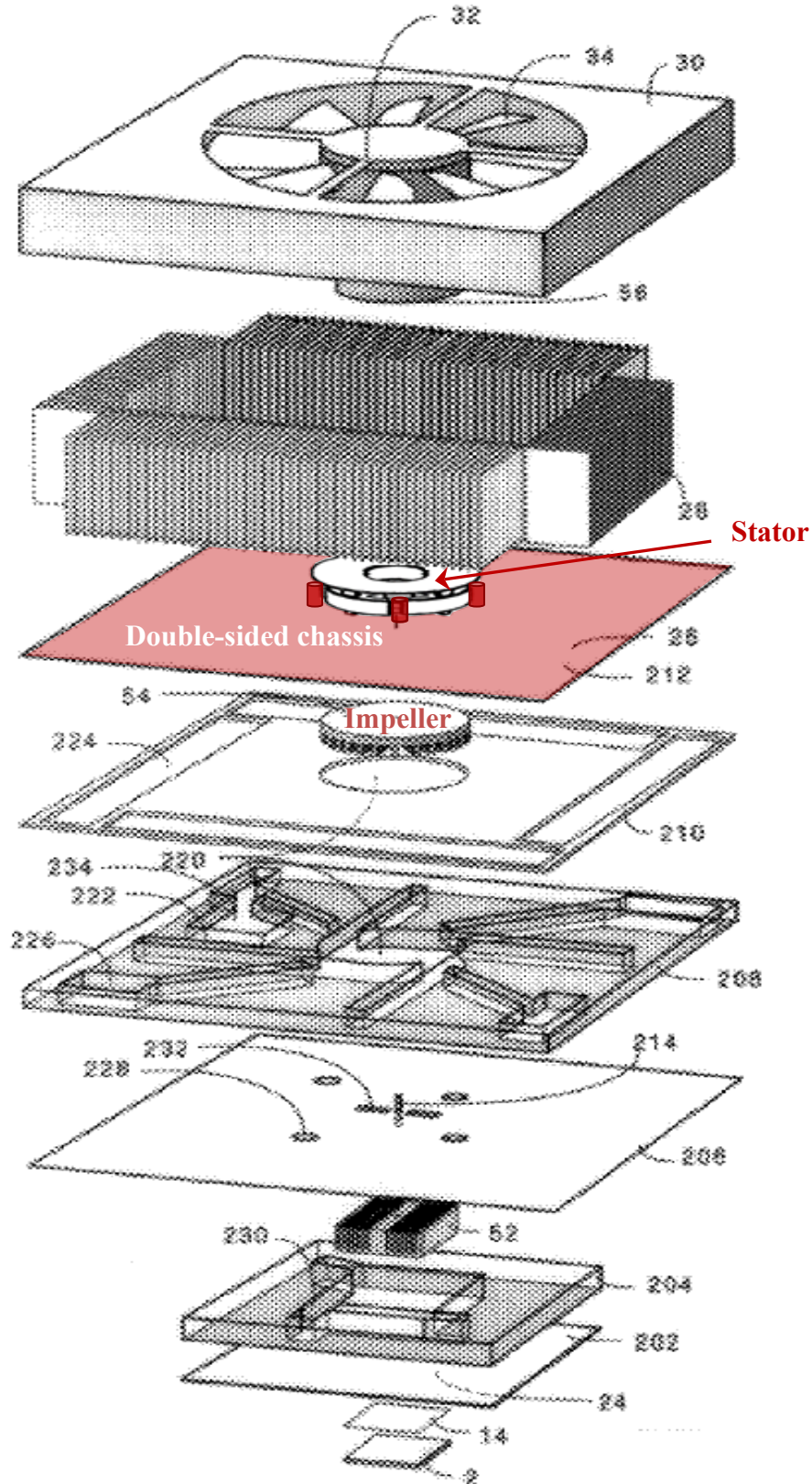
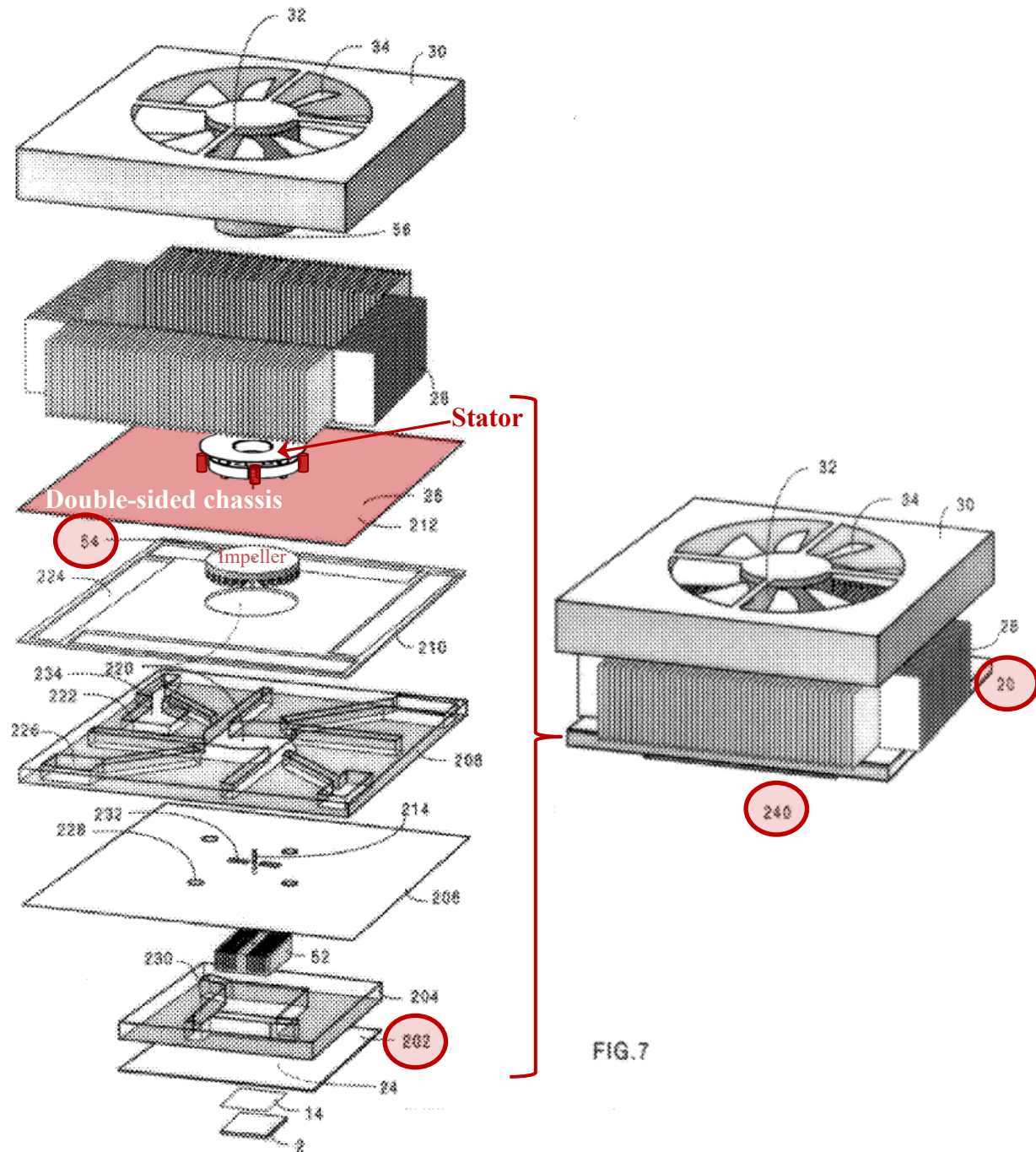


FIG. 7

165. As shown above, it would have been obvious to secure a stator (such as the coil stage 221 in Duan) onto the top sheet 212 with integrated fixtures therein to drive both the impeller 54 and the fan's magnet 56 directly and concurrently. The stator is positioned on the upper side of the chassis (top sheet 212) and isolated from the cooling liquid, just like the coil stage 221 in Duan. One of Batchelder's objectives was "to provide a heat sink design for electronic components that uses a single motor to impel atmospheric motion and the motion of an additional heat transfer fluid." (Batchelder, 2:52-55.) Positioning the stator above the double chassis, and the rotor actuating the fan, would help facilitate that objective.

**[1-b] "a reservoir adapted to pass the cooling liquid therethrough, the reservoir including:"**

166. Batchelder in view of Duan teaches this limitation.

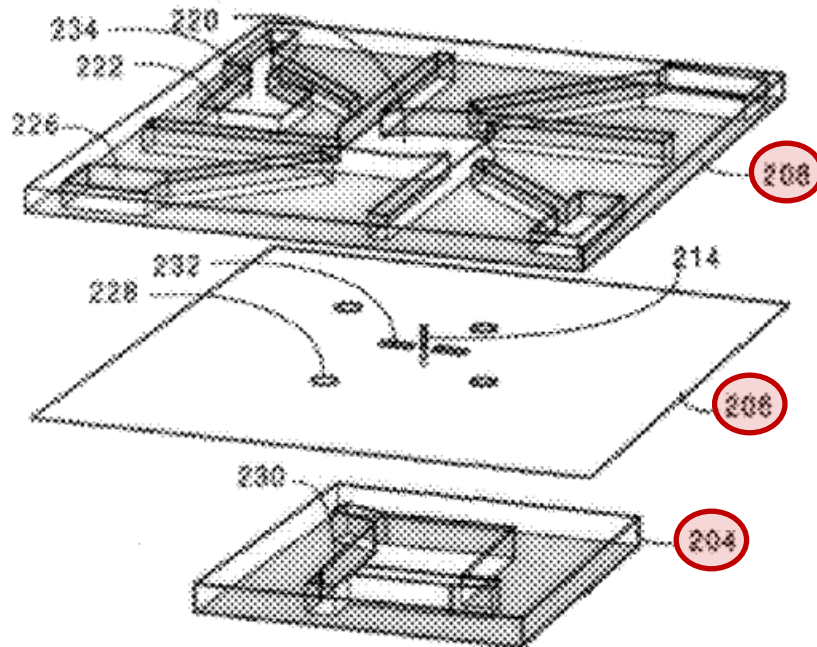


167. Batchelder's active spreader plate teaches a "reservoir"—i.e., a single receptacle defining a flow path and configured to circulate a cooling liquid

therethrough—as claimed in the '764 patent. Batchelder describes its active spreader plate as a “geometry” (Batchelder, 1:65) that can take various shapes, such as “a large hemispherical shell” (*id.*, at 3:49-51). Batchelder discloses that “[t]he lower stamped plate (204), the medial sheet (206), the upper stamped plate (204), 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.” (*Id.*, 7:52-55, 8:4-8.)

168. 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. (*Id.*, 8:8-12.) 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.*)

169. A POSITA would have understood that the lower stamped plate (204), medial sheet (206), and upper stamped plate (204), shown below, can be combined into a unitary “single receptacle” structure with injection molding.

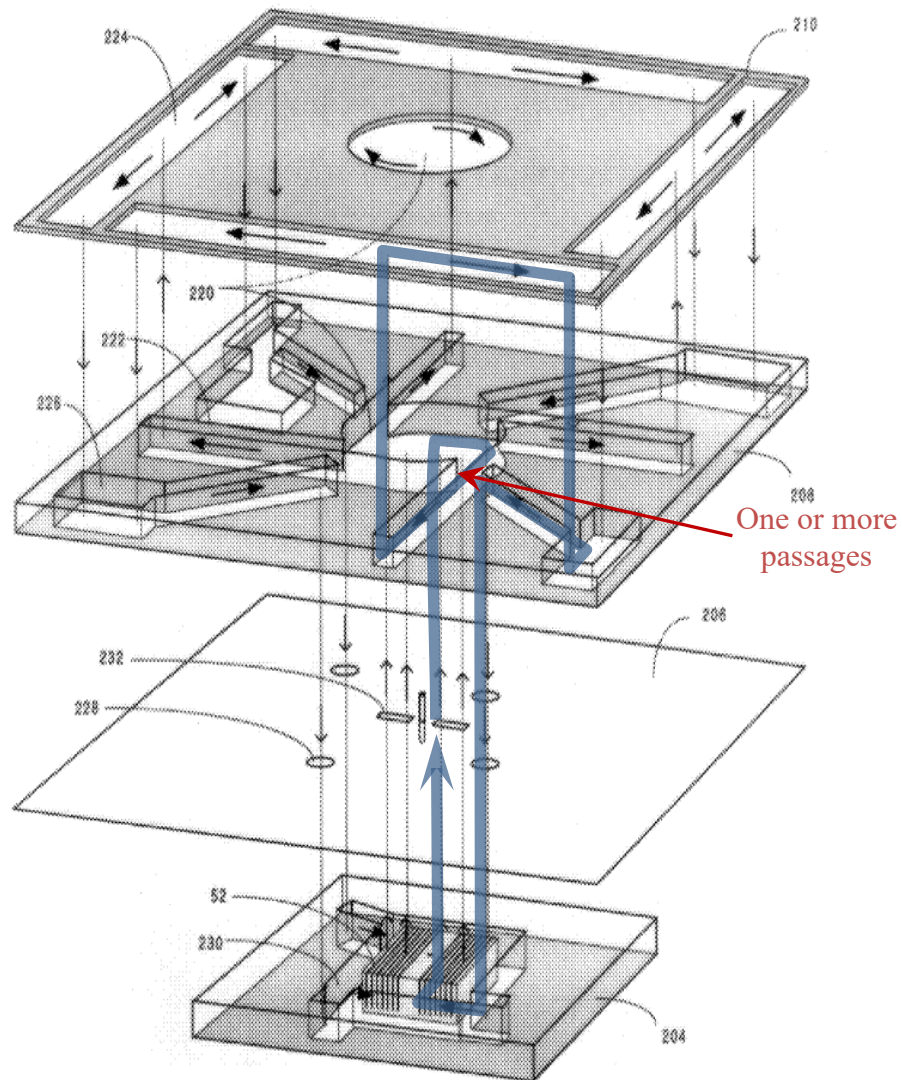


(Batchelder, FIG. 7 (excerpt) (shaded red circles added).)

