

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ERICSSON INC. and VERIZON COMMUNICATIONS, INC.
Petitioners,

v.

PROCOMM INTERNATIONAL PTE. LTD.
Patent Owner.

U.S. Patent No. 7,724,521
Issue Date: May 25, 2010

Title: SYSTEMS AND METHODS FOR VENTURI FAN-ASSISTED COOLING

Inter Partes Review No.: Unassigned

**DECLARATION OF EMAD Y. TANBOUR, PHD IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,724,521**

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I. INTRODUCTION

1. I am over the age of eighteen (18) and otherwise competent to make this Declaration.

2. I have been retained by Ericsson, Inc. and Verizon Communications, Inc. (Petitioners) as an independent, technical expert consultant in this proceeding before the United States Patent and Trademark Office (USPTO). I am being compensated at my rate of \$750 per hour for my services. No part of my compensation is dependent on my opinions or on the outcome of this proceeding. I have no financial interest in any of the parties to this proceeding.

3. This Declaration is in support of the Petition for *inter partes* review involving U.S. Patent 7,724,521 (the “’521 Patent” or “the Patent”) (EX-1001), entitled “SYSTEMS AND METHODS FOR VENTURI FAN-ASSISTED COOLING” and listing Michael J. Nelson and Michael J. Wayman as the inventors.

4. For the purposes of this *inter partes* review as I discuss later, I have been instructed to assume that the effective filing date of the Claims of the ’521 Patent challenged by the Petitioner in this *inter partes* review is no earlier than June 11, 2008.

5. I understand that, according to USPTO records, the '521 Patent is currently assigned to ADC Telecommunication, Inc. I have been instructed to assume for purposes of this proceeding that Procomm International Pte. Ltd is the patent owner.

6. The '521 Patent is generally directed to cooling of electronic equipment with Venturi fan assistance. I am familiar with the technology described in the '521 Patent as of the earliest possible priority date of June 11, 2008, the filing date of Application No. 12/137,309.

7. In preparing this Declaration, I have reviewed the '521 Patent (EX-1001) and its prosecution history (EX-1002), as well as the patents and documents cited herein, and I have considered these documents in light of the general knowledge in the art as of June 2008. In formulating my opinions, I have relied upon my experience in the relevant art. I have also considered the viewpoint of a person of ordinary skill in the art ("POSA") in the relevant field, as of June 2008, who I describe below (§ V.E). For convenience, the materials I considered in arriving at my opinions are listed in Appendix A.

8. I have been asked to provide my technical expertise, analysis, insights and opinions regarding the '521 Patent and relevant references that form the basis of the arguments set forth in the accompanying Petition for

inter partes review of the '521 Patent. As described in detail below, I offer the following opinions in this Declaration:

9. A POSA would have found Claims 1, 3-5, 14-16 of the '521 obvious over Sterner in view of the knowledge of a POSA and a POSA would have been motivated to make modifications known to a POSA.

10. A POSA would have found Claims 1-2, 4-5, 14-17 of the '521 Patent obvious over Aakalu in view of the knowledge of a POSA and a POSA would have been motivated to make modifications known to a POSA.

11. A POSA would have found Claims 3, 18-20 of the '521 Patent are obvious over Aakalu, alone, or in further view of Jones and a POSA would have been motivated to combine these references.

12. Unless otherwise indicated, the emphasis in quotations has been added.

II. QUALIFICATIONS

13. My qualifications as an expert in the fields of mechanical engineering and thermodynamic used for forming the opinions set forth in this declaration are summarized here and explained in more detail in my curriculum vitae, which is included as Appendix B. Appendix B also includes a list of my publications and patents.

14. In 1997, I earned a Doctorate or Ph.D. Degree in Mechanical Engineering from The University of Iowa. In 1987, I earned a Bachelor's Degree in Mechanical Engineering, and in 1990, I earned a Master's of Science Degree in Mechanical Engineering.

15. I served as the Chair of Mechanical Engineering at Eastern Michigan University in Ypsilanti, Michigan (2017 to 2021). I served as the Interim Associate Dean for the College of Engineering at Eastern Michigan University. I currently serve as full Professor of Mechanical Engineering at Eastern Michigan University.

16. In these positions, I am responsible for teaching, research, financial, and managerial matters in the engineering department at a major university. I have also supervised more than 46 graduate students and 7 doctoral fellows in the areas of Mechanical Engineering.

17. I have taught engineering at the university and collegiate levels for over 34 years. At the university and collegiate levels, I have taught scores of courses on heat transfer, thermodynamics, fluid mechanics, mechanical engineering, and engineering management.

18. I have authored over forty (40) publications and have given scores of research lectures. My research interests include thermodynamics,

heat transfer, and energy systems. A list of my publications is included in Appendix B.

19. I also have significant industry experience in the engineering fields. My industry experience spans over 18 years, including on thermal systems design. Over the course of my career, I have led thermal design projects for NASA projects, I have managed product development engineering for Whirlpool and A.O. Smith water heaters, and I have served in Director of Engineering roles.

20. I am a named inventor on over 17 U.S. pending and issued patents, all of which resulted in products sold in North America. The vast majority of my patents fall in the thermal science fields.

21. Based on my experience described above, and as indicated in my *curriculum vitae*, I am qualified to provide the following opinions with respect the patent in this case. Additionally, I am at least a person having ordinary skill in the art, as I have set forth in §V.E below, as of the priority date of the '521 Patent.

III. RELEVANT LEGAL STANDARDS

22. I do not provide any legal opinions in this Declaration. I have been informed and understand that certain legal standards are to be applied by technical experts in forming opinions regarding the meaning and validity of patent claims. I have been asked to provide my opinions regarding whether the claims of the '521 Patent would have been obvious to a person having ordinary skill in the art at the time of the alleged invention, in light of the prior art.

23. Further, I have been informed and understand that a patent claim is not patentable as obvious (a requirement I understand to be governed by a statute, 35 U.S.C. § 103) if the differences between the patent claim and the prior art are such that the claimed subject matter as a whole would have been obvious at the time the claimed invention was made to a person having ordinary skill in the relevant art. Obviousness, as I have been informed and understand, is based on the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and, to the extent that they exist, certain objective indicia of non-obviousness.

24. I understand that objective indicia can be important evidence regarding whether a patent is obvious or nonobvious, if it has an

appropriate nexus to the claimed invention, i.e., is a result of the merits of a claimed invention (rather than the result of design needs or market-pressure advertising or similar activities). Such indicia include: commercial success of products covered by the patent claims; a long-felt need for the invention; failed attempts by others to make the invention; copying of the invention by others in the field; unexpected results achieved by the invention as compared to the closest prior art; praise of the invention by the infringer or others in the field; the taking of licenses under the patent by others; expressions of surprise by experts and those skilled in the art at the making of the invention; the patentee proceeded contrary to the accepted wisdom of the prior art, and, the contemporaneous development of the subject matter claimed by others.

25. I have been informed that whether there are any relevant differences between the prior art and the claimed invention is to be analyzed from the view of a person of ordinary skill in the relevant art at the time of the invention. As such, my opinions below as to a person of ordinary skill in the art are as of the time of the invention, even if not expressly stated as such; for example, even if stated in the present tense.

26. In analyzing the relevance of the differences between the claimed invention and the prior art, I have been informed that I must

consider the impact, if any, of such differences on the obviousness or non-obviousness of the invention as a whole, not merely some portion of it. The person of ordinary skill faced with a problem is able to apply his or her experience and ability to solve the problem and also look to any available prior art to help solve the problem.

27. I have been informed that a precise teaching in the prior art directed to the subject matter of the claimed invention is not needed. I have been informed that one may take into account the inferences and creative steps that a person of ordinary skill in the art would have employed in reviewing the prior art at the time of the invention. For example, if the claimed invention combined elements known in the prior art and the combination yielded results that were predictable to a person of ordinary skill in the art at the time of the invention, then this evidence would make it more likely that the claim was obvious. On the other hand, if the combination of known elements yielded unexpected or unpredictable results, or if the prior art teaches away from combining the known elements, then this evidence would make it more likely that the claim that successfully combined those elements was not obvious.

28. I have been informed and understand that there are recognized, exemplary, rationales for combining or modifying references to show

obviousness of claimed subject matter. Some of the rationales include the following: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to yield predictable results; use of a known technique to improve a similar device (method or product) in the same way; applying a known technique to a known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art teachings to arrive at the claimed invention.

IV. OVERVIEW

29. The '521 Patent identifies “a need in the art for improved systems and methods for thermal management of telecommunications infrastructure equipment” and describes as its purported solution “systems and methods for utilizing Venturi fan-assisted cooling of electrical

equipment, such as but not limited to telecommunications equipment, housed inside an enclosure.” EX-1001 2:12-14, 3:1-4. The Challenged Claims are generally directed to a method and system of cooling an enclosure housing electronic devices by (1) directing heat from the devices to a heatsink, (2) drawing a first airflow across openings of the heatsink, and (3) using a Venturi effect created by the first airflow to draw air through the heatsink.

