

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

GREEN REVOLUTION COOLING, INC.,
Petitioner

v.

MIDAS GREEN TECHNOLOGIES, LLC,
Patent Owner.

Patent No. 10,405,457 to Boyd, et al.

IPR2025-00196

**DECLARATION OF WERNER J.A. DAHM, Ph.D. IN
SUPPORT OF PETITION FOR *INTER PARTS* REVIEW**

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TABLE OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 10,405,457 (“the ’457 patent”)
1002	File history of U.S. Patent No. 10,405,457 (“’457FH”)
1004	U.S. Patent Application Publication No. 2011/0132579 to Best et al. (“Best-2008”)
1005	Japanese Patent No. 2001-181898 (“Osada”)
1006	U.S. Patent Application Publication No: 2014/0211412 to Best (“Best-2012”)
1007	File history of U.S. Patent No. 10,820,446 (“’446FH”)
1008	U.S. Patent No. 10,820,446 (“the ’446 patent”)
1009	Comparison of Challenged Claims
1010	Patent Owner Preliminary Response in IPR2021-01175
1017	H. Müller-Steinhagen, “Fouling: The Ultimate Challenge for Heat Exchanger Design,” in Transport Phenomena in Thermal Engineering, Vol. 2, pp. 811-823 (1993) Begell House, Inc., ISBN Print: 1-56700-015-0
1018	D. Bouris & G. Bergeles, “Particle-Surface Interactions in Heat Exchanger Fouling,” Journal of Fluids Engineering, Vol. 118, pp. 574-581 (1996) ASME Fluids Engineering Division
1019	Sandu & D. Lund, “Minimizing Fouling in Heat Exchanger Design,” Biotechnology Progress, Vol. 1, No. 1, pp. 10-17 (1985)
1020	Curriculum Vitae of Dr. Werner J. A. Dahm
1021	H. Müller-Steinhagen, “Cooling-Water Fouling in Heat Exchangers,” Advances in Heat Transfer, Vol. 33, pp. 415-496 (1999), ISBN 0-02-020033-3
1022	A. Royne & C.J. Dey, “Effect of nozzle geometry on pressure drop and heat transfer in submerged jet arrays,” Int’l Journal of Heat and Mass Transfer, Vol. 49, pp. 800-804 (2006)

I, Werner J.A. Dahm, Ph.D., declare as follows:

I. Introduction and Qualifications

1. I am over the age of 21 and am competent to make this declaration.
2. I have been retained on behalf of Petitioner Green Revolution Cooling, Inc. (“GRC”) to provide my opinions regarding the validity of claims 1-16 of U.S. Patent No. 10,405,457 (Ex-1001, the “’457 patent”). I submit this declaration based on my relevant education, knowledge, experience, and expertise and in support of GRC’s *inter partes* review Petition (the “Petition”) against the ’457 patent.
3. I have been asked to provide my independent analysis of the ’457 patent in light of the materials cited below and my education, knowledge, experience, and expertise in this field during the relevant period. I have been asked to consider whether the references cited in the Petition render obvious the invention described by claims 1-16.
4. I am being compensated at my normal hourly rate for my time. My compensation is not contingent in any way on the content of my analysis or the outcome of this proceeding. I am not and never have been an employee or agent of GRC.
5. My opinions are based on my education, knowledge, and background discussed below, informed by my extensive experience and expertise regarding the subject matter of the ’457 patent and the related prior art.

6. I have 46 years of experience in mechanical and aerospace engineering, including as a practicing engineer in industry, as an engineering professor, as an engineering consultant to industry, and as an engineering consultant to national laboratories and to the U.S. Government.

A. Education Background

7. My findings are also based on my education as a mechanical engineer. I hold a B.S.E. degree in Mechanical Engineering from the University of Alabama in Huntsville, awarded in 1978, an M.S. degree in Mechanical Engineering from the University of Tennessee, awarded in 1981, and a Ph.D. degree from the Division of Engineering and Applied Science at the California Institute of Technology (Caltech), awarded in 1985.

8. The graduate courses and research that led to my M.S. and Ph.D. degrees were focused almost entirely on subjects dealing with fluid dynamics, thermodynamics, heat transfer, thermal sciences, and related areas. These included courses on the theoretical aspects of these subjects as well as their practical implementation in engineered systems. Additionally, my doctoral dissertation at Caltech was on the fluid dynamics associated with mixing in a liquid system, and my doctoral research involved designing, building, and operating a liquid circulation tank in which I conducted experiments on mixing in a liquid system.

B. Professional Experience

9. I am the ASU Foundation Professor of Mechanical and Aerospace Engineering in the Ira A. Fulton Schools of Engineering at Arizona State University (ASU) and am also Professor Emeritus of Aerospace Engineering at the University of Michigan. Foundation Professorships at ASU are endowed and chaired positions awarded by ASU, the largest single university in the U.S., to an exceedingly small number of its faculty members in recognition of exceptional technical and professional accomplishments. I have served on the Mechanical and Aerospace Engineering faculty at ASU for the past 14 years, and previously served for 25 years as a Professor of Aerospace Engineering at the University of Michigan, where I continue to serve as Professor Emeritus.

10. The fields of mechanical and aerospace engineering are closely related, and both are based on the same major technical areas. Whereas mechanical engineering generally focuses on applying these technical areas – which include the areas in which I specialize, namely fluid dynamics, thermodynamics, combustion, heat transfer, thermal sciences, and related areas, including their utilization in a wide range of applications – toward designs for lower-cost production and maintenance, aerospace engineering generally focuses on applying these technical disciplines toward designs for higher performance, lower weight and volume, and more extreme

environments.

11. The main technical areas involved in this litigation, including fluid dynamics, thermodynamics, heat transfer, thermal sciences, and related areas, are taught to students of both mechanical and aerospace engineering. At most universities, mechanical and aerospace engineering are grouped together in a single “Mechanical and Aerospace Engineering” program, as they are at ASU.

12. In the nearly 40 years that I have served on the engineering faculty of the University of Michigan and Arizona State University, I have performed extensive teaching and research on various subjects that relate to fluid dynamics, thermodynamics, combustion, heat transfer, thermal sciences, and related areas, including their utilization in a wide range of applications. I have taught aspects of these subjects to over 5,000 engineering students ranging from undergraduates to M.S. and Ph.D. students, and I have guided the doctoral dissertation research of more than two dozen Ph.D. recipients in various aspects of these subjects. I have also conducted research on various aspects of these subjects that has been published widely in leading national and international archival technical journals in these fields.

13. I am an author of over 200 refereed technical articles, conference papers, and technical publications in my fields of specialization, I hold six U.S. and

international patents, and have given over 260 technical presentations, including more than 190 invited, plenary, and keynote lectures worldwide on topics dealing with fluid dynamics, thermodynamics, combustion, heat transfer, thermal sciences, and related areas, including their utilization in a wide range of mechanical, aerospace, and other industrial applications, and broadly with mechanical and aerospace engineering.

14. I have also served extensively as a reviewer of technical papers, books, and research proposals related to my areas of expertise, as an organizer and advisor for national and international conferences in my technical field of specialization, as an invited and plenary speaker at numerous technical conferences in my fields, and as an invited speaker on these subjects at leading universities and research organizations in my technical field throughout the world.

15. In my research work over the past 43 years – initially at Caltech, then at the University of Michigan, and then at Arizona State University – I have conceived, designed, built, and operated numerous fluid circulation systems involving the application of fluid dynamics and heat transfer principles. These include liquid tanks for liquid circulation, some of which also involved filtration of the fluid.

16. I am a member and Fellow of the American Physical Society (APS) in

the Division of Fluid Dynamics (DFD), a member and Fellow of the American Institute of Aeronautics and Astronautics (AIAA), and a member of the American Society of Mechanical Engineers (ASME). These are all leading professional technical societies in fluid dynamics, thermodynamics, combustion, heat transfer, thermal sciences, and related areas, including their utilization in a wide range of applications. Elevation to Fellow is an honor bestowed on less than one percent of the active membership of these professional organizations in recognition of exceptional technical accomplishments.

17. I have received numerous other honors and awards for my work in fluid dynamics, thermodynamics, combustion, heat transfer, thermal sciences, and related areas, including the 2023 AIAA Fluid Dynamics Best Paper Award, the 1938E Distinguished Achievement Award from the University of Michigan, the George J. Huebner Research Excellence Award from The University of Michigan, and the William F. Ballhaus Prize from Caltech.

18. I have previously served as an Associate Editor for the AIAA Journal and in leadership roles in major professional technical societies associated with my technical fields, including on the APS/DFD Executive Committee, the AIAA Publications Committee, and others.

19. Due to my expertise in fluid dynamics, thermodynamics, combustion,

heat transfer, thermal sciences, and related areas, from 2006 to 2021 I was asked to serve as a member of the highly prestigious U.S. Air Force Scientific Advisory Board (SAB), including as the Chairman of the Board from 2014-2017 and as a member of the SAB Executive Committee. In recognition of my technical accomplishments on the U.S. Air Force Scientific Advisory Board, in 2018 I was awarded the Secretary of the Air Force Distinguished Public Service Award – the highest honor the Air Force can bestow on a non-employee civilian.

20. In part as a result of my technical accomplishments on the U.S. Air Force SAB and my expertise in fluid dynamics, thermodynamics, combustion, heat transfer, thermal sciences, and related areas, in 2008 I was asked by the Chief of Staff of the U.S. Air Force to take a temporary leave of absence from the University of Michigan to serve as the Chief Scientist of the U.S. Air Force within Headquarters Air Force in the Pentagon. I accepted this highly prestigious full-time position, at the civilian-equivalent rank of a three-star general, as the direct science and technology advisor to the Secretary of the Air Force and the four-star Air Force Chief of Staff. In recognition of my technical contributions and accomplishments as the Chief Scientist of the U.S. Air Force, in 2010 the Secretary of the Air Force awarded me the Air Force Decoration for Exceptional Civilian Service – the highest honor the U.S. Air Force can bestow on a civilian employee of the Air Force.

21. I have also served on technical advisory boards for NASA and Lawrence Livermore National Laboratory, and in numerous other technology advisory and technical review roles for various organizations and companies. These roles all involved, in part, matters pertaining to fluid dynamics, thermodynamics, combustion, heat transfer, thermal sciences, and related areas in various engineered systems. I have also served extensively on technical advisory and organizational committees for numerous technical conferences in my fields, and as a consultant for industry in these fields.

22. Attached as Ex-1020 is my curriculum vitae, which includes a more detailed statement of my professional qualifications, including education, publications, honors and awards, professional activities, consulting engagements, and other relevant experience.

II. Methodology and Materials Considered

23. As described in more detail below, based on my engineering experience including as a consultant to industry, I understand and know the capabilities of a person of ordinary skill in the art of the '457 patent in 2012, when the earliest of the applications to which the '457 patent claims priority was filed. I have relevant personal knowledge and experience, in addition to working directly with many such persons in these fields during that time frame.

24. I have also relied on my review and analysis of the prior art cited in the Petition, information provided to me in connection with this case, and information I have independently reviewed.

25. In forming my opinions, I have been asked to review the '457 patent including the specification and claims 1-16 (the "Challenged Claims"). I have also considered the materials cited herein, including those itemized in the Table of Exhibits that precedes this declaration.

26. My opinions are based on the materials I reviewed and my knowledge and professional judgment. My opinions have also been guided by my understanding of how a person of ordinary skill in the art would have understood the claims of the '457 patent in the relevant time frame.

27. I also understand from counsel that the prior art references cited herein (e.g., Ex-1004 through Ex-1006) qualify as prior art under U.S. law.

28. In my analysis below, emphasis in my citations has been added unless otherwise noted. Likewise, annotations to images and figures have been added unless otherwise noted.

29. I reserve the right to supplement and amend any of my opinions in this declaration based on documents, testimony, and other information that becomes available to me after the date of this declaration.

III. Legal Standards

30. I am not a lawyer. My understanding of the legal standards to apply in reaching the conclusions in this declaration is based on discussions with counsel for Petitioner, my experience applying similar standards in other patent-related matters, and my reading of the documents submitted in this proceeding. In preparing this declaration, I have tried to faithfully apply these legal standards to the challenged claims.

31. I have been informed that there are two ways in which prior art may render a patent claim unpatentable. First, I have been informed that the prior art can “anticipate” a claim. Second, I have been informed that the prior art can render a claim “obvious” to a person of ordinary skill in the art. I understand that a claim is patentable if it was not anticipated and would not have been obvious by the prior art as of the effective filing date of the patent. In this declaration, I only address obviousness.

32. I have been asked to provide my opinions as to whether the cited prior art renders obvious claims 1-16 of the ’457 patent from the perspective of a person of ordinary skill in the art at the ’457 patent’s earliest possible effective filing date in 2012, as described in more detail below.

33. I have been informed that in *inter partes* review proceedings, such as

this one, the party challenging the patent bears the burden of proving unpatentability by a preponderance of the evidence. I understand that a preponderance of the evidence means “more likely than not.”

34. For purposes of this declaration, I have been asked to provide my opinions on issues regarding unpatentability. I have been informed of the following legal standards, which I have applied in forming my opinions.

35. I have been informed that a dependent claim is a patent claim that refers back to another patent claim. I have been informed that a dependent claim includes all of the limitations of the claim to which it refers.

A. Level of Ordinary Skill

36. I understand that my assessment of the claims of the '457 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 '457 patent on its earliest effective filing date, which I understand is sometimes referred to as the “priority date,” and in light of the specification and file history of the '457 patent. I will refer to such a person as a “POSITA.”

37. 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 '457 patent. I also understand that a POSITA is a hypothetical person who is

presumed to know the relevant art as of the earliest effective filing date of the alleged invention claimed in the '457 patent.

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

- the educational level and experience of active workers in the field,
- the type of problems encountered in the art or field of invention,
- the nature of prior art solutions to those problems,
- sophistication of the technology, and
- the rapidity with which innovations are made.

39. I have been instructed to assume a person of ordinary skill in the art is not a specific real individual, but rather a hypothetical individual having the qualities reflected by the factors discussed above.

40. 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.

B. Prior Art

41. I have been advised and understand that the information used to evaluate whether an invention was new and not obvious when made is generally referred to as “prior art.” I understand that prior art in an IPR proceeding includes patents and printed publications that existed before the earliest filing date of the patent.

42. I have been informed and understand that a patent or published patent application is prior art if it was published or filed before the effective filing date of the claimed invention.

43. I have also been informed and understand that a printed publication is prior art if it was publicly available before the earliest filing date and could be located by a POSITA exercising reasonable diligence.

C. Obviousness

44. I understand that a claim may be invalid if the subject matter described by the claim as a whole would have been obvious to a POSITA in view of a prior art reference, or in view of a combination of references at the time the claimed invention was made. Therefore, I understand that obviousness is determined from the

perspective of a POSITA, and that the asserted claims of the patent should be read from the point of view of such a person as of the priority date of the patent at issue. I further understand that a POSITA is assumed to know and to have all relevant prior art in the field of endeavor covered by the patent in suit and all analogous prior art. I understand that obviousness in an *inter partes* review proceeding is evaluated using a preponderance of the evidence standard, which means that the claims must be more likely obvious than nonobvious.

45. I also understand that an analysis of whether a claimed invention would have been obvious should be considered in light of the scope and content of the prior art, the differences (if any) between the prior art and the claimed invention, and the level of ordinary skill in the pertinent art involved. I understand as well that a prior art reference should be viewed as a whole. I understand that in considering whether an invention for a claimed combination would have been obvious, I may assess whether there are apparent reasons to combine known elements in the prior art in the manner claimed in view of interrelated teachings of multiple prior art references, the effects of demands known to the design community or present in the marketplace, and/or the background knowledge possessed by a POSITA. I also understand that other principles may be relied on in evaluating whether a claimed invention would have been obvious, and that these principles include the following:

- A combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- When a device or technology is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a POSITA can implement a predictable variation, the variation is likely obvious;
- If a technique has been used to improve one device, and a POSITA would have recognized that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill;
- An explicit or implicit teaching, suggestion, or motivation to combine two prior art references to form the claimed combination may demonstrate obviousness, but proof of obviousness does not depend on or require showing a teaching, suggestion, or motivation to combine;
- Market demand, rather than scientific literature, can drive design trends and may show obviousness;
- One of the ways in which a patent's subject can be proved obvious is by noting that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims;
- Any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed;
- "Common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a POSITA will be able to fit the teachings of multiple patents together like pieces of a puzzle;
- A POSITA is also a person of ordinary creativity, not an automaton;
- A patent claim can be proved obvious by showing that the claimed combination of elements was "obvious to try," particularly when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions such that a POSITA would have had good reason to pursue the known options within his or

her technical grasp; and

- One should be cautious of using hindsight in evaluating whether a claimed invention would have been obvious.

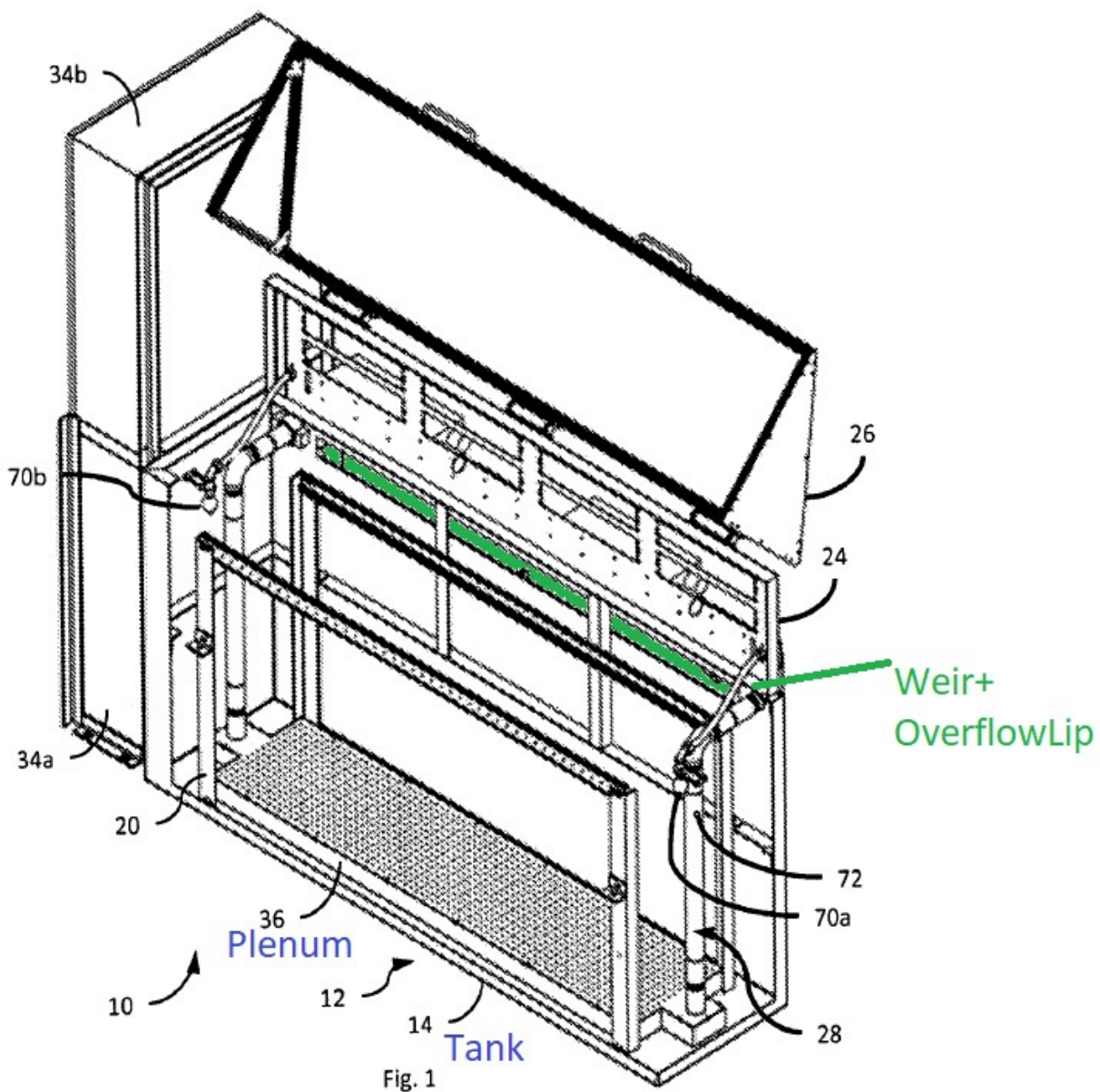
46. As I explain in §IV.B., below, for my obviousness analysis, counsel for Petitioner instructed me to assume that the effective filing date of the '457 patent is December 14, 2012. My opinions would not change if I assumed a later date of invention.

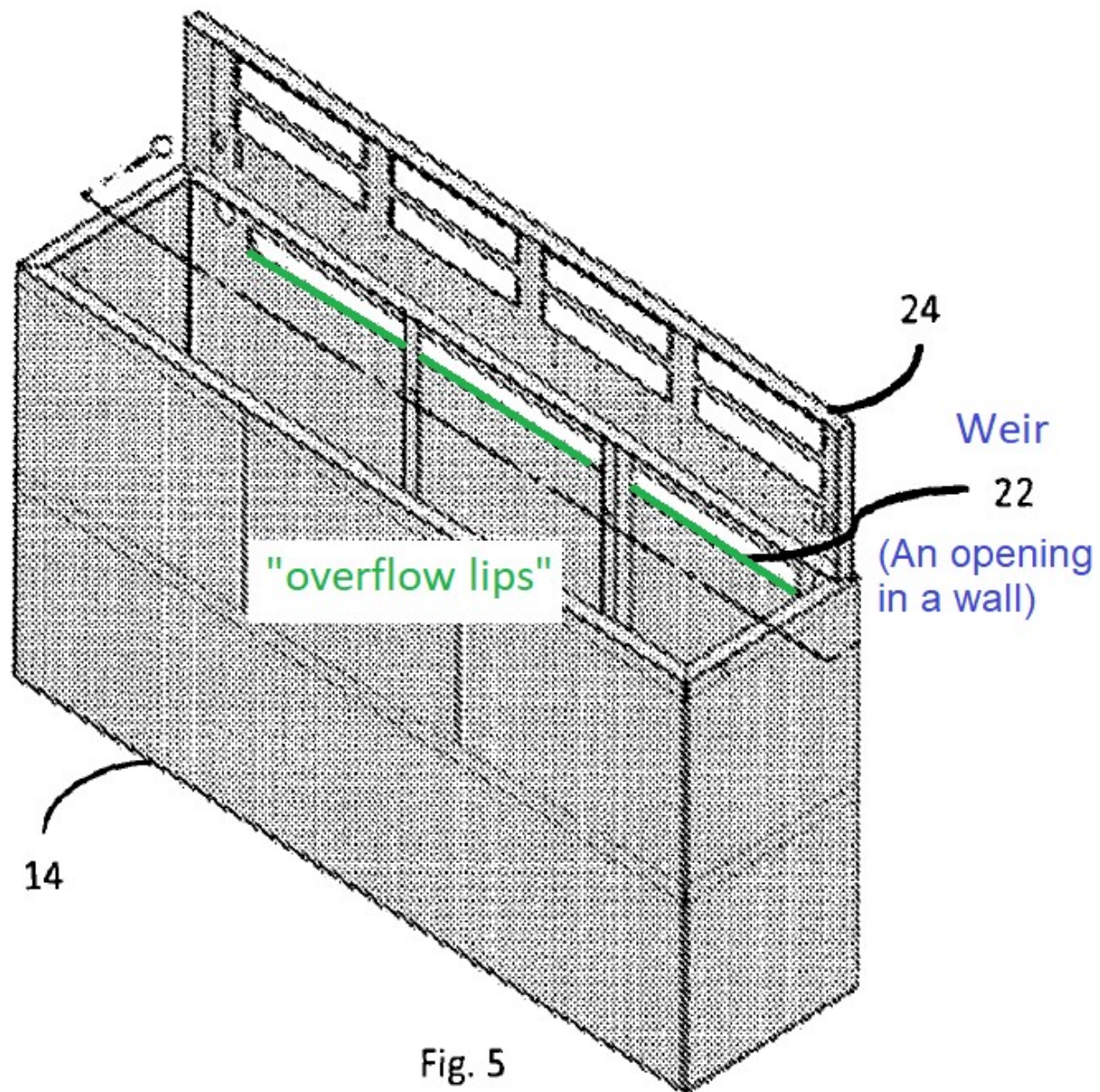
IV. The '457 Patent

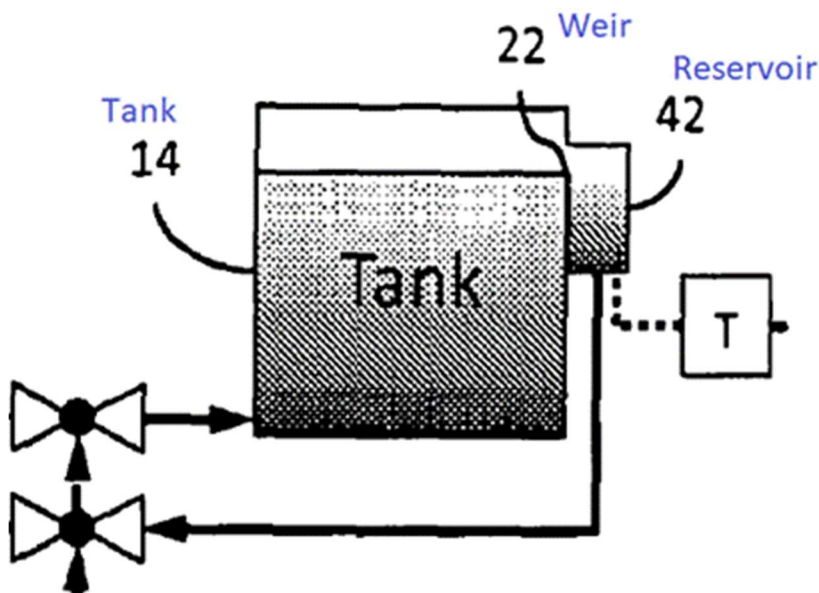
A. General Overview

47. The '457 patent concerns cooling systems for electrical appliances, namely immersion cooling systems which can include a tank, plenum, weir with an overflow lip, and an external reservoir to capture coolant flowing out of the weir. (Ex-1001 at 1:21-24, 3:39-56; 4:15-17, 4:27-32, FIGS 1, 3, 5, 13.) The captured coolant is recycled back to the tank via the plenum after it is cooled in heat exchangers in a “primary circulation facility”. (*Id.* at 4:27-32, 4:50-62.)