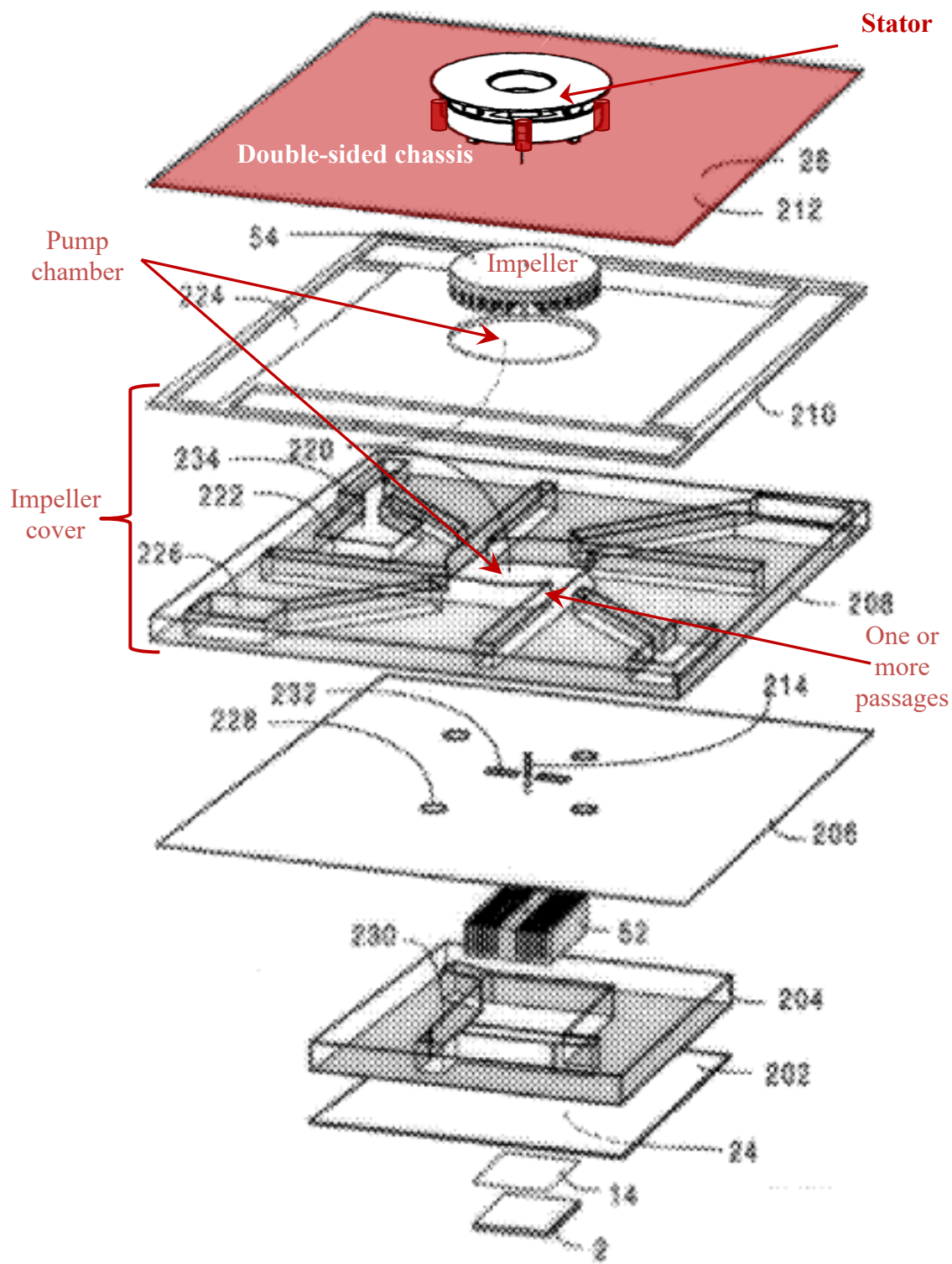
170. After the impeller 54 is placed in the coaxial cavities (220) (Batchelder, 7:46-48), the channel forming sheet (210) and the top sheet (212) in FIG. 7 can be further combined with this “single receptacle” using “ultrasonic bonding, solvent bonding, or welding” to fuse all of them together into a continuous, seamless, and permanently unitary structure that, as a whole, can be the “reservoir.” (*Id.*, 8:8-12.)

**[1-c] “a pump chamber including the impeller and formed below the chassis, the pump chamber being defined by at least an impeller cover having one or more passages for the cooling liquid to pass through”**

171. Batchelder in view of Duan teaches limitation [1-c].



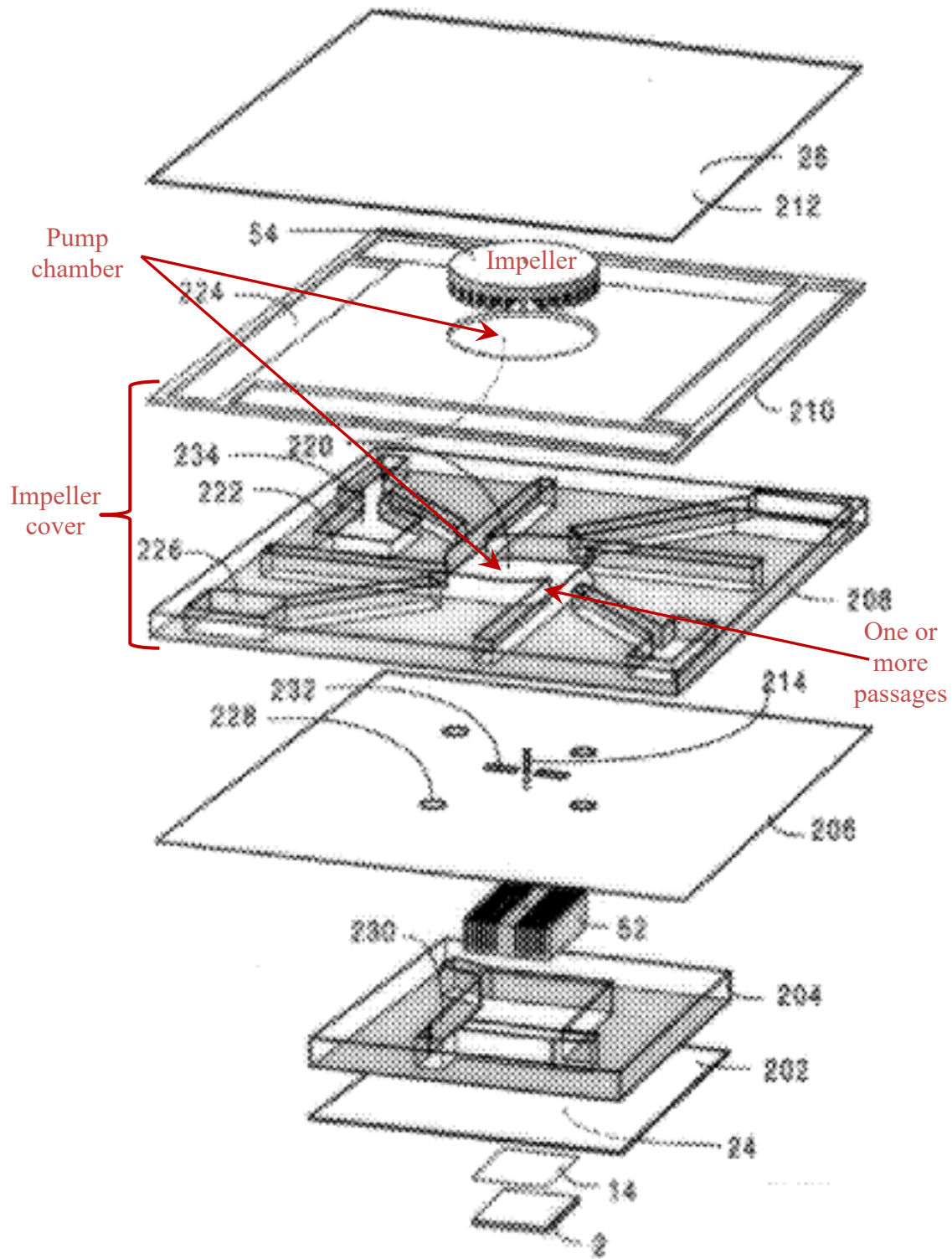
(Batchelder, FIG. 7 (modified and annotated excerpt).)



172. As shown, Batchelder’s “reservoir” has a pump chamber—i.e., the space in the channel forming sheet 210 and the upper stamped plate 208—including an impeller (54) defined by at least an impeller cover (channel forming sheet 210 and the upper stamped plate 208) having one or more passages for cooling liquid to pass through.

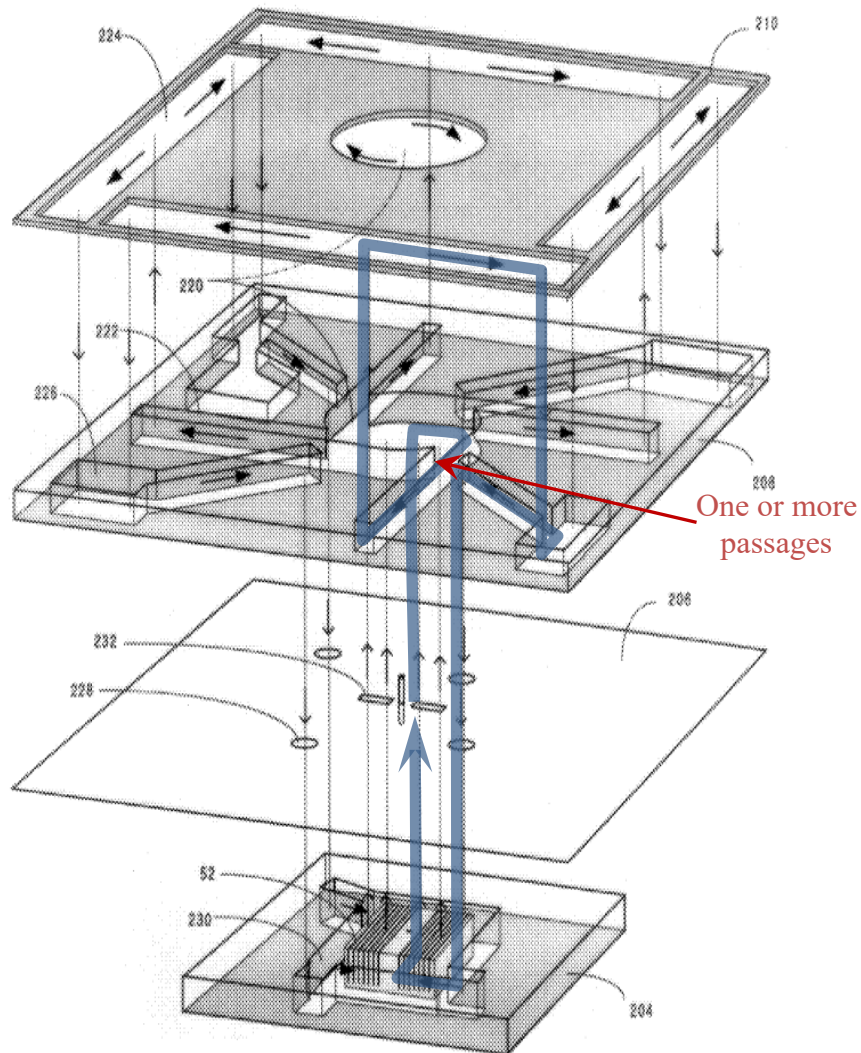
**[1-d] “a thermal exchange chamber formed below the pump chamber and vertically spaced apart from the pump chamber, the pump chamber and the thermal exchange chamber being separate chambers that are fluidly coupled together by the one or more passages; and”**

173. Batchelder in view of Duan teaches limitation [1-d].



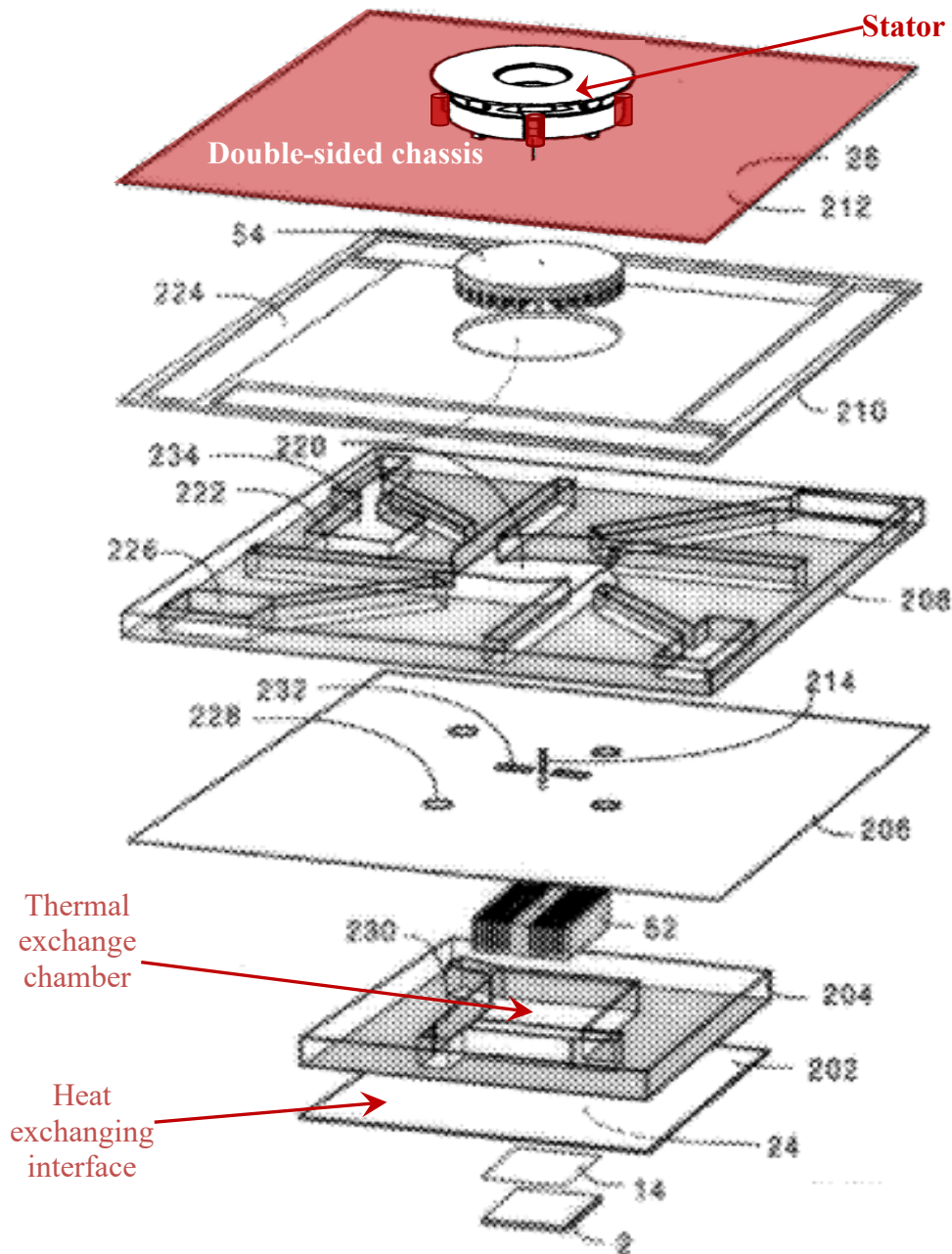
(Batchelder, FIG. 7 (annotated, modified, excerpt).)

174. In addition to a pump chamber (discussed above), Batchelder also discloses or teaches a thermal exchange chamber (or compartment)—i.e., the center space in the lower stamped plate 204 in FIGS. 7 and 8. The pump and thermal exchange chambers are vertically displaced and separated from each other by medial sheet 206, and fluidly coupled by one or more passages (holes 228 and slots 232).



**[1-e] “a heat-exchanging interface, the heat-exchanging interface forming a boundary wall of the thermal exchange chamber, and configured to be placed in thermal contact with a surface of the heat-generating component; and”**

175. Batchelder in view of Duan teaches limitation [1-e].



(Batchelder, FIG. 7 (excerpt).)

176. Batchelder's heat-exchanging interface (bottom surface 24) forms a boundary of the thermal exchange chamber, as shown in the annotated figures above.

177. As would be understood to a POSITA, the heat-exchanging interface is also configured to be placed in thermal contact with a surface of the heat-generating component (heat source 2). (See Batchelder, 7:30-33 (“Heat from the heat source passes through the bottom surface (24) of the bottom sheet (202) and into a fin means (52) attached to the top surface of the bottom sheet (202).”).)

**[1-f] “a heat radiator fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid.”**

178. As discussed below, Duan disclosed or suggested a heat radiator fluidly coupled to the reservoir and configured to dissipate heat from the cooling liquid, and it would have been obvious to a POSITA to modify Batchelder’s devices to include such a heat radiator.

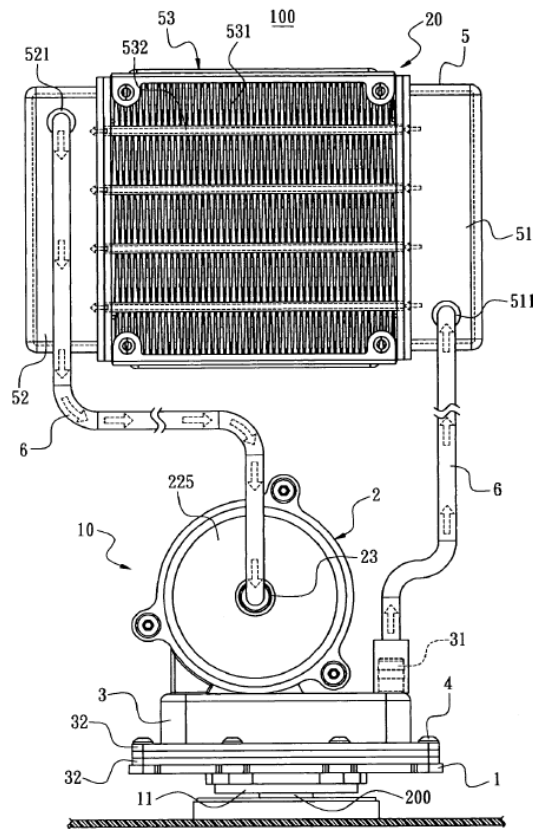


FIG. 6

(Duan, FIG. 6.)