30. FIG. 3 illustrates the claimed method and FIG. 2D illustrates the system for implementing the method:

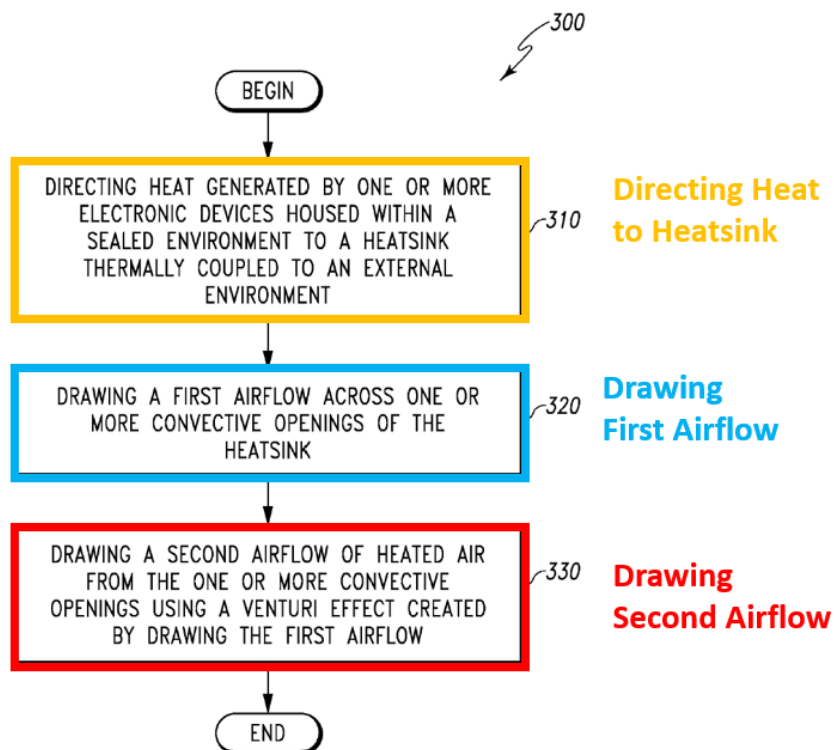
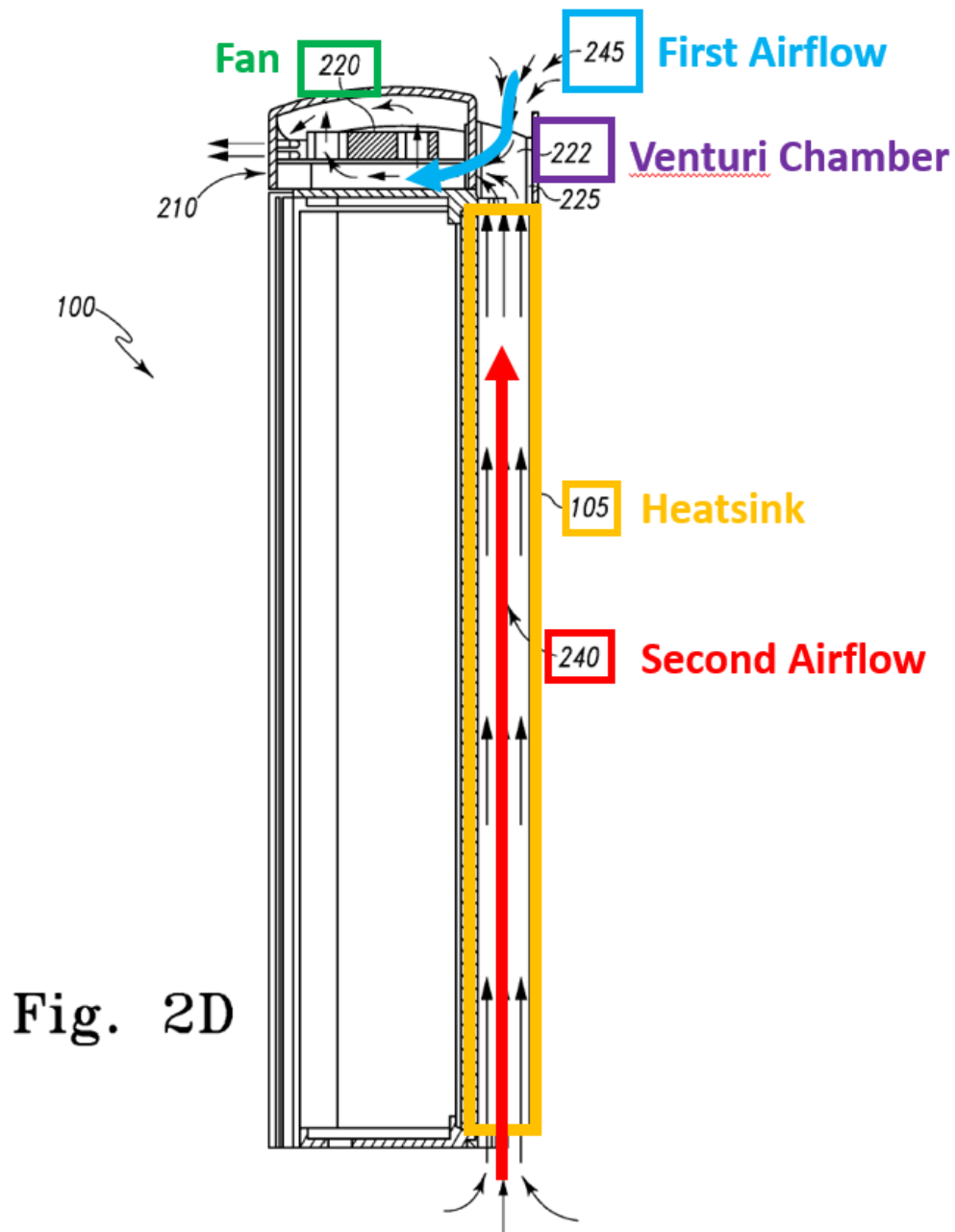


Fig. 3



¹ All annotations and text in color have been added to the figures.

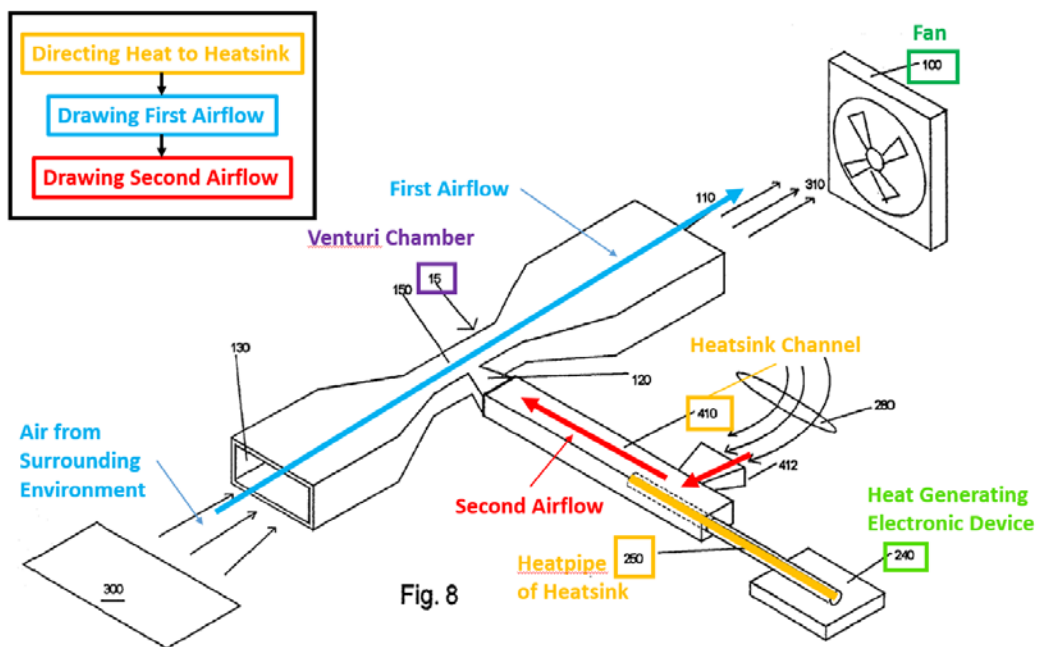
EX-1001 FIG. 2D

31. Claim 14 is directed to the embodiments shown in FIGs. 2D and 3, and reads:

14. A method for cooling a sealed environment of an enclosure for housing electronics, the method comprising:
directing heat generated by one or more electronic devices housed within a sealed environment of an enclosure to a heatsink thermally coupled to an external environment;
drawing a first airflow across one or more convective openings of the heatsink, wherein the first airflow does not flow into the one or more convective openings of the heatsink;
drawing a second airflow of heated air from the one or more convective openings using a Venturi effect created by drawing the first airflow.

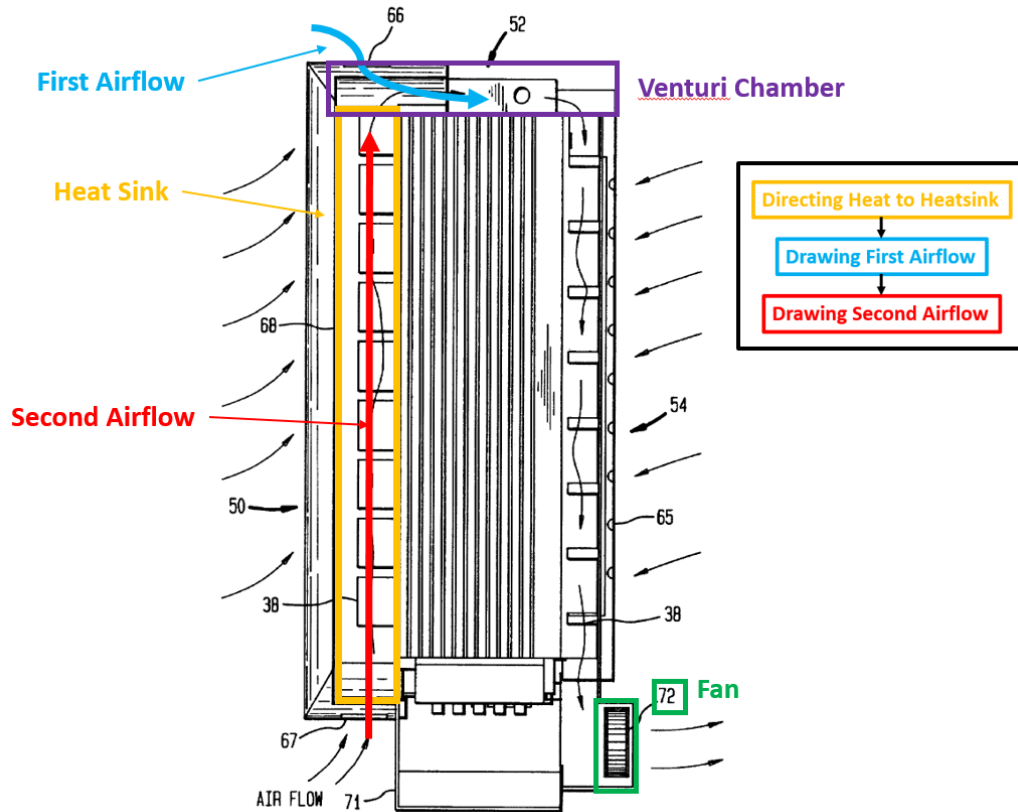
EX-1001 Claim 14

32. However, the Challenged Claims are merely directed to a combination of conventional components (e.g., heatsinks, fans, Venturi chambers) having known physical properties used for their intended purpose to remove heat from enclosures housing electronic devices. A comparison of U.S. Patent No. 7,028,753 (“Stern”) (EX-1004) to Claim 14 demonstrates that the claimed method and system were well-known prior to the purported invention of the ’521 Patent. FIG. 8 of Stern is annotated below to show the elements recited in Claim 14:



EX-1004 FIG. 8.