48. The '457 patent includes several figures illustrating its subject matter, for example:







(*Id.* at FIGS. 1, 5, 13.)

49. The '457 patent acknowledges prior immersion tank systems for cooling electronic appliances, including computer servers, namely Best-2008 (Ex-1004):

“US Patent Application Publication 2011/0132579 [Best-2008] discloses a [sic] appliance immersion tank system, include [sic] support apparatus for extracting waste heat from the tank cooling fluid and dissipating to the environment the heat so extracted. Although an improvement in several respects over the prior art discussed above, this system exhibits, inter alia, the following problems: generally non-uniform flow patterns through the several appliance slots within the tank, potentially resulting in uneven cooling across all slots; constricted dielectric fluid supply and return ports resulting in unnecessarily high fluid flow velocities at the respective points of connection to the tank; poor scalability; and inadequate attention to fail-soft operation.”

(*Id.* at 2:23-38.)

50. This description is inaccurate, however, in its criticism of Best-2008,

as explained below.

51. The '457 patent suggests that it improves upon Best-2008 with its coolant recirculation loop in which coolant flows out of the top of the tank to an external reservoir from which it is pumped through a filter, heat exchanger, then back to the tank via a plenum.

52. This was not new or inventive when it was claimed in the '457 patent. My analysis in §§VI-VIII shows this to be the case in view of various prior art references including Best-2008.

53. For example, overall, the '457 patent admits that Best-2008 discloses many elements claimed by the '457 patent:

- An appliance immersion tank;
- The tank having several appliance slots for receiving appliances;
- The use of dielectric fluid for cooling the appliances; and
- A system for cooling the dielectric fluid.

54. As I explain herein, the coolant recirculation loop of the '457 patent was known and obvious to a POSITA.

B. Effective Filing Date

55. I have been instructed to assume that the effective filing date of the '457 patent is December 14, 2012, which is the filing date of the first provisional

application to which the '457 patent claims priority (U.S. application no. 61/737,200). My opinions would not change, however, if the effective filing date of the '457 patent is determined to be a later date, such as the filing date of the second provisional application to which the '457 patent claims priority (U.S. application no. 61/832,211), i.e., June 7, 2013, or the filing date of the PCT application to which the '457 patent claims priority, i.e., December 13, 2013.

C. Prosecution History and the Prior IPR

56. I understand that an overview of the prosecution history is provided in the Petition. I have reviewed the prosecution history (Ex-1002), and the overview provided in the Petition which I adopt here, but I am not a lawyer as stated above and thus do not offer opinions on the overall process. Instead, I highlight below issues that arose during prosecution that relate to my technical analysis and the understanding of various claim terms of the '457 patent.

57. First, the examiner found that Best-2008 disclosed all limitations of the '457 patent except “a weir ... having an overflow lip.” (Ex-1002 at 406-413, 422-428.) As it relates to these terms, the Examiner reasoned that “as far as the ‘weir’ structure is defined in the disclosure it merely amounts to an opening in a wall and its ‘lip’ is never defined as more than the bottom surface of that opening.” (*Id.* at 437-38.) I do not disagree with the Examiner’s analysis as it is consistent with the

usage of those terms in the '457 patent. (Ex-1001 at 4:27-32 (describing weir and overflow lip); FIG. 5 (showing overflow lip is the bottom surface of the openings in the tank wall defining the weir).)

58. Second, the examiner also concluded that the claim limitation “adjacent all appliance slots” modifies the claim limitation “the long wall of the tank” not the claimed “weir.” (*Id.* at 437-38.)

59. Third, during prosecution, the applicant did not identify any “further structural limitation that should be associated with the term weir” when invited to do so by the examiner. (*Id.* at 438.) Instead, applicant amended the pending claims to include an external reservoir to receive the dielectric fluid from the weir. (*Id.* at 467-475.)

60. I understand Patent Owner filed a continuation application from the '457 patent, which resulted in U.S. Pat. No. 10,820,446 (“the '446 patent”; Ex-1008). During prosecution, the Examiner did not raise any issues pertinent to my analysis of the '457 patent’s claims—the '446 patent’s claims were not rejected based on any prior art and the application was allowed after Patent Owner filed additional paperwork (e.g., a Terminal Disclaimer) with the patent office. (Ex-1007 at 66-76, 80-85, 97-101.)

61. I also understand that another party challenged the '457 patent claims

in a previous IPR (“the prior IPR”) but the patent office denied institution of that prior IPR based on procedural issues. Nonetheless, I have reviewed Patent Owner’s preliminary submission in that proceeding in preparing my opinions. (Ex-1010.)

D. The Challenged Claims

62. The Challenged Claims are all claims of the ’457 patent, i.e., claims 1-16. Claims 1, 6, and 11 are independent.

E. Person of Ordinary Skill in the Art (“POSITA”)

63. Based on my review and analysis of the ’457 patent, the prior art cited herein, and the ordinary skill factors described in this section, a POSITA in the field of the ’457 patent at the assumed earliest effective filing date (December 14, 2012) would have had a Bachelor of Science degree in mechanical or chemical engineering and at least two years of experience relating to the design and/or implementation of fluid circulation systems involving application of fluid dynamics and heat transfer principles. Additional education may serve as a substitute for a lack of experience and vice versa.

64. Fluid dynamics is the technical branch of engineering and science that deals with how fluids (gases, liquids) move under the effects of various driving forces, geometric constraints, etc. This includes understanding of flows where the

resulting fluid inertia is large compared to the fluid viscosity¹. These flow phenomena cannot always be seen, particularly where the fluid is transparent, but they have a profound effect on the convective heat transfer that the circulation of fluid produces.

65. Heat transfer is the technical branch of engineering and science that deals with thermal energy transfer by conduction, convection, and radiation, where *convection* refers to enhancement of heat transfer that results from fluid motion.

66. My opinion relies on various factors. For example, the “Field” of the ’457 patent indicates that the patent “relates generally to electrical appliance cooling systems, and, in particular, to an improved appliance immersion cooling system and method of operation.” (Ex-1001 at 1:21-24.) People working in this field usually had a mechanical or chemical engineering degree, as I note above, and ordinary skill would require at least two years of experience relating to the design and/or implementation of fluid circulation systems involving application of fluid dynamics and heat transfer principles.

67. Likewise, the “Background” section describes a problem that the ’457

¹ In the field of fluid dynamics this is technically referred to as “high Reynolds number flow”.

patent purports to solve – difficulty and disruption to server operation when draining cooling fluid. (*Id.* at 1:62-2:6.) The “Background” states:

“One particular problem in the vertical-stack-type systems disclosed in the above references is the necessity of draining the cooling fluid whenever physical access to the electronic modules was required. In general, such an operation, besides being time consuming, requires the entire system to be switched off, especially if the component requiring attention is an essential element in the system architecture, such as the central processing unit (“CPU”). One possible solution to this problem is to immerse circuit assemblies vertically into a tank containing the cooling fluid such that each of the various assemblies can be withdrawn independently from the tank for servicing, replacement, upgrade, etc.”

(Ex-1001 at 1:62-2:6.) The ’457 patent also describes several prior art systems. (*Id.* at 1:33-61, 2:1-22.)

68. Additionally, the ’457 patent explains that “the key concept here is to move the secondary fluid to the point of heat exchange with the primary fluid, rather than to move the primary fluid to the point of heat exchange with the secondary fluid,” to minimize “the total volume of the dielectric fluid circulating throughout each immersion module.” (*Id.* at 8:47-55.) A POSITA would have been familiar with the underlying technical concepts related to this background information.

69. The educational level of active workers in the field of the invention also informs my opinion. Such individuals usually had at least a Bachelor of Science degree in mechanical or chemical engineering and at least two years of experience relating to the design and/or implementation of fluid circulation systems involving

application of fluid dynamics and heat transfer principles.

70. As of December 14, 2012, I had more than ordinary skill in the art. I am, however, familiar with the skills and knowledge possessed by those I would have considered to be of ordinary skill in the art as of that date. When I refer to the understanding of a POSITA, I am referring to the understanding of such a person as of December 14, 2012.

V. Claim Construction

71. I understand that claim terms in an IPR are generally interpreted 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. I also understand that extrinsic evidence may be helpful when construing a claim term, but that it is less relevant than the intrinsic evidence and is often unreliable.

72. I understand that the Petition gives an overview of prior litigation constructions that Patent Owner agreed to, as well as claim construction issues that arose during prosecution of the '457 patent, in a prior IPR proceeding, and prior litigation. I have reviewed and adopt that overview here, and note certain issues that relate to my technical analysis.

73. Specifically, for the limitation "a weir, integrated into the long wall of

the tank adjacent all appliance slots,” as noted above, during prosecution the examiner concluded that “the phrase ‘adjacent all appliance slots’, as presently claimed modifies ‘the long wall of the tank’ and not the weir” (Ex-1002 at 437) in relation to this limitation.

74. While applicant did not dispute this conclusion by the examiner during prosecution, in the prior IPR, Patent Owner argued that the claimed “weir” must be both “integrated into the long wall of the tank” and “adjacent all appliance slots.” Specifically, Patent Owner stated:

“The specification emphasizes the preferential goal of “substantially equal flow of the dielectric fluid upwardly into each appliance slot.” ... To that end, in a preferred embodiment, a long, open weir (22) is “integrated into the long rear wall of the tank.” ... The weir (22) extends to substantially the entire length of the tank, adjacent all the appliance slots. This arrangement facilitates substantially uniform recovery of the dielectric fluid as it flows through each appliance slot across the length of the tank. ... If the weir (22) were not so extended, substantially uniform recovery of the dielectric fluid would not be achieved.”
(Ex-1010 at 4.)

75. While I agree with the examiner’s conclusion (the long wall of the tank, not the weir, must be “adjacent all appliance slots”), in my opinion, the prior art discussed herein renders obvious these claim limitations even under Patent Owner’s position from the prior IPR (namely, that the weir must extend along the long wall adjacent all appliance slots).

76. Additionally, for the limitation “a weir ... having an overflow lip,”

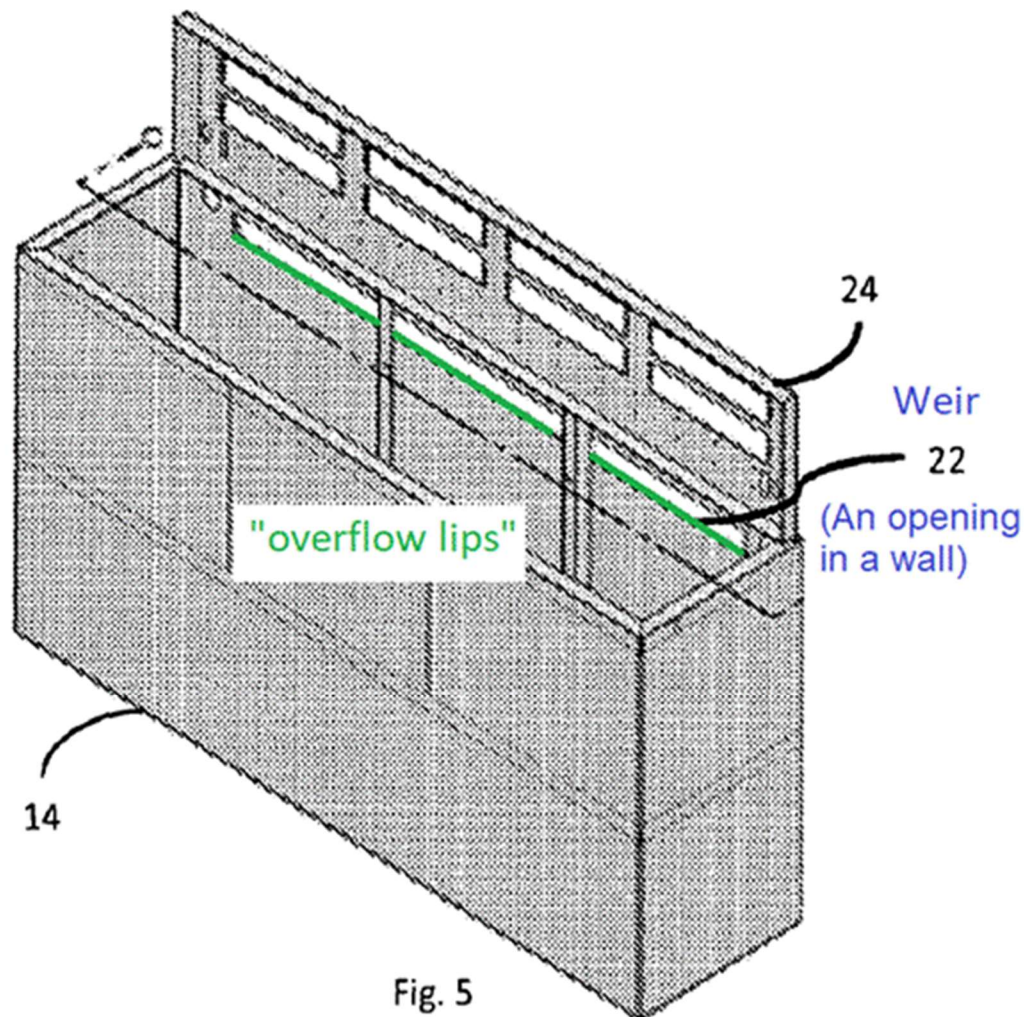
during prosecution the examiner found that this claimed “weir” can be an opening in a wall, and a “lip” can be “the bottom surface of [the weir] opening.” (Ex-1002 at 438.) At that time the applicant did not identify any “further structural limitation that should be associated with the term weir” when invited to do so by the examiner. (*Id.* at 438.)

77. I agree with the examiner that a weir can be an opening in a wall. This is also consistent with the definition previously agreed to by Patent Owner in a prior litigation (“an overflow structure or barrier that determines the level of a liquid”). (Ex-1010 at 26.)

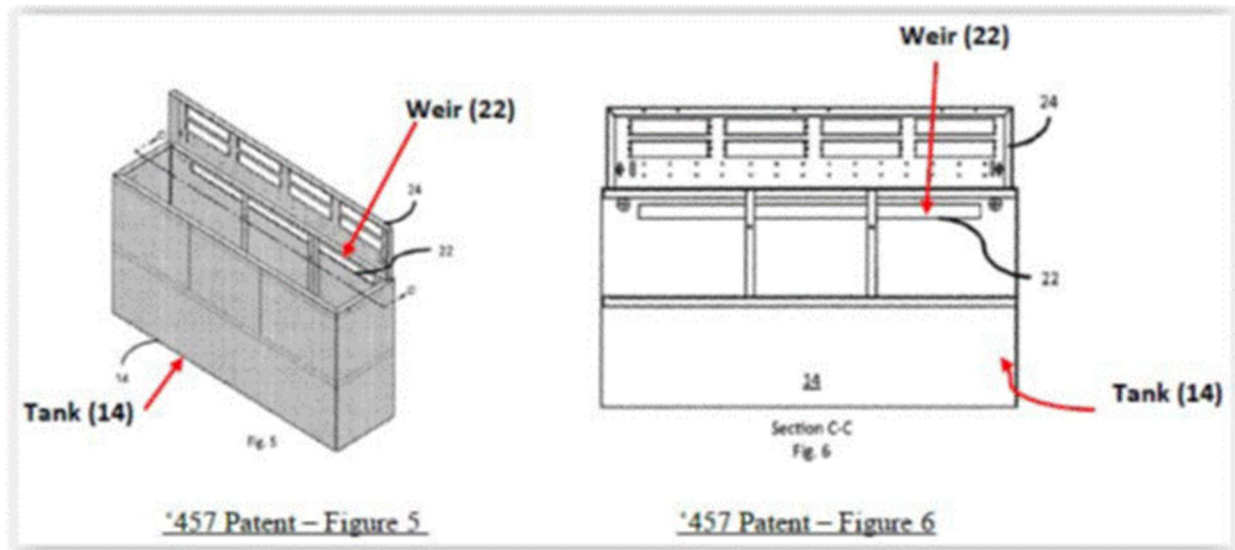
78. Regarding “lip,” the ’457 patent specification includes only one reference:

“One further shared component is the dielectric fluid recovery facility 40 (FIG. 2) comprising a dielectric fluid recovery reservoir 42 (see, FIG. 3, FIG. 4 and FIG. 13) positioned vertically beneath the overflow **lip** of the weir 22 and adapted smoothly to receive the dielectric fluid as it flows over the weir 22[.]” (Ex-1001 at 4:27-32.)

79. My review of the ’457 patent specification confirms the examiner’s conclusion. Specifically, FIG. 5 illustrates weir (22) as an opening in a wall and the “overflow lips” highlighted green are the bottom surfaces of those openings (i.e., the weir).



80. I understand that, in the prior IPR proceeding, Patent Owner submitted similarly annotated versions of the '457 patent FIGS. 5-6:



(Ex-1010 at 3.)

81. I also understand that, in a prior litigation, Patent Owner agreed that “plenum” as recited in the Challenged Claims means “a structure for dispensing liquid.” (Ex-1010 at 26.) In that same litigation, Patent Owner also agreed that “weir” as recited in the Challenged Claims means “an overflow structure or barrier that determines the level of a liquid.” (*Id.*)

82. In my opinion, the Challenged Claims use terms and phrases that would have been readily understood by a POSITA, and the prior art discussed herein would disclose the Challenged Claims under any reasonable construction. Thus, I believe no formal claim constructions are required.

VI. Overview of the Prior Art

83. I understand that the Petition addresses two obviousness grounds,

identified below:

- Ground 1: all claims (1-16) are obvious based on Best-2008 (Ex-1004) in view of Osada (Ex-1005); and
- Ground 2: all claims (1-16) are obvious based on Best-2008 (Ex-1004) in view of Osada (Ex-1005) and Best-2012 (Ex-1006).

I provide an overview of these references below.

A. Best-2008 (Ex-1004, US2011/0132579)

84. Best-2008 is U.S. Patent Application Publication No. 2011/0132579, which published June 9, 2011 and which claims priority to a PCT Application filed August 10, 2009, and three provisional applications, the earliest of which was filed August 11, 2008. I have been informed that Best-2008 qualifies as prior art.

85. Best-2008 “concerns application of heat-generating electronics such as, for example, rack mounted servers in data centers”. (Ex-1004-Best-2008 at 0005.) Best-2008 further relates to “novel apparatus, systems, and methods for efficiently cooling computing devices having heat-generating electronic components, such as, for example, independently operable servers immersed in a dielectric liquid coolant in a tank.” (*Id.* at 0025.) As such, Best-2008 is in the same field as the ’457 patent (liquid immersion / recirculation systems).

86. The dielectric coolant recirculation loop (which can also be referred to

as a fluid circuit) that continuously cools the servers in Best-2008 is illustrated in several figures, including FIG. 1A, annotated below:

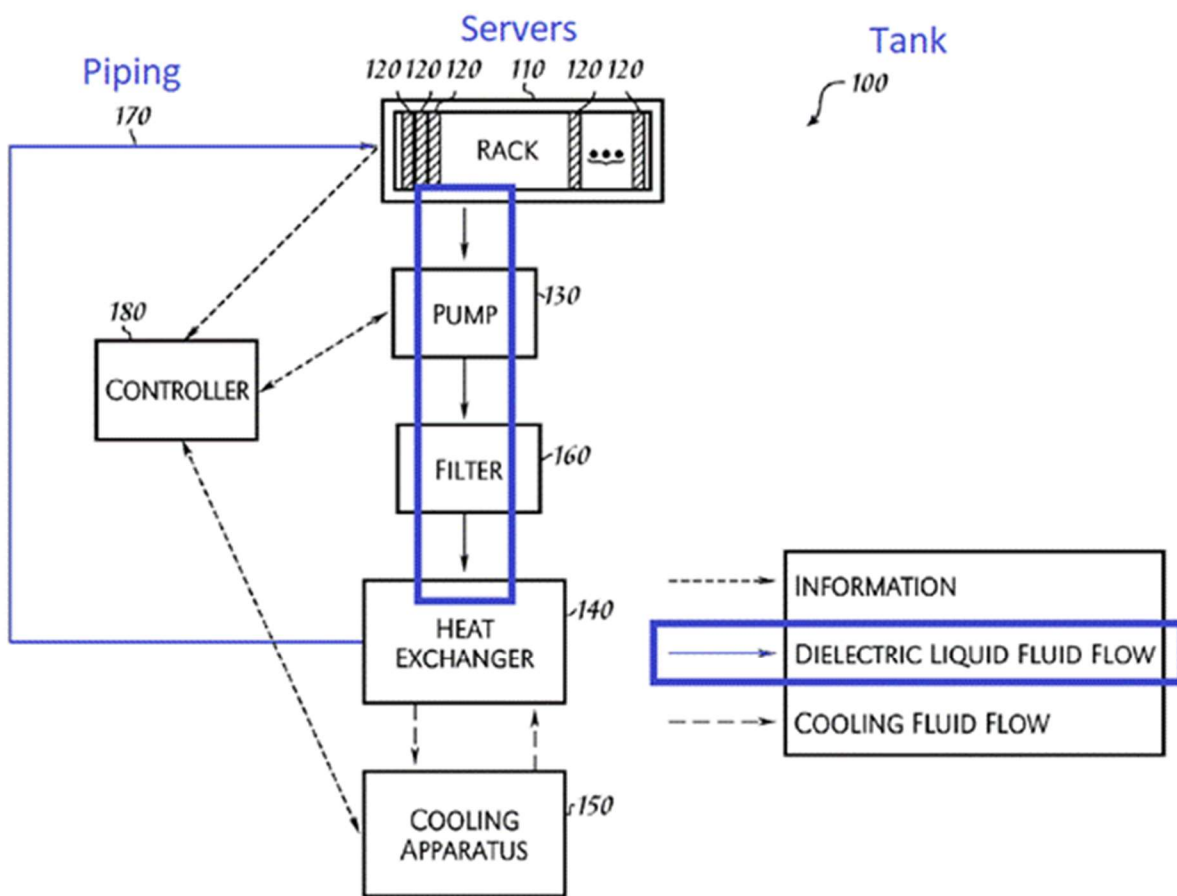


Fig. 1A

(Ex-1004-Best-2008 at FIG. 1A, 0065-67.)