179. Duan discloses that:

[T]he water tank 20 of the liquid cooling cyclic mechanism 100 comprises a box 5 with a liquid entrance region 51 and a liquid exit region 52 provided on both sides of the water tank 20, respectively. The box 5 comprises a cooling stage 53 at center thereof and composed of a plurality of stacked heat-dissipating fins 531 arranged in rows. Runners 532 are defined between rows of the heat-dissipating fins 531; both ends of the runner 532 are communicated with the liquid entrance region 51 and the liquid exit region 52.

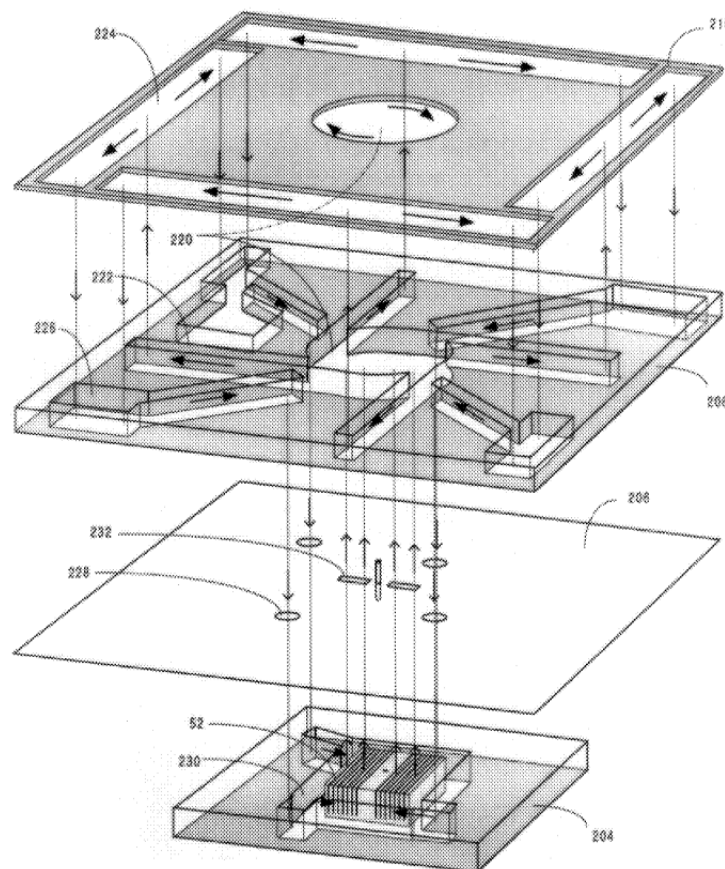
(Duan, [0025].)

180. It would have been obvious to a POSITA to connect Batchelder's heat spreader plate to a radiator, a well-known component used to transfer thermal energy (i.e., heat) from one medium to another. As the cooling liquid in the lower chamber heats up, a POSITA would have been motivated to use an external radiator to help further cool the heated cooling liquid, which is a conventional technique known to a POSITA, before the cooling liquid returns to the pump.

181. A POSITA would have been motivated to combine Duan with Batchelder to further increase heat management efficiency by using an external radiator that cools the heated cooling liquid via "heat-dissipating fins." (Duan, [0025].) This technique allows heat to escape the system more efficiently. Adding a radiator to Batchelder would have been an obvious modification to improve Batchelder's objective of cooling electronic components. (Batchelder, 2:46-50.)

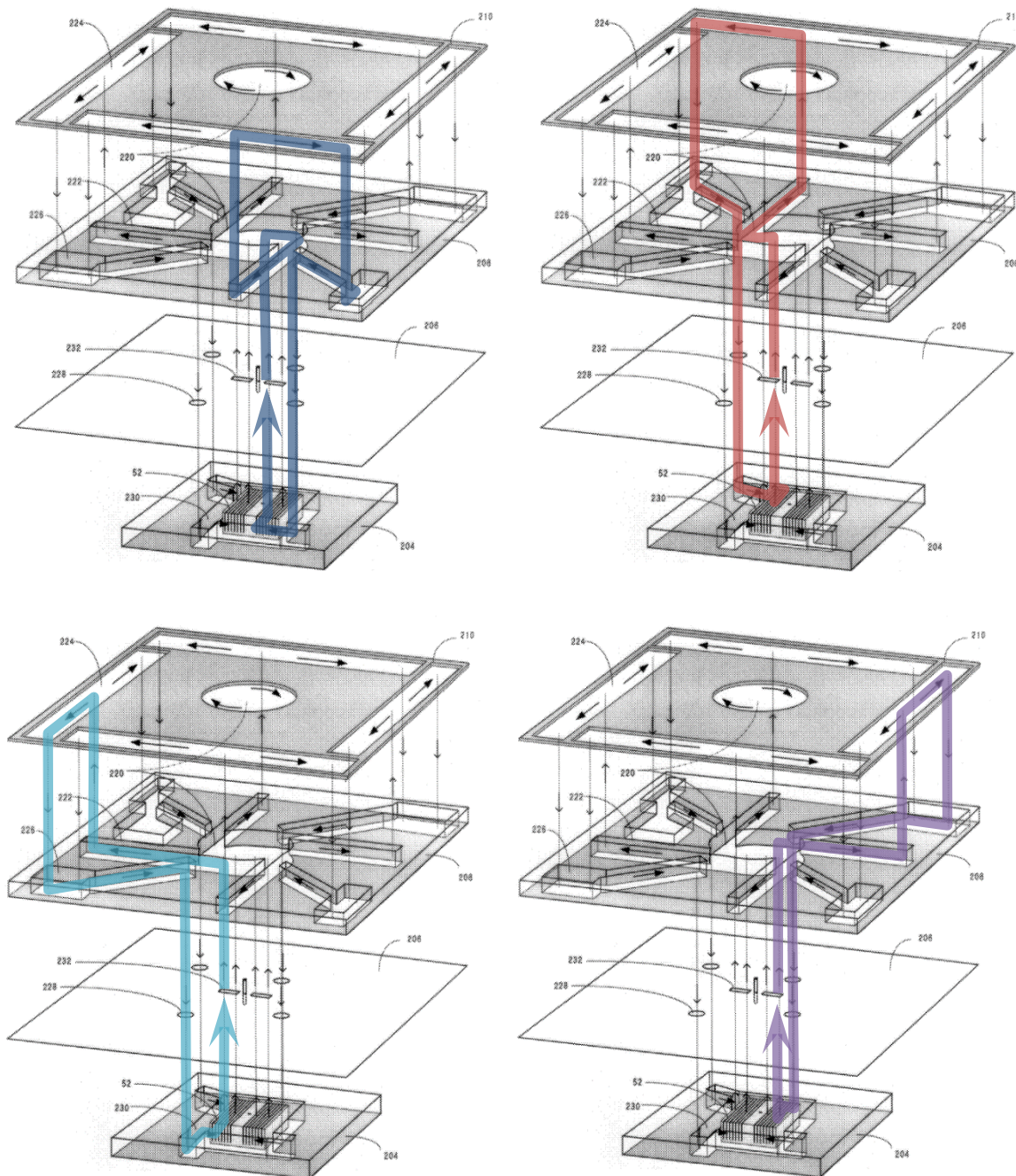
182. A POSITA would have also been motivated to modify Batchelder in view of Duan to add an external radiator when the heat load is too high for Batchelder's existing heat spreader plate. Batchelder recognized that heat-generating components will continue to advance and produce more heat. (Batchelder, 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 Duan to add heat dissipation in FIGS. 7 and 8 of Batchelder.



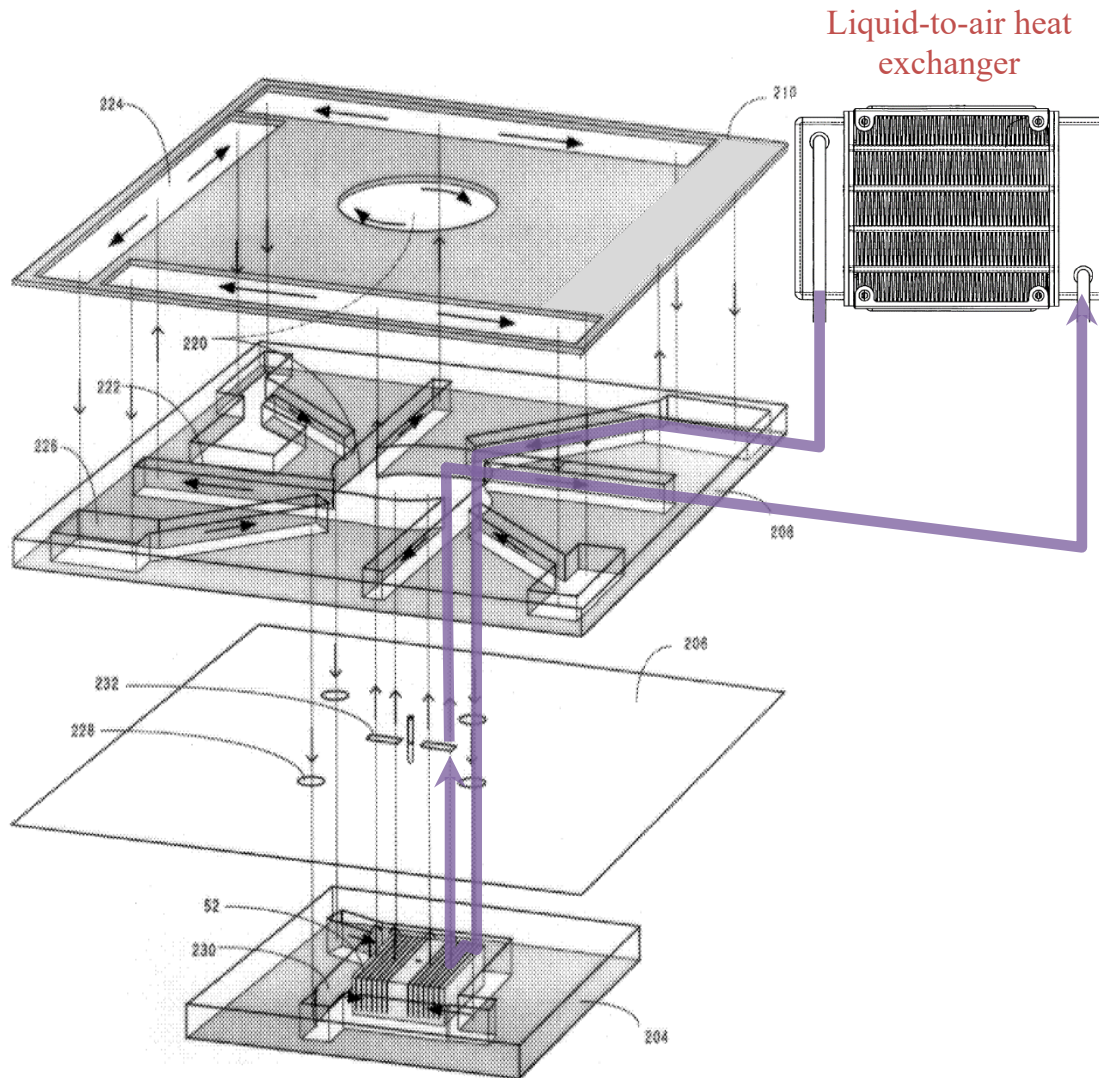
(Batchelder, FIG. 8.)

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



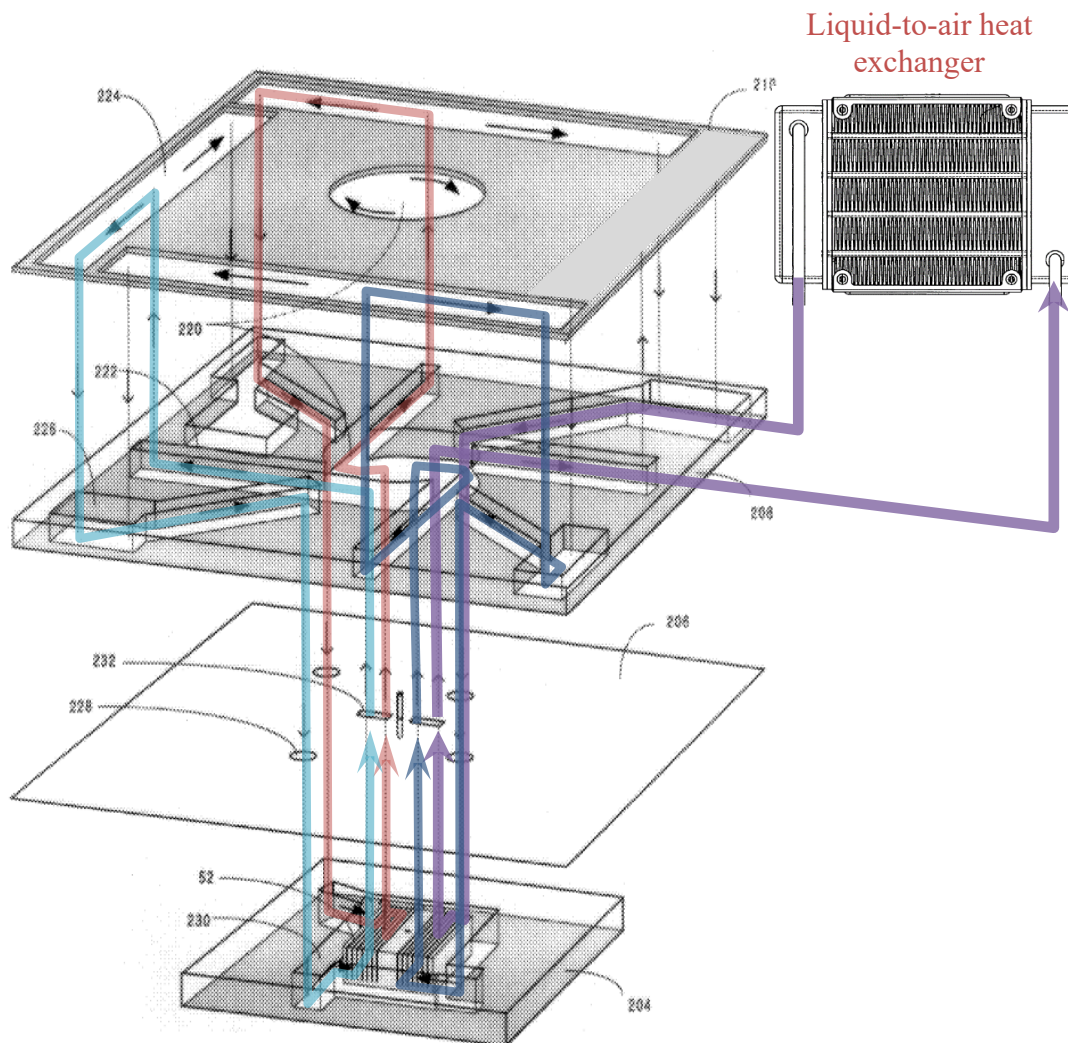
184. A POSITA would have known how to, and would have been motivated

to, modify one of the four exemplary looped flow paths in Batchelder's Figure 8 in view of Duan to connect Batchelder's "reservoir" to an external radiator with a reasonable expectation of success as follows:



185. 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 Duan, to become the following system:



186. Accordingly, a POSITA would have been motivated to modify Batchelder in view of Duan to incorporate a radiator into the embodiment in FIGS. 7 and 8, and would have had a reasonable expectation of success in doing so.