33. U.S. Patent No. 5,894,407 (Aakalu) (EX-1005) also discloses the claimed method and the system. FIG. 10 of Aakalu is annotated below to show the elements recited in Claim 14:



EX-1005 FIG. 10.

34. Sterner and Aakalu each demonstrate that the purported invention recited in the Challenged Claims was well-known at the time of the '521 Patent and is unpatentable as set forth in Grounds 1-3 below.

V. BACKGROUND

A. Summary of the '521 Patent

35. The '521 Patent is titled "Systems and Methods for Venturi Fan-Assisted Cooling" and is directed to a method for cooling enclosures housing electronic devices using a fan-driven Venturi effect to draw air

through a heatsink, and a system implementing the cooling method. EX-1001 Title, Abstract, 2:18-21.

36. The '521 Patent explains that “in the field of telecommunications, there is a trend to reduce both the size and the expenses associated with infrastructure equipment” while retaining all the functionality of legacy equipment resulting in “thermal management challenges for dissipating heat generated by telecommunications infrastructure equipment.” EX-1001 1:65-2:14. As a solution, the '521 Patent describes systems and methods for cooling electrical equipment housed within an enclosure having air flowing through a heatsink using a fan to both (1) draw air from openings of the heatsink and (2) draw air past the openings of the heatsink to produce a Venturi effect, the combination of which “generates an increased airflow through the heatsink which in turn draws in relatively cool air in from the bottom side ... of the heatsink.” EX-1001 6:8-15.

37. FIG. 3 shows a “flow chart illustrating a method 300 of one embodiment of the present invention for cooling an enclosure for housing electronics.” EX-1001 5:39-41.

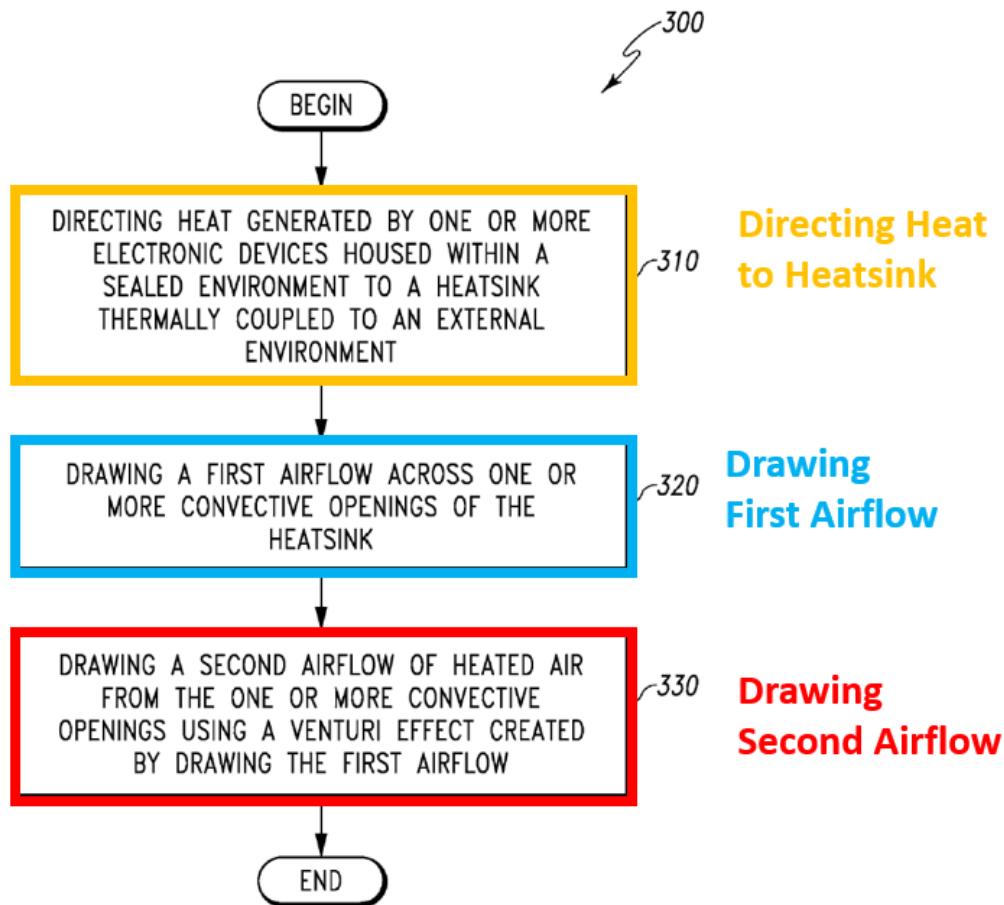


Fig. 3

EX-1001 FIG. 3.

38. The '521 Patent explains that the method begins at 310 (**gold**) with directing heat generated by one or more electronic devices to a heatsink thermally coupled to an external environment. EX-1001 5:41-43. The method proceeds to 320 (**blue**) with drawing a first airflow across one or more convective openings (air ducts/channels) of the heatsink, and to 330 (**red**) with drawing a second airflow of heated air from the one or

more convective openings of the heatsink using a Venturi effect created by drawing the first airflow. EX-1001 5:61-65. The '521 Patent further explains that

the airflow flowing up from the heatsink's convective openings will be heated by the heat dissipated from high powered internal electronics and thus will be significantly more buoyant than the ambient first airflow. As a result, drawing the first airflow across the convective openings of the heatsink will establish a Venturi affect [sic] which will pull in more air through the heat sink than would flow naturally due to natural convention.

* * *

The combination of drawing both the heated airflow from the heatsink and the ambient airflow from above is what produces the Venturi effect that generates an increased airflow through the heatsink which in turn draws in relatively cool ambient air in from the bottom side convective openings of the heatsink.

EX-1001 5:66-6:6, 6:8-15.

39. The Challenged Claims include independent Claims 14 and 19 directed to the method of cooling an enclosure housing electronics. A side-by-side comparison of Claims 14 and 19 is provided below:

Claim 14	Claim 19
----------	----------

[pre] A method for cooling a sealed environment of an enclosure for housing electronics, the method comprising:	[pre] A method for cooling a sealed environment of an enclosure for housing electronics, the method comprising:
[a] directing heat generated by one or more electronic devices housed within a sealed environment of an enclosure to a heatsink thermally coupled to an external environment;	[a] directing heat generated by one or more electronic devices housed within a sealed environment of an enclosure to a heatsink thermally coupled to an external environment;
[b] drawing a first airflow across one or more convective openings of the heatsink, wherein the first airflow does not flow into the one or more convective openings of the heatsink;	[b] when a temperature exceeds a first predetermined threshold, operating a fan to draw a first airflow across one or more convective openings of the heatsink and
[c] drawing a second airflow of heated air from the one or more convective openings using a Venturi effect created by drawing the first airflow.	[c] [draw] a second airflow of heated air from the one or more convective openings of the heatsink using a Venturi effect created by drawing the first airflow, wherein the first airflow does not flow into the one or more convective openings of heatsink;
	[d] when the temperature does not exceed a second predetermined threshold,

	allowing a natural circulation airflow to flow from the one or more convective openings of the heatsink by not operating the fan.
--	---

40. As shown above, Claims 14 and 19 are each directed to the steps ([a], [b], and [c]) described in the flow chart of FIG. 3, with Claim 19 adding an additional step of turning the fan on/off based on temperature. The dependent method claims are directed to specifics related to the control and position of the fan.

41. The '521 Patent also describes an apparatus for implementing the method. FIGs. 1A – 1D are provided as “diagrams illustrating an enclosure 100 of one embodiment of the present invention.” EX-1001 3:5-6. FIG. 1D illustrates the enclosure with the doors open showing the area where the electronic devices are housed:

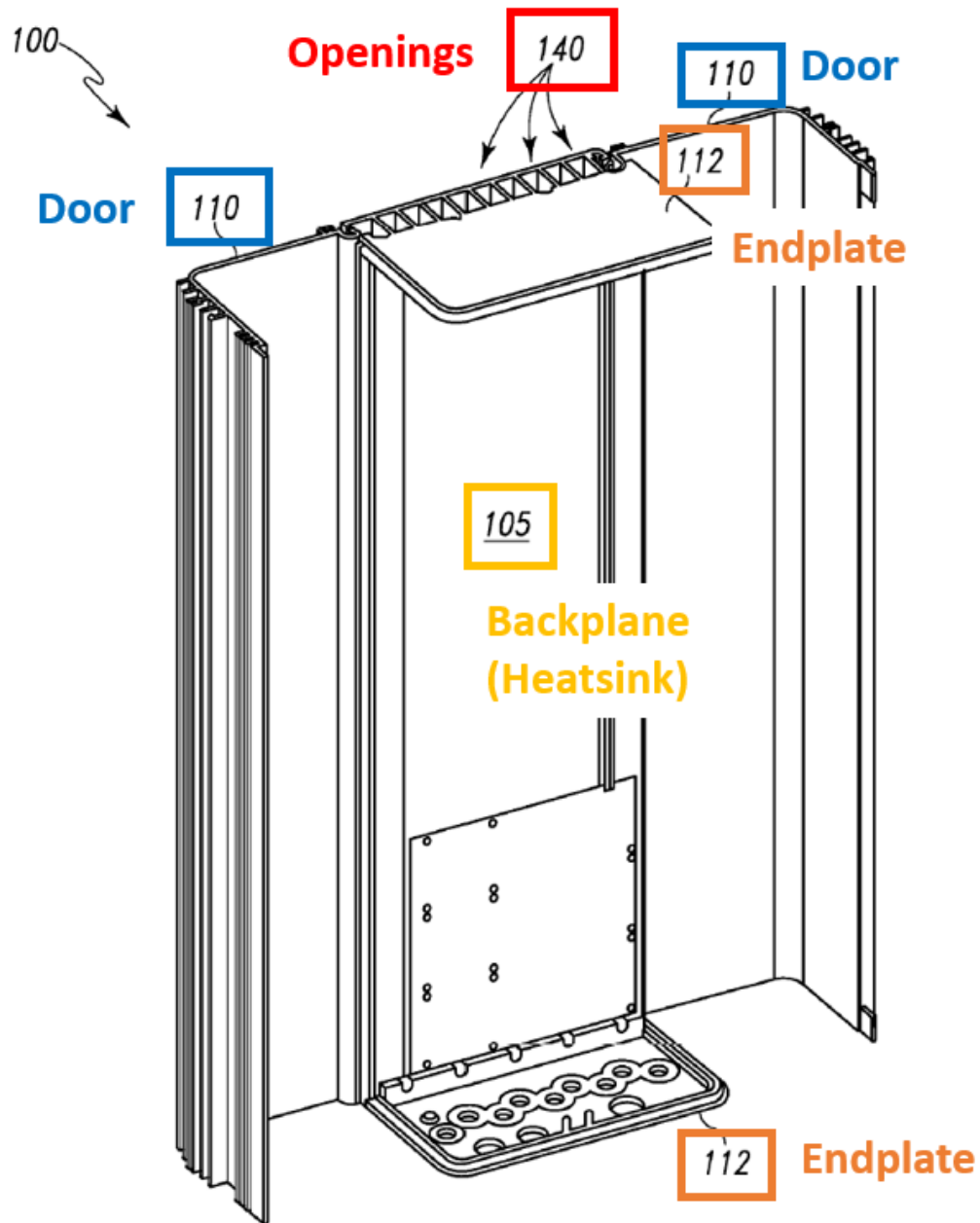
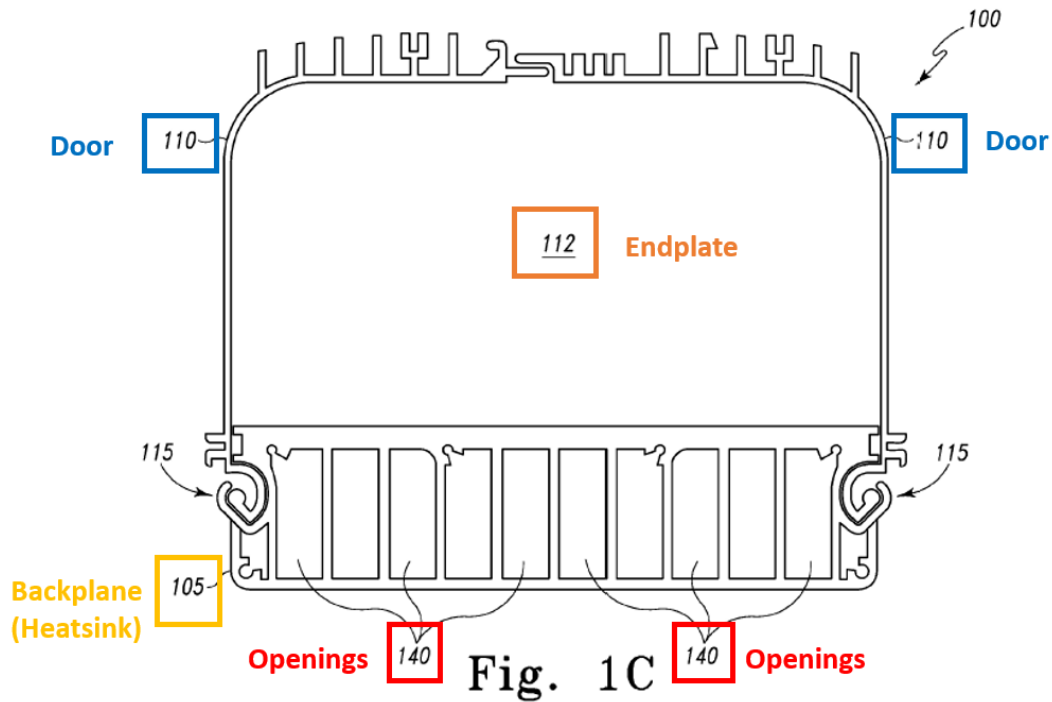


Fig. 1D

EX-1001 FIG. 1D

42. FIG. 1C illustrates an end view of the enclosure shown in FIG. 2D, but with the doors closed:

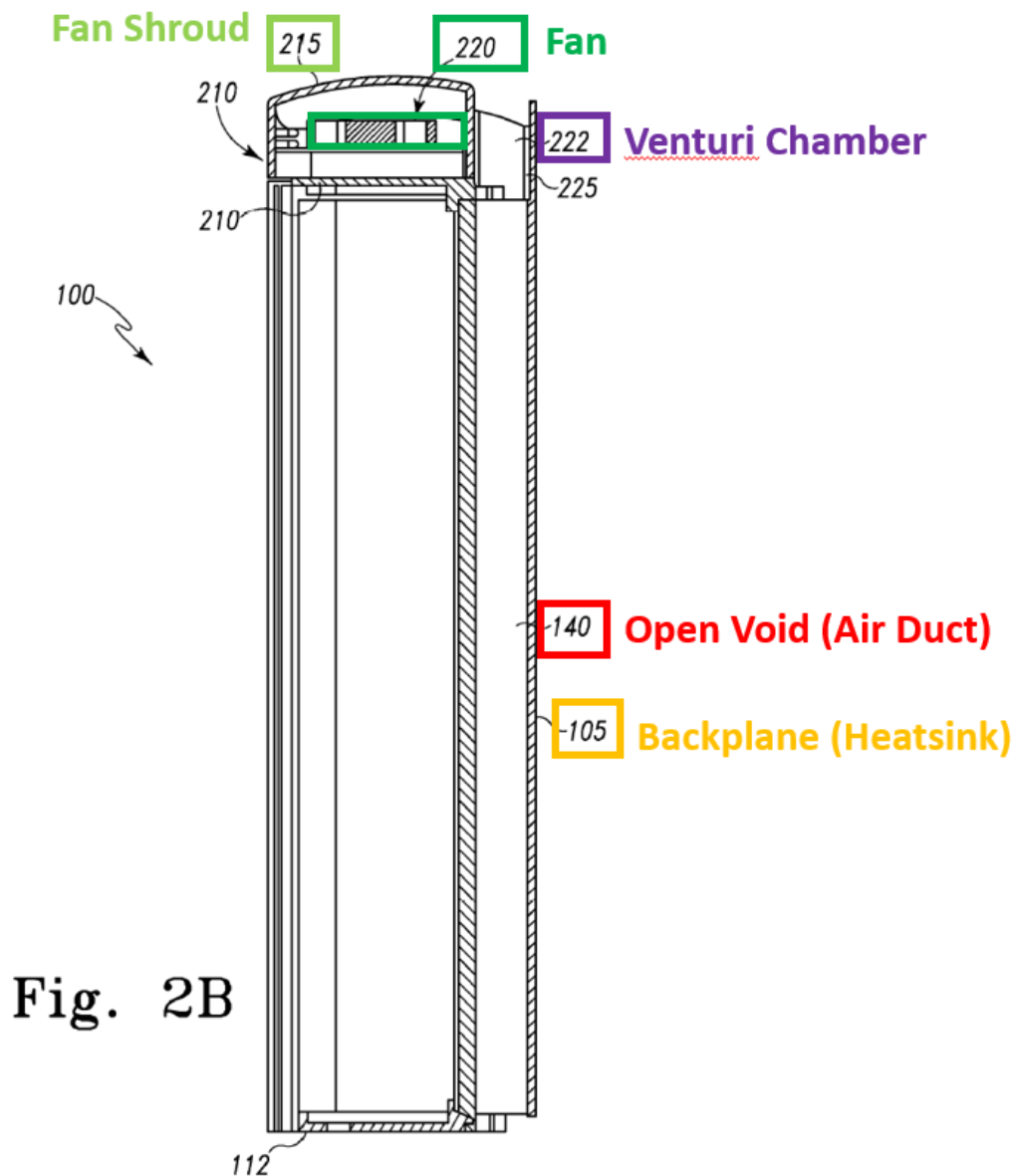


EX-1001 FIG. 1C

43. The '521 Patent explains that enclosure 100 comprises a structural backplane 105 (**gold**) , two doors 110 (**blue**) that each pivot around respective hinges 115, and two endplates 112 (**orange**) attached respectively to the ends of structural backplane 105 so that when doors 110 are closed (as illustrated in FIG. 1C), a sealed environment is created within enclosure 100. The '521 Patent discloses that in in some embodiments, the sealed environment is not weatherproof, but in alternate embodiments, a weatherproof sealed environment is provided. EX-1001 3:4-13.

44. The '521 Patent further explains that backplane 105 functions as a heatsink for internal electronics 130 (shown in FIGs. 1A and 1B) housed within enclosure 100. EX-1001 3:29-44. Backplane 105 includes a plurality of convective openings 140 (**red**) forming open voids (air ducts) that run the length of backplane 105. EX-1001 3:48-54.

45. The '521 Patent provides FIGs. 2A-2E as illustrating “a Venturi assisted cooling unit for the enclosure of one embodiment of the present invention.” EX-1001 2:44-46. FIG. 2B illustrates a cutaway view of the embodiment:



EX-1001 FIG. 2B.