87. Best-2008 discloses multiple implementations of its dielectric liquid recirculation loop, including inlet and outlet pipes noted below:

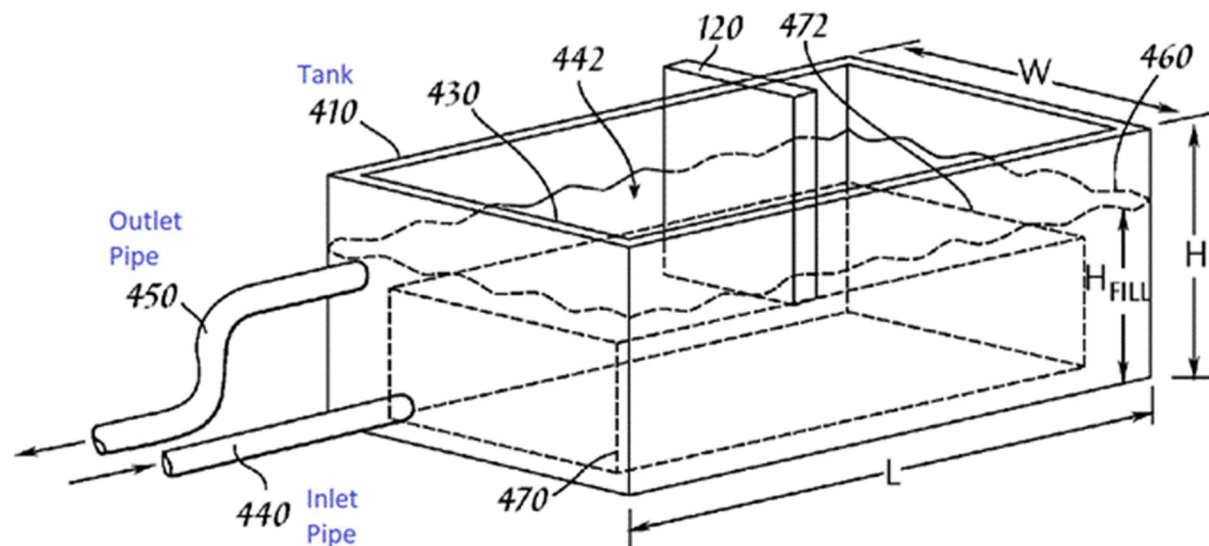


Fig. 3

(Ex-1004-Best-2008 at FIG. 3.)

88. Best-2008 discloses:

“The tank is fabricated to have an inlet pipe or line 440 from a piping system connected to a heat exchanger for the flow of lower temperature or cooled liquid coolant into the tank 410 and an outlet pipe or line 450 connected to collection piping for the flowing or pumping of heated coolant out of the tank to the external heat exchanger associated with one or more of the heat-rejection or cooling systems described in connection with FIGS. 1A, 1B, and 2.”

(*Id.* at 0084.)

89. The tanks in the Best-2008 systems are open on the top, which facilitates adding and removing servers. However the open tanks leave the dielectric liquid exposed to particulates and other materials, requiring filtration in the system.

(*Id.* at 0069, 0083, 0091-92, 0094, 0097, 0110.) Indeed, Best-2008 discloses filtering downstream of the tank and upstream of the heat exchanger. (Ex-1004-Best-2008

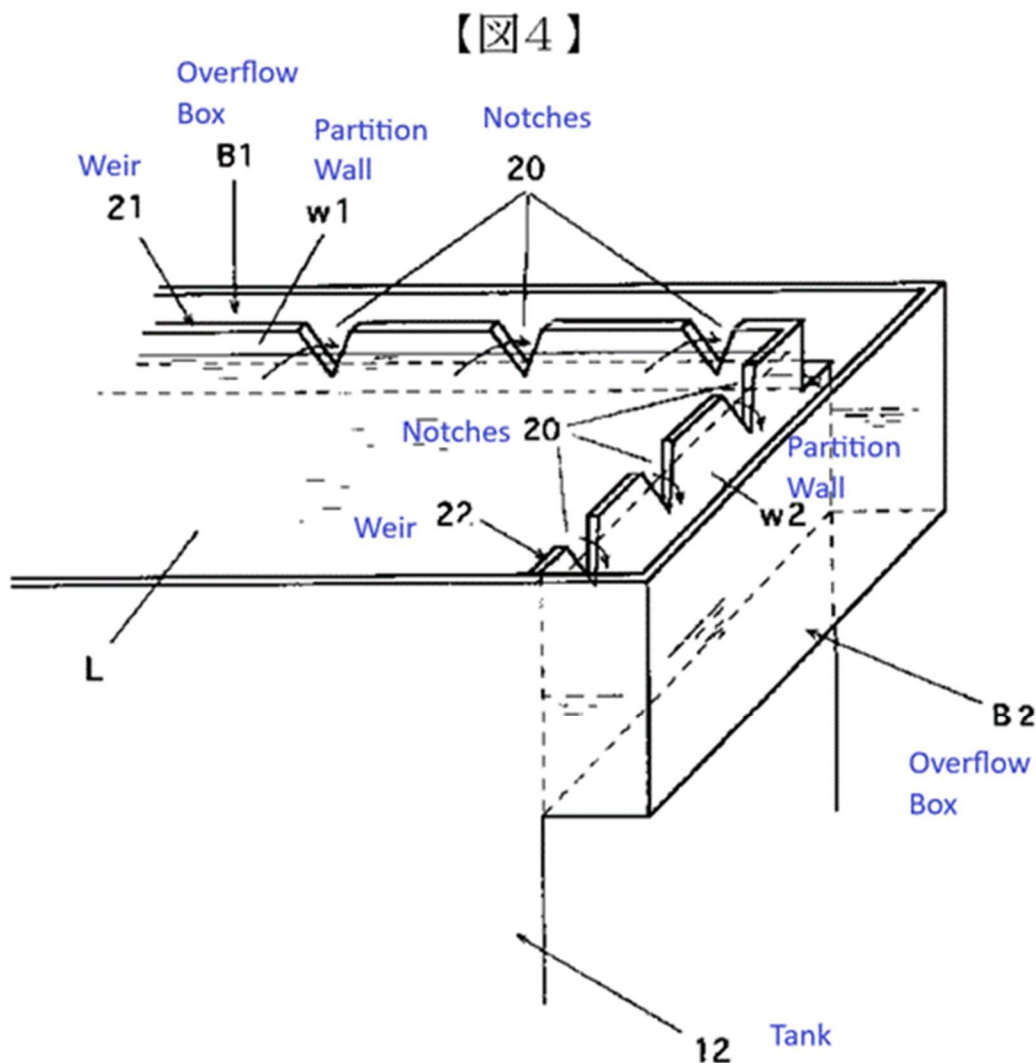
FIGS. 1A, 2, 0081.)

B. Osada (Ex-1005; JP2001-181898)

90. Osada is a certified English translation of Japanese Patent Application Publication No. 2001/181898, which published on July 3, 2001. I have been informed that Osada qualifies as prior art.

91. Osada discloses an immersion tank system having an open top tank and a recirculation loop similar to that of Best-2008. (Ex-1005-Osada at Abstract, 0002-3, FIGS. 3, 4, 16A.) Osada's immersion tank uses an overflow-weir arrangement designed to maintain an appropriate liquid level and assist with filtration. As such, Osada is in the same field as the '457 patent (liquid immersion / recirculation systems).

92. Osada discloses several implementations of its system, including the figure annotated below:

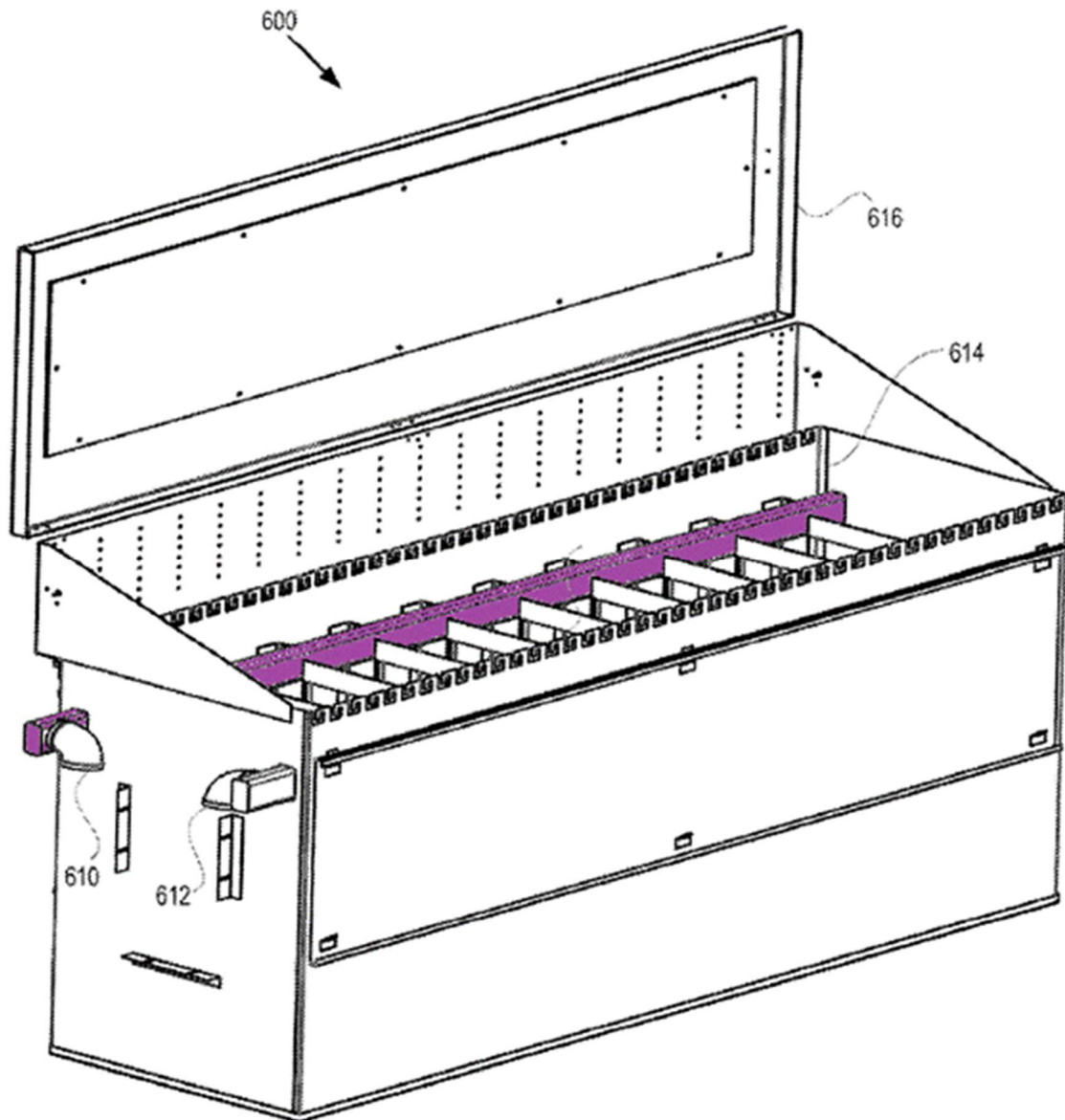


(Ex-1005-Osada at FIG. 4.)

C. Best-2012 (Ex-1006, US2014/0211412)

93. Best-2012 is U.S. Patent Application Publication No. 2014/0211412, which claims priority to a PCT Application filed August 12, 2012, and a provisional patent application filed August 5, 2011. (Ex-1006-Best-2012, (22), (60).) I have been informed that Best-2012 qualifies as prior art.

94. Compared to Best-2008, Best-2012 discloses several new embodiments including an embodiment in which the dielectric liquid flows through a recirculation loop comprising a suction manifold (purple), as illustrated below.



(Ex-1006-Best-2012 at FIG. 6.)

95. The suction manifold extends the entire length of the long wall of the

holding tank, and Best-2012 explains that this assists with “coolant flow [that] is approximately equal along the length of the entire tank 600.” (Ex-1006-Best-2012 at FIG. 6; 0070; *id.* at 0023, 0037-38, 0069, 0071-73; FIGS. 7a-7b.)

96. As such, Best-2012 is in the same field as the ’457 patent (liquid immersion / recirculation systems).

VII. GROUND 1: Best-2008 in view of Osada

A. Reasons for Combining Prior Art and Expectation of Success

97. In Ground 1, I describe why a POSITA would have combined Best-2008 and Osada.

98. Best-2008 is a published patent application relating to liquid immersion / recirculation systems, titled “Liquid Submerged, Horizontal Computer Server Rack and Systems and Method of Cooling Such a Server Rack.” (Ex-1004-Best-2008 at (54), 0005, 0025.)

99. Best-2008 teaches a cooling system comprising a tank having an open top in which is mounted a plurality of servers immersed in a dielectric liquid. (Ex-1004-Best-2008 at 0027-30, 0069, 0083, 0091-94, 0097, 0114.)

100. Best-2008 discloses that data centers are an envisioned application for the disclosed invention, and that such a data center “can comprise several large warehouse-sized buildings enclosing tens of thousands of square feet and housing

thousands of servers.” (Ex-1004-Best-2008 at 0007.)

101. A POSITA knew that an open-top tank containing a liquid in a warehouse-sized building would have allowed diverse organic and inorganic contaminants from numerous sources to fall onto or into the liquid in the tank.

102. Such contaminants include, for example, dust, pollen, other airborne particulates, insects, ceiling paint flakes, other larger contaminants, contaminants on servers when they were installed in the tank, and numerous other types of contaminants from numerous sources. (Ex-1017 (H. Müller-Steinhagen, “Fouling: The Ultimate Challenge for Heat Exchanger Design”, in *Transport Phenomena in Thermal Engineering*, Vol. 2, pp. 811-823 (1993), Begell House, Inc., ISBN Print: 1-56700-015-0).) I have access through my work to technical journals and to commonly used search tools for finding relevant technical articles in such journals. The above-noted technical article is a publication that a POSITA would have been able to find and have access to as of December 14, 2012.

103. A POSITA knew that some such contaminants may settle into the liquid and become suspended in it, while others may remain on the liquid surface due to the effect of surface tension.

104. A POSITA knew that such contaminants may accumulate over time as the liquid continued to be used for cooling the servers in the open tank, causing the

liquid to become increasingly contaminated during its use for cooling the servers in the open tank.

105. Best-2008 further teaches the use of (1) a pump and valves to circulate the dielectric liquid, (2) a heat exchanger to transfer heat out of the dielectric liquid, and (3) a filter to filtrate the dielectric liquid, which filter is located upstream of the heat exchanger. (Ex-1004-Best-2008 at 0080-81.)

106. Best-2008 discloses:

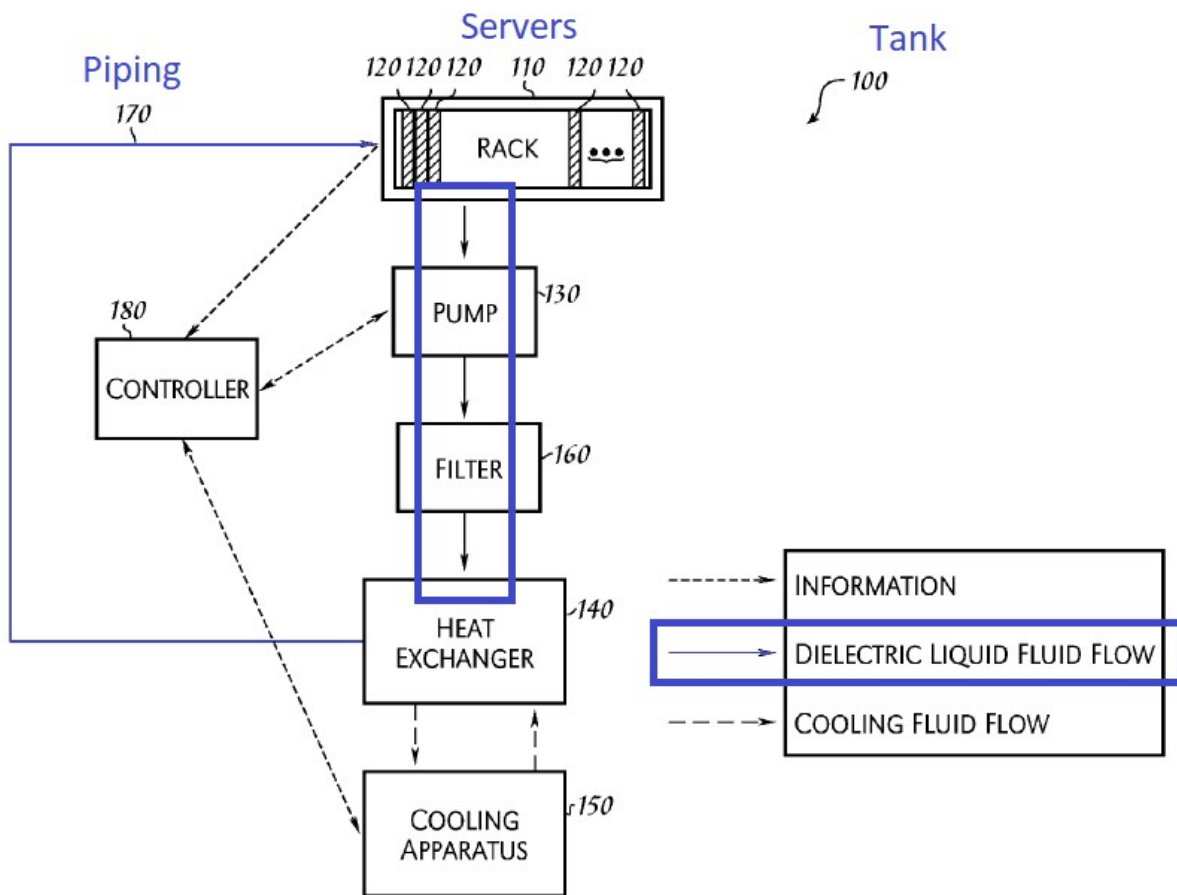


Fig. 1A

(Ex-1004-Best-2008 at FIG. 1A, 0065-67.)

107. Best-2008 also discloses that:

“The liquid coolant heated by the servers 120 in the server rack is then fluidly coupled through suitable piping or lines to a pump 130, which pumps the heated liquid coolant through suitable piping or lines to a remotely or distally located heat exchanger 140 associated with a heat-rejection or cooling apparatus 150. The distally heat exchanger 140 rejects the heat from the incoming heated liquid coolant and fluidly couples the cooled liquid coolant through a return fluid line or piping 170 back into the tank 110. Thus, at least a portion of the liquid coolant completes a fluid circuit through the servers 120 in the tank 110, pump 130, heat exchanger 140, and back into the tank 110.”

(Id. at 0067.)

108. Best-2008 illustrates several embodiments of its dielectric liquid recirculation system, including Figures 3-6. For example, annotated Figures 3 and 6 illustrate:

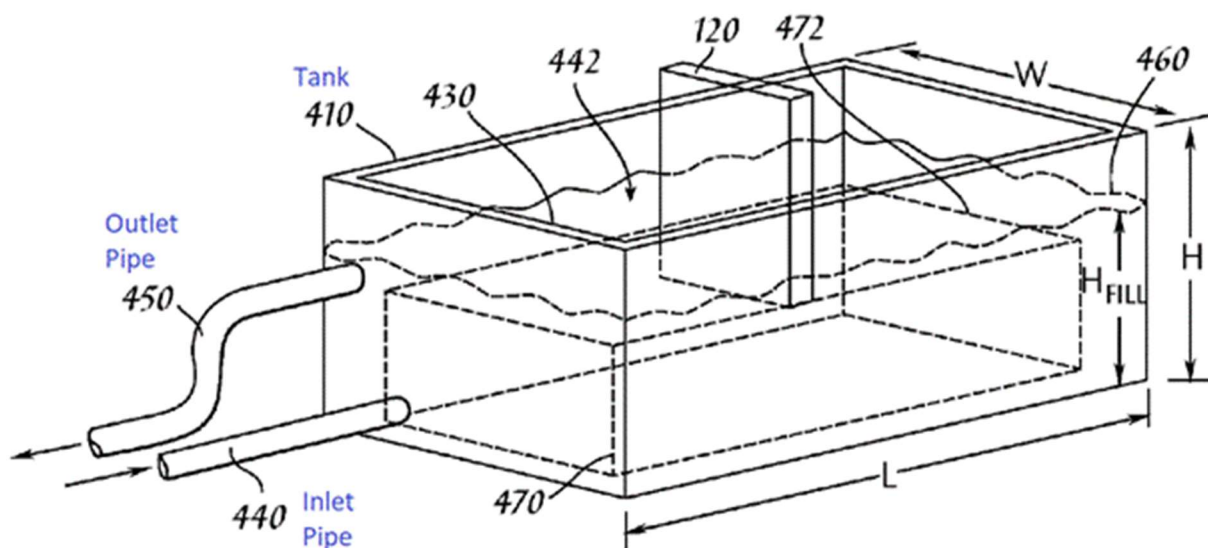
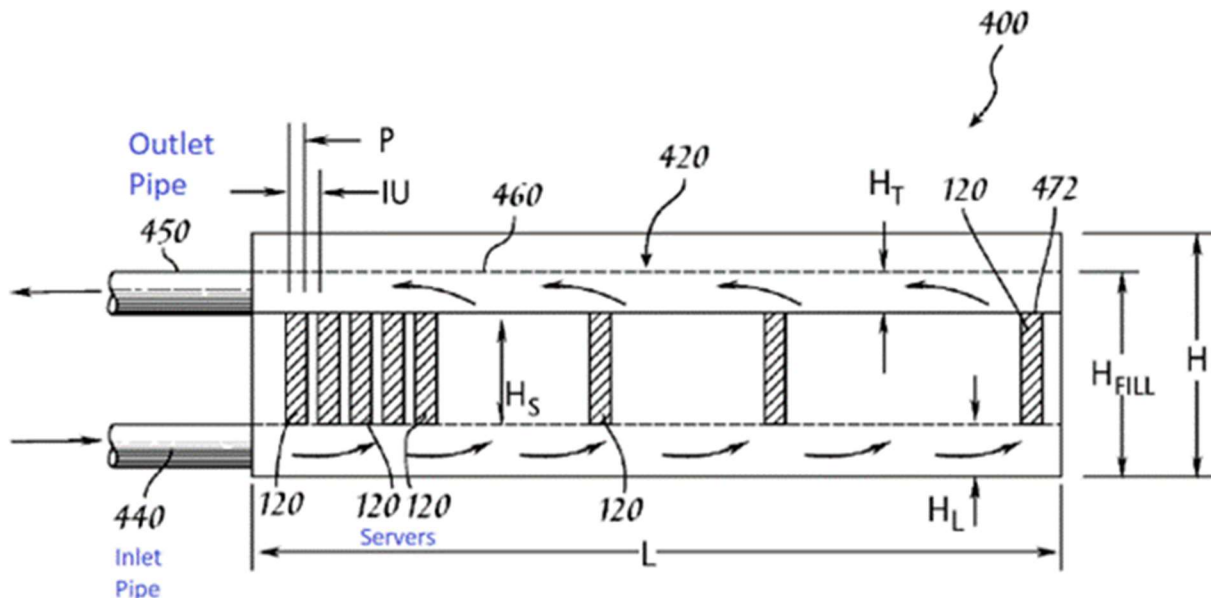


Fig. 3



(Ex-1004-Best-2008 at FIGS. 3, 6.)