187. For the reasons discussed above, Batchelder in view of Duan renders

limitation [1-f] obvious.

188. 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.

189. 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.

190. 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.)

\* \* \*

191. For at least the reasons stated above, Batchelder and Duan teach or suggest each limitation of claim 1 and render it obvious.

**2. Batchelder teaches each limitation of claims 2-9.**

**[Claim 2] “The cooling system of claim 1, wherein the chassis shields the stator from the cooling liquid in the reservoir.”**

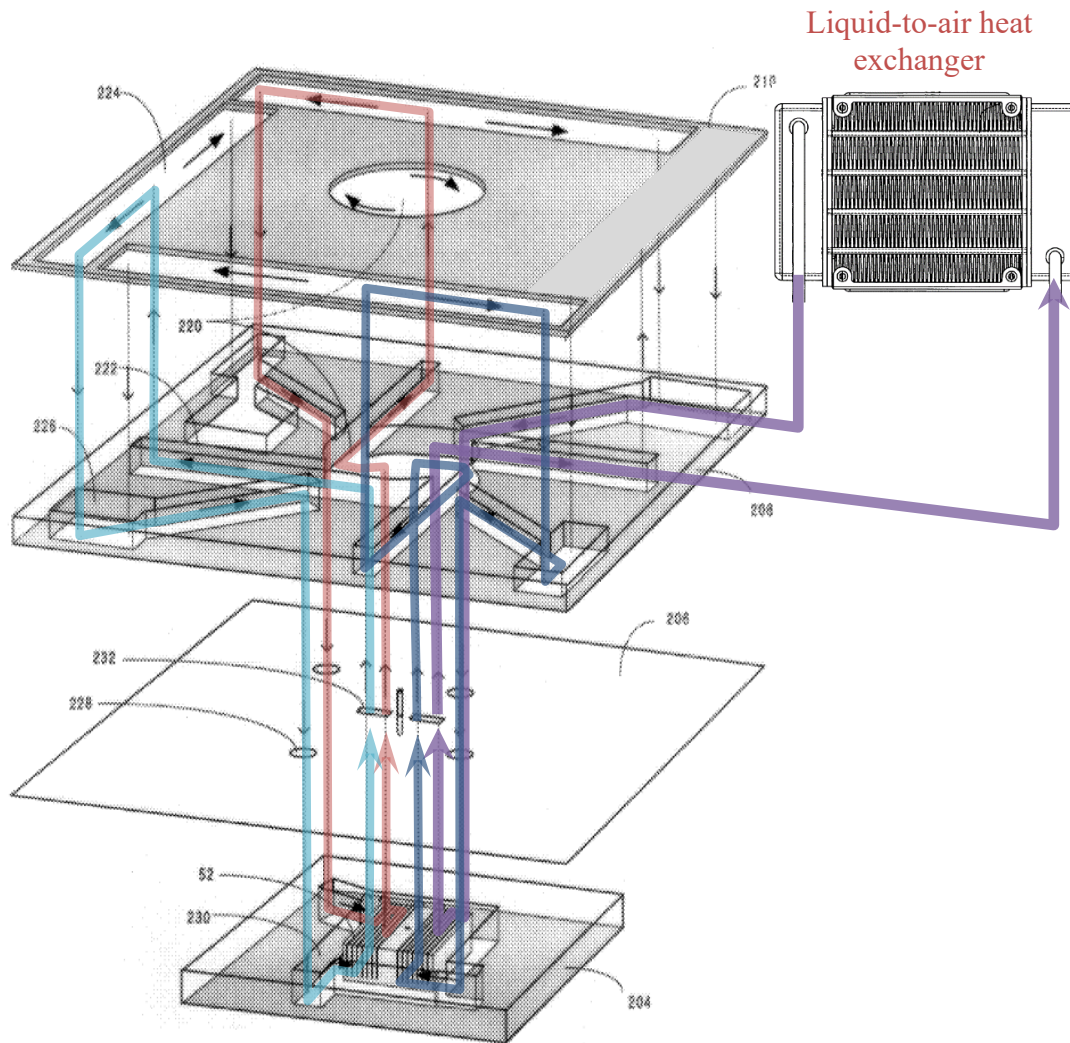
192. Batchelder in view of Duan teaches or renders obvious the limitation that the stator is positioned on the upper side of the chassis (top sheet 212) and isolated from the cooling liquid, as discussed above with respect to [1-a], hereby incorporated by reference. For the same reason, Batchelder teaches or renders obvious the limitation in claim 2 that “the chassis shields the stator from the cooling liquid in the reservoir.”

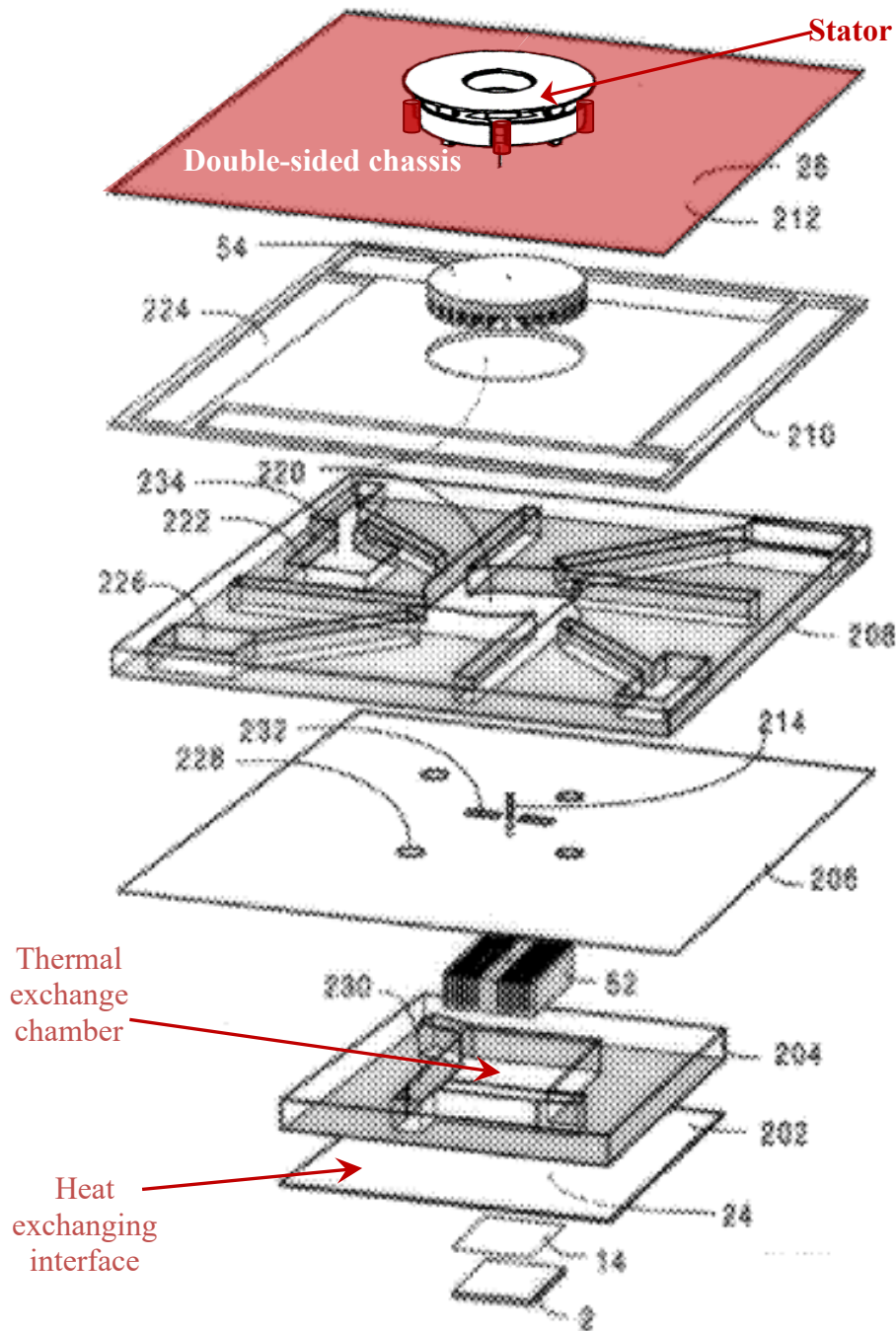
**[Claim 3] “The cooling system of claim 1, wherein the heat-exchanging interface includes a first side and a second side opposite the first side, and wherein the heat-exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side and the heat-exchanging interface**

**is configured to be in thermal contact with the surface of the heat-generating component on the second side.”**

193. Batchelder in view of Duan teaches a heat-exchanging interface that forms a boundary of thermal exchange chamber and that is positioned in thermal contact with the heat-generating component for the same reason as discussed above with respect to limitation [1-e], hereby incorporated by reference.

194. The heat-exchanging interface contacts the cooling liquid in the thermal exchange chamber on the first side (top side of bottom sheet 24) and is configured to be in thermal contact with the surface of the heat-generating component (2) on the second side (bottom side of bottom sheet 24), as shown in the figure below:





(Batchelder, FIG. 8 (modified); FIG. 7 (excerpt); *Id.*, 7:30-33.)

195. For the reasons discussed above, Batchelder teaches or suggests the

limitations of claim 3, and Batchelder in view of Duan render claim 3 obvious.

**[Claim 4] “The cooling system of claim 3, wherein the first side of the heat-exchanging interface includes features that are adapted to increase heat transfer from the heat-exchanging interface to the cooling liquid in the thermal exchange chamber.”**

**[Claim 5] “The cooling system of claim 4, wherein the features include at least one of pins or fins.”**

196. Batchelder in view of Duan teaches the limitations of claims 4 and 5.

197. 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 transferred 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.)

198. Batchelder’s FIG. 6 discloses various “fin means” including fins 112 and pins 102:

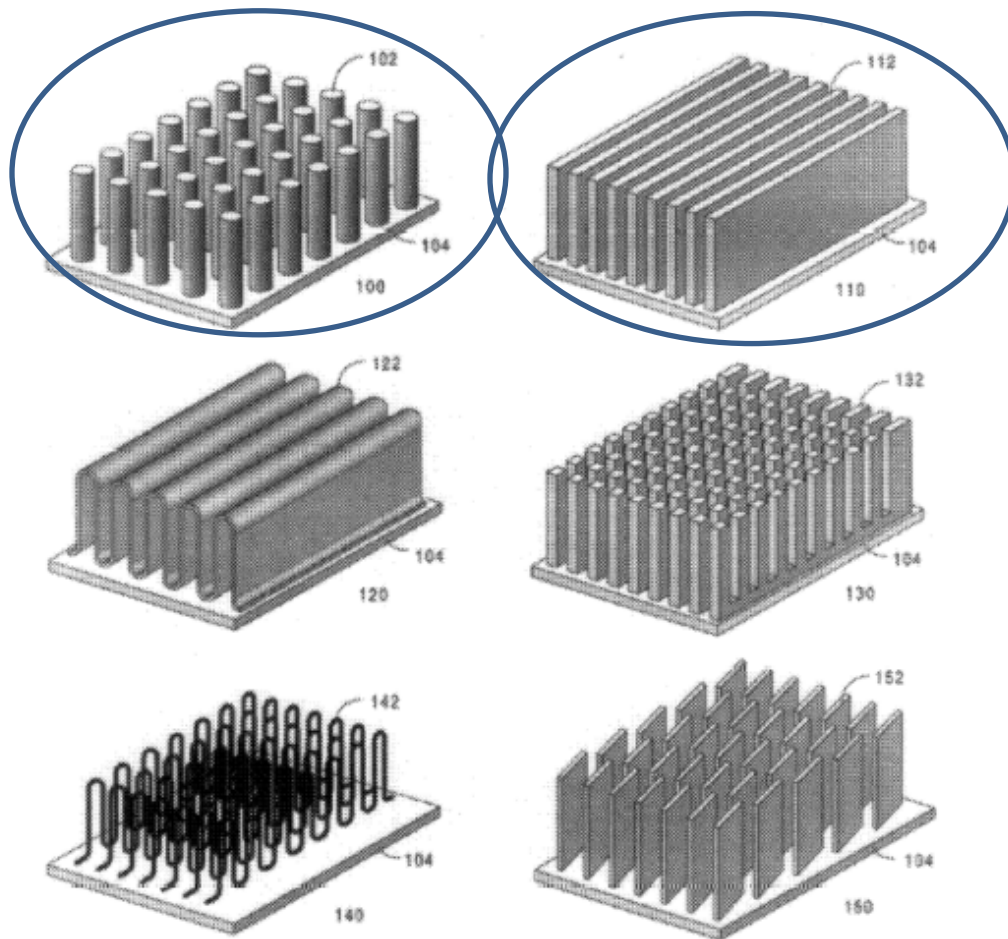


FIG. 6

(Batchelder, FIG. 6, 7:4-8.)

199. A POSITA would have understood that the fins or pins are positioned on the first side of the heat-exchanging interface. The fins or pins are adapted to increase heat transfer by “increase[ing] the effective area of contact between a heat transfer fluid such as the atmosphere and one or more surfaces (104).” (Batchelder,

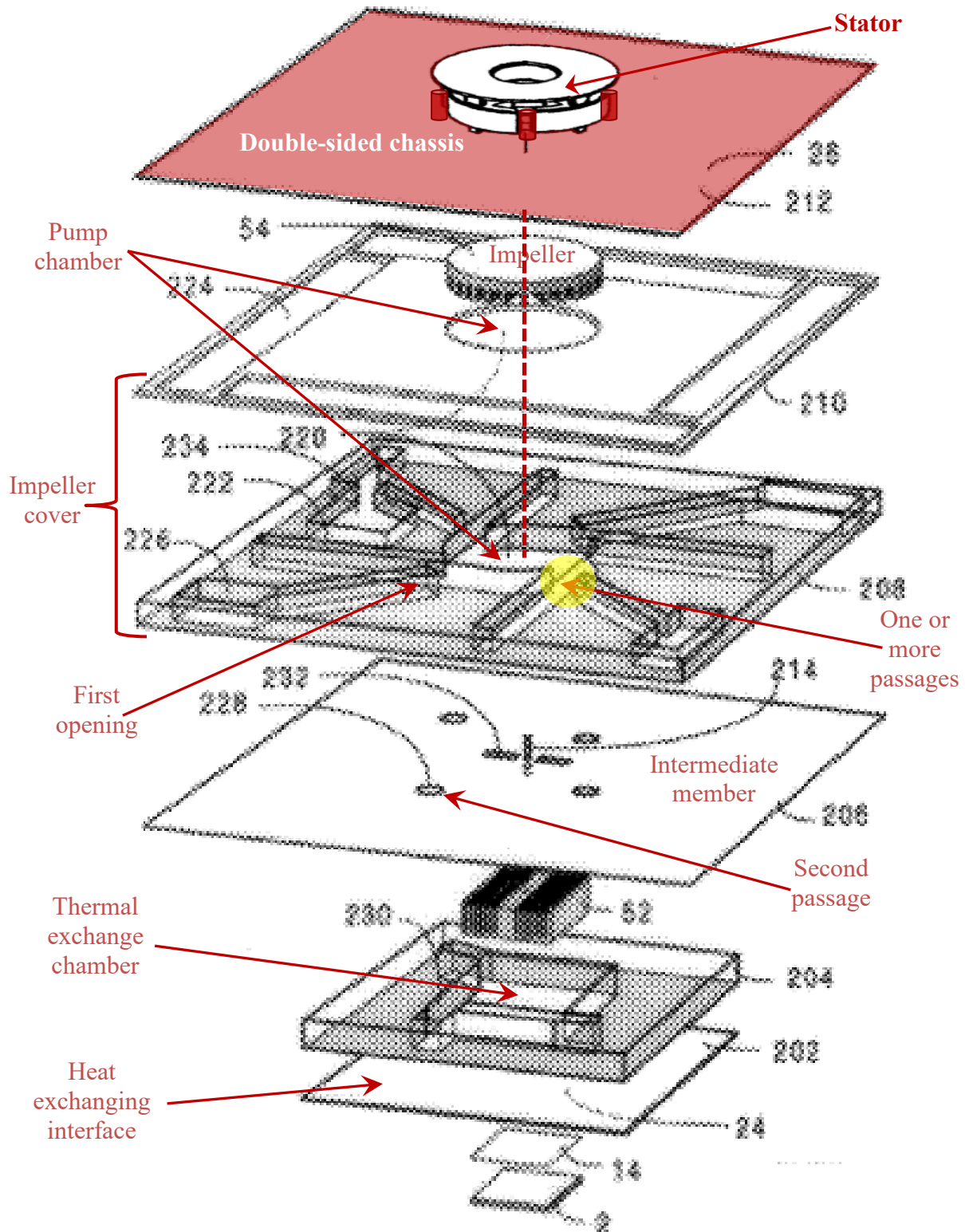
7:11-14.)