46. The '521 Patent explains that a fan assisted cooling unit 210 may be positioned at the top of enclosure 100. Fan assisted cooling unit 210 comprises fan shroud 215 (light green) and at least one electrical fan 220 (green). EX-1001 4:11-16. Cooling unit 210 further comprises a

Venturi chamber 222 (**purple**) formed from continuous wall 225 connected on each end to fan shroud 215. As illustrated in FIG. 2C, fan 220 is placed in an offset position outside of Venturi chamber 222 so as to not impede the natural circulation of air through convective openings 140 when fan 220 is not operating. EX-1001 4:28-31.

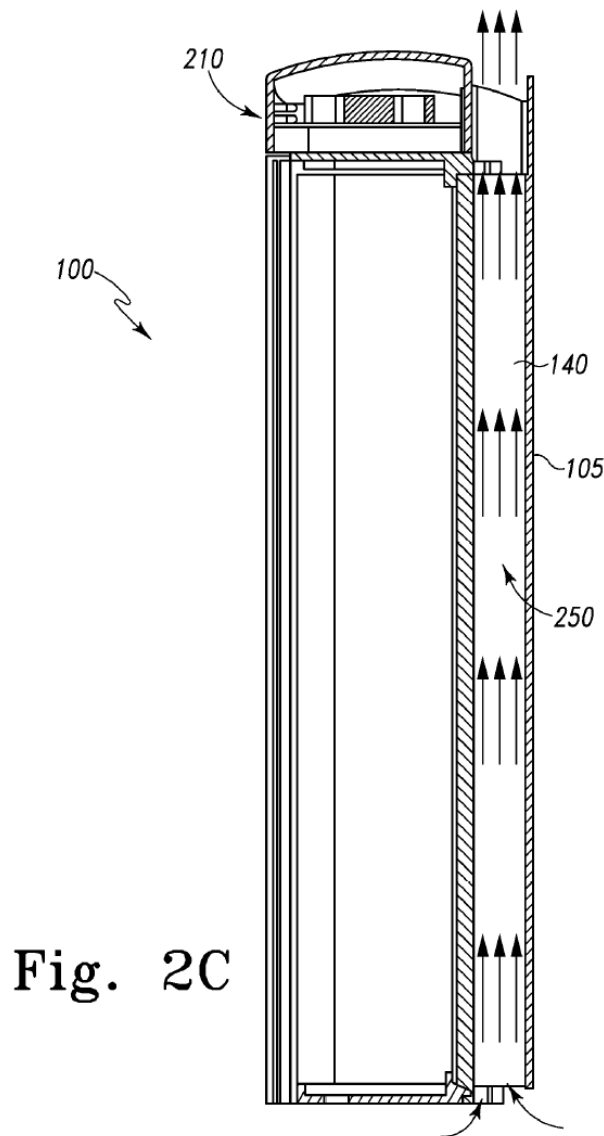
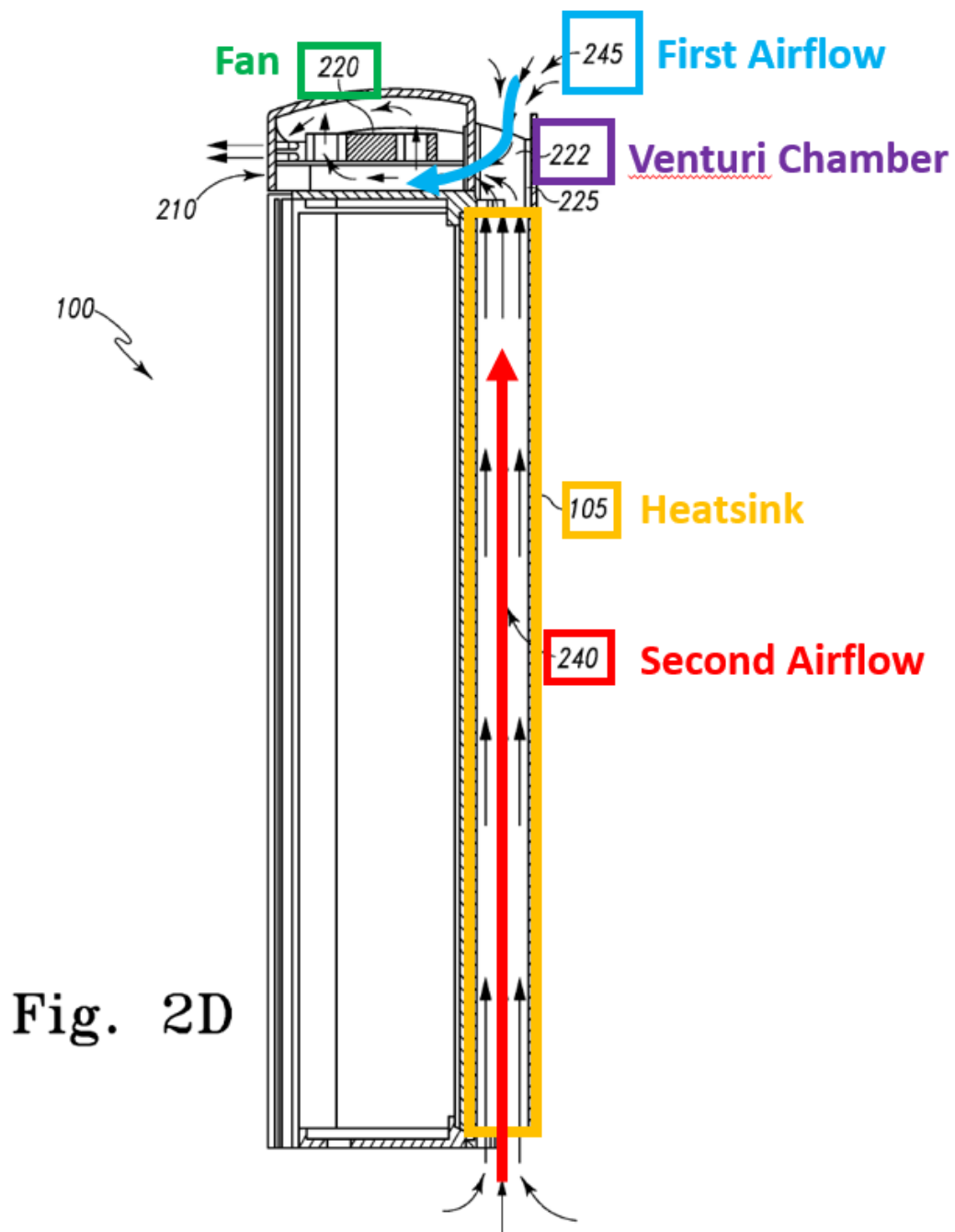


Fig. 2C

EX-1001 FIG. 2C.

47. FIG. 2D illustrates the air flow during operation of fan 220:



EX-1001 FIG. 2D.

48. The '521 Patent explains that fan 22 (**green**) draws air from Venturi chamber 222 (**purple**), and due to the positioning of wall 225, air drawn into fan 220 must flow into Venturi chamber 222 either through the convective openings 140 of backplane 105 (shown generally by second airflow 240 (**red**)), or drawn in from the ambient environment above Venturi chamber 222 (shown generally by first airflow 245 (**blue**)). The second airflow 240 (**red**) flowing through the openings 140 of backplane (heatsink) 105 (**gold**) is heated by the heat dissipated from high powered internal electronics (130). The '521 Patent further explains that fan 220 pulls in the hot buoyant air off the top of backplane 105 and at the same time also pulls in ambient air from the top of Venturi chamber 222 such that the ambient air coming in from the top of Venturi chamber 222 is directed across the heated airflow drawn from backplane 105. According to the '521 Patent, drawing the first airflow 245 (**blue**) from above into Venturi chamber 222 and through fan 220 produces a Venturi effect increasing airflow in the heated second airflow 240 (**red**) through backplane (heatsink) 105. EX-1001 4:35-45.

49. The Challenged Claims include independent Claims 1 directed to a cooling unit for an enclosure housing electronics (Claim 1

Claim 1

[pre] A cooling unit for an enclosure housing electronics,
the cooling unit comprising:
[a] a fan shroud having at least one electrical fan; and
[b] a Venturi chamber having
[b.1] a first inlet for receiving a heated airflow from a heatsink,
[b.2] a second inlet for receiving an airflow from a surrounding environment, and
[b.3] an outlet coupled to the fan shroud, the fan drawing air from the Venturi chamber via the outlet when the fan is on;
[b.4] wherein the Venturi chamber comprises a wall for directing the airflow air from the surrounding environment in from the second inlet and across the heated airflow from the heatsink in a manner to as to draw the heated airflow through the heatsink using a Venturi effect, when the fan is on.

50. As shown above, Claim 1 recites a cooling device having [a] a shroud and fan, and [b.1 – b.4] a specific configuration of a Venturi chamber. The dependent claims are directed to various configurations of the cooling.

B. Prosecution History

51. I have reviewed the prosecution history in forming my opinion.

C. Claim Construction

52. I have been informed to give each claim term in the Challenged Claims its plain and ordinary meaning in this proceeding. It is my opinion

that no specific construction of any claim term is required because the prior art I have relied upon meets each of the claim terms under any reasonable construction.

D. Priority Date of the Challenged Claims

53. I understand the application that issued as the '521 Patent was filed Jun. 11, 2008 and I have been instructed to assume that the earliest priority date is Jun. 11, 2008.

E. Person of Ordinary Skill in the Art

54. With respect to the '521 Patent, a POSA in 2008 would have been familiar with thermal management of electronic devices, including devices housed within a sealed enclosure. A POSA would have gained knowledge of these concepts through a mixture of training and work experience, such as by having a Bachelor's degree mechanical engineering and four years of experience; or by obtaining a Master's degree in mechanical engineering, but having only one to two years of experience; or by having no formal education but experience in such systems of at least eight years.