109. In these implementations, the pipes, including inlet 440 and outlet 450 are connected to a heat exchanger “for the flow of lower temperature or cooled liquid coolant into the tank 410 and ... for the flowing or pumping of heated coolant out of the tank to the external heat exchanger.” (Ex-1004-Best-2008 at 0084.)

110. Best-2008 explains that the system for heat-rejection or cooling may be any of those “described in connection with FIGS. 1A, 1B, and 2.” (*Id.*)

111. A POSITA knew that effective filtration of the liquid to remove its contaminants was essential for the pump, valves, and heat exchanger(s) in Best-2008's cooling system to function effectively.

112. For example, some contaminants can act to obstruct the flow through

the pump, valves, and other components, which reduces the liquid circulation performance and thereby increases the energy cost to operate the cooling system.

113. Other contaminants can accumulate on the heat exchanger surfaces, which reduces the heat transfer coefficient from the liquid and thereby increases the energy cost to operate the cooling system. (*See* Ex-1018 (D. Bouris & G. Bergeles, “Particle-Surface Interactions in Heat Exchanger Fouling”, *Journal of Fluids Engineering*, Vol. 118, pp. 574-581 (1996), ASME Fluids Engineering Division).) I have access through my work to technical journals and to commonly used search tools for finding relevant technical articles in such journals. The above-noted technical article is a publication that a POSITA would have been able to find and have access to as of December 14, 2012.

114. Best-2008 repeatedly teaches that reducing the energy cost to operate the cooling system it teaches is one of the central objectives of the invention. (Ex-1004-Best-2008 at 0026-28, 31, 68, 73, 82 126, 128, 131-136, claims 1, 24, 38, 40, 43.)

115. Best-2008 also teaches the use of a filter in its liquid circuit (Ex-1004-Best-2008 at 81), but neither specifies nor restricts the filtration method(s) that can be used.

116. A POSITA knew that there were many ways of filtering a liquid that

flows in a circuit and would have understood that Best-2008 thus teaches the use of any suitable filtering method or any combination of suitable filtering methods. (*See, e.g.,* Ex-1019 (C. Sandu & D. Lund, “Minimizing Fouling in Heat Exchanger Design”, *Biotechnology Progress*, Vol. 1, No. 1, pp. 10-17 (1985))). I have access through my work to technical journals and to commonly used search tools for finding relevant technical articles in such journals. The above-noted technical article is a publication that a POSITA would have been able to find and have access to as of December 14, 2012.

117. Methods for filtering contaminants (1) on the liquid surface and (2) suspended within the liquid would therefore have been of great interest to a POSITA reading the disclosure of Best-2008.

118. A POSITA would have sought filtration methods that could achieve filtration without interfering with – or ideally that could assist with – other objectives taught by Best-2008.

119. Best-2008 discloses several objectives, such as flowing the dielectric coolant liquid between the plurality of servers, efficiently cooling each of the plurality of servers, varying the liquid level in the tank to vary the depth to which the servers are immersed in the dielectric liquid (*Id.* at 0098 (explaining that “after the two racks of multiple servers are mounted inside the tank 810, the level 824 of

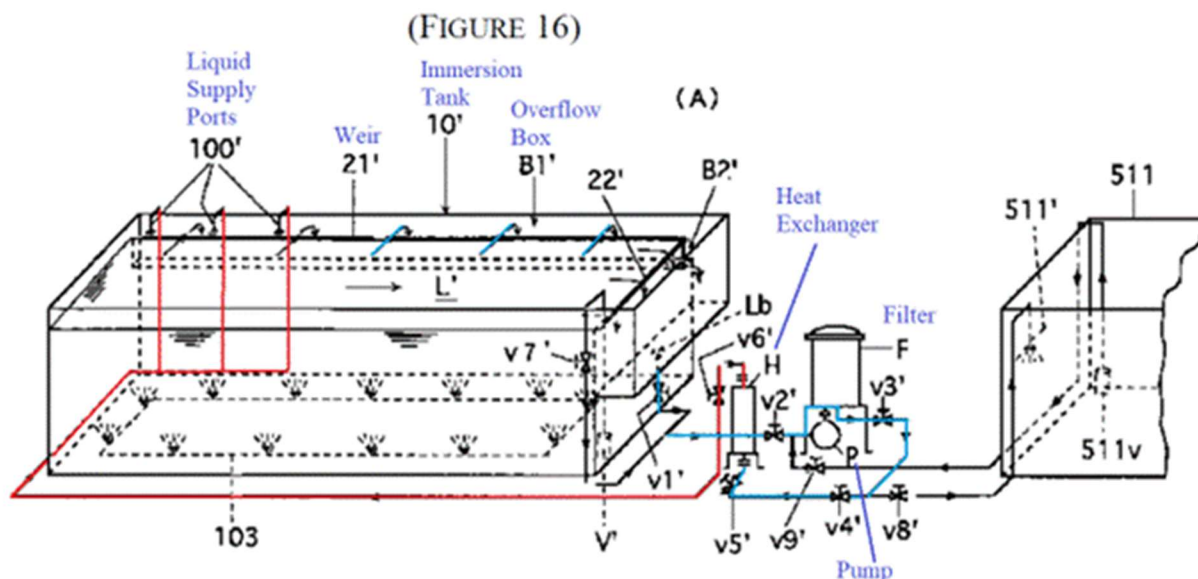
the liquid coolant 822 may be carefully controlled to adjust the amount of flow of the liquid coolant through the multiple servers and to adjust the amount of heat removal from the heat generating electronic components in the servers,”), 0027-0030 (e.g., explaining that “at least a substantial portion of each server is submerged within the dielectric liquid coolant for sufficiently cooling each respective server when the tank is sufficiently full of the liquid coolant,”), 0066 (explaining that at least “a portion of each server 120 is submerged within the dielectric liquid coolant for sufficiently cooling each respective server when the tank 110 is sufficiently full of the liquid coolant” and that preferably, each of the servers during operation is completely submerged within the dielectric liquid coolant,” 0080, 0102), adjusting the flow of the dielectric liquid coolant through the fluid circuit (*Id.* at 0026, 0073, 0082, 0098, 0102-0103, 0107, 0116, FIG. 17A-B), monitoring the temperature of the liquid at one or more locations in the liquid (*Id.* at 0027-28, 0068-69, 0073, 0082, 0126-127, FIG. 16, FIG. 17A), maintaining an elevated temperature in the liquid (*Id.* at 0027-28, 0074, 0111, FIG. 16, FIG. 17B), achieving a relatively uniform temperature in the coolant liquid (*Id.* at 0104, 0107), transferring heat from the liquid via a heat exchanger (*Id.* at 0030-31, 0070, 0081, 0105, 0126, FIG. 16, FIG. 17A), making use of vertical natural convection of the liquid coolant flow between servers (*Id.* at 0087, 0104), reducing coolant flow that bypasses the servers (*Id.* at 0088), and

using the fluid velocity augmentation devices to enhance the flow of liquid coolant through the servers (*Id.* at 0107, 0117, 0131, FIG. 17B).

120. In my opinion, a POSITA would have been motivated and found it obvious to implement the teachings of Osada with Best-2008 to ensure that these stated objectives of Best-2008 are met.

121. As I detailed above, Osada concerns liquid immersion tanks “that can be utilized in an article processing device to perform processing using a liquid, and in particular, to an article processing device that involves a liquid for which filtration of the processing liquid is desired.” (Ex-1005-Osada at 0001.) Like Best-2008, Osada seeks to control “the liquid quality and liquid composition of said liquid, the volume of processing liquid in the liquid tank, filtration volume, temperature, and the like, as necessary.” (*Id.* at 0002.) Osada also illustrates several implementations to meet these objectives.

122. As one example, Osada illustrates a “conventional” immersion tank and liquid system in FIG. 16A, annotated below:



(Ex-1005-Osada at FIG. 16A.)

123. A POSITA would have known of a system like this at the time of Osada.

124. Similar to Best-2008, the system includes an open-air tank (10), a pump, a filter (F), and a heat exchanger (H). (Ex-1005-Osada at FIG. 16(A); 0050-54.)

125. As indicated in the above figure, liquid in the immersion tank (L') flows out of the tank (10') through weirs (21', 22') into overflow boxes (B1', B2'). (*Id.*) Next, the liquid flows through an exit port (Lb) and is pumped through the filter (F) for impurity control. (*Id.*) Finally, the liquid is pumped through the heat exchanger (H) for temperature control, and back to the tank to recirculate through liquid supply ports (100'). (*Id.*) As such, Osada's fluid recirculation loop is nearly identical to Best-2008's.

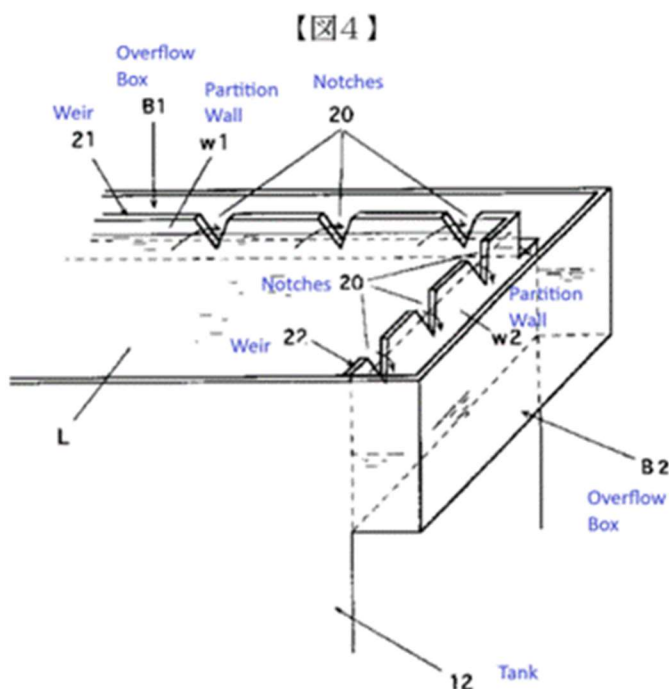
126. Osada explains, as a POSITA at the time would know, that such conventional systems “widely used” a “rectangular weir” that extends “linearly in the horizontal direction” into a “overflow box” located on the outside of the tank for filtration / removal of impurities. (*Id.* at 0006.) In particular, Osada teaches that the conventional weir removes impurities from the liquid located near the top of the tank, but not impurities suspended lower in the liquid in the tank, leading to increased impurity concentrations in the liquid over time. (*Id.* at 0010.) Osada further explains that the conventional weir may lead to “inflow of the processing liquid into said box without any elevation difference,” *e.g.*, backflow into the tank due to a generally linear increase in flow rate into the overflow boxes. (*Id.* at 0006-7, 0133, 0137-43.)

127. As such, Osada also discloses an improved implementation of the open air tank liquid recirculation system, in which the tank is “characterized by having one, two, or more overflow boxes in order to force the overflow of impurities that may be suspended in the top layer part in liquid accumulated in the liquid tank along with liquid from a weir part, in which weir part, **an overflow notch** is formed in a top margin part of a partition wall between the overflow box and the liquid tank.” (*Id.* at 0015.)

128. Using these overflow notches advances two of the shared objectives of

Osada and Best-2008: (1) removing “impurities that are more likely to be suspended in the lower layers” to “reduce the amount of impurities remaining in the liquid tank,” and (2) maintaining liquid level in the tank because “there will be no significant change in the amount of liquid flowing into the overflow box,” “even if the liquid level position in the liquid tank changes vertically.” (*Id.* at 0010-12.)

129. Osada illustrates one such embodiment in FIG. 4, annotated below:



(Ex-1005-Osada at FIG. 4.)

130. Osada further teaches that it is “preferable to provide multiple notches over a broad range, and it is even more preferable to provide these notches at uniform spacing to ensure that it is possible to force the flow of all of the floating impurities that are easily suspended on the liquid surface and impurities that are

more likely to be suspended in the lower layers into the overflow box over *the entirety of the liquid in the liquid tank.*” (*Id.* at 0018.)

131. Osada also teaches that these notches may have any shape, including “an inverted triangle shape” i.e., a V-shape, a U-shape, or a rectangular shape, and any number of overflow boxes may also be used in the system, including “one, two, or more.” (*Id.* at 0017, 0019-21.)

132. A POSITA would have been motivated and found it obvious to implement overflow weirs and boxes along the long side of Best-2008 as taught in Osada. A POSITA would have implemented these solutions to at least ensure proper control of impurities and temperature of the recirculating liquid through an open-air liquid immersion tank; maintenance of liquid level height to prevent backflow is thereby also facilitated. Moreover, implementing Osada’s weir or weir-and-notches system into the long wall of a tank as opposed to the short wall of a tank provides greater flow of surface liquid into the overflow boxes while keeping the liquid level in the tank more nearly constant.

133. While Best-2008 discloses one way to remove recirculating liquid from the tank, via outlet pipe(s) in wall(s) of the tank, it would have been obvious to a POSITA to use an overflow-weir system to do so. This is confirmed by Osada’s recognition of a “conventional,” horizontal, rectangular weir being “widely used”

with open-air liquid immersion tanks. (Ex-1005-Osada at 0006.) Applying this teaching to Best-2008 would have been an obvious alternative manner to remove recirculating liquid from the immersion tank to then flow through conventional filtration and temperature control apparatus, as taught by both Best-2008 and Osada.

134. Similarly, a POSITA would have found it obvious to apply Osada's weir-and-notch system to Best-2008's open-air tank liquid recirculation system, as it was a known improved alternative to the conventional rectangular weir design recognized by Osada.

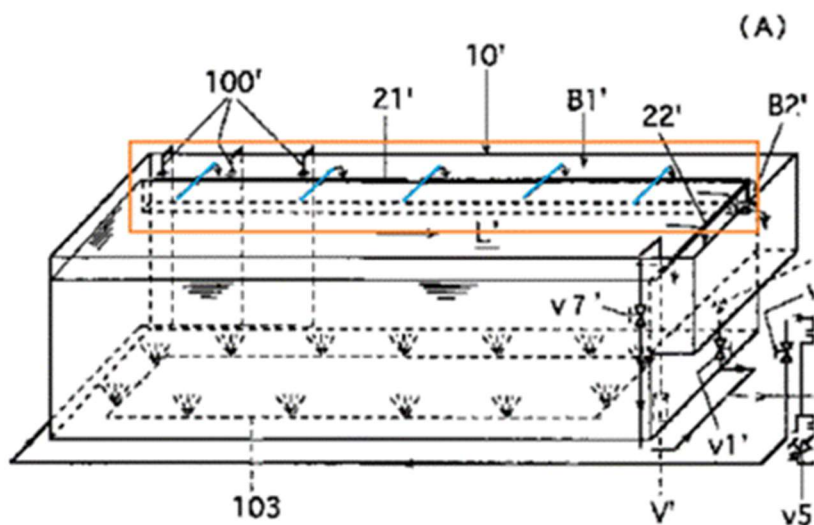
135. A POSITA would have reasonably expected to succeed in implementing Osada's conventional weir or weir-and-notch system with the Best-2008 tank. To do so, all that would be required is a simple mechanical reconfiguration of the tank to use Osada's conventional weir or Osada's weir-and-notch system, which would be straightforward for a POSITA to implement. These improvements would achieve Best-2008's objectives including appropriate filtration and temperature control, as well as controlling the liquid level, and would have been easy to implement as design alternatives.

136. Specifically, a POSITA would understand that Osada's designs not only improves removing impurities from the liquid in the open-air tank while also assisting in controlling the liquid level, but also furthers temperature uniformity. As

described above, Best-2008 discloses the use of multiple outlet pipes in the fluid recirculation system. A POSITA considering Best-2008 and Osada would have understood that Osada's weir design improves temperature uniformity by facilitating substantially uniform flows through and out of the open-air tank.

137. For example, Osada FIG. 16A, annotated below, illustrates these flows:

(FIGURE 16)



(Ex-1005-Osada at FIG. 16(A).)

138. Osada's fluid flow arrows (highlighted in blue and circled in orange), illustrate the liquid uniformly flowing out through the weir (21') in the long side of the tank. A POSITA knew that the outflow of liquid from the tank through Osada's overflow notches would have induced an upward flow of liquid within the tank. Implementing this in Best-2008 would enhance upward flow of coolant within and

out of the tank, which would have assisted in meeting Best-2008's objective of having upward flow of coolant within the tank. It would also have assisted in addressing potential stagnant locations in the Best-2008 that could be present due to the use of a single outlet pipe. (Ex-1004-Best-2008 at FIGS. 8, 9, 10, and 14.)

139. A POSITA knew that, where coolant flow in an immersion tank is stagnant or largely stagnant, or even just flowing at lower flow speed than elsewhere in the liquid tank, the heat transferred from the immersed servers to the liquid coolant in those parts of the tank is reduced.

140. Thus, the induced liquid flow from Osada's weir-and-notches system assists in Best-2008's objectives including:

- “the flow of the dielectric liquid coolant through the servers is improved ... such that the flow of the dielectric liquid coolant through the servers is enhanced” (Ex-1004-Best-2008 at 0086.)
- “such that the flow of the dielectric liquid coolant through the plurality of servers is improved ... such that the flow of the dielectric liquid coolant through the plurality of servers is enhance [sic].” (*Id.* at 0102.)
- “improving the flow of the coolant through the plurality of servers” (*Id.* at 0107.)

141. A POSITA also knew that the resulting induced upward flow of liquid

coolant within the tank of Best-2008 would have increased the rate of heat transfer from the servers into the liquid, since the rate of convective heat transfer from the servers into the liquid coolant was known to increase as the liquid flow speed relative to the servers increases.

142. Thus, the induced coolant flow from Osada's overflow notches would have assisted in meeting Best-2008's objective of sufficiently cooling each respective server.

143. Additionally, a POSITA knew that the upward flow of liquid within the tank that is induced by the outflow of liquid from the tank through Osada's conventional weir or weir-and-notches system produces increased heat transfer from the servers into the liquid, exceeding the far smaller heat transfer that is produced solely from buoyancy-driven upward flow due to natural convection within the tank.

144. A POSITA knew that the resulting induced upward flow of liquid within the tank facilitated by Osada's conventional weir or weir-and-notches system would have produced additional forced convection that would increase the heat transferred from the servers into the liquid as compared to the heat transferred solely by the buoyancy-driven natural convection. This also would have assisted in meeting Best-2008's objective that its configuration "permits the liquid coolant heated by the heat generating components in the servers to naturally rise through the servers and

exit through the top of the servers. (Ex-1004-Best-2008 at 0087, 0104.) This also would have assisted in meeting Best-2008's objective for flowing the dielectric coolant liquid between the plurality of servers.

145. A POSITA further knew that the upward flow of liquid within the tank that is induced by the outflow of liquid from the tank through Osada's overflow notches also would have "increase[d] the mixing of the dielectric liquid coolant within the tank" as taught by Best-2008. (Ex-1004-Best-2008 at 0107.)

146. A POSITA knew that the resulting increased mixing of the dielectric liquid coolant in the tank would have assisted in meeting three of Best-2008's stated objectives.

147. First, the resulting increased mixing would act to homogenize the liquid temperature field within the tank, thereby enabling Best-2008's measurement of the liquid temperature "at one or more locations" to provide a more accurate value for the actual liquid temperatures within the tank. Doing so allows Best-2008's controller to more readily implement changes in flow rates through the tanks and/or heat exchanger(s) to facilitate maintenance of one or more target temperatures within the tank(s) of Best-2008.

148. Second, the resulting increased mixing acts to decrease the maximum liquid temperature within the tank. A POSITA knew that this decrease in the

maximum liquid temperature within the tank would have increased the heat transferred from the servers into the liquid coolant, due to the resulting increased temperature difference between the server components and the liquid. This assists in meeting Best-2008's objective of efficiently cooling the servers.

149. Third, the resulting increased mixing acts to increase the minimum liquid temperature within the tank. A POSITA knew that the increase in the minimum liquid temperature within the tank would have increased the heat transferred from the coolant in the heat exchanger of the system. This assists in Best-2008's objective of maximizing the temperature of the coolant in the heat exchanger to minimize the energy needed to cool the servers.

150. A POSITA would also have used Osada's overflow boxes when implementing its weir teachings with the Best-2008 tank. Indeed, it was not an option to exclude Osada's overflow boxes when adopting its Osada's conventional weir or weir-and-notches teachings because, otherwise, the liquid would not be captured as it overflowed over the weir out of the tank and would simply be lost.

151. Osada teaches placing the overflow boxes at the "upper peripheral side of the wall surrounding the liquid tank" (Ex-1005-Osada at 0018.) Doing so has many benefits that a POSITA would have recognized. For example, such placement of the overflow boxes would have minimized splash of the overflow liquid entering

the liquid surface in the overflow boxes due to the lower kinetic energy of the liquid at the point where it reaches the liquid surface in the overflow boxes. This is a benefit because it prevents splash loss of recoverable liquid, assisting with Best-2008's efficiency objectives.

152. Additionally, such placement of the overflow boxes would have restricted or lowered the amount of air ingestion (aeration) and associated oxygenation of the liquid in the overflow box, also due to the lower kinetic energy of the overflow liquid entering the liquid surface in the overflow boxes. Minimizing oxygenation in turn decreases the likelihood of microbial fouling of the dielectric liquid. (*See, e.g.,* Ex-1017 at 818; Ex-1019 at 11-12; Ex-1021 (H. Müller-Steinhagen, "Cooling-Water Fouling in Heat Exchangers", *Advances in Heat Transfer*, Vol. 33, pp. 415-496 (1999), esp. 416, 422, 457 (discussing biological fouling)).) I have access through my work to technical journals and books and to commonly used search tools for finding relevant technical articles in such journals or books. The above-noted technical articles and book excerpt are publications that a POSITA would have been able to find and have access to as of December 14, 2012.

153. A POSITA would also have reasonably expected to succeed in implementing Osada's overflow box teachings. It was straightforward for a POSITA to attach an exterior box to a tank, such as taught by Osada, and doing so was well

within the capabilities of a POSITA.

B. Challenged Claims

154. As noted herein, claims 1-16 of the '457 patent are obvious. In my opinion, the claim sets are highly aligned. Thus, like Petitioner, I have grouped my analysis below by claim sets:

- Claim Set 1: claims 1-5;
- Claim Set 2: claims 6-10;
- Claim Set 3: claims 11-16.