200. For the reasons discussed above, Batchelder teaches or suggests the limitations of claims 4 and 5, and Batchelder in view of Duan render claims 4 and 5 obvious.

**[Claim 6] “The cooling system of claim 1, wherein a passage of the one or more passages that fluidly couple the pump chamber and the thermal exchange chamber is offset from a center of the impeller.”**

201. Batchelder in view of Duan teaches the pump and thermal exchange chambers that are fluidly coupled by one or more passages, as discussed above with respect to limitation [1-d], hereby incorporated by reference.

202. A passage (highlighted in yellow) of the one or more passages is “offset from a center of the impeller”, as shown in the figures below:



(Batchelder, FIG. 7.)

**[Claim 7] “The cooling system of claim 1, wherein the impeller includes a plurality of curved blades.”**

203. Batchelder in view of Duan teaches the limitations of claim 7.

204. As taught by Batchelder, different pumps can be used as the impeller 54 in the active spreader plate 20 in Figure 2. In the embodiment shown in Figure 2 of Batchelder, “the impeller (54) is a centripetal or centrifugal pump[.]” (Batchelder, 5:26-32.) Batchelder also discloses that the “centripetal or centrifugal pump 300,” shown 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” (i.e., item 20 of FIG. 2) (*Id.*, 8:14-15, 8:36-47):

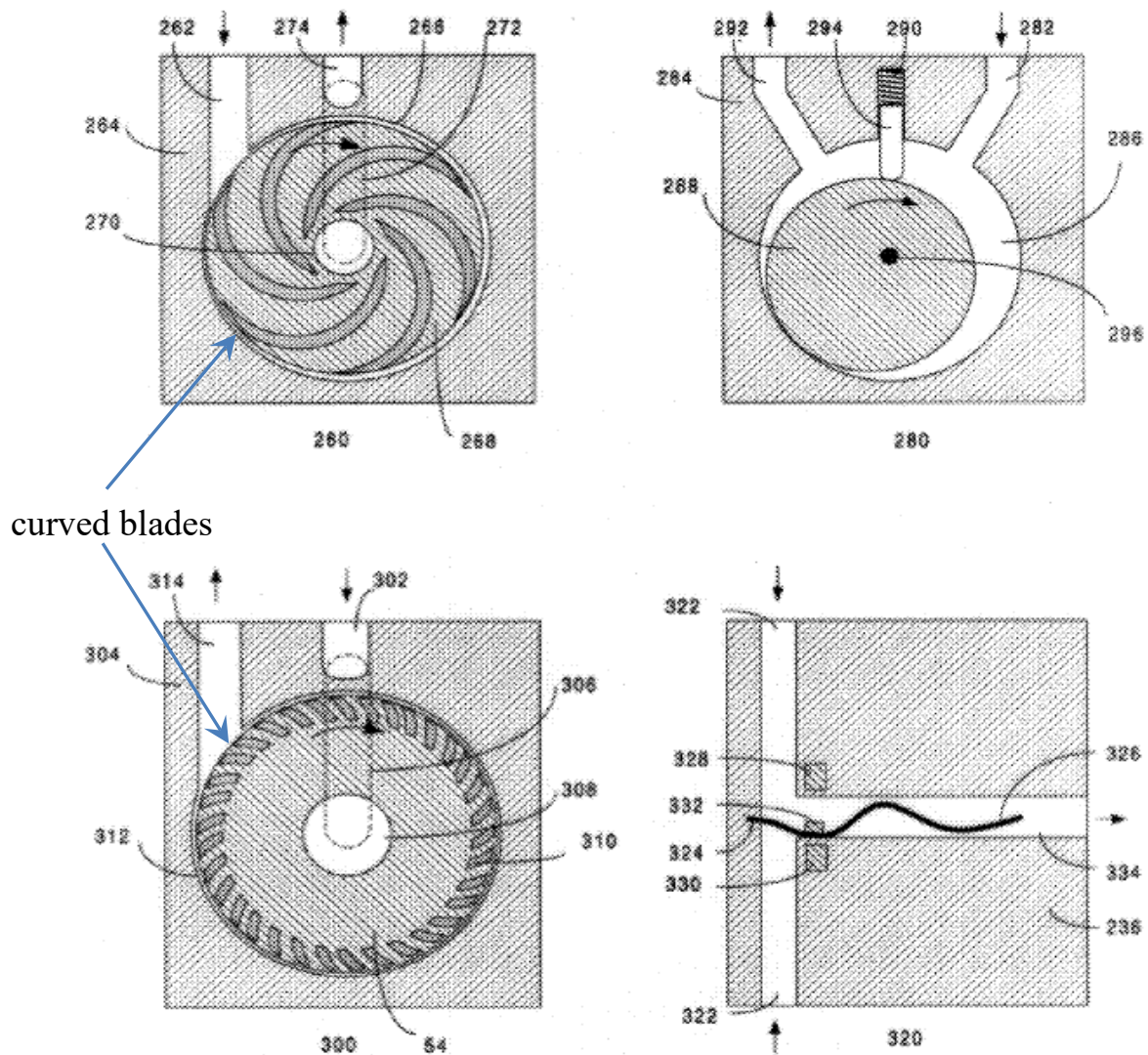


FIG. 9

205. As can be seen above and below, when either the “viscosity pump 260” (top left) or the “centripetal or centrifugal pump 300” (bottom left) is adopted for impeller 54, the “rotatable impeller 54” has a plurality of curved blades. (Batchelder, 8:14-27, 8:36-47.)

**[Claim 8] “The cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum.”**

206. Batchelder in view of Duan teaches a heat-exchanging interface, as discussed above with respect to limitation [1-e], hereby incorporated by reference. Batchelder discloses that the components of its cooling system can be formed from plastic, metal, or a combination of the two. (Batchelder, 4:9-19.) Batchelder recognizes that aluminum and copper are typically used in constructing spreader plates. (*Id.*, 4:44-47 (“The passive spreader plate is typically aluminum owing to aluminum’s good thermal conductivity, low cost, and low weight. Other materials used for the spreader plate are steel, copper, pyrolytic graphite composite, and diamond, in order of increasing performance and increasing cost.”)) Batchelder also discloses that the fins of the heat-exchanging interface “are preferably composed of aluminum, and can also be formed using...copper....” (*Id.*, 7:16-19.) Accordingly, Batchelder teaches or suggests that the heat-exchanging interface includes copper or aluminum.

207. It also would be obvious to a POSITA to use copper or aluminum because they are used extensively in electronics cooling applications due to their high thermal conductivity (especially copper) and low cost (especially aluminum).

A POSITA would have been motivated to use a copper or aluminum for the heat-exchanging interface to increase heat transfer between the cooling liquid and the heat-generating component. In addition, it also would have been obvious to try using copper or aluminum, as they are well-known materials for constructing cooling systems and a POSITA reasonably would have expected them to work.

**[Claim 9] “The cooling system of claim 1, wherein the heat radiator is fluidly coupled to the reservoir using flexible conduits, and the heat radiator is configured to be positioned remote from the reservoir.”**

208. Batchelder in view of Duan teaches claim 9. Duan discloses a heat radiator fluidly coupled (via ducts 6) to a reservoir, as discussed with respect to limitation [1-f], hereby incorporated by reference. Although Duan does not explicitly disclose that the duct 6 is flexible, a POSITA would have been motivated to use flexible tubing such as rubber tubing to facilitate assembly.

**3. Batchelder and Duan teach each limitation of claim 10 and render it obvious.**

**[10-PRE] “A cooling system for a computer system, comprising:”**

209. Batchelder in view of Duan teaches [10-PRE] for the same reasons discussed above for [1-PRE], hereby incorporated by reference.

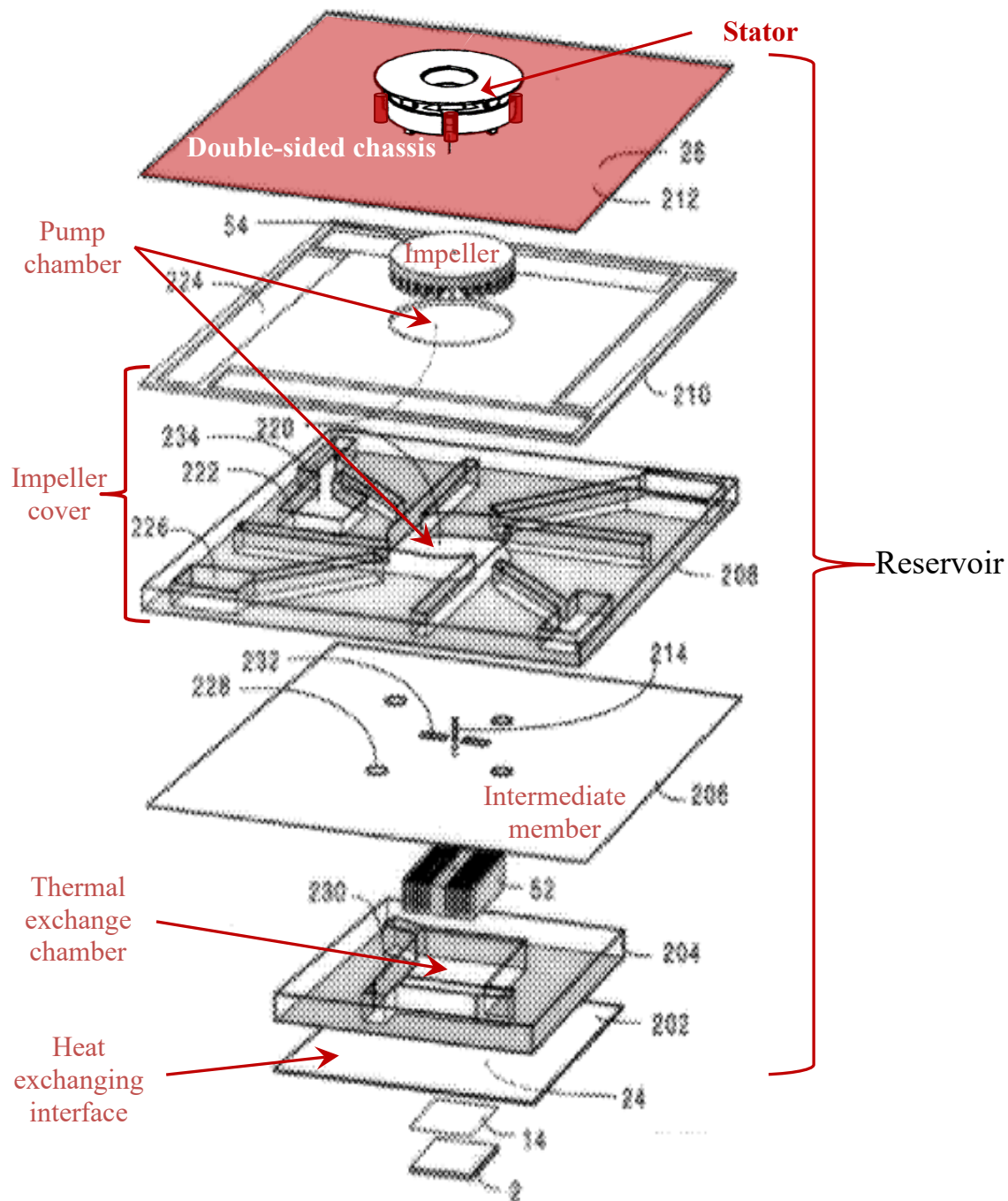
**[10-a] “a centrifugal pump adapted to circulate a cooling liquid, the pump including: an impeller exposed to the cooling liquid; and a stator isolated from the cooling liquid:”**

210. Batchelder in view of Duan renders obvious a pump adapted to circulate

cooling liquid, including an impeller exposed to the liquid and a stator isolated from it, as discussed above for [1-a], hereby incorporated by reference. Batchelder discloses that, “[i]n the most preferred embodiment, the impeller (54) is a centripetal or centrifugal pump[.]” (Batchelder, 5:26-32.) Accordingly, Batchelder teaches or suggests limitation [10-a].

**[10-b] “a reservoir configured to be thermally coupled to a heat-generating component of the computer system, the reservoir including:”**

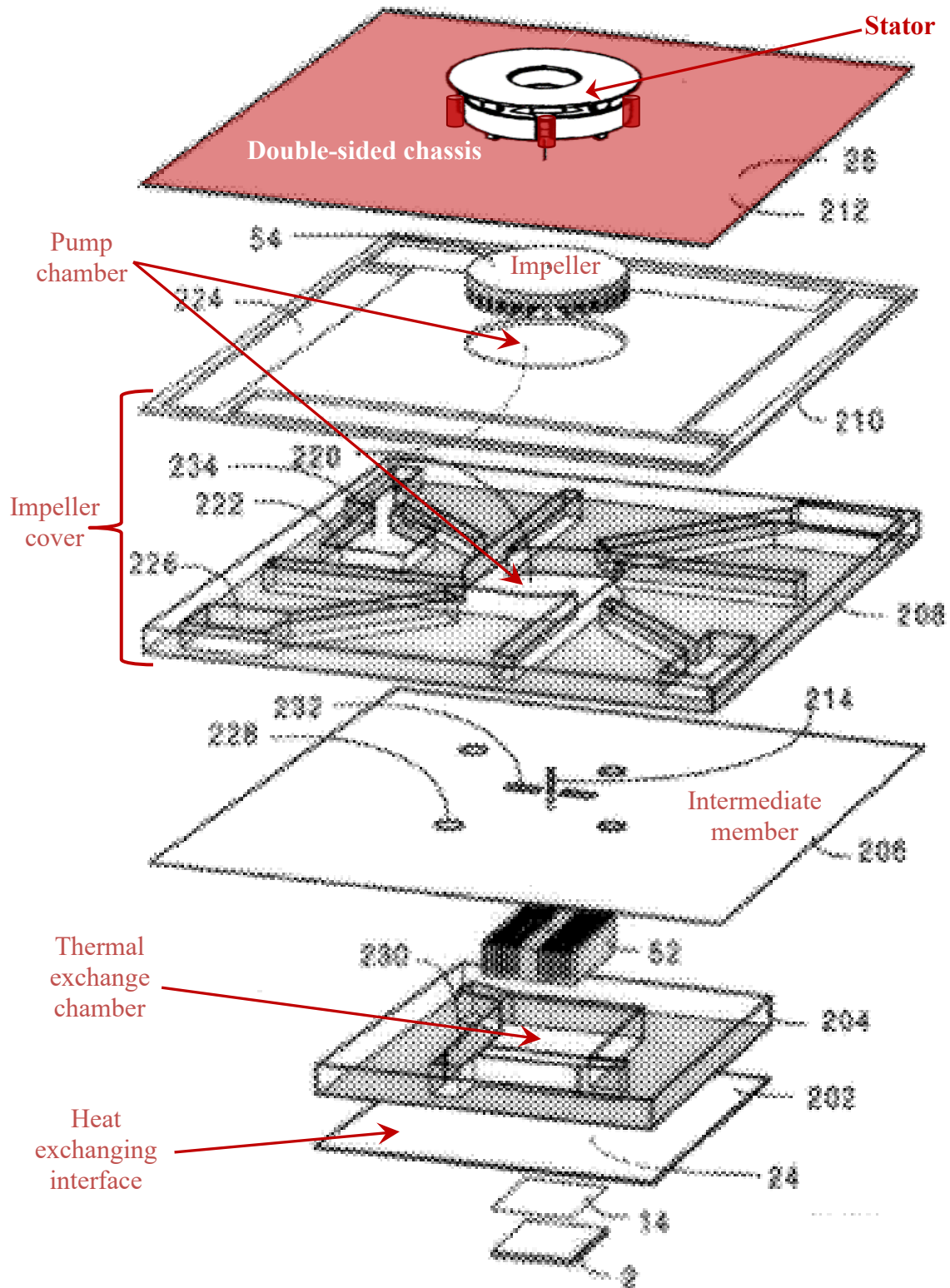
211. Batchelder in view of Duan teaches a reservoir for the same reasons discussed above for [1-b], hereby incorporated by reference. Batchelder’s reservoir, which includes, is thermally coupled to a heat-generating component of the computer system (2), as shown below:



(Batchelder, FIG. 7 (annotated excerpt; *see also* [1-e] above.)