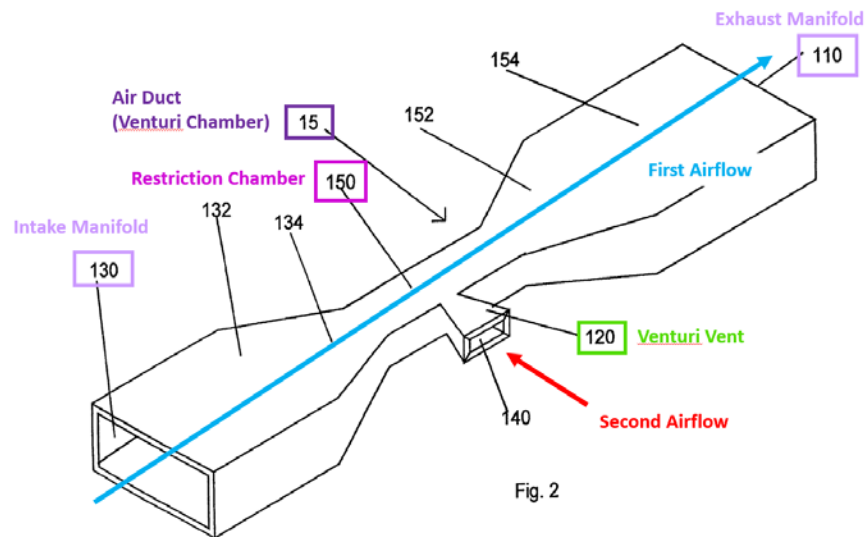
F. State of the Art

55. The following section describes the state of the art in cooling systems for electronics housed in enclosures as of the filing of the '521 Patent. The prior art references, and the discussions of what was known

to a POSA, provide the factual support for the general description of the state of the art and provide additional motivation to modify or combine the references. Accordingly, these references should be considered by the Board.

1. The Venturi Effect and Its Use in Cooling Electronics

56. The purported invention of the '521 Patent is the use of a fan-driven Venturi effect to draw an airflow in a forced convection cooling system for electronic enclosures. A POSA understood the Venturi effect was a well-known observation that the rate of fluid flow in a closed system, such as a pipe, increases as the fluid encounters a constricted region, and that this Venturi effect is based on Bernoulli's principle. A POSA also understood that it was common and well-known to use the Venturi effect to increase the airflow used to cool electronics. For example, Sterner illustrates an air duct (Venturi chamber) used in drawing an airflow to cool electronics.



EX-1004 FIG. 2

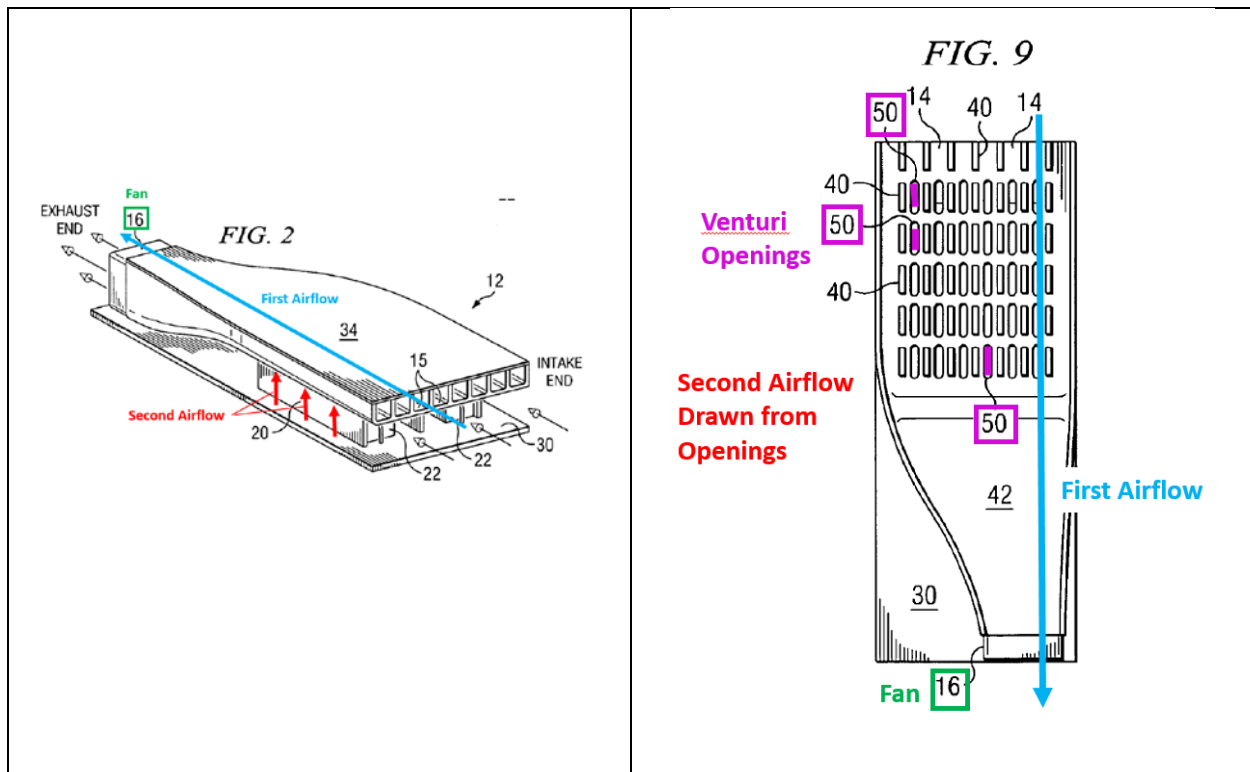
57. With reference to FIG. 2, Sterner explains this well-known phenomenon and how it is used in its cooling device for electronics. EX-1004 3:10-33. *See also* § VII.A.2 [1.3] below. A POSA understood from Sterner that air within the first volume is forced to increase its velocity as it leaves the intake manifold 130 and is coupled with first coupling 134 into restriction chamber 150. As the air velocity increases, its pressure must decrease to conserve the energy of air mass moving through the air duct 15 according to the principle of conservation of energy and Bernoulli's principle. When the velocity increases in the restriction chamber 150, the air pressure against the sidewalls of the air duct 15 in restriction chamber 150 reduces. This reduction in pressure as the air velocity increases is known as the Bernoulli principle, which is another form of the principle of

conservation of energy or the simple form of the first law of thermodynamics. EX-1004 3:10-24. Sterner also explains that

The restriction chamber 150 further has an opening or optionally a flared opening 140 on at least one sidewall to create a venturi vent 120. This venturi vent 120 then allows air outside of the air duct 15 to enter the opening thus allowing air outside of air duct 15 to mix with the air entering the intake manifold 130.

EX-1004 3:28-33.

58. Further by way of example, Lord used a fan-driven Venturi effect to draw an airflow in a forced convection cooling system for electronic enclosures. Specifically, Lord discloses an electronics plenum wherein “[a]ir communicating through the passageways defined by the fins removes heat from the fins, and also creates a venturi effect to remove heat from within a housing via the openings to further cool the portable electronic device.” EX-1007 Abstract.



EX-1007 FIGs. 2, 9.

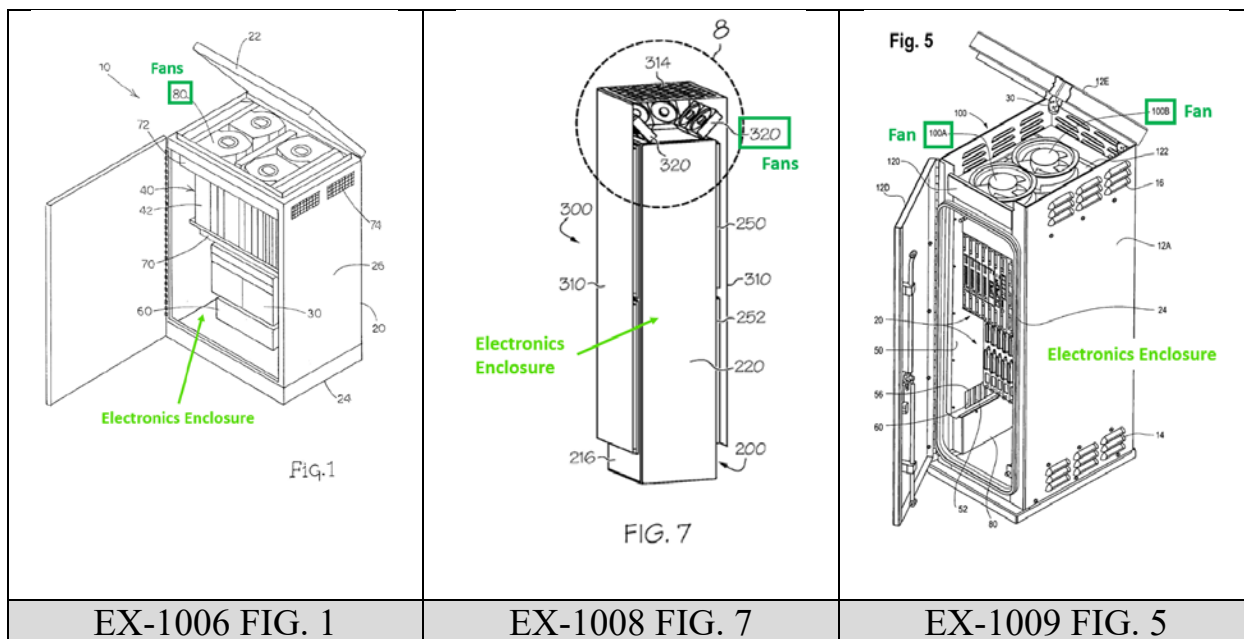
59. Lord explains that:

Openings 50 extend through the generally planar intake end of unitary base 38, each opening into the cavity 26 of device 10 proximate the heat generating components 22, as well as other electrical components 28 shown in FIG. 1. Advantageously, as air flows across each of these openings 50, a venturi effect is created, which venturi effect draws the heating [sic] air from within cavity 26 into the passageways 14 for exhausting via fan 16.

EX-1007 3:53-63.