155. Comparing the three claim sets (*see* Ex-1009), with minor differences italicized, confirms my opinion:

Claim Set 1 (claims 1-5)	Claim Set 2 (claims 6-10)	Claim Set 3 (claims 11-16)
[1.0] An appliance immersion cooling system comprising:	[6.0] A <i>tank module adapted for use in</i> an appliance immersion cooling system, <i>the tank module</i> comprising:	[11.0] <i>A tank module (10) adapted for use in</i> an appliance immersion cooling system, <i>the tank module</i> comprising:
[1.1] a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:	[6.1] a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:	[11.1] a tank (12) adapted to immerse in a dielectric fluid a plurality of electrical appliances (16), each in a respective appliance slot (18) distributed vertically along, and extending transverse to, a long wall of the tank (10), the tank (10) comprising:
[1.2] a weir, integrated	[6.2] a weir, integrated	[11.2] a weir 22,

Claim Set 1 (claims 1-5)	Claim Set 2 (claims 6-10)	Claim Set 3 (claims 11-16)
horizontally into the long wall of the tank adjacent all appliance slots, <u>having an overflow lip</u> adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and;	horizontally into the long wall of the tank adjacent all appliance slots, <u>having an overflow lip</u> adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and;	integrated horizontally into the long wall of the tank (10) adjacent all appliance slots (18), adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot (18);
[1.3] a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir;	[6.3] a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir;	N/A
[1.4] a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot;	[6.4] a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot; <u>and</u>	[11.3] a primary circulation facility (28) adapted to circulate the dielectric fluid through the tank (10), comprising: a plenum (36), positioned adjacent the bottom of the tank (10), adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot (18); and
[1.5] a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary	N/A	See Claim 16

Claim Set 1 (claims 1-5)	Claim Set 2 (claims 6-10)	Claim Set 3 (claims 11-16)
circulation facility, and to dissipate to the environment the heat so extracted; <i>and</i>		
[1.6] a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank.	[6.5] a control facility adapted to control the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank.	[11.4] a control facility (58) adapted to control the operation of the primary fluid circulation facility (28) as a function of the temperature of the dielectric fluid in the tank (10).
2. The system of claim 1 wherein the tank and primary circulation facility comprise a highly-integrated module.	7. The <i>module of claim 6</i> wherein the tank and primary circulation facility comprise a highly-integrated module.	N/A
3. The system of claim 1 wherein the tank further comprises:	8. The <i>module of claim 6</i> wherein the tank further comprises:	12. The <i>tank module of claim 11</i> wherein the tank further comprises:
an interconnect panel facility adapted to mount appliance support equipment.	an interconnect panel facility adapted to mount appliance support equipment.	an interconnect panel facility (24) adapted to mount appliance support equipment.
4. The system of claim 1 wherein the primary circulation facility further comprises:	9. The <i>module of claim 6</i> wherein the primary circulation facility further comprises:	13. The <i>module of claim 11</i> wherein the primary circulation facility further comprises:
at least first and second primary circulation sub-facilities, each adapted to	at least first and second primary circulation sub-facilities, each adapted to	at least first and second primary circulation sub-facilities (28a, 28b), each

Claim Set 1 (claims 1-5)	Claim Set 2 (claims 6-10)	Claim Set 3 (claims 11-16)
operate independently to circulate the dielectric fluid through the tank;	operate independently to circulate the dielectric fluid through the tank;	adapted to operate independently to circulate the dielectric fluid through the tank;
wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities <u>and the secondary fluid circulation facilities</u> so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.	wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.	wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.
5. The system of claim 1 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.	10. The <u>module of claim 6</u> wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.	14. The <u>module of claim 11</u> wherein the control facility further comprises a communication facility (62, 64) adapted to facilitate monitoring and control of the control facility from a remote location.
N/A	N/A	15. An appliance immersion cooling system comprising a tank module according to any one of the preceding claims 11 through 14.

Claim Set 1 (claims 1-5)	Claim Set 2 (claims 6-10)	Claim Set 3 (claims 11-16)
See claim 1	N/A	16. An appliance immersion cooling system according to claim 15, further comprising:
See claim 1	N/A	a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted.

156. Claim sets 2 and 3 recite “tank module” in the preambles. This is an intended use and does not change my opinion as to how the prior art discussed herein discloses and renders obvious “tank modules” for use in “appliance immersion cooling systems”.

157. Dependent claim 15, in claim set 3, recites an “appliance immersion cooling system comprising a tank module according to any one of the preceding claims 11 through 14.” This does not make sense, because claim 11, from which claim 15 depends, already recites “A tank module (10) adapted for use in an appliance immersion cooling system,”. This aspect of claim 15 does not change my opinion as to how the prior art discussed herein discloses and renders obvious tank

modules used in appliance immersion cooling systems.

1. Claim Set 1

[1.0] “An appliance immersion cooling system comprising:”

158. Best-2008 teaches “an appliance immersion cooling system comprising.” For example, Best-2008 discloses “novel apparatus, systems, and methods for efficiently cooling computing devices having heat-generating electronic components, such as, for example, independently operable servers immersed in a dielectric liquid coolant in a tank.” (Ex-1004-Best-2008 at 0025.)

159. Additionally, the ’457 patent admits Best-2008 teaches this limitation. (Ex-1001 at 2:23-27.)

160. Accordingly, Best-2008 teaches the preamble of claim 1.

[1.1] “a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:”

161. Best-2008 teaches “a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:”. For example, Best-2008 discloses several tank arrangements, each of which is “adapted to immerse in a dielectric fluid a plurality of electrical appliances.” (*Id.* at FIGS. 3-15, 0060-0120.)

162. For example, FIG. 3 of Best-2008 depicts a tank (410) “for immersing

a rack of independently operable servers in a liquid coolant.” (*Id.* at 0083.) The liquid coolant may be a dielectric fluid. (*Id.* (“The tank 410 may be fabricated of [material] that is compatible with the dielectric liquid coolant used as a cooling medium.”).)

163. Further, this tank of Best-2008 is configured to form a server rack (470) where the servers are generally in a vertical orientation with the front facing upwards. Best-2008 discloses:

“Suitable mounting members may be used to mount the servers in the tank to form the server rack 470 within the tank.”
(*Id.*)

“[T]he mounting members are configured to mountably receive the plurality of servers in a vertical orientation, thereby minimizing the footprint of the servers relative to the ground, and with the ‘front’ panel facing upward for easy installation and removal of a server without the need to remove or disturb any other server within the tank 410.”
(*Id.* at 0085.)

“Ears” of the servers may be used to hold the servers in the rack:

“Suitable mounting members may be used to mount the servers in the tank to configure the server rack 830 and 832 within the tank. Specifically, the mounting members (not shown) may be fixedly attached along the length L of each longer side of the tank 810 and in the middle of the tank 810 between the two shorter ends of the tank to support *the rack ears 836 of a standard rack-mountable server 820 shown in FIG. 12A.*” (*Id.* at 0097.)

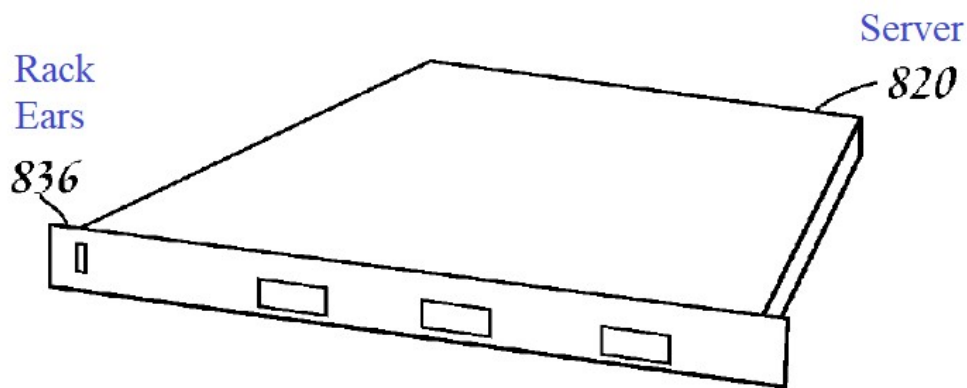


Fig. 12A

164. Best-2008 FIGs. 4 and 6 illustrate that “a respective appliance slot [is] distributed vertically along the long wall of the tank:”

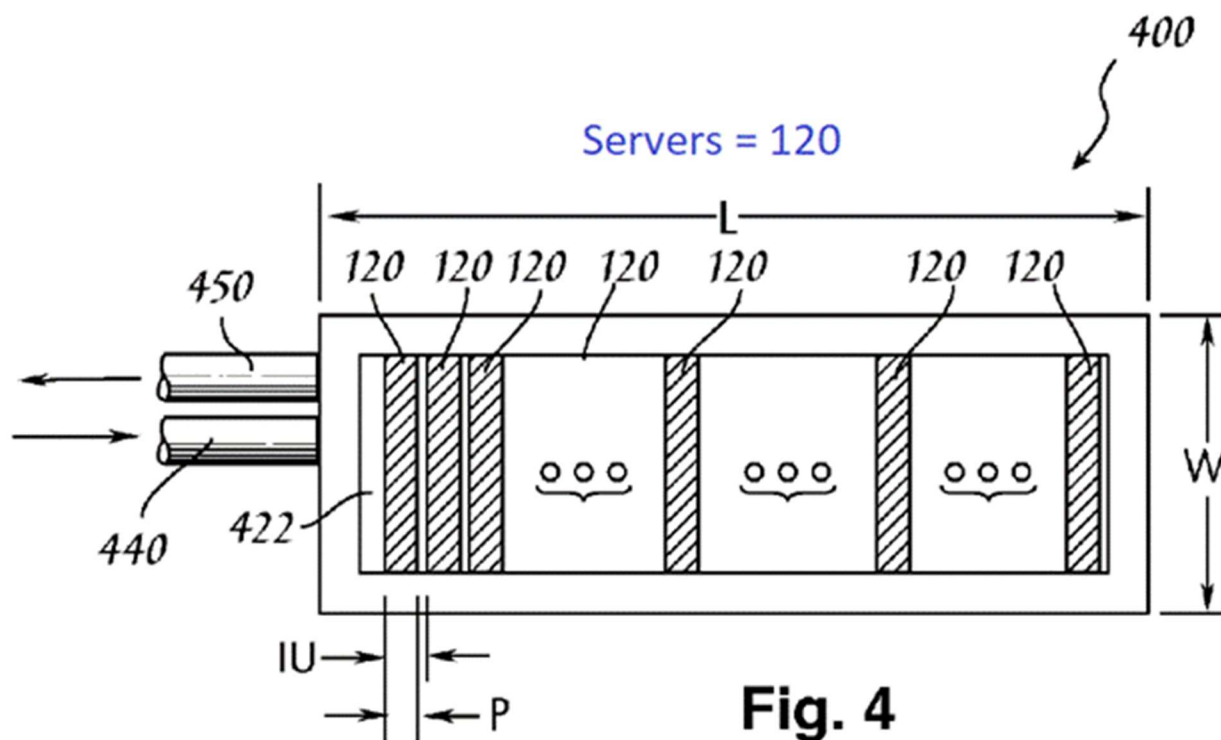
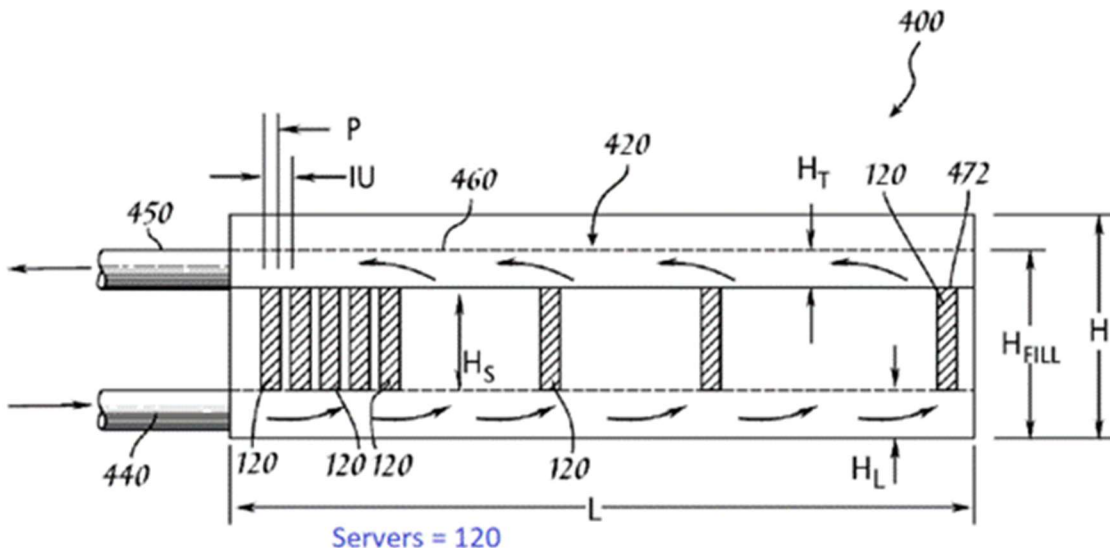


Fig. 4



(Ex-1004-Best-2008 at FIGS. 4, 6.)

165. Best-2008 explains:

“The tank 410 may face upward with an open top 430 to form an open interior volume and may be shaped to have a length L , width W , and height H with the minimum footprint to insert multiple servers 120.”

(*Id.* at 0083; *see also id.* at FIG. 11, 0097-107.)

166. The '457 patent also confirms that Best-2008 discloses the “slot” aspect of this limitation (*see* Ex-1001 at 2:31-33 (“through the several appliance slots within the tank”).)

167. Indeed, Best-2008 discloses that the tank may include a dedicated bin for each appliance, as each bin is sized to receive one server with an up-ward facing front panel:

“In another alternative rack design (not shown in the drawings), the tank 410 is divided into a plurality of bins with each bin being sized to receive one

corresponding server with the ‘front panel’ facing upward.”
(*Id.* at 0090.)

168. This additional disclosure confirms a POSITA would find it obvious for the tank of Best-2008 to include the claimed “slot”—because each bin is “sized to receive one corresponding server with the ‘front panel’ facing upward,” Best-2008’s bins also disclose or suggest the use of slots for holding each server that is immersed and cooled in dielectric liquid.

169. For at least these reasons, Best-2008 discloses and shows it was obvious for the tank of Best-2008 to include the claimed “slot” to hold each respective appliance, with each “respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank” where the “plurality of electrical appliances” is immersed in the dielectric fluid as claimed in this limitation.

170. Thus, Best-2008 teaches limitation 1.1.

[1.2] “a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and”

171. As described herein, Best-2008 in view of Osada teaches this limitation.

172. As detailed above, Best-2008 discloses outlet pipe(s) integrated into the short and/or long walls of the tank. (Ex-1004-Best-2008 at FIGS. 3-4 and 6.)

173. Though FIGS. 3-6 illustrate a system with the outlet pipe (450) in a short wall of the tank, Best-2008 also discloses that the outlet pipe may be located

in (in other words, integrated in) the long wall of the tank. For example, Best-2008 teaches that both inlet and outlet pipes “may be located nearer one end of one of the longer sides of the rectangular tank.” (*Id.* at 0092).

174. As noted above, in my opinion, a weir can be an opening in a wall. Accordingly, Best-2008 discloses “a weir, integrated . . . into the long wall of the tank.”

175. As also explained above, Patent Owner previously argued that limitation 1.2 requires that the weir is integrated into the long wall of the tank adjacent all appliance slots. While Best-2008 does not expressly disclose this design, it would have been obvious to a POSITA in view of Osada.

176. As explained above in Section VII.A, a POSITA would have been motivated and found it obvious to use the conventional weir or weir-and-notch designs taught by Osada to advance the shared objectives of Osada and Best-2008: achieving improved filtration, temperature uniformity, and maintenance of liquid level in the immersion tank. A POSITA also would have had a reasonable expectation of success in doing so. (*See* Section VII.A.)

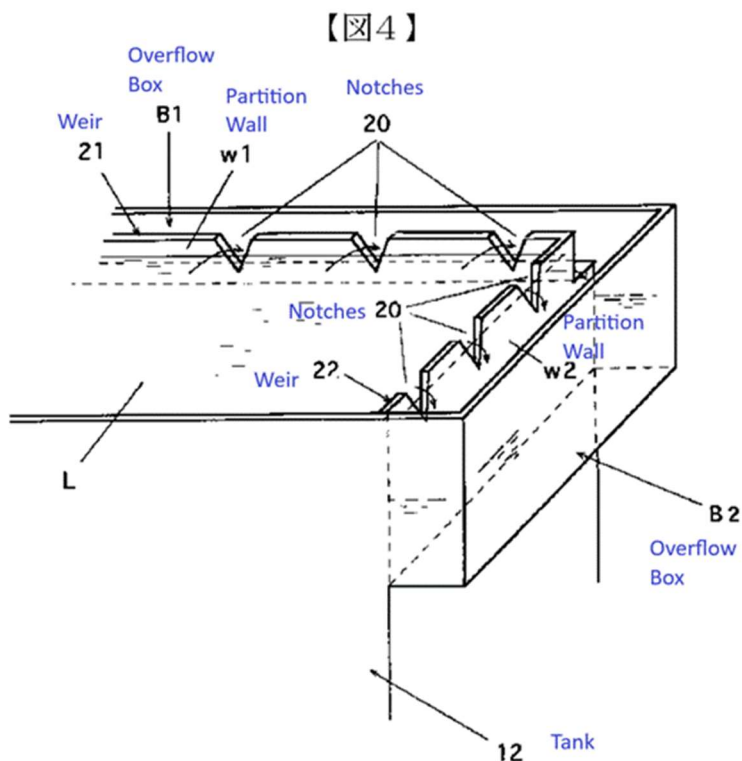
177. In view of the specific disclosures of Osada, it would be obvious to a POSITA to place Osada’s conventional weir or weir-and-notches along the entire length of the long wall of Best-2008’s tank. For example, Osada illustrates a

(FIGURE 16)



Petitioner Green Revolution Cooling, Inc., Ex-1003
IPR2025-00196

179. Further, the combination of Best-2008 and Osada's weir-and-notches design also teaches this limitation. For example, a POSITA would recognize that Osada's weir-and-notches arrangement includes notches along the full length of the long wall of the tank. Specifically, FIG. 4 illustrates:



(Ex-1005-Osada at FIG. 4.)

180. While FIG. 4 is a partial view of the Osada system, the notches shown are spaced regularly and uniformly along the long wall of the tank. And, Osada teaches that “multiple notches over a broad range,” and “at uniform spacing to ensure that it is possible to force the flow of all of the floating impurities that are easily suspended on the liquid surface and impurities that are more likely to be suspended

in the lower layers into the overflow box over the entirety of the liquid in the liquid tank.” (*Id.* at 0018.)

181. Thus, a POSITA would have been motivated and found it obvious to include multiple, uniformly spaced notches along the long wall of the tank of Best-2008 when implementing Osada’s weir-and-notches to achieve the objectives described above.²

182. Best-2008 also teaches “dielectric fluid flowing through each appliance slot.” Specifically, Best-2008 discloses that the “liquid coolant may flow through each installed server,” and “the liquid coolant heated by the heat generating components in the servers” should “naturally rise through the servers and exit through the front panel of the servers” to achieve a “relatively uniform temperature.” (Ex-1004-Best-2008 at 0104.)

² I note that Osada also illustrates its conventional weir and weir-and-notch arrangements in the short wall of the tank. The Challenged Claims of the ’457 patent do not preclude this arrangement. Further, Osada also teaches that a single overflow box may be used, in view of which a POSITA would find it obvious to include a conventional weir or weir-and-notch arrangement in only the long wall of Best-2008’s tank. *See also* para. 132, above.

183. Best-2008 additionally discloses:

“The mounting members may also be configured to mount the servers in the server rack 470 above the bottom of the tank to create a volume of liquid coolant **between** each respective server and the bottom of the tank **such that the flow of the dielectric liquid coolant through the servers is improved**. Preferably, the mounting members are configured to mount the servers closely adjacent to one another in the server rack to restrict the flow of the dielectric liquid coolant between the vertically-oriented servers, such that the flow of the dielectric liquid coolant through the servers is enhanced.”

(Ex-1004-Best-2008 at 0086.)

184. As such, a POSITA would have been motivated and found it obvious to include Osada’s notches adjacent each appliance slot in Best-2008’s immersion tank. This arrangement furthers the objectives detailed above in Section VII.A, including achieving coolant flowing through and between each installed server, “such that the flow of the dielectric liquid coolant through the servers is improved” while also achieving a “relatively uniform” liquid coolant temperature” in Best-2008’s tank.

185. Thus, Best-2008 in view of Osada teaches limitation 1.2.

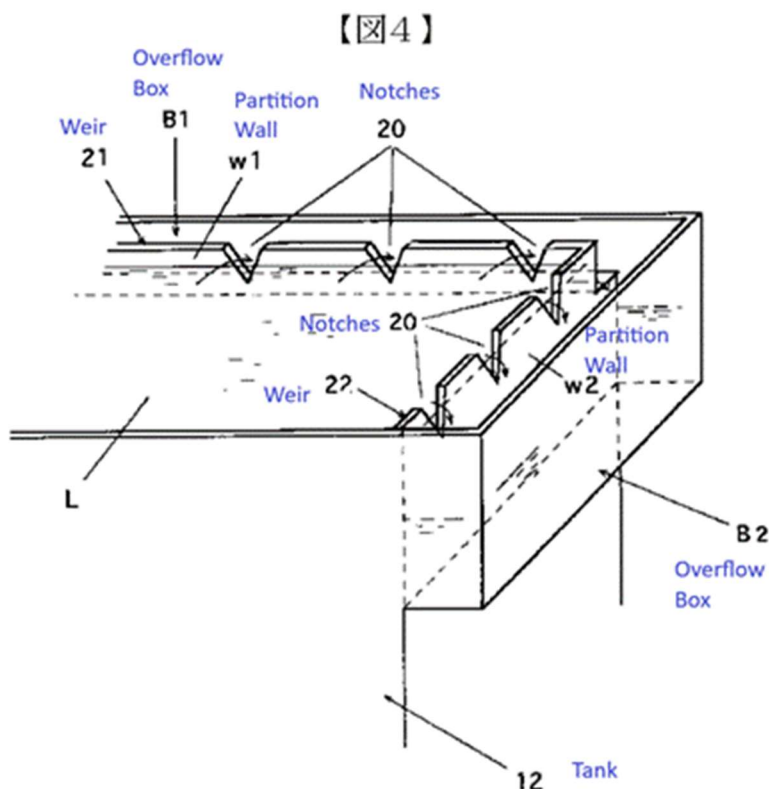
[1.3] “a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir; and”

186. Best-2008 in view of Osada teaches limitation 1.3.

187. A POSITA would have been motivated and found it obvious to employ Osada’s conventional weir and weir-and-notch teachings with Best-2008’s system,

as explained above in Section VII.A and in connection with limitation 1.2. A POSITA also would have had a reasonable expectation of success with this combination. (See Section VII.A.)

188. In this arrangement, a POSITA would implement Osada's overflow box to receive the liquid overflowing the tank through the weirs. Without the overflow box, the fluid would not be captured to recirculate through the system. Osada FIG. 4 illustrates:



(Ex-1005-Osada at FIG. 4.)

189. As explained above in Section VII.A, Osada teaches placing the

overflow boxes at the “upper peripheral side of the wall surrounding the liquid tank” (Ex-1005-Osada at 0018.) Doing so has many benefits that a POSITA would recognize, including minimizing splash of the liquid into the box (and liquid contained therein) and oxygenation of the liquid in the overflow box, each also due to the lower kinetic energy. Doing so also results in a Osada’s overflow boxes being “positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir.”

190. Thus, Best-2008 in view of Osada teaches limitation 1.3.

[1.4] “a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot;”

191. Best-2008 teaches “a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot.”

192. The ’457 patent explains that the claimed “primary circulation facility” includes at least the pumps, valves, and/or piping necessary to move the dielectric fluid through the tank. For example:

“As can be best seen in FIG. 2, the primary circulation facility 28...comprises both passive (conduits, couplers, etc.) and active (valves, pumps, sensors, etc.) components...”

(Ex-1001 at 4:5-8.)

“At this point in the primary circulation facility 28, we provide fully redundant sub-facilities 28a and 28b, each comprising a primary circulation pump (48a and 48b) and associated passive and active components which, collectively, provide the motive power for circulating the dielectric fluid through the shared components and tank 14. As can be generally seen, each of these sub-facilities 28a and 28b is adapted to recover the dielectric fluid exiting the tank 14 via the weir 22, re-pressurize the recovered fluid, pass the re-pressurized fluid through a respective one of the heat exchangers 32a and 32b, and then back to the plenum facility 36 via the header 38.”

(Ex-1001 at 4:50-61.)

193. As shown in, for instance, Best-2008 at FIGS. 1A, 1B, and 2, a variety of pumps, heat exchangers, and piping arrangements may be used to recirculate the dielectric fluid through Best-2008’s tank via a liquid circuit. Additionally, Best-2008 discloses:

“The liquid coolant heated by the servers 120 in the server rack is then fluidly coupled through suitable piping or lines to a pump 130, which pumps the heated liquid coolant through suitable piping or lines to a remotely or distally located heat exchanger 140 associated with a heat-rejection or cooling apparatus 150. The distally heat exchanger 140 rejects the heat from the incoming heated liquid coolant and fluidly couples the cooled liquid coolant through a return fluid line or piping 170 back into the tank 110. Thus, at least a portion of the liquid coolant completes a fluid circuit through the servers 120 in the tank 110, pump 130, heat exchanger 140, and back into the tank 110.”