**[10-c] “a thermal exchange chamber adapted to be positioned in thermal contact with the heat-generating component;”**

212. Batchelder in view of Duan teaches a thermal exchange chamber for the same reasons discussed above for [1-d], hereby incorporated by reference. Batchelder’s thermal exchange chamber is positioned in thermal contact with the heat-generating component:



(Batchelder, FIG. 7.)

213. Batchelder also discloses that (“Heat from the heat source passes through the bottom surface (24) of the bottom sheet (202) and into a fin means (52) attached to the top surface of the bottom sheet (202).” (Batchelder, 7:30-33.)

**[10-d] “a separate pump chamber vertically spaced apart from the thermal exchange chamber and coupled with the thermal exchange chamber through one or more passages configured for fluid communication between the pump chamber and the thermal exchange chamber, and.”**

214. Batchelder in view of Duan teaches limitation [10-d] for the same reasons discussed above for limitations [1-c] and [1-d], hereby incorporated by reference.

**[10-e] “wherein at least one of the one or more passages is offset from a center of the impeller.”**

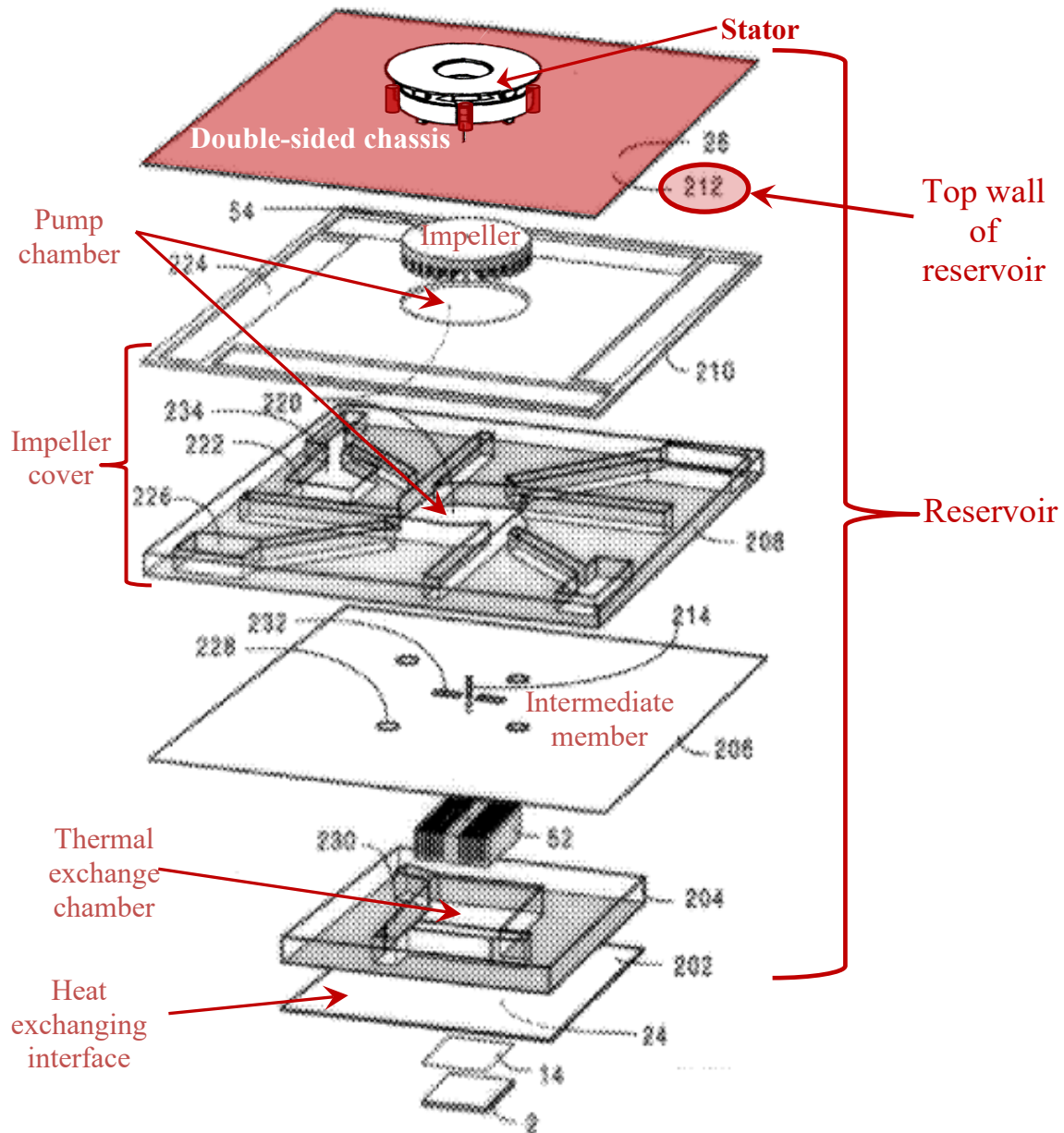
215. Batchelder in view of Duan teaches limitation [10-e] for the same reasons discussed above for claim 6, hereby incorporated by reference.

216. For at least the reasons stated above, Batchelder and Duan teach each limitation of claim 10 and render it obvious.

**4. Batchelder and Duan disclose or teach each limitation of claims 11-14.**

**[Claim 11] “The cooling system of claim 10, wherein a top wall of the reservoir physically separates the impeller from the stator:”**

217. Batchelder in view of Duan teaches claim 11. Batchelder teaches a reservoir bounded on the top by top sheet (212), as discussed above for [1-b], hereby incorporated by reference. Batchelder also renders obvious a pump having an impeller and stator that are physically separated, as discussed above for [1-a], hereby incorporated by reference. As shown below, the top wall of the reservoir (top sheet 212) physically separates the impeller and stator:



**[Claim 12] “The cooling system of claim 10, wherein the thermal exchange chamber includes a heat-exchange interface configured to be placed in thermal contact with the heat-generating component.”**

218. Batchelder in view of Duan teaches claim 12 for the same reasons

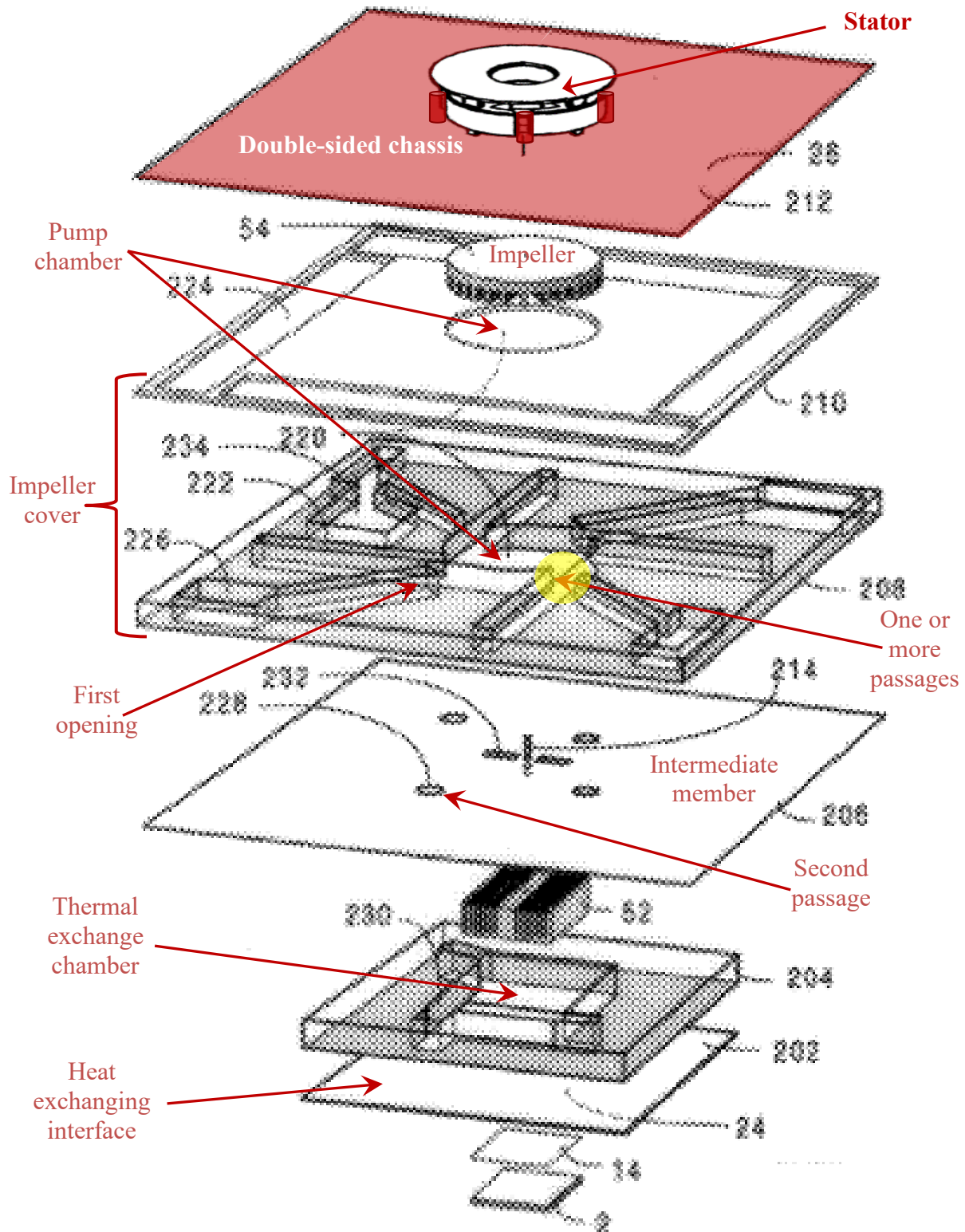
discussed above for limitation [1-e], hereby incorporated by reference.

**[Claim 13] “The cooling system of claim 10, further including a heat radiator fluidly coupled to the reservoir using flexible conduits, wherein the heat radiator is configured to be positioned remote from the reservoir.”**

219. Batchelder in view of Duan teaches claim 13 for the same reasons discussed above for limitation [1-f] and claim 9, hereby incorporated by reference.

**[Claim 14] “The cooling system of claim 10, wherein the fluid passage that is offset from the center of the impeller is positioned tangentially to the circumference of the impeller.”**

220. Batchelder in view of Duan teaches claim 14 for the same reasons discussed above for claim 6, hereby incorporated by reference. Batchelder’s offset passage is positioned tangentially to the circumference of the impeller (54), as shown below:



**5. Batchelder and Duan disclose or teach each limitation of claim 15 and render it obvious.**

**[15-PRE] “A cooling system for a heat-generating component, comprising:”**

221. Batchelder in view of Duan teaches limitation [15-PRE] for the same reasons discussed above for limitation [1-PRE], hereby incorporated by reference.

**[15-a] “a pump adapted to circulate a cooling liquid, the pump including: an impeller exposed to the cooling liquid; and a stator isolated from the cooling liquid;”**

222. Batchelder in view of Duan teaches limitation [15-a] for the same reasons discussed above for limitation [1-a], hereby incorporated by reference.

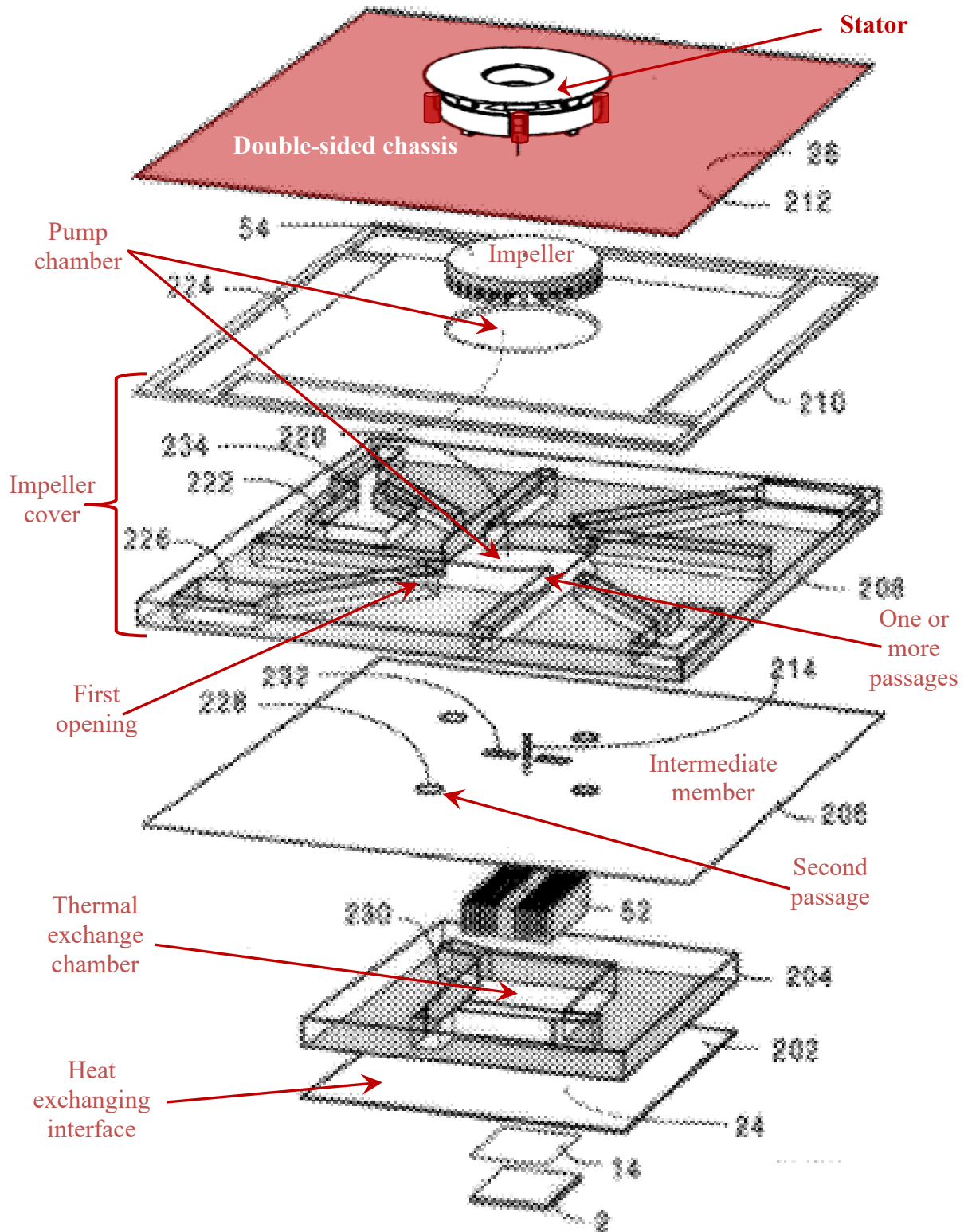
**[15-b] “a reservoir including”**

223. Batchelder in view of Duan teaches limitation [15-b] the same reasons discussed above for limitation [1-b], hereby incorporated by reference.