2. Forced Convection Cooling With Fan/Shroud Above Enclosure

60. In forced convection cooling systems for electronics enclosures, it was well-known to position one or more fans and the associated fan shrouds above the enclosure such that air is drawn in at the bottom of the heat sink(s) and exhausted at the top. For example, each of Jones (EX-1006), Fischer (EX-1008), and Morrell (EX-1009) disclose such a fan/shroud arrangement:



61. A POSA understood that it was common to put a fan above a heat sink since warm air naturally rises and thus exposing the warm air to the suction side of a fan facilitates the amount of airflow being drawn from the heatsink and exhausted by the fan.

VI. IDENTIFICATION OF CHALLENGES

A. Challenged Claims

62. Claims 1-5 and 14-20 of the '521 Patent are challenged in this Petition.

B. Statutory Grounds for Challenges

63. The Challenges are set forth in detail below and summarized as follows:

Ground	Claims	Basis	Reference
1	1. 3-5, 14-16	§ 103	Sterner in view of the knowledge of a POSA
2	1-2, 4-5, 14-17	§ 103	Aakalu in view of the knowledge of a POSA
3	3, 18-20	§ 103	Aakalu, alone, or in further view of Jones

64. I have been informed that U.S. Patent No. 7,028,753 (“Sterner”)(EX-1004), U.S. Patent No. 5,894,407 (“Aakalu”)(EX-1005) and U.S. Patent No. 6,104,003 (“Jones”)(EX-1006) qualify as prior art under §102(b) for purposes of this IPR.

VII. IDENTIFICATION OF HOW THE CHALLENGED CLAIMS ARE UNPATENTABLE

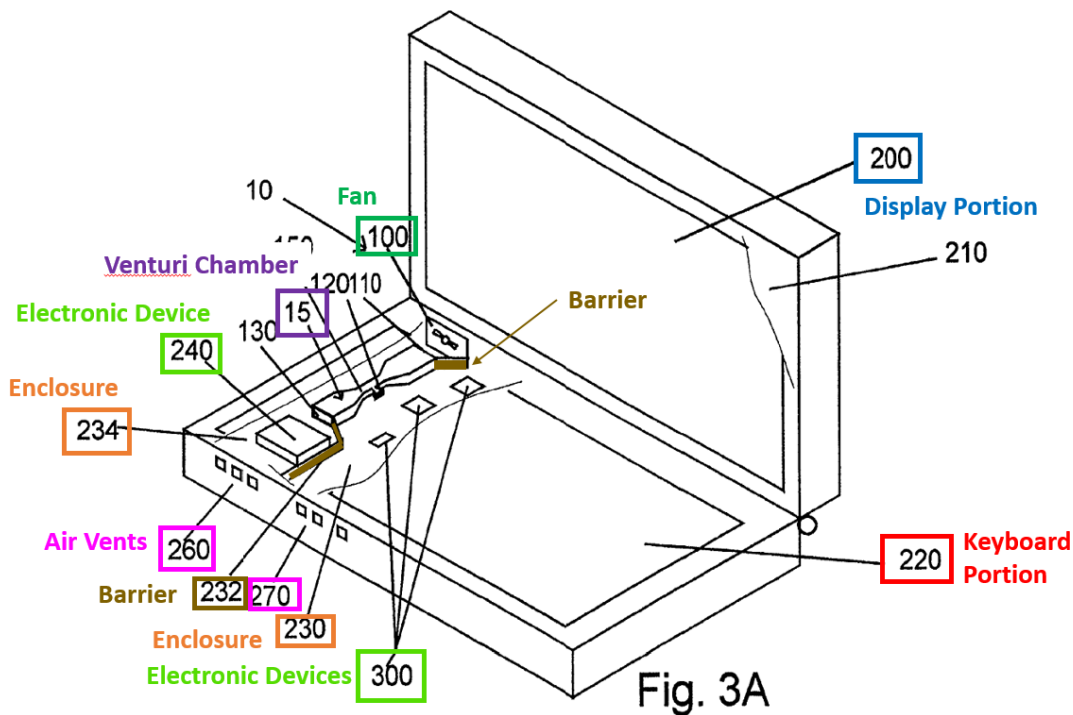
A. Challenge 1: Claims 1, 3-5, 14-16 are obvious over Sterner alone

1. Sterner

65. Sterner is titled “Apparatus to Enhance Cooling of Electronic Device” and, like the '521 Patent, is directed to a method for cooling

electronic devices using a fan-driven Venturi effect to draw air through a heatsink, and a system implementing the cooling method. EX-1004 Title, Abstract. Specifically, Sterner identifies the field of invention as “a heat transfer system ... using a venturi to create separate air flows in an electronic device to cool components.” EX-1004 1:10-12.

66. FIG. 3A as illustrates an embodiment.

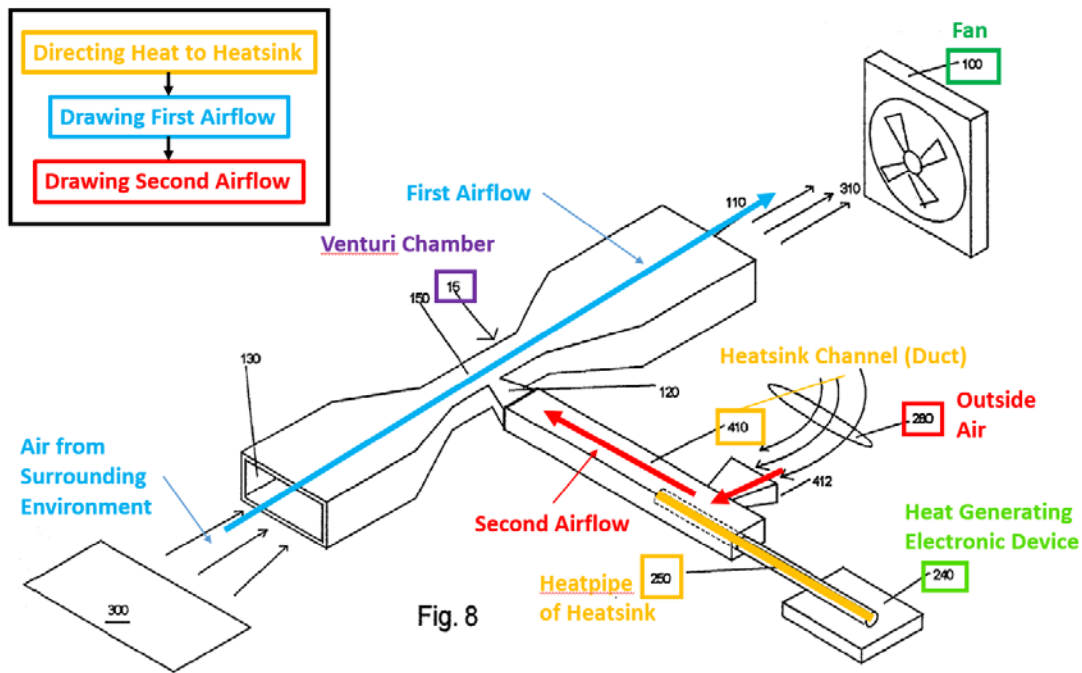


EX-1004 FIG. 3.

67. Sterner explains that electronic device 10, such as a notebook computer, includes a keyboard portion 220 (**red**) and a display portion 200 (**blue**). The keyboard portion 220 includes barriers 232 (**brown**) forming isolated enclosures or cavities 234, 230 (**orange**) that house heat producing

electronic devices 240, 300 (green) respectively. A cooling device comprising air-moving device 100 (dark green), such as a fan or blower, and air duct (venturi chamber) 15 (purple) is positioned in enclosure 234. Air is drawn into the enclosures 234, 230 (orange) through vents 260, 270 (pink) respectively to remove heat produced by components 240, 300 housed within the enclosures. EX-1004 3:45-4:7.

68. FIG. 8 illustrates one embodiment of the arrangement and operation of components for removing heat generated by components 240, 300 within enclosures 230, 234 respectively.



EX-1004 FIG. 8.

69. Sterner explains that heatpipe 250 (gold) is thermally coupled to heat producing component 240 (green). Heatpipe 250 (gold) is further

coupled to second duct 410 (gold) forming a heatsink. Fan 100 (green) draws a first airflow (blue) through the air duct (venturi chamber) 15 (purple) by pulling an exhaust air flow 310 from exhaust manifold 310 to thereby create an airflow into intake manifold 130. A low pressure region is created by drawing air through the restriction chamber 150. The restriction chamber is coupled to second duct 410 (which is coupled to the condensing end of a heat pipe 250) through venturi vent 120. Second duct 410 has an opening 412 used to draw in outside air 280, which is air external from electronic device 10 (FIG. 3A). Thus, a second airflow (red) is drawn through the second duct 410 using a venturi effect created by drawing the first airflow (blue) through air duct (venturi chamber) 15 (purple) to remove heat from heatsink 250 (gold) using the outside air 280. EX-1004 5:14-30.