(Ex-1004-Best-2008 at 0067.)

194. Thus, Best-2008 teaches the claimed “primary circulation facility.”

195. Best-2008 also discloses the claimed plenum. As noted above, Patent Owner previously agreed that “plenum” as recited in the Challenged Claims means

“a structure for dispensing liquid.” (See Section V.) Best-2008 discloses structures for dispensing liquid as claimed.

196. For example, Best-2008 FIG. 6 illustrates that the inlet pipe (440) dispenses the dielectric fluid (after it is cooled by the heat exchanger), through a plenum adjacent the bottom of the tank:

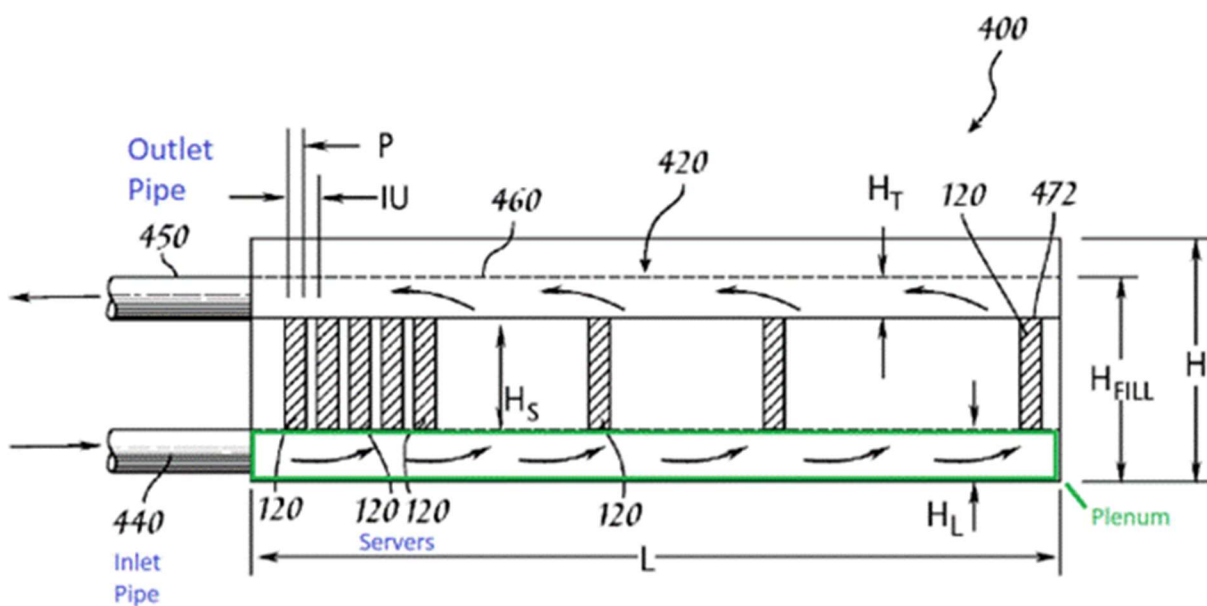


Fig. 6

(Ex-1004-Best-2008 at FIG. 6.)

197. The arrows in FIG. 6 indicate that the fluid is dispensed “substantially uniformly upwardly through each appliance slot” as claimed. As such, Best-2008 discloses the claimed “plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot.”

198. Best-2008 also discloses using mechanical structures below the immersed servers to uniformly distribute the liquid. For example:

“The mounting members may also be configured to mount the servers in the server rack 470 above the bottom of the tank to create a volume of liquid coolant between each respective server and the bottom of the tank such that the flow of the dielectric liquid coolant through the servers is improved. Preferably, the mounting members are configured to mount the servers closely adjacent to one another in the server rack to restrict the flow of the dielectric liquid coolant between the vertically-oriented servers, such that the flow of the dielectric liquid coolant through the servers is enhanced.”

(Ex-1004-Best-2008 at 0086.)

“Additional fluid velocity augmentation devices, such as multiple fans 880 may be mounted under each of the server racks 830 and 832 in the volume of liquid coolant between the plurality of servers in each respective rack and the bottom of the tank to increase the mixing of the dielectric liquid coolant within the tank, and improving the flow of the coolant through the plurality of servers.”

(*Id.* at 0107.)

“The various components of the system 900 controlled by the controller 920 include any fluid velocity augmentation devices positioned below the server racks...”

(*Id.* at 0123.)

199. The disclosed fluid velocity augmentation devices include fans and nozzles. (*Id.* at 0107, 0123.)³.

³ As I explain in Ground 2, below, a POSITA would know that “nozzles” in the context of liquid immersion systems, such as Best-2008, includes orifices (holes, apertures).

200. Thus, for this additional reason, Best-2008 discloses the claimed “plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot,” and Best-2008 teaches limitation 1.4.

[1.5] “a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and”

201. Best-2008 teaches “a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and”

202. As shown in, for instance, FIGS. 1A, 1B, and 2, Best-2008 discloses a “secondary fluid circulation facility” that may be used “to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted.”

203. For example, FIG. 1A illustrates a cooling apparatus (150) that employs a cooling liquid in second fluid circuit in communication with a heat exchanger (140):

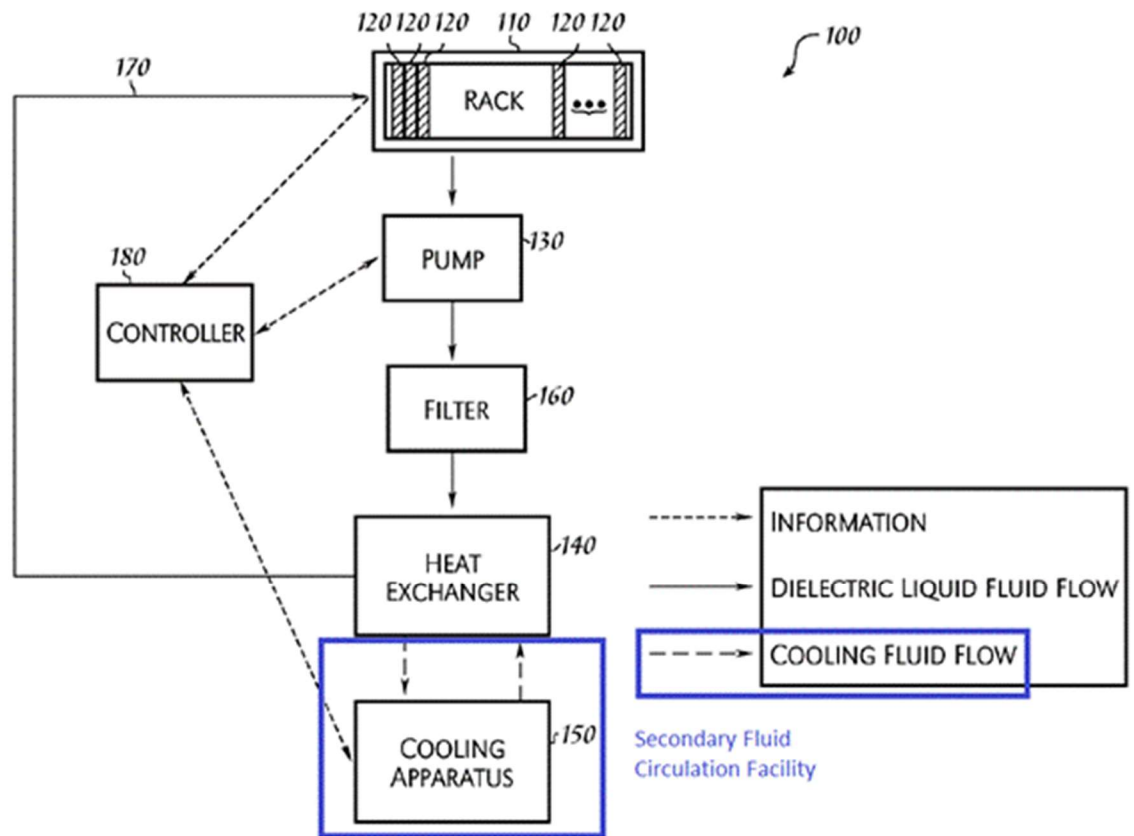


Fig. 1A

(Ex-1004-Best-2008 at FIG. 1A.)

204. Best-2008 further discloses:

“The heat rejected from the heated liquid coolant through the heat exchanger 140 may then be selectively used by alternative heat rejection or cooling apparatus 150...to dissipate, recover, or beneficially use the rejected heat depending on the different environmental conditions and/or server operating conditions to which the system is subject.”

(*Id.* at 0067)

205. Thus, Best-2008 teaches limitation 1.5.

[1.6] “a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank.”

206. Best-2008 teaches “a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank.”

207. As shown, for instance, in Best-2008 FIGS. 1A, 1B, and 2, a “control facility” may be used “to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank.” (See Ex-1004-Best at 0068, 0073, FIGS. 1A, 1B, 2.)

208. For example, FIG. 1A illustrates a controller (180) that coordinates operation of a pump (130) and cooling apparatus (150):

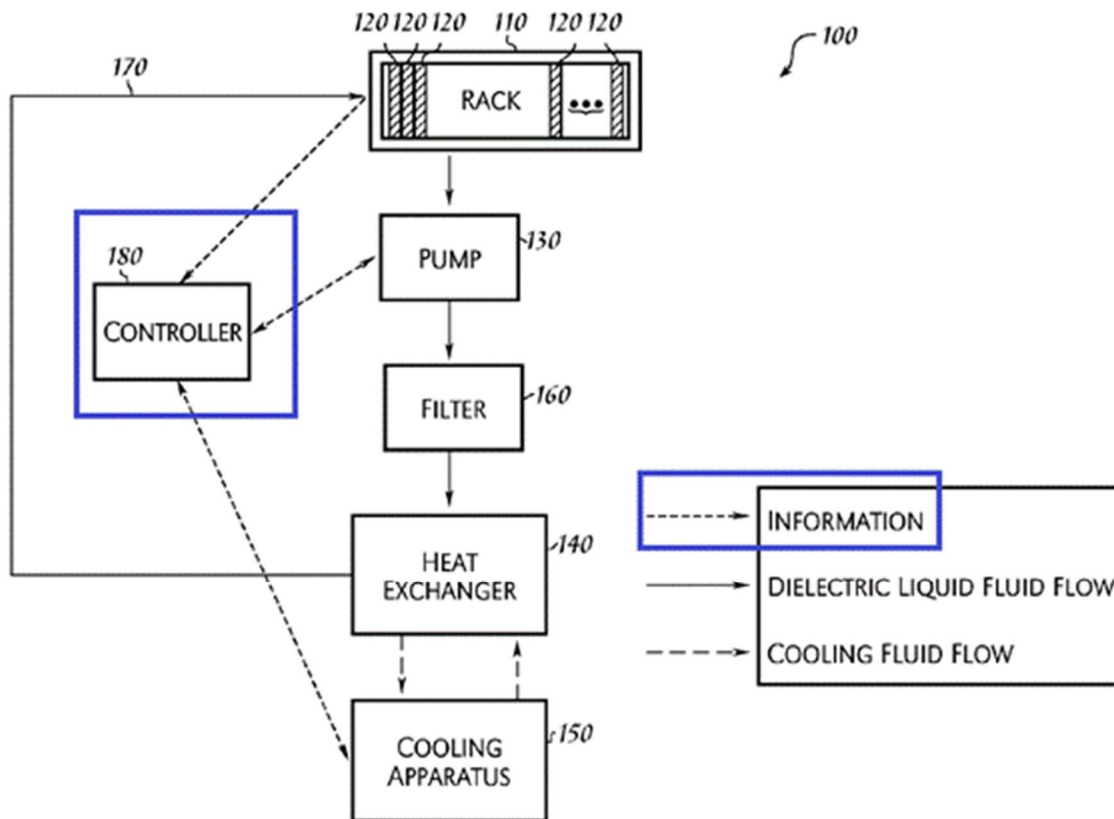


Fig. 1A

(Ex-1004-Best-2008 at FIG. 1A.)

209. Best-2008 further discloses:

“The system 100 includes a computer controller 180 of conventional design ... The controller 180 may receive monitor signals of various operational parameters from various components of the cooling system 100 and the environment and may generate control signals to control various components of the cooling system to maintain the heated liquid coolant exiting the servers in the tank at a specific elevated temperature in order to sufficiently cool each of the servers while reducing the total amount of energy needed to cool the servers.... Based upon such information, the controller 180 may output signals to the pump 130 and heat rejection or cooling apparatus 150 to adjust the flow of the liquid coolant through the fluid circuit and the amount of the heat being rejected by the heat rejection or cooling apparatus 150 for sufficiently cooling each respective server while maintaining the heated liquid

coolant exiting the servers at the elevated temperature to reduce the amount of energy consumed to sufficiently cool each of the servers in the server rack.” (*Id.* at 0068.)

210. Best-2008 also includes a flow chart in FIG. 17B illustrating controller implementation of “computer controller-based steps in the method of cooling one or more independently operable servers immersed in a tank of liquid coolant employing the system of FIG. 1A,” (*Id.* at FIG. 17B, 0052, 0135.) Best also shows a remote controller in FIG. 15, which manages the thermal requirements and input of multiple server racks as well as the heat exchanger. (*Id.* at FIG. 15; 0120-25.)

Indeed, the controller of FIG. 15:

- “may receive monitoring signals of the temperature of the heated liquid coolant exiting the server racks through control lines 924;”
“may also receive monitoring signals of the flow rate of the liquid coolant at various locations in the piping 902 through control lines 925 and the flow rate through the pump 904 through control lines 926;”
- “may also receive monitoring signals relating to the type of secondary cooling apparatus selected and the flow rate of the cooling fluid in the selected secondary cooling apparatus through control lines 928;”
- “operates an application program that processes the information received from the various monitoring signals to selected an optimum elevated temperature, the energy needed to be rejected by the system to cool the servers and maintain the elevated temperature, and then determine the various settings of the system 900 components that will be needed to maintain the elevated temperature of the liquid coolant exiting the servers in the multiple server racks 310;”

- “may adjust the flow of the cooled liquid coolant through each of the valves 918 to adjust the volume of the flow of the cooled liquid coolant among the different server racks 310”
- “may control any fluid velocity augmentation devices in the server racks through control lines and may also control the pumping rate of the pump 904 through control line 930;” and
- “may select one of a plurality of secondary cooling apparatus 352, 354, 356, etc to optimize the secondary cooling apparatus to the environmental and server rack conditions and control the amount of heat being rejected by the selected secondary cooling apparatus by adjusting the flow of the cooling fluid in the secondary cooling apparatus”

(*Id.* at 0122-25.)

These disclosures surrounding FIGS. 15 and 17B further confirm that Best-2008 discloses the claimed control facility.

211. Thus, Best-2008 teaches limitation 1.6, and Best-2008 in view of Osada renders obvious claim 1.

[Claim 2] “The system of claim 1 wherein the tank and primary circulation facility comprise a highly-integrated module.”

212. I find the term “a highly-integrated module” not reasonably certain to a POSITA. However, to the extent it can be understood, Best-2008 teaches “The system of claim 1 wherein the tank and primary circulation facility comprise a highly-integrated module.”

213. For example, Best-2008 discloses that the heat exchanger is a component of the primary circulation facility:

“At this point in the primary circulation facility 28, we provide fully redundant sub-facilities 28a and 28b, each comprising a primary circulation pump (48a and 48b) and associated passive and active components which, collectively, provide the motive power for circulating the dielectric fluid through the shared components and tank 14. As can be generally seen, each of these sub-facilities 28a and 28b is adapted to recover the dielectric fluid exiting the tank 14 via the weir 22, re-pressurize the recovered fluid, pass the re-pressurized fluid through a respective one of the heat exchangers 32a and 32b, and then back to the plenum facility 36 via the header 38.”

(Ex-1001 at 4:50-61.)

214. Best-2008 further discloses that its heat exchanger (280) may be located inside the tank. This arrangement is illustrated in FIG. 1B:

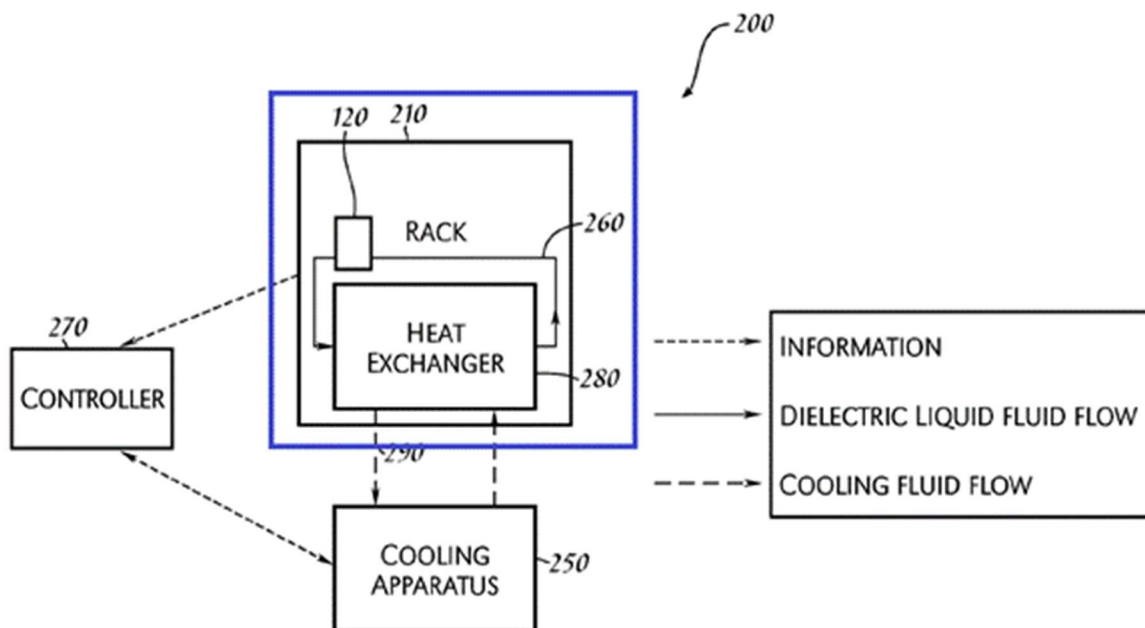


Fig. 1B

(Ex-1004-Best-2008 at FIG. 1B; 0069-70.)

215. Such an arrangement constitutes a “highly-integrated module” to the

same extent understood and disclosed by the '457 patent.

216. Moreover, in addition to one or more heat exchanger(s) being located in or near Best-2008's tank, it was also obvious to include filtration in a "highly-integrated" manner. Specifically, Osada discloses to employ filtration (e.g., "suction heads") in its overflow boxes to address "inorganic and organic impurities in the processing liquid that flow into said box over the weir part that range in size from large to small particle diameters, and further, the bits of the article being processed that have dropped into said box from the outside [that] may clog the outflow port at the bottom of said box." (Ex-1005 at 0026-27; *id.* at 0031, 0047-49, FIGS. 6(C), 7-8.) It would have been obvious to include such filtration when implementing the overflow boxes of Osada for the reasons stated by Osada. Further, because such filtration is in the overflow boxes connected to the Best-2008 tank, such filtration also reads on a "highly integrated module."

217. As such, both Best-2008 and Osada teach this limitation and Best-2008 in view of Osada renders obvious claim 2.

[Claim 3] "The system of claim 1 wherein the tank further comprises: an interconnect panel facility adapted to mount appliance support equipment."

218. Best-2008 teaches "wherein the tank further comprises: an interconnect panel facility adapted to mount appliance support equipment."

219. According to the '457 patent specification, an "interconnect panel

facility” is “adapted to mount various appliance power distribution equipment, cable interconnection panels and the like (none shown);” (Ex-1001 at 3:56-60). In other words, it is a location where power distribution equipment, cable connection panels, and the like may be mounted.

220. Best-2008 discloses:

“As shown in FIG. 13, the apparatus 800 also may have cable trays 840 mounted along two sides of the tank 810 paralleling the sides of the server racks 830 and 832 to organize the signal and control network cabling 842 from the servers to the controller and other computers in the data center and beyond. The apparatus 800 may further have power distribution units (‘PDUs’) 844 mounted above the space between the server racks in order to distribute needed electrical power through suitable power cables 846 to the multiple servers.”

(Ex-1004-Best-2008 at 0100.)

221. As such, Best-2008 teaches this limitation, and Best-2008 in view of Osada renders obvious claim 3.

[Claim 4] “The system of claim 1 wherein the primary circulation facility further comprises: at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank; wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities and the secondary fluid circulation facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.”

222. Best-2008 teaches “wherein the primary circulation facility further comprises: at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank; wherein

the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities and the secondary fluid circulation facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.”

223. Best-2008 teaches that its disclosures relating to FIGS. 1A and 1B, detailed above, may be combined, such that the first sub-facility (remote heat exchanger) cools the dielectric liquid, and a second sub-facility (heat exchanger in the tank) may alternatively be used independently. For example, Best-2008 discloses:

“FIG. 9 depicts an end elevation view of yet another illustrative embodiment of a suitable fixture or server rack apparatus 600 for use in connection **with a combination of system 100 of FIG. 1A and system 200 of FIG. 1B.** In such a combination, there are two alternative modes of operating the cooling system for cooling the dielectric liquid coolant wherein the controller may switch the mode of operation depending on the environmental conditions. ... In the first mode of operation utilizing a mode of operation comparable to that of FIG. 1A, the fluid flow 660 of the liquid coolant entering the tank through the inlet piping 640 is initially through the space 662 formed by the bottom of the side of the tank containing the inlet piping 640 and the bottom 672 of the server rack 670 of servers 120 and then through the bottom 672 of the server rack through the servers 120 and out the front panel side 674 of the server rack into a space 676 formed by the top 674 of the server rack and the top surface 622 of the liquid coolant and nearer the outlet piping 650. To permit the second mode of operation similar to FIG. 1B, a second heat exchanger 680 associated with an additional secondary cooling apparatus is mounted within the tank 610 and a second inlet piping 682 and a second output piping 684 are inserted through the wall of the tank 610 and fluidly coupled to the heat

exchanger to permit the flow of a separate second cooling fluid through the input piping 682, second heat exchanger 680, and outlet piping 684 back to the second secondary cooling apparatus.”

(Ex-1004-Best-2008 at 0092.)

“In the second mode of operation, the pump associated with the first mode of operation is deactivated by the controller such that the fluid circuit flow of the dielectric liquid coolant to the external heat exchanger of the first secondary cooling apparatus is deactivated. Next the internal heat exchanger 680 associated with the second alternative secondary cooling apparatus is activated by the controller. In this mode the fluid flow of the dielectric fluid within the tank is reconfigured such that the heated dielectric liquid coolant fluid flow 660 flowing out of the servers 120 does not flow out of the outlet piping 650. Instead, at least a portion of the liquid coolant fluid flow 660 is through the heat exchanger 680 to the bottom of the tank 610 and then back through the servers 120. The heat rejected from the heat exchanger 680 is thermally coupled to the second cooling fluid of the second secondary cooling system for dissipation or recovery.”

(*Id.* at 0093.)