**[15-c] “an impeller cover, an intermediate member and”**

224. Batchelder in view of Duan teaches an “impeller cover” as discussed above for limitation [1-c], hereby incorporated by reference.

225. Batchelder in view of Duan also teaches an intermediate member, as shown in the excerpt of FIG. 7 below:



(Batchelder, FIG. 7 (annotations added); see also; 7:33-36 (“The fin means (52) is contained in a pocket (230) bounded by a lower stamped plate (204), the bottom sheet (202), and a medial sheet (206).”). As shown, Batchelder discloses an intermediate member (medial sheet 206).

**[15-d] “a heat exchange interface...wherein a first side of the heat-exchanging interface is in contact with a cooling liquid in the thermal exchange chamber and a second side of the heat-exchanging interface opposite the first side is configured to be placed in thermal contact with a surface of the heat-generating component; and”**

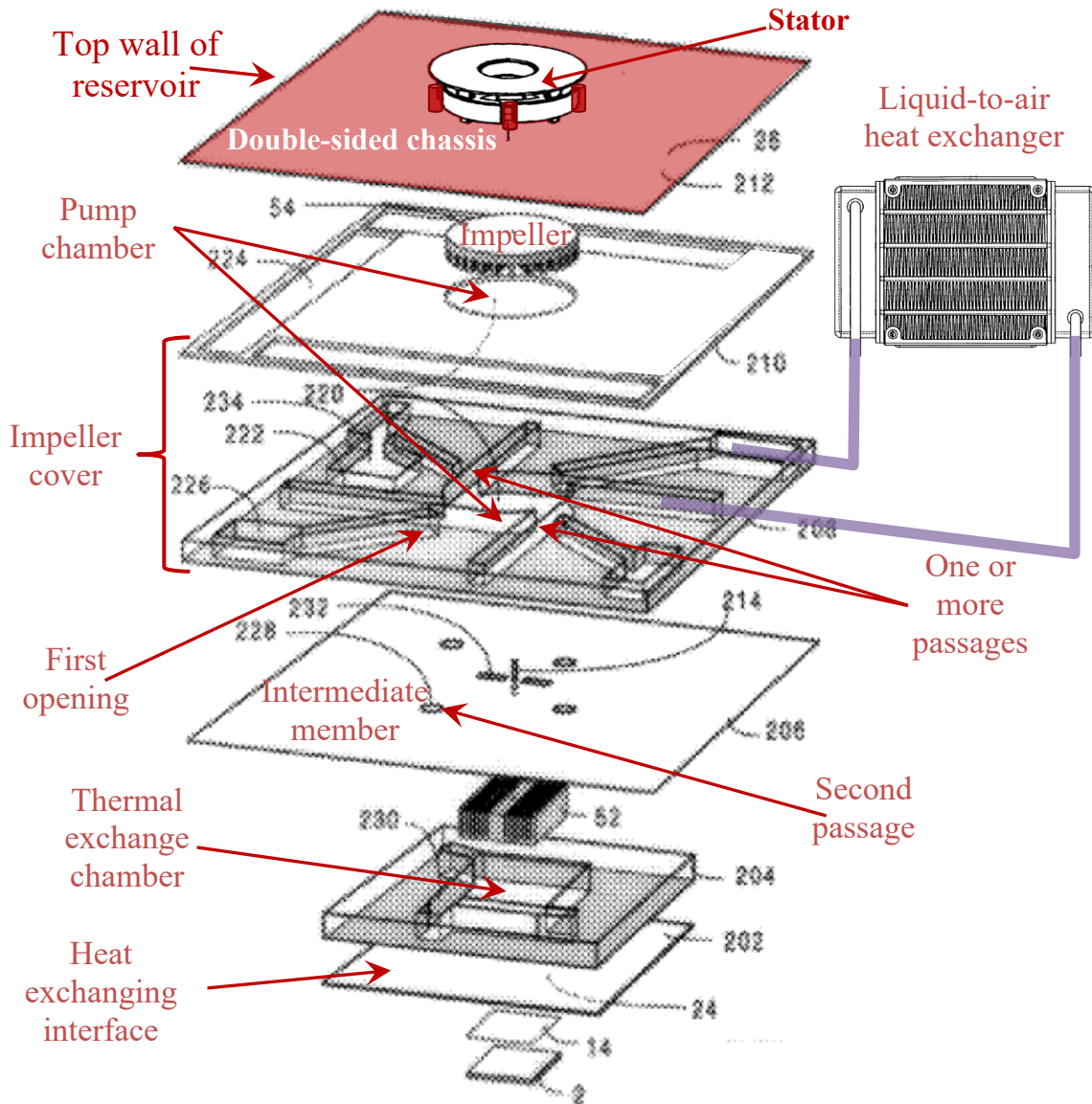
226. Batchelder in view of Duan teaches limitation [15-d] for the same reasons discussed above for limitation [1-e] and claim 3, hereby incorporated by reference.

**[15-e] “wherein a top wall of the reservoir and the impeller cover define a pump chamber for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber, the pump chamber and the thermal exchange chamber being spaced apart from each other in a vertical direction and fluidly coupled together; and”**

227. Batchelder in view of Duan teaches limitation [15-e].

228. As can be seen below, a top wall of the reservoir (212) and the impeller cover define a pump chamber for housing the impeller, and the intermediate member and the heat exchange interface define a thermal exchange chamber, the pump chamber and the thermal exchange chamber being spaced apart from each other by at least the thickness of the intermediate member in a vertical direction and fluidly

coupled together by at least the one or more passages and the second passage.



**[15-f] “a liquid-to-air heat exchanger fluidly coupled to the reservoir using flexible conduits, the heat exchanger being configured to be positioned remote from the reservoir.”**

229. A POSITA would understand Duan’s heat radiator to be “a liquid-to-air heat exchanger.” Accordingly, Batchelder in view of Duan teaches limitation [15-f] for the same reasons discussed above for limitation [1-f] and claim 9, hereby incorporated by reference.

230. For at least the reasons discussed above, Batchelder and Duan teach or suggest every limitation of claim 15 and render it obvious.

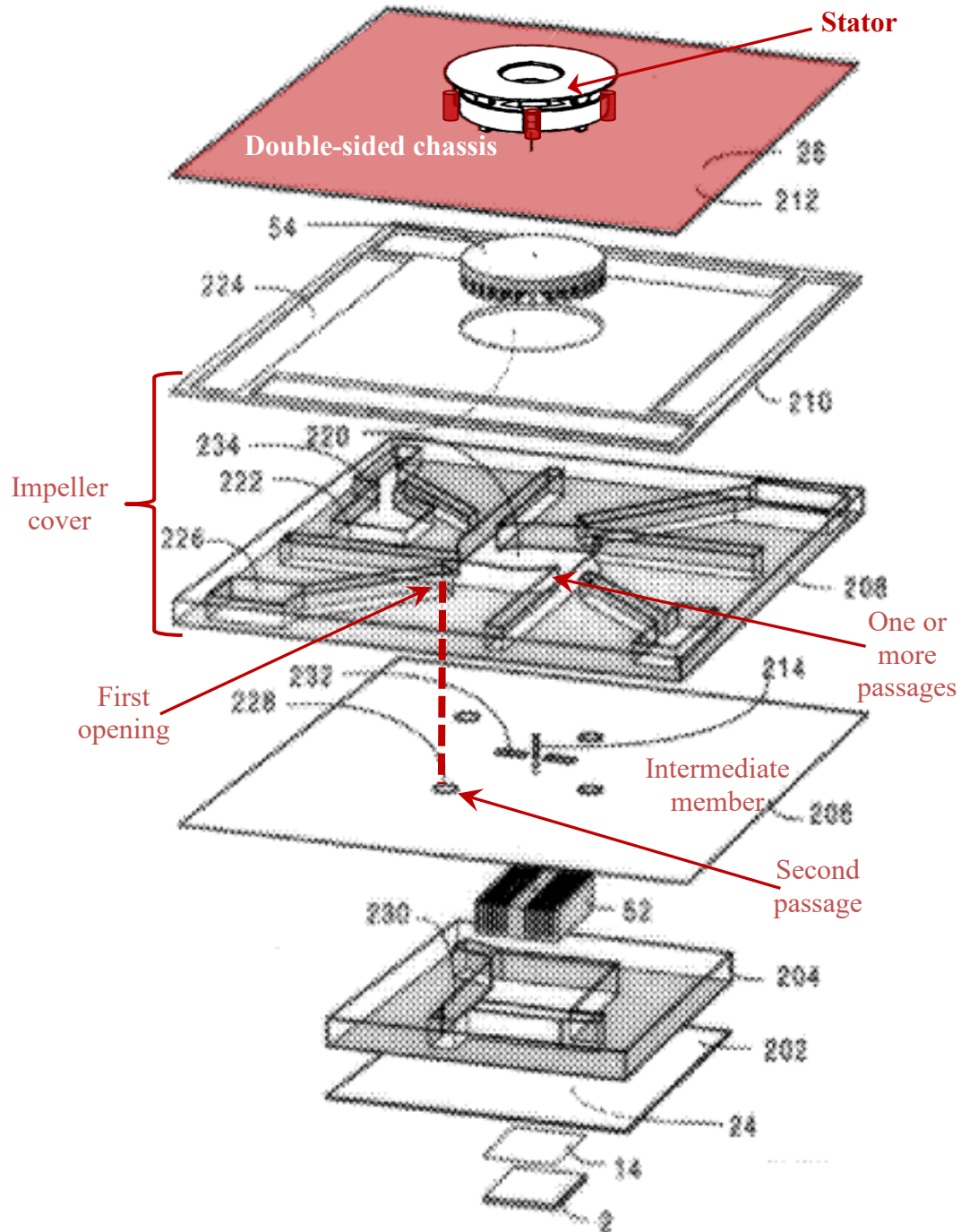
**6. Batchelder teaches each limitation of claims 16-29.**

**[Claim 16] “The cooling system of claim 15, wherein the impeller cover includes a first opening radially offset from a center of the impeller and the intermediate member includes a second passage that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal exchange chamber.”**

231. Batchelder in view of Duan an impeller cover and intermediate member, as discussed above for limitations [1-c] and [15-c], hereby incorporated by reference.

232. Batchelder’s impeller cover has a first opening radially offset from a center of the impeller and the intermediate member includes a second passage (228) that is aligned with the first opening, the first and the second opening being configured to direct the cooling liquid from the pump chamber into the thermal

exchange chamber, as shown below:



(Batchelder, FIG. 7 (annotated excerpt).)

**[Claim 17] “The cooling system of claim 15, wherein the first side of the heat-exchanging interface includes at least one of pins or fins.”**

233. Batchelder in view of Duan teaches claim 17 for the same reasons discussed above for claim 5, hereby incorporated by reference.

**[Claim 18] “The cooling system of claim 15, wherein the top wall of the reservoir extends between the stator and the impeller and shields the stator from the cooling liquid in the reservoir.”**

234. Batchelder in view of Duan teaches claim 18 for the same reasons discussed above for limitations [1-a] and [1-b] and claim 2, hereby incorporated by reference.

**[Claim 19 / Claim 23] “The cooling system of claim [1 / 10 / 15], wherein the one or more passages include a passage configured to direct cooling liquid from the pump chamber directly into the thermal exchange chamber.”**

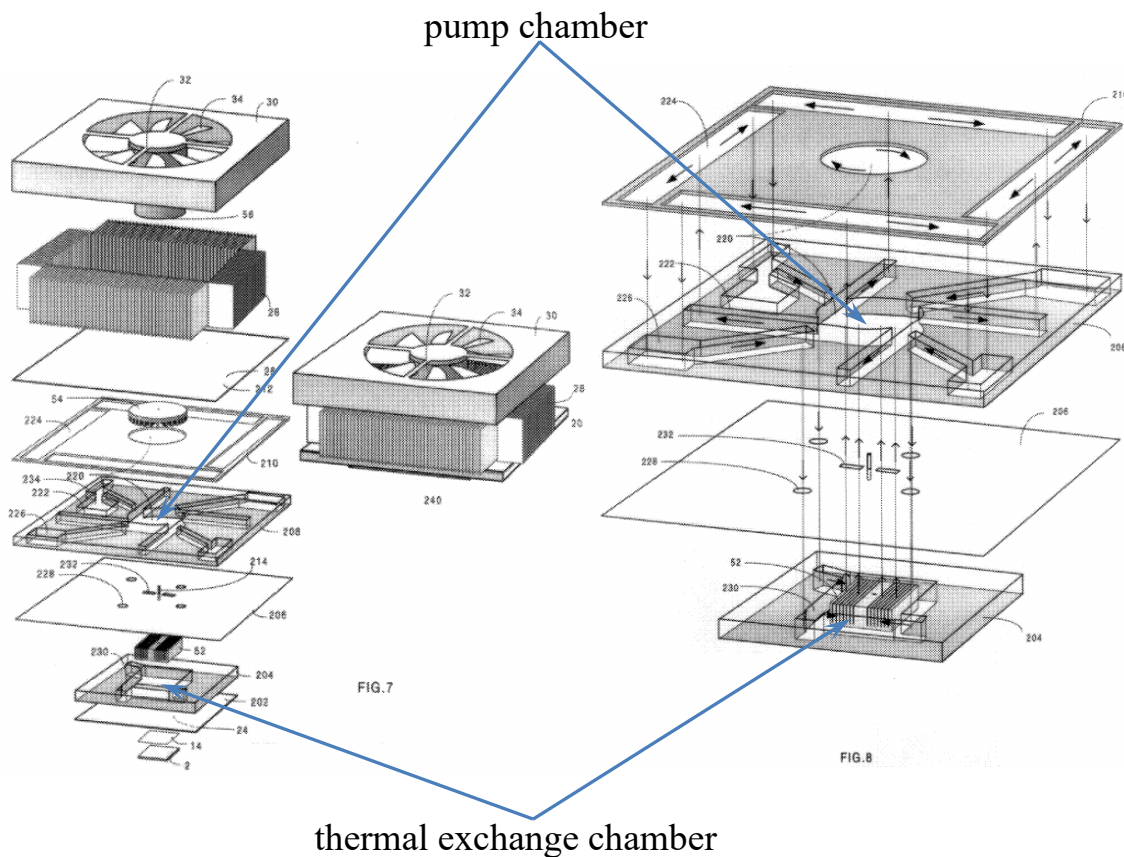
235. Batchelder in view of Duan teaches this limitation for the same reasons discussed above for limitation [1-d], hereby incorporated by reference. This limitation is also taught for the same reasons discussed below for claim 27] hereby incorporated by reference.

**[Claim 20] “The cooling system of claim 1, wherein the one or more passages include a plurality of passages positioned within the reservoir that opens into the thermal exchange chamber.”**

**[Claim 28] “The cooling system of claim 15, wherein the pump chamber and the thermal exchange chamber are fluidly coupled together by a plurality of passages positioned within the reservoir that open into the thermal exchange chamber.”**

236. Batchelder in view of Duan teaches pump and thermal exchange chambers that are fluidly coupled by one or more passages, as discussed above with respect to limitation [1-d], hereby incorporated by reference.