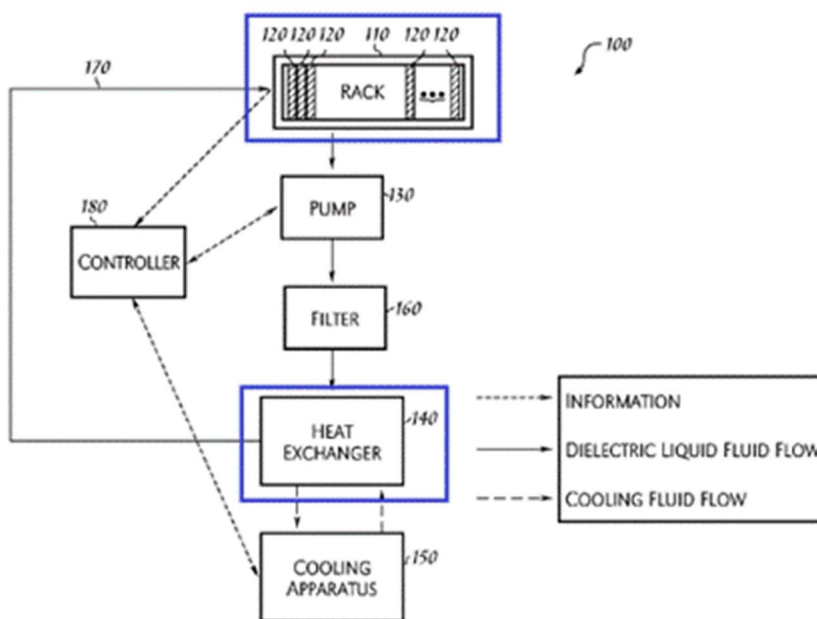


Fig. 1A

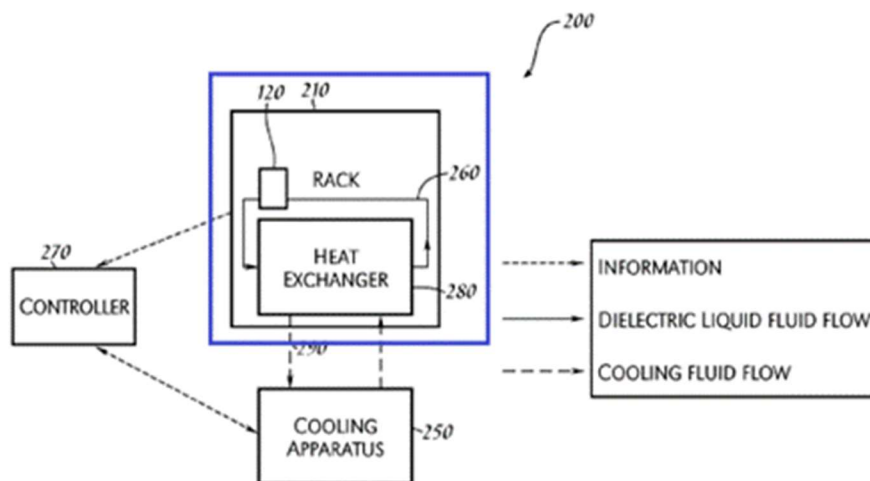


Fig. 1B

(Ex-1004-Best-2008 at FIGS. 1A-1B.)

224. Further, Best-2008 at FIG. 10 illustrates an embodiment combining the systems of Fig 1A and 1B. (Ex-1004-Best-2008 at 0094-96, FIG. 10.)

225. Thus, Best-2008 teaches “The system of claim 1 wherein the primary circulation facility further comprises: at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank; wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities and the secondary fluid circulation facilities.”

226. Best-2008 also teaches the remainder of this claim limitation: “to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.”

227. For example, Best-2008 discloses:

“In summary, the implementation of the methods disclosed in the exemplary alternate embodiments described herein for cooling server racks immersed in a dielectric liquid coolant by maintaining an elevated temperature can minimize the amount of power required to cool the servers....The reduction of temperature differences between the incoming cool liquid coolant and the heated outgoing liquid coolant is made possible by: ... a controller maintaining coolant temperature at the maximum allowable temperature (e.g., *between 90 and 130 degrees F*) by using the efficient heat removal methods described. The computer controller doesn't necessarily have to separate from the servers that are being cooled.”

(Ex-1004-Best-2008 at 0136-138.)

228. A POSITA reviewing this disclosure of Best-2008 would understand that it applies to the dual-mode operation explained above, e.g., the combined systems of FIG. 1A-1B, and that the purpose is to maintain the server temperatures within the predetermined operating range. For instance, Best-2008 further discloses:

“A combination of the system 100 and 200 using the alternative server rack apparatus of FIG. 9 and FIG. 10 that permit two different modes of operating the server rack cooling system for cooling the dielectric liquid coolant may be useful in certain applications and climates, for example, in an arid climate having cool nights and very hot days. During the cool days, the combination system employing the embodiments of FIG. 9 or FIG. 10 may be used in a first mode similar to that of FIG. 1A wherein the dielectric fluid is fluidly coupled to an external heat exchanger associated with a radiator-type secondary cooling system. During the hot days, the combination system may be used in a second mode similar to that of FIG. 1B wherein the dielectric liquid coolant is fluidly coupled through the internal heat exchanger, which is associated with a second secondary cooling apparatus, such as a vapor-compression cycle refrigeration cooling system.”

(Ex-1004-Best-2008 at 0096.)

229. A POSITA would understand from these disclosures that Best-2008 is

using the two different operational modes to maintain the servers within a predetermined temperature range, consistent with the objectives outlined above in Section VII.A.

230. As such, Best-2008 teaches this limitation, and Best-2008 in view of Osada renders obvious claim 4.

[Claim 5] “The system of claim 1 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.”

231. Best-2008 teaches “wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.”

232. The ’457 patent specification describes the claimed “remote location” once and in the context of conventional electronic communications:

“One desirable enhancement that we recommend is a remote control facility, implemented, e.g., via the master controller 62 (or by way of a direct, per-controller interface), adapted to facilitate remote monitoring of system status (e.g., temperatures, pressures, etc.) and control over system control parameters (e.g., temperature and pressure limits, etc.) to the primary controllers 58 and secondary controllers 60. For example, using a conventional data communication hardware module 64, e.g., an ethernet card implementing the TCP/IP protocol, a modern web browser can be adapted to provide a graphical user interface (“GUI”) with sufficient functionality to facilitate monitoring and control of an entire installation from a remote location. Such a GUI may be implemented using any of a number of programming paradigms, e.g., PHP, .NET and the like.”
(Ex-1001 at 6:7-21.)

233. Best-2008 teaches this limitation. For example, FIGS. 1A, 1B and 2 of Best-2008 illustrate that the controller of Best-2008 is located remotely relative to the tank. For example:

“The system 100 includes a computer controller 180 of conventional design with suitable novel applications software for implementing the methods of the present invention. The controller 180 may receive monitor signals of various operational parameters from various components of the cooling system 100 and the environment and may generate control signals to control various components of the cooling system to maintain the heated liquid coolant exiting the servers in the tank at a specific elevated temperature in order to sufficiently cool each of the servers while reducing the total amount of energy needed to cool the servers.”

(Ex-1004-Best-2008 at 0068.)

234. Best-2008 also discloses that components such as the fluid valves may be “remotely controlled.” For example:

“The fluid valve 390 may be remotely controlled to connect the heated liquid coolant being pumped through the collection piping from the tank 310 to a controller-selected one of alternative remotely or distally located heat exchangers associated with alternative heat rejection or cooling apparatus 350.”

(Ex-1004-Best-2008 at 0081.)

235. Best-2008 additionally discloses that “[t]he computer controller doesn’t necessarily have to [be] separate from the servers that are being cooled.” (*Id.* at 0138.) In other words, the computer controller may be separate (remote) from the servers that are being cooled in the immersion tank, and a POSITA would not find anything inventive about remotely monitoring or controlling components of the

Best-2008 fluid recirculation system (which is comprised of common/conventional components).

236. Further, Best-2008 discloses for the embodiment illustrated in FIG. 15 that “various components of the system 900 [are] controlled by the controller 920 includ[ing] any fluid velocity augmentation devices positioned below the server racks, the pump 904, valves 918, the valve 390 (FIG. 2) for switching the flow of the heated liquid coolant between secondary cooling apparatus to be used, and the selected secondary cooling apparatus.” (Ex-1004-Best-2008 at 0123; *see also id.* at 0122.)

237. In FIG. 15 of Best-2008, that controller 920 as well as heat exchanger 910 are located outside of server room 901:

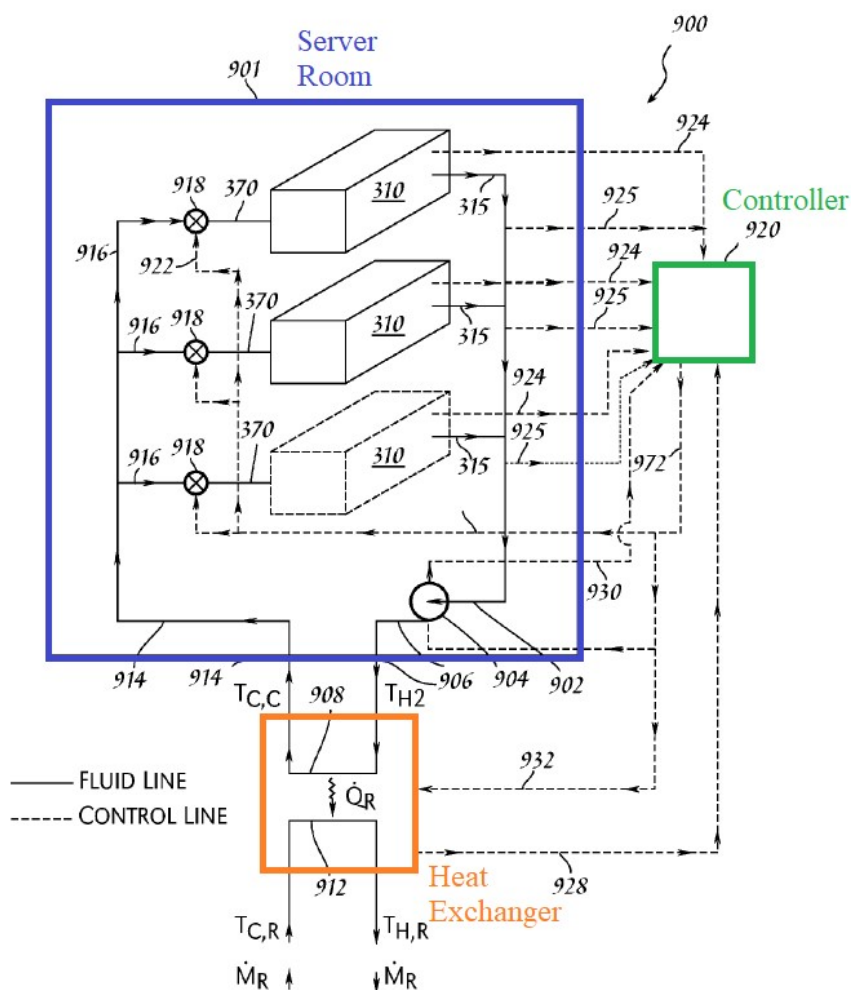


Fig. 15

(Ex-1004-Best-2008 at FIG. 15, 0049, 0120, claim 37.)

238. While Best-2008 does not describe reference number 901 in the specification, FIG. 15 shows that box 901 (highlighted in blue above) is the “server room.” I note that box 901 in original FIG. 15 of Best-2008 is thicker than the identified “fluid line” and “control line” indicators, or the outlines of components such as server racks 310. (*Id.* at FIG. 15.) Box 901 also has a similar thickness as the

unnumbered box highlighted in orange above that surrounds the heat exchanger (identified as 910 in the Best-2008 specification text). (*Id.* at FIG. 15, 00120-121.) Best-2008 discloses a heat exchanger as “distally located” (*Id.* at 0030, 129), and a server room “externally located.” (*Id.* at claim 37.)

239. Thus, a POSITA would recognize that Best-2008 teaches and renders obvious a “communication facility adapted to facilitate monitoring and control of the control facility from a remote location.”

240. As such, Best-2008 teaches this limitation, and Best-2008 in view of Osada renders obvious claim 5.

2. Claim Set 2

241. As explained previously in §VII.B. and shown below, claim 6 and its dependents correspond directly to similar limitations in Claim Set 1.

[6.0] “A tank module adapted for use in an appliance immersion cooling system, the tank module comprising:”

[6.1] “a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:”

242. Best-2008 teaches the preamble and limitation 6.1 for the reasons described above regarding the preamble of claim 1 and limitation 1.1. *See* limitations [1.0]-[1.1]. As described above, Best-2008 discloses a tank module adapted for use in an appliance immersion cooling system and comprising certain components,

including the tank recited in limitation 6.1. For example, FIG. 3 illustrates a tank (410) “for immersing a rack of independently operable servers in a liquid coolant.” (Ex-1004-Best-2008 at 0083; *see id.* at 0025 (disclosing “novel apparatus, systems, and methods for efficiently cooling computing devices having heat-generating electronic components, such as, for example, independently operable servers immersed in a dielectric liquid coolant in a tank.”), FIGS. 3-15, 0060-0120.)

243. Thus, Best-2008 teaches the preamble of claim 6 and limitation 6.1.

[6.2] “a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and”

244. Best-2008 in view of Osada teaches this limitation for the reasons provided above regarding limitation 1.2.

[6.3] “a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir; and”

245. Best-2008 in view of Osada teaches this limitation for the reasons provided above regarding limitation 1.3.

[6.4] “a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot;”

246. Best-2008 teaches this limitation for the reasons provided above regarding limitation 1.4.

[6.5] “a control facility adapted to coordinate the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank.”

247. Best-2008 teaches this limitation for the reasons provided above regarding limitation 1.6.

248. Thus, Ground 1 renders obvious claim 6.

[Claim 7] “The module of claim 6 wherein the tank and primary circulation facility comprise a highly-integrated module.

249. To the extent this limitation can be understood, Best-2008 teaches it for the reasons provided above regarding claim 2, and claim 7 is rendered obvious by Best-2008 in view of Osada.

[Claim 8] “The module of claim 6 wherein the tank further comprises: an interconnect panel facility adapted to mount appliance support equipment.”

250. Best-2008 teaches this limitation for the reasons provided above regarding claim 3, and claim 8 is rendered obvious by Best-2008 in view of Osada.

[Claim 9] “The module of claim 6 wherein the primary circulation facility further comprises: at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank; wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.”

251. Best-2008 teaches this limitation for the reasons provided above regarding claim 4, and claim 9 is rendered obvious by Best-2008 in view of Osada.

[Claim 10] “The module of claim 6 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.”

252. Best-2008 teaches this limitation for the reasons provided above regarding claim 5, and claim 10 is rendered obvious by Best-2008 in view of Osada.

3. Claim Set 3

253. As explained previously in §VII.B. and shown below, claim 11 and its dependents correspond directly to similar limitations in Claim Set 1.

[11.0] “A tank module (10) adapted for use in an appliance immersion cooling system, the tank module comprising:”

[11.1] “a tank (12) adapted to immerse in a dielectric fluid a plurality of electrical appliances (16), each in a respective appliance slot (18) distributed vertically along, and extending transverse to, a long wall of the tank (10), the tank (10) comprising:”

254. Best-2008 teaches the preamble and limitation 6.1 for the reasons described above regarding the preamble of claim 1 and limitation 1.1 as well as the preamble of claim 6.0 and limitation 6.1.⁴

⁴ Claim 11 recites “tank (10)” multiple times, but also uses (12) once when reciting “tank” and uses (10) once when reciting “tank module.” “[T]ank module (10)” appears to refer to “tank facility 12” in the ’457 patent. (See Ex-1001 at 3:40-41 (“we have illustrated in FIG. 1 the tank facility 12 of the immersion module 10”), 3:43-60 (“In general the tank facility 12 comprises: a tank 14 ...; an appliance rack facility

[11.2] “a weir 22, integrated horizontally into the long wall of the tank (10) adjacent all appliance slots 18, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot (18); and”

255. Best-2008 in view of Osada teaches this limitation for the reasons provided above regarding limitation 1.2.

[11.3] “a primary circulation facility (28) adapted to circulate the dielectric fluid through the tank (10), comprising: a plenum (36), positioned adjacent the bottom of the tank (10), adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot (18);”

256. Best-2008 teaches this limitation for the reasons provided above regarding limitation 1.4.

20...; a weir 22 ..., integrated horizontally into one long wall of the tank 14 adjacent all appliance slots 18, and adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each of the appliance slots 18; an inter connect panel facility 24 ...; and a cover 26”); *id.* at FIGs. 1, 12.) The ’457 patent also refers to “tank” as 14, and “immersion module” as 10. (*Id.* at 3:63-64 (“In addition to the tank facility 12, the immersion module 10 comprises:...”); *id.* at FIGs. 1, 12.) I assume that “tank (10)” and “tank (12)” in claim 11 refer to “tank 14” from the ’457 patent specification.

[11.4] “a control facility (58) adapted to coordinate the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank.”

257. Best-2008 teaches this limitation for the reasons provided above regarding limitation 1.6.

258. Thus, Ground 1 renders obvious claim 11.

[Claim 12] “The tank module of claim 11 wherein the tank further comprises: an interconnect panel facility (24) adapted to mount appliance support equipment.”

259. Best-2008 teaches this limitation for the reasons provided above regarding claim 3, and claim 12 is rendered obvious by Best-2008 in view of Osada.

[Claim 13] “The module of claim 11 wherein the primary circulation facility further comprises: at least first and second primary circulation sub-facilities (28a, 28b), each adapted to operate independently to circulate the dielectric fluid through the tank; wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.”

260. Best-2008 teaches this limitation for the reasons provided above regarding claim 4, and claim 13 is rendered obvious by Best-2008 in view of Osada.

[Claim 14] “The module of claim 11 wherein the control facility further comprises a communication facility (62, 64) adapted to facilitate monitoring and control of the control facility from a remote location.”

261. Best-2008 teaches this limitation for the reasons provided above regarding claim 5, and claim 14 is rendered obvious by Best-2008 in view of Osada.

[Claim 15] “An appliance immersion cooling system comprising a tank module according to any one of the preceding claims 11 through 14.”

262. Ground 1 teaches this limitation for the reasons provided above regarding claims 1-5, and claim 15 is rendered obvious by Best-2008 in view of Osada.

[Claim 16] “An appliance immersion cooling system according to claim 15, further comprising a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and”

263. Best-2008 teaches this limitation for the reasons provided above regarding limitation 1.5, and claim 16 is rendered obvious by Best-2008 in view of Osada.

VIII. GROUND 2: Best-2008 in view of Osada and Best-2012

A. Reasons for Combining Prior Art and Expectation of Success

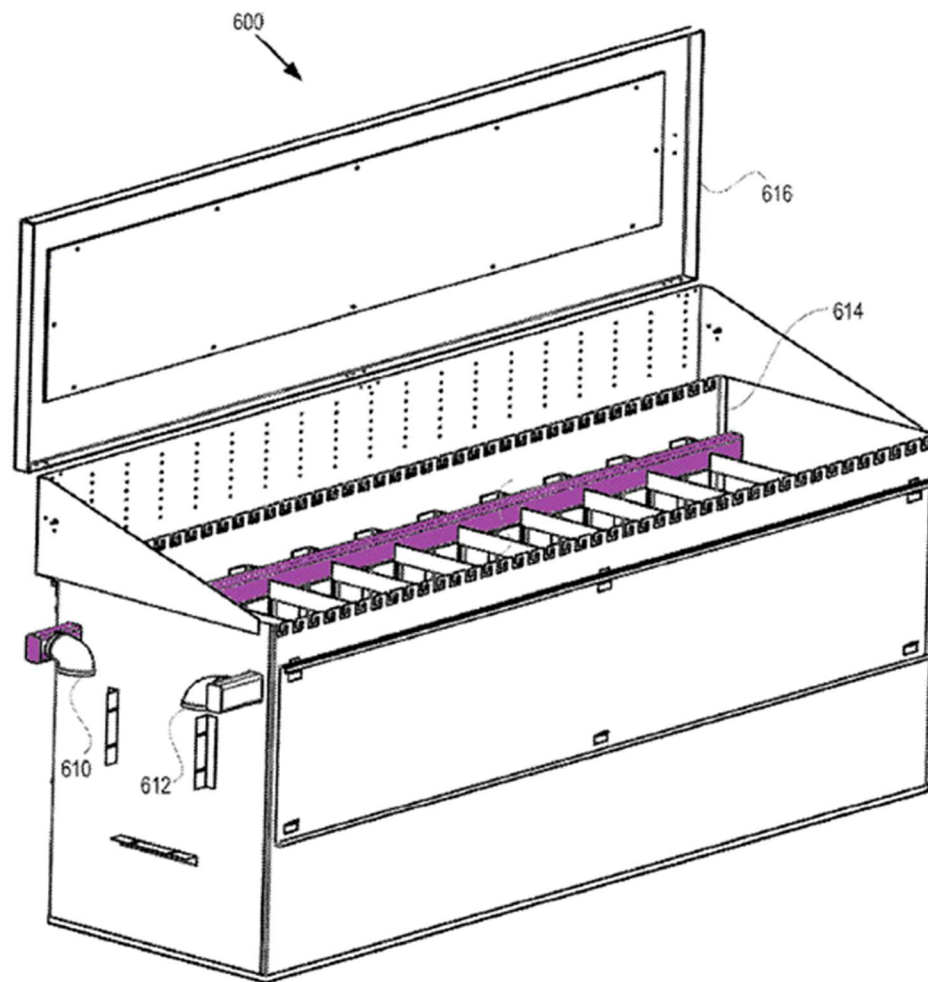
264. As detailed above in Section VII concerning Ground 1, combining Best-2008 and Osada renders obvious the claim limitation that Patent Owner added during prosecution, after the examiner found the remaining limitations disclosed by Best-2008: “a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot.”

265. The disclosures of Best-2012 confirm my opinion that it was obvious to implement Osada’s weir-and-notches design in Best-2008’s tank “adjacent all

appliance slots.”

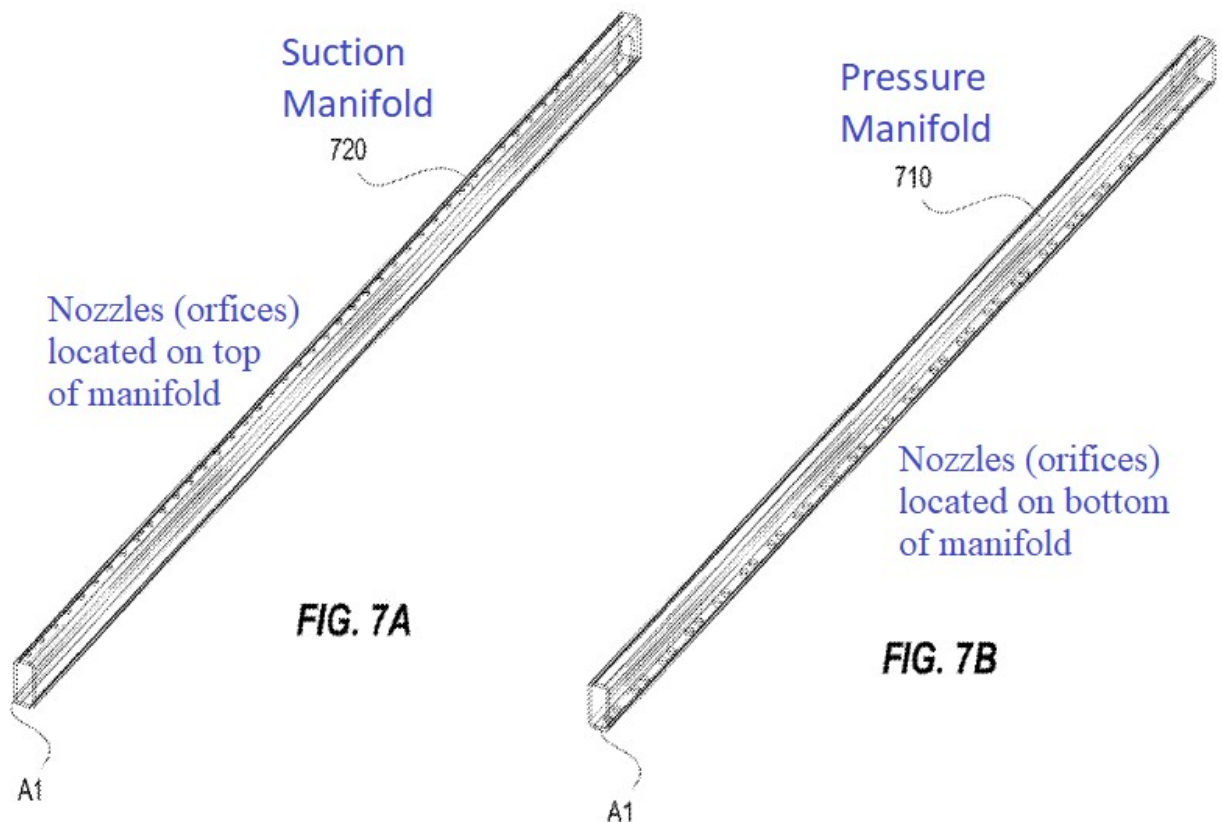
266. Notably, Best-2012 is a later patent application filed by the Best-2008 inventor (Christiaan Best). Among other things, Best-2012 includes updated designs for the dielectric tank disclosed in Best-2008.