237. As shown below, there are a “plurality of passages” that open into the thermal exchange chamber:

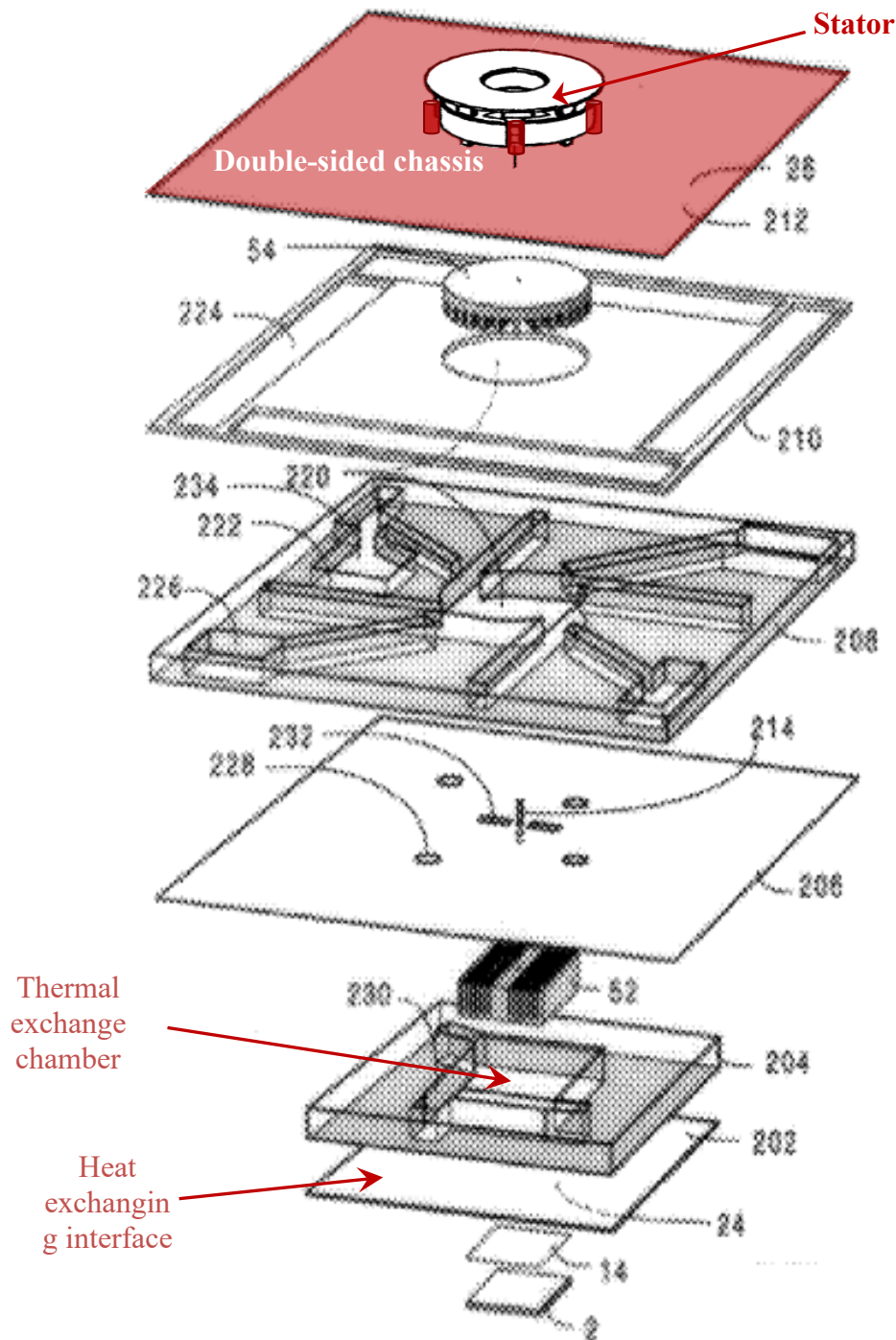


(Batchelder, FIG. 7.)

**[Claim 21 / Claim 25 / Claim 29] “The cooling system of claim [1 / 10 / 15], wherein an entire surface of the heat-exchanging interface in contact with the cooling liquid in the reservoir forms the boundary wall of the thermal exchange chamber.”**

238. Batchelder in view of Duan teaches claim 21, claim 25, and claim 29

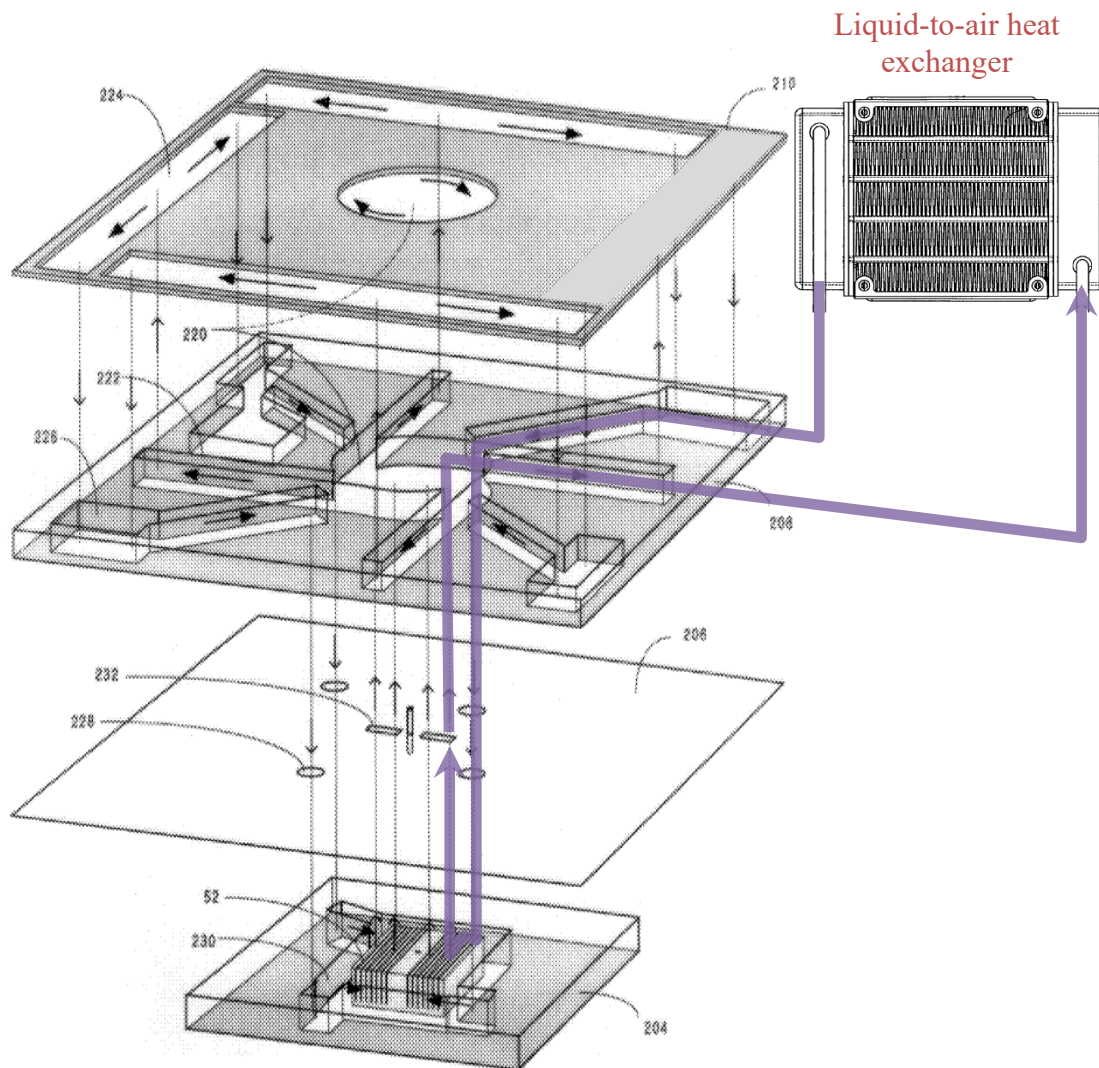
for the same reasons discussed above for limitation [1-e], hereby incorporated by reference. The “entire surface of the heat-exchanging interface in contact with the cooling liquid” (i.e., the entire portion of the top surface of bottom sheet 24 in contact with the cooling liquid) “forms the boundary wall of the thermal exchange chamber in the Batchelder:



(Batchelder, FIG. 7 (excerpt).)

**[Claim 22 / Claim 26] “The cooling system of claim [1 / 10], wherein the reservoir further includes an inlet configured to direct the cooling liquid into the reservoir and an outlet configured to discharge the cooling liquid from the reservoir.”**

239. Batchelder in view of Duan teaches claim 22 and claim 26. It would have been obvious to modify Batchelder to include an external radiator, as taught by Duan, as discussed above with respect to [1-f], hereby incorporated by reference. The modified system would necessarily include an inlet and outlet the fluid would need to enter the system reservoir via an inlet and exit via an outlet, so that the radiator could be fluidly coupled with the reservoir, as shown below:



(Batchelder; FIG. 7 (modified and annotated).)

**[Claim 27] “The cooling system of claim 15, wherein the pump chamber and the thermal exchange chamber are fluidly coupled together by one or more passages, the one or more passages including a passage configured to direct cooling liquid from the pump chamber directly into the thermal exchange chamber.”**

240. Batchelder in view of Duan teaches claim 27 for the same reasons discussed above for limitation [1-d], hereby incorporated by reference. A POSITA would have understood that the cooling liquid flowing from the pump chamber through a passage itself on the intermediate member (e.g., the medial sheet) is still directed by the passage to the pump chamber “directly.” This is because claim 15 recites that the thermal exchange chamber is defined by the intermediate member and the heat exchanging interface, meaning any liquid flowing into the thermal exchange chamber will have to flow through at least either the intermediate member or the heat exchanging interface via a passage.

**7. Batchelder discloses or teaches each limitation of claim 30.**

**[30-a] “30. The cooling system of claim 15, wherein the pump chamber and thermal exchange chamber are fluidly coupled together by one or more passages, and”**

241. Batchelder in view of Duan teaches limitation [30-a] for the same reasons discussed above for limitations [1-c] and [1-d], hereby incorporated by reference.

**[30-b] “the reservoir further includes an inlet configured to direct the cooling liquid into the reservoir and an outlet configured to discharge the cooling liquid from the reservoir.”**

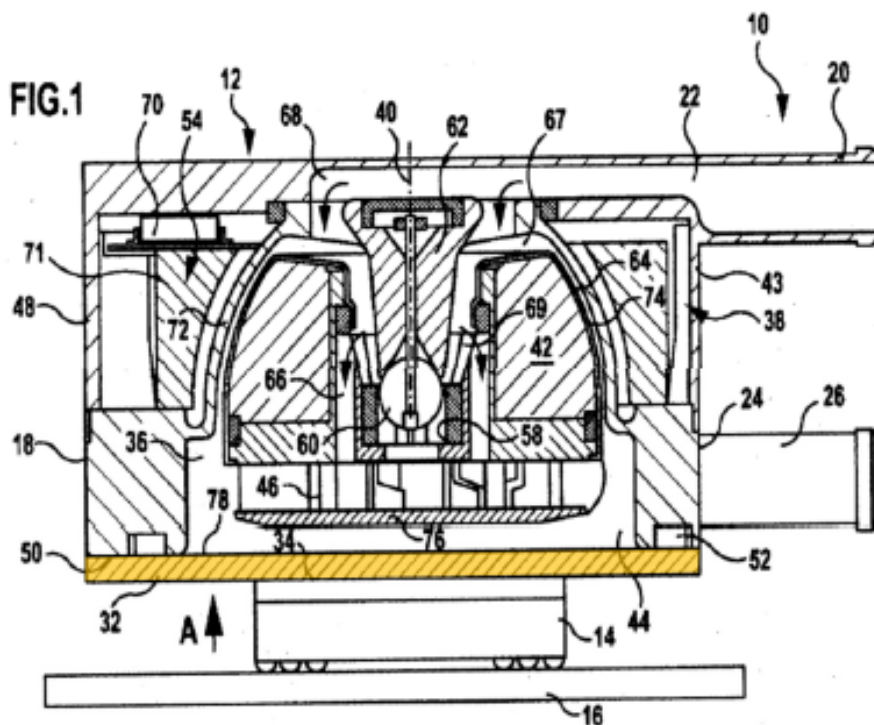
242. Batchelder in view of Duan teaches limitation [30-b] for the same reasons discussed above for claim 19 and claim 23, hereby incorporated by

reference.

**D. GROUND 6: Claim 8 is obvious over Batchelder in view of Duan and further in view of Laing.**

**[Claim 8] “The cooling system of claim 1, wherein the heat-exchanging interface includes one of copper and aluminum.”**

243. Claim 8 is obvious over Batchelder in view of Duan and further in view of Laing for the same reasons discussed above in Grounds 3 and 4, hereby incorporated by reference.



244. A POSITA would have been motivated to combine Laing with Duan, Duan I, and/or Batchelder. Like Duan, Duan I, and/or Batchelder, Laing attempts to solve similar issues — how to cool, with liquids, the increasing temperature of

increasingly powerful semiconductor devices (Laing, [0002]-[0004]), which motivates a POSITA to combine the teachings of these two references.

245. In addition, a POSITA would have been further motivated to combine the teachings of these references in light of their specific disclosures. Notably, Laing teaches that “the thermal contact element is made from a metallic material, such as copper, in order to achieve a high thermal conductivity, in order, in turn, to allow optimum dissipation of heat from an object[.]” (Laing, [0015].) A POSITA would have been motivated to apply Laing’s copper “heat exchange interface” to Duan, Duan-I, and/or Batchelder “to achieve a high thermal conductivity ... to allow optimum dissipation of heat from” the heat generating component. A POSITA would know that copper is normally used in electronic cooling applications when the thermal conductivity of the aluminum is not sufficiently high and/or corrosion from water needs to be prevented and a coating is not used.

## **IX. CONCLUDING STATEMENT**

246. 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.

247. 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.

248. 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

|                                                                                 |                                     |
|---------------------------------------------------------------------------------|-------------------------------------|
| <b>Tufts University</b><br><i>PhD Mechanical Engineering</i>                    | <b>Medford, MA</b><br>2018          |
| <b>Tufts University</b><br><i>MS Mechanical Engineering</i>                     | <b>Medford, MA</b><br>2015          |
| <b>Aristotle University of Thessaloniki</b><br><i>BS Mechanical Engineering</i> | <b>Thessaloniki, Greece</b><br>2012 |

## EXPERIENCE

|                                                                                                                                                                                                                                                                                                                                                                             |                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| <b>Transport Phenomena Technologies, LLC</b><br><i>Co-Founder and Senior Engineer</i>                                                                                                                                                                                                                                                                                       | <b>Medford, MA</b><br>October 2017–present        |
| <ul style="list-style-type: none"> <li>• Technical and business activities related to development of hardware and software for thermal management of electronics and optimization of heat sinks and cold plates.</li> <li>• Consulting on transport phenomena, including legal consulting.</li> <li>• Design of custom electromechanical devices.</li> </ul>                |                                                   |
| <b>Tufts University</b><br><i>Research Assistant Professor (Part-Time)</i>                                                                                                                                                                                                                                                                                                  | <b>Medford, MA</b><br>December 2021–Present       |
| <ul style="list-style-type: none"> <li>• Modeling and experimental techniques pertaining to mass, momentum, and heat transfer, and supercritical drying of silica aerogels.</li> <li>• ME193 Simulation for Mechanical Engineers: Structural, thermal, and fluid flow analysis using commercial software packages (SOLIDWORKS, COMSOL, ANSYS Workbench, MATLAB).</li> </ul> |                                                   |
| <i>Consultant</i>                                                                                                                                                                                                                                                                                                                                                           | August 2018–December 2021                         |
| <ul style="list-style-type: none"> <li>• Modeling of supercritical drying of silica aerogels.</li> </ul>                                                                                                                                                                                                                                                                    |                                                   |
| <i>Instructor</i>                                                                                                                                                                                                                                                                                                                                                           | Spring Semester 2020                              |
| <ul style="list-style-type: none"> <li>• ME193 Simulation for Mechanical Engineers: Structural, thermal, and fluid flow analysis using commercial software packages (SOLIDWORKS, COMSOL, ANSYS Workbench, MATLAB).</li> </ul>                                                                                                                                               |                                                   |
| <b>Imperial College</b><br><i>Invited Researcher</i>                                                                                                                                                                                                                                                                                                                        | <b>London, UK</b><br>September 2016–December 2016 |
| <ul style="list-style-type: none"> <li>• Modeling of the extended Graetz–Nusselt problem for liquid flow over isothermal parallel ridges; Microchannel liquid cooling in the presence of apparent slip.</li> </ul>                                                                                                                                                          |                                                   |

## 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)

---

**JOURNAL PUBLICATION**


---

**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.

---

**CONFERENCE PUBLICATION**


---

- [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.