267. For instance, Best-2012 implements a manifold (highlighted purple) that extends along the length of the long wall of the tank, as illustrated in FIG. 6:



(Ex-1006-Best-2012 at FIG. 6.)

268. Best-2012 teaches that the manifold (720) is “attached to the coolant outlet 610 inside the interior volume of the tank 600” and has “a plurality of nozzles or velocity augmentation devices of area A_2 **distributed along [its] length**. (Id. at 0069.) For example, Best-2012 illustrates:



(Ex-1006-Best-2012 at FIG. 7A-7B.)

269. As a POSITA would have known, the term “nozzles,” in Best-2012 (and Best-2008) includes not only apertures having tapered or curved surfaces, but also includes simple “straight” orifices with a uniform cross-section. For instance, the 2006 article by Anja Royne, entitled “*Effect of nozzle geometry on pressure drop and heat transfer in submerged jet arrays*,” uses the terms “nozzle” and “orifices” interchangeably and also illustrates mere uniform apertures (holes) as being “nozzles:”

Table 1
Overview of orifice plates used in the study

Device	Nozzle configuration		
Short/straight			
Long/straight			
Sharp-edged			
Countersunk			

(Ex-1022 at 801.) Instances of the interchangeable use of “nozzles” and “orifice,” or an orifice being described as a mere aperture or hole by Royne are below:

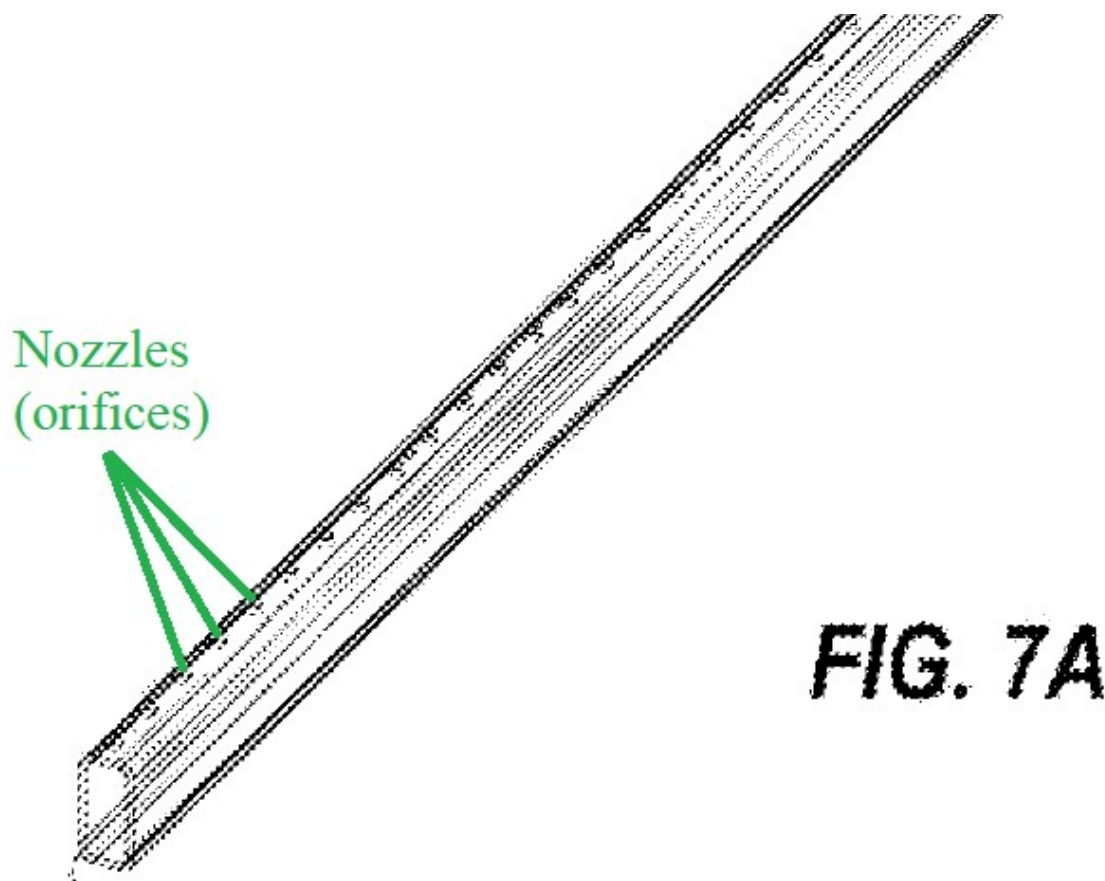
- “The sharp-edged nozzle was found to yield the highest heat transfer coefficient....The average heat transfer coefficients were found to follow the

same trend, with the sharp-edged orifice performing better than the other three nozzle types.” (*Id.* at 802.)

- “The pressure drop through the different nozzles can be easily predicted from theory. Bernoulli’s equation... This can be used to find the pressure difference across the orifice.” (*Id.*)
- “Taking into account the losses through the orifice, the theoretical velocity is reduced by a factor C_v called the velocity coefficient, defined as the ratio of actual to theoretical velocity at the orifice exit.” (*Id.*)
- “It has been found previously that very small diameter orifices can behave differently from larger orifices.” (*Id.* at 802-03.)
- “This relates to the fact that while the sharp-edged nozzles yield a higher pressure drop at a given Reynolds number, they also require a lower flow rate for a given heat transfer coefficient than the other orifices.” (*Id.* at 803.)

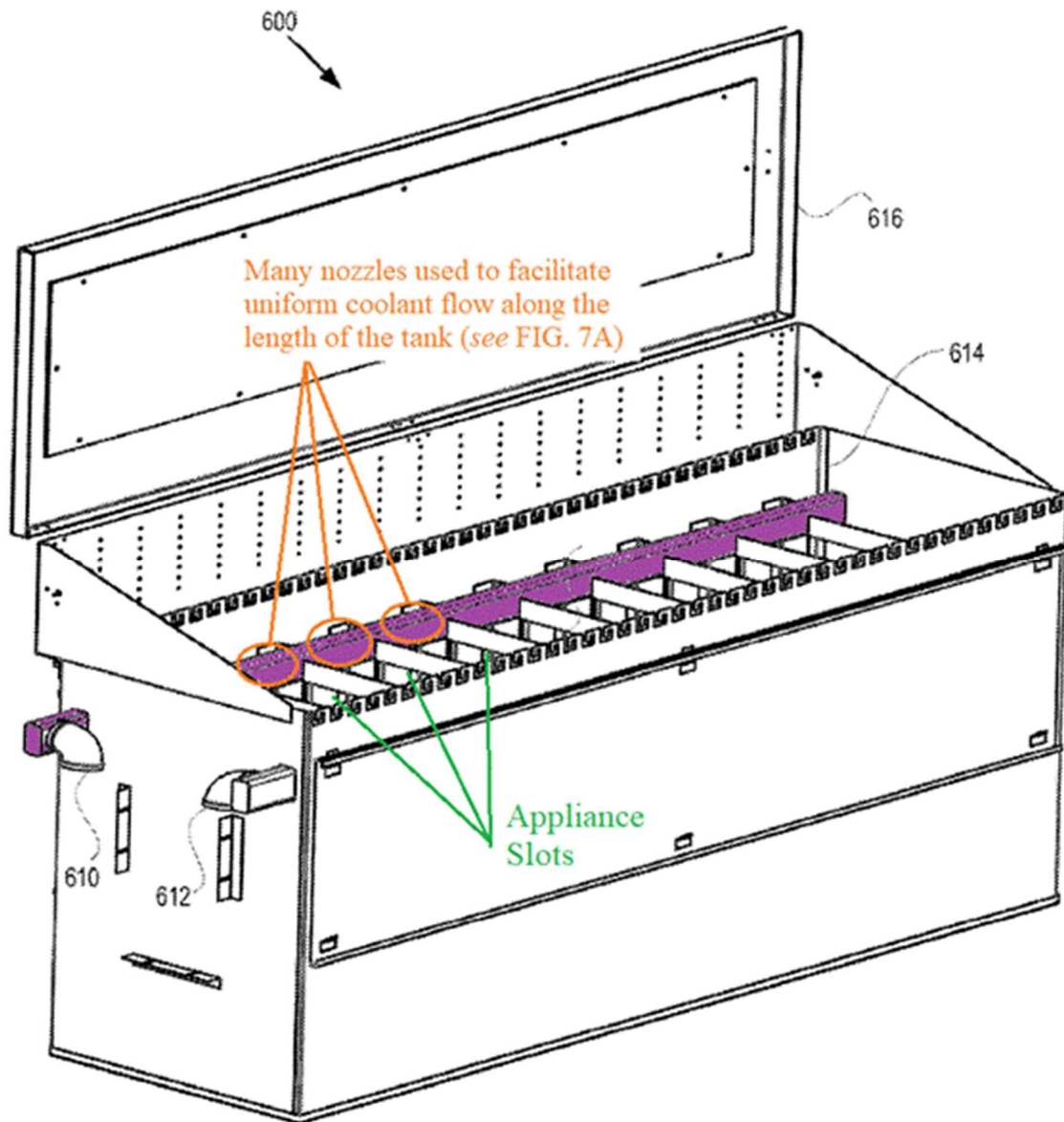
Thus, a POSITA would have understood the manifolds of Best-2012 to include any suitable nozzles (orifices, such as uniform apertures or holes) to allow the fluid to exit or enter such manifolds.

270. The nozzles in the manifold are illustrated in FIG. 7A as located uniformly cross the upper surface of the manifold:



(Ex-1006-Best-2012 at FIG. 7A.)

271. A POSITA would understand from this disclosure that these nozzles are placed “adjacent all appliance slots” in the Best-2012 immersion tank:



(Ex-1006-Best-2012 at FIG. 6.)

272. Specifically, similar to Best-2008, Best-2012 discloses that the cooling system includes a rack which “is a frame or enclosure that contains multiple mounting slots called bays, each designed to hold a hardware unit secured in place with fastening devices such as screws.” (Ex-1006-Best-2012 at 0041.) In the

embodiment illustrated in FIG. 6, the “interior volume of the tank 600 includes a rack system 614 for holding the computing systems 230 and HDDs 240.” (Ex-1006-Best-2012 at 0068.)

273. Best-2012 further discloses that this arrangement facilitates creating uniform coolant flow through the tank:

“The area [] of the velocity augmentation devices along the length of the pressure manifold 710 is much smaller than the area [] of the pressure manifold 710. This allows for the pressure lost through the velocity augmentation devices to be much greater than the pressure lost through the pressure manifold 710. Consequently, the pressure across the velocity augmentation devices is approximately equal over the entire length of the tank 600. Likewise, suction across the suction manifold 720 is approximately equal along the entire length of the tank 600. Hence, coolant flow is approximately equal along the length of the entire tank 600.”
(*Id.* at 0070.)

274. As such, a POSITA would understand from Best-2012 that it is beneficial to extract dielectric liquid from the immersion cooling tank by using a mechanical structure (for example, a manifold having evenly spaced nozzles/orifices or other velocity augmentation devices) placed along the long wall of the tank.

275. A POSITA would have been motivated to apply these teachings from Best-2012 to Best-2008 and Osada. As detailed above in Section VII concerning Ground 1, it is an objective of Best-2008 to achieve uniform coolant flow through the servers immersed in the tank and between server slots. The teachings of Best-2012 further assist with achieving that objective.

276. As additionally explained above in Section VII concerning Ground 1, a POSITA would have found it obvious to use Osada's weir-and-notch teachings with Best-2008's tank. The nozzle disclosure and placement of Best-2012 confirms that these notches should be implemented in Best-2008's tank "adjacent all appliance slots" to facilitate "coolant flow [that] is approximately equal along the length of the entire tank 600." (Ex-1006-Best-2012 at 0070.)

277. A POSITA would not have any difficulty with and would have had a reasonable expectation of success in implementing the Best-2012 teachings with Best-2008 and Osada. As noted above in Section VII concerning Ground 1, it would be simple for a POSITA to implement Osada's weir-and-notch teachings in Best-2008; Best-2012 confirms the placement of those notches.

278. Finally, I note that a POSITA would have understood that the nozzles or velocity augmentation devices of Best-2012 are the same as those disclosed by Best-2008, as discussed above in Section VII.B in connection with claim limitation 1.4. (Ex-1004-Best-2008 at 00107, 123.)

B. Challenged Claims

279. Petitioner challenges claims 1-16 of the '457 patent. As explained above in Ground 1, there are no material differences between claims 1-5 and claims 6-10 or claims 11-16. (*See* Ex-1009.) Thus, like Petitioner, I have grouped my

analysis below by claim sets:

- Claim Set 1: claims 1-5;
- Claim Set 2: claims 6-10;
- Claim Set 3: claims 11-16.

1. Claim Set 1

[1.0] “An appliance immersion cooling system comprising:”

[1.1] “a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:”

280. Best-2008 discloses these limitations for the reasons provided in Ground 1.

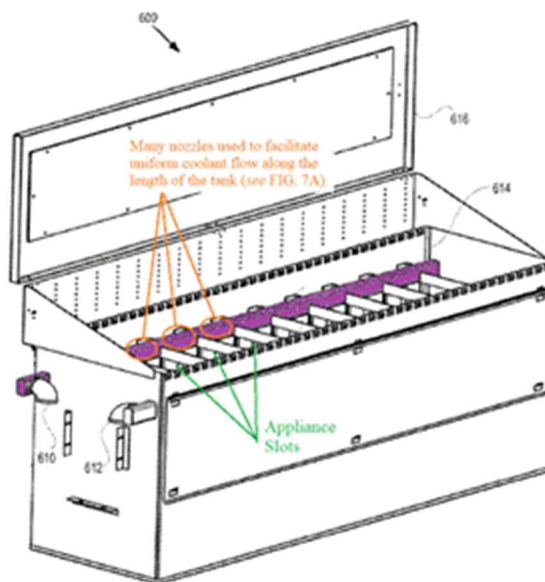
[1.2] “a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and”

281. Best-2008 in view of Osada and Best-2012 teaches “a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot;”

282. As explained above in Section VII concerning Ground 1, it was obvious to implement Osada’s weir-and-notch teachings with Best-2008. Doing so teaches “a weir, integrated horizontally into the long wall of the tank... having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot.”

283. And, as detailed in Section VII.A above, Osada further teaches that it is “preferable to provide multiple notches over a broad range, and it is even more preferable to provide these notches at uniform spacing to ensure that it is possible to force the flow of all of the floating impurities that are easily suspended on the liquid surface and impurities that are more likely to be suspended in the lower layers into the overflow box over **the entirety** of the liquid in the liquid tank.” (Ex-1005-Osada at 0018.)

284. Best-2012 teaches that Osada’s notches should be spaced uniformly on the long wall of the Best-2008 tank, located adjacent each appliance slot to facilitate uniform “coolant flow...along the length of the entire tank 600:”



(Ex-1006-Best-2012 at 0070, FIG. 6.)

285. As such, Best-2008 in view of Osada and Best-2012 teaches limitation

1.2.

[1.3] “a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir; and”

[1.4] “a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot;”

[1.5] “a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and”

[1.6] “a control facility adapted to coordinate the operation of the primary and secondary fluid circulation facilities as a function of the temperature of the dielectric fluid in the tank.”

286. Best-2008 in view of Osada teaches these limitations for the reasons provided in Ground 1, and Best-2008 in view of Osada and Best-2012 render obvious claim 1.

[Claim 2] “The system of claim 1 wherein the tank and primary circulation facility comprise a highly-integrated module.”

[Claim 3] “The system of claim 1 wherein the tank further comprises: an interconnect panel facility adapted to mount appliance support equipment.”

[Claim 4] “The system of claim 1 wherein the primary circulation facility further comprises: at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank; wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities and the secondary fluid circulation facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.”

[Claim 5] “The system of claim 1 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.”

287. Best-2008 in view of Osada teaches these limitations for the reasons provided in Ground 1. Thus, Best-2008 in view of Osada and Best-2012 renders obvious claims 2-5.

2. Claim Set 2

288. As explained previously in §VII.B. and shown below, claim 6 and its dependents correspond directly to similar limitations in Claim Set 1.

[6.0] “A tank module adapted for use in an appliance immersion cooling system, the tank module comprising:”

[6.1] “a tank adapted to immerse in a dielectric fluid a plurality of electrical appliances, each in a respective appliance slot distributed vertically along, and extending transverse to, a long wall of the tank, the tank comprising:”

289. Best-2008 teaches the preamble of claim 6 and limitation 6.1 for the reasons provided in Ground 1 regarding the preamble of claim 1 and limitation 1.1.

[6.2] “a weir, integrated horizontally into the long wall of the tank adjacent all appliance slots, having an overflow lip adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot; and”
Best-2008 in view of Osada and Best-2012 teaches this limitation for the reasons provided above regarding limitation 1.2.

[6.3] “a dielectric fluid recovery reservoir positioned vertically beneath the overflow lip of the weir and adapted to receive the dielectric fluid as it flows over the weir; and”

290. Best-2008 in view of Osada teaches these limitations for the reasons provided in Ground 1 regarding limitation 1.3.

[6.4] “a primary circulation facility adapted to circulate the dielectric fluid through the tank, comprising: a plenum, positioned adjacent the bottom of the tank, adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot;”

291. Best-2008 teaches this limitation for the reasons provided above in Ground 1 regarding limitation 1.4.

[6.5] “a control facility adapted to coordinate the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank.”

292. Best-2008 teaches this limitation for the reasons provided above in Ground 1 regarding limitation 1.6.

293. Thus, claim 6 is rendered obvious by Best-2008 in view of Osada and Best-2012.

[Claim 7] The module of claim 6 wherein the tank and primary circulation facility comprise a highly-integrated module.

294. To the extent this limitation can be understood, Best-2008 teaches it for

the reasons provided above in Ground 1 regarding claim 2, and claim 7 is rendered obvious by Best-2008 in view of Osada. and Best-2012.

[Claim 8] “The module of claim 6 wherein the tank further comprises: an interconnect panel facility adapted to mount appliance support equipment.”

295. Best-2008 teaches this limitation for the reasons provided above in Ground 1 regarding claim 3, and claim 8 is rendered obvious by Best-2008 in view of Osada and Best-2012.

[Claim 9] “The module of claim 6 wherein the primary circulation facility further comprises: at least first and second primary circulation sub-facilities, each adapted to operate independently to circulate the dielectric fluid through the tank; wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.”

296. Best-2008 teaches this limitation for the reasons provided above in Ground 1 regarding claim 4, and claim 9 is rendered obvious by Best-2008 in view of Osada and Best-2012.

[Claim 10] “The module of claim 6 wherein the control facility further comprises a communication facility adapted to facilitate monitoring and control of the control facility from a remote location.”

297. Best-2008 teaches this limitation for the reasons provided above in Ground 1 regarding claim 5, and claim 10 is rendered obvious by Best-2008 in view of Osada and Best-2012.

2. Claim Set 3

298. As explained previously in §VII.B. and shown below, claim 11 and its dependents correspond directly to similar limitations in Claim Set 1.

[11.0] “A tank module (10) adapted for use in an appliance immersion cooling system, the tank module comprising:”

[11.1] “a tank (12) adapted to immerse in a dielectric fluid a plurality of electrical appliances (16), each in a respective appliance slot (18) distributed vertically along, and extending transverse to, a long wall of the tank (10), the tank (10) comprising:”

299. Best-2008 teaches the preamble of claim 11 and limitation 11.1 for the reasons provided above regarding Ground 1, 1.0-1.1 and 11.0-11.1.⁵

[11.2] “a weir 22, integrated horizontally into the long wall of the tank (10) adjacent all appliance slots 18, adapted to facilitate substantially uniform recovery of the dielectric fluid flowing through each appliance slot (18); and”

300. Best-2008 in view of Osada and Best-2012 teaches this limitation is obvious for the reasons provided above regarding limitation 1.2.

[11.3] “a primary circulation facility (28) adapted to circulate the dielectric fluid through the tank (10), comprising: a plenum (36), positioned adjacent the bottom of the tank (10), adapted to dispense the dielectric fluid substantially uniformly upwardly through each appliance slot (18);”

301. Best-2008 teaches this limitation for the reasons provided above regarding Ground 1, limitation 1.4.

⁵ See Ground 1 at claim 11 regarding the numbers recited in claim 11.

[11.4] “a control facility (58) adapted to coordinate the operation of the primary fluid circulation facility as a function of the temperature of the dielectric fluid in the tank.”

302. Best-2008 teaches this limitation for the reasons provided above regarding Ground 1, limitation 1.6.

303. Thus, claim 11 is rendered obvious by Best-2008 in view of Osada and Best-2012.

[Claim 12] “The tank module of claim 11 wherein the tank further comprises: an interconnect panel facility (24) adapted to mount appliance support equipment.”

304. Best-2008 teaches this limitation for the reasons provided above regarding Ground 1, claim 3, and claim 12 is rendered obvious by Best-2008 in view of Osada and Best-2012.

[Claim 13] “The module of claim 11 wherein the primary circulation facility further comprises: at least first and second primary circulation sub-facilities (28a, 28b), each adapted to operate independently to circulate the dielectric fluid through the tank; wherein the control facility is further adapted to coordinate the operation of the first and second primary circulation sub-facilities so to maintain the temperature of the dielectric fluid in the tank substantially between a predetermined minimum temperature and a predetermined maximum temperature.”

305. Best-2008 teaches this limitation for the reasons provided above regarding Ground 1, claim 4, and claim 13 is rendered obvious by Best-2008 in view of Osada and Best-2012.

[Claim 14] “The module of claim 11 wherein the control facility further comprises a communication facility (62, 64) adapted to facilitate monitoring and control of the control facility from a remote location.”

306. Best-2008 teaches this limitation for the reasons provided above regarding Ground 1, claim 5, and claim 14 is rendered obvious by Best-2008 in view of Osada and Best-2012.

[Claim 15] “An appliance immersion cooling system comprising a tank module according to any one of the preceding claims 11 through 14.”

307. Ground 2 teaches this limitation for the reasons provided above regarding claims 1-5, and claim 15 is rendered obvious by Best-2008 in view of Osada and Best-2012.

[Claim 16] “An appliance immersion cooling system according to claim 15, further comprising a secondary fluid circulation facility adapted to extract heat from the dielectric fluid circulating in the primary circulation facility, and to dissipate to the environment the heat so extracted; and”

308. Best-2008 teaches this limitation for the reasons provided above regarding Ground 1, limitation 1.5, and claim 16 is rendered obvious by Best-2008 in view of Osada and Best-2012.

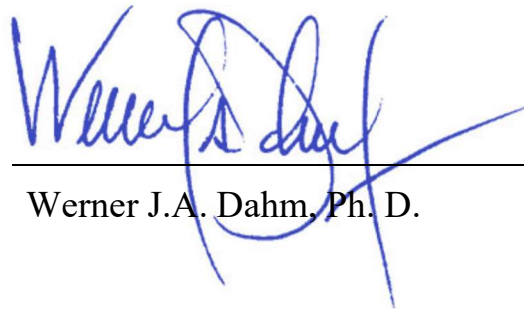
IX. DECLARATION IN LIEU OF OATH

309. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further 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 § 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. If called to testify as to the truth of the matters stated herein, I could and would testify competently.

I declare under penalty of perjury that the foregoing is true and correct.

November 19, 2024

A handwritten signature in blue ink, appearing to read 'Werner J.A. Dahm', is written over a horizontal line.

Werner J.A. Dahm, Ph. D.