2. Detailed Application of Sterner to the Challenged Claims

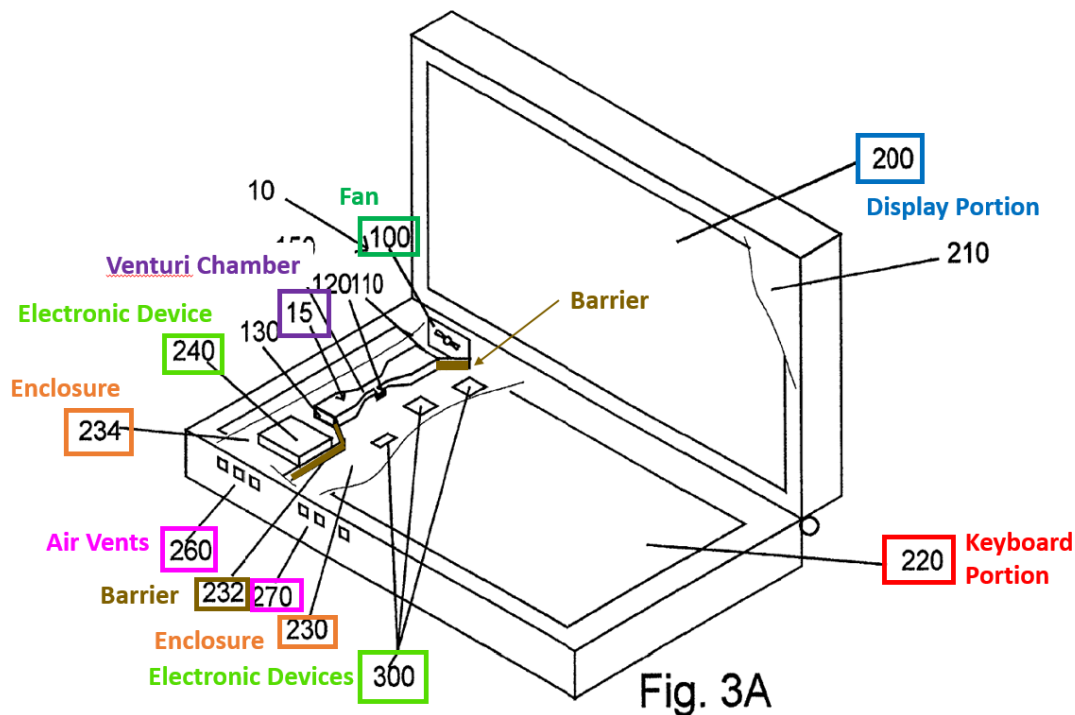
Claim 1

[1.0] *A cooling unit for an enclosure housing electronics, the cooling unit comprising:*

70. To the extent the preamble is limiting, Sterner discloses element [1.0]. Sterner is titled “Apparatus to Enhance Cooling of Electronic Device” and identifies the field of invention as “a heat transfer

system ... using a venturi to create separate air flows in an electronic device to cool components.” EX-1004 Title, Abstract, 1:10-12.

71. FIG. 3A illustrates an embodiment of the invention.



EX-1004 FIG. 3A.

72. Sterner discloses device 10, such as a laptop computer, including barrier 232 (**brown**), fan 100 (**green**) and air duct 15 (**purple**) [collectively, the *cooling device*] that provides cooling for enclosures (cavities) 234, 230 (**orange**) [*enclosure*] housing electronic devices 240, 300 (**green**) [*electronics*]. A POSA understood that device 10 includes a cooling unit that provides cooling to an enclosure housing electronics. Thus, Sterner discloses element [1.0].

[1.1] *a fan shroud having at least one electrical fan; and*

73. Sterner discloses element [1.1]. FIG. 10 is “an isometric drawing of an air duct useful for designing an exemplary embodiment of the invention” (EX-1004 2:53-54) showing the operational arrangement of fan 100 (green), fan shroud (green), and air duct 15 (purple) forming the cooling device.

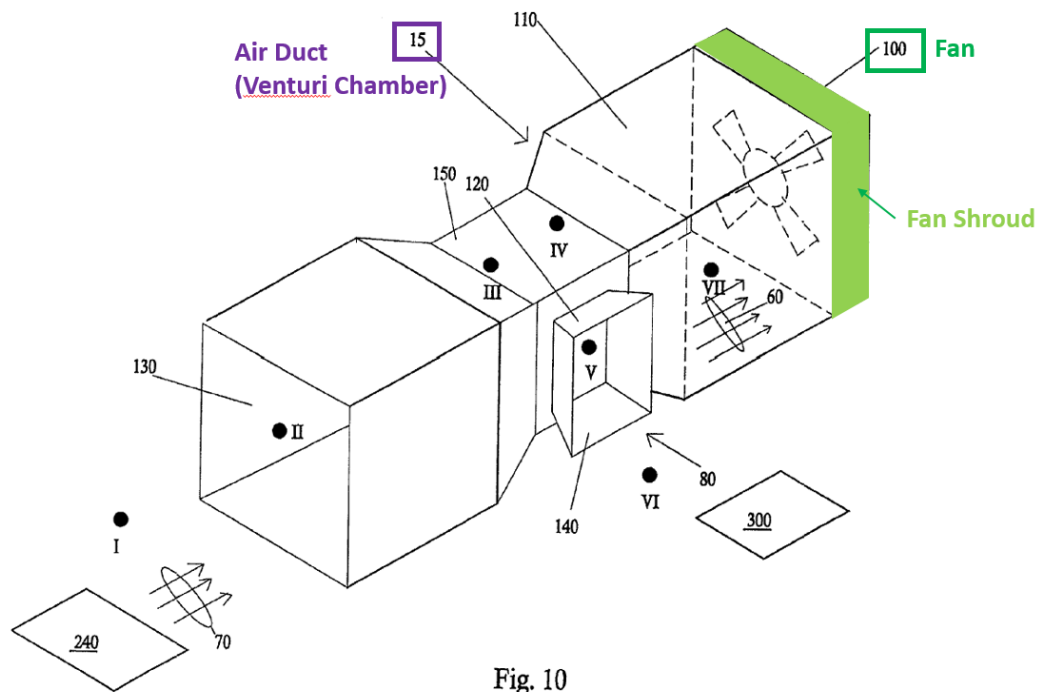
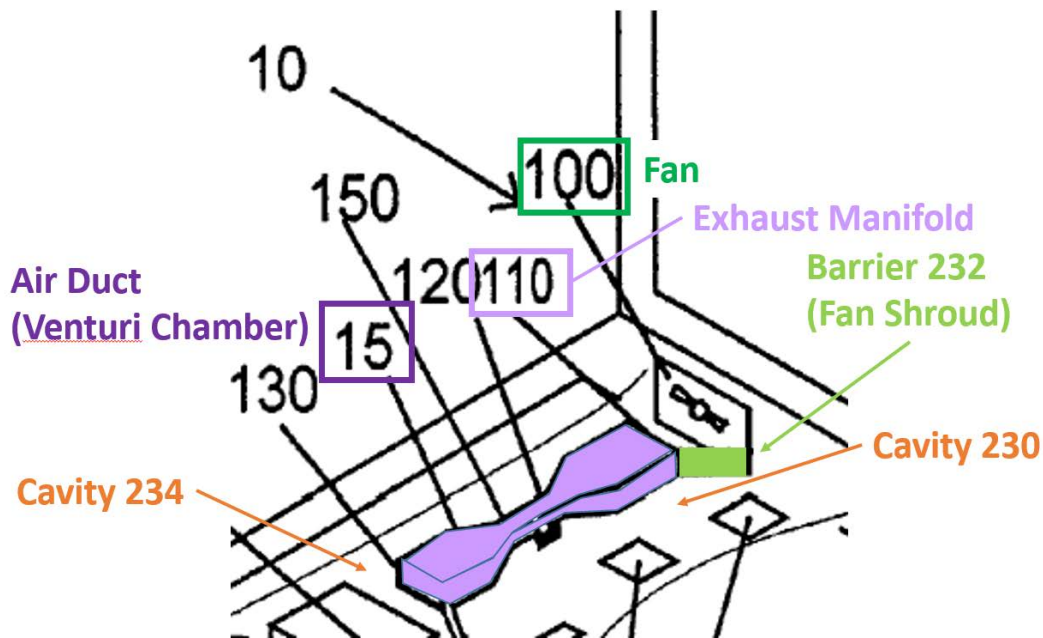


Fig. 10

EX-1004 FIG. 10.

74. A partial blow-up of FIG. 3A is shown below:



EX-1004 FIG. 3A (partial blow-up).

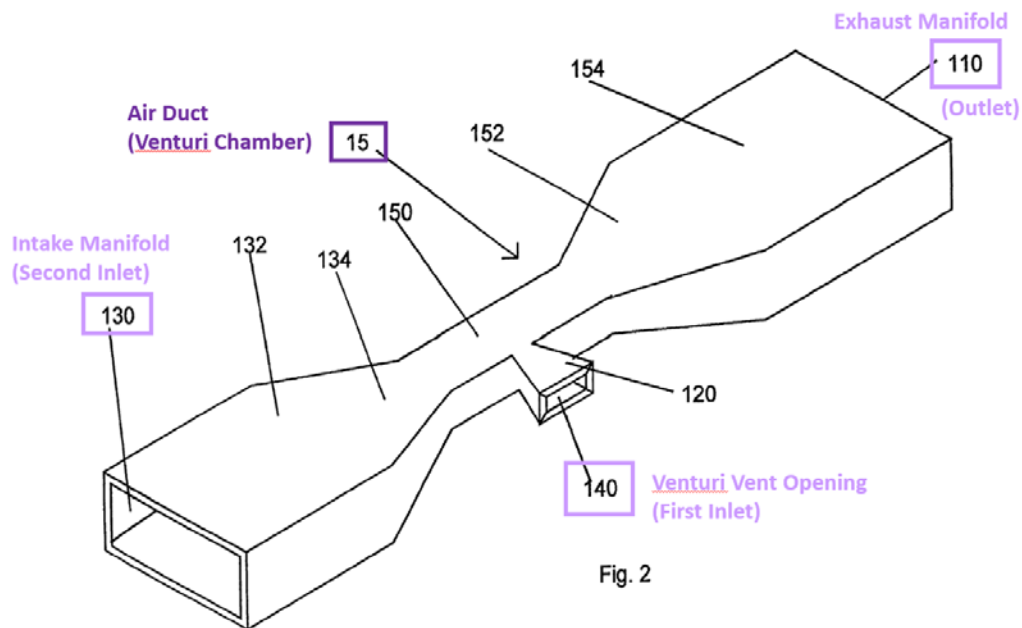
75. Sterner discloses that barrier 232 (**green**) isolates cavity 234 (**orange**) from cavity 230 (**orange**). EX-1004 3:57-59. Sterner further discloses that fan 100 (**green**) is positioned “proximal to the exhaust manifold 110 [**lavender**] of the air duct 15 (**purple**).” EX-1004 3:56-57. As shown, a portion of the barrier (**green**) extends between exhaust manifold 110 of air duct 15 (**purple**) to the intake of fan 100 (**green**) positioned proximal thereto, thereby providing isolation between the cavities such that airflow drawn from the exhaust manifold 110 is guided to the intake of fan 100 to be expelled from device 10. EX-1004 4:4-7.

76. A POSA understood that, in addition to the portion of the device casing surrounding the fan, the portion of barrier 232 (**green**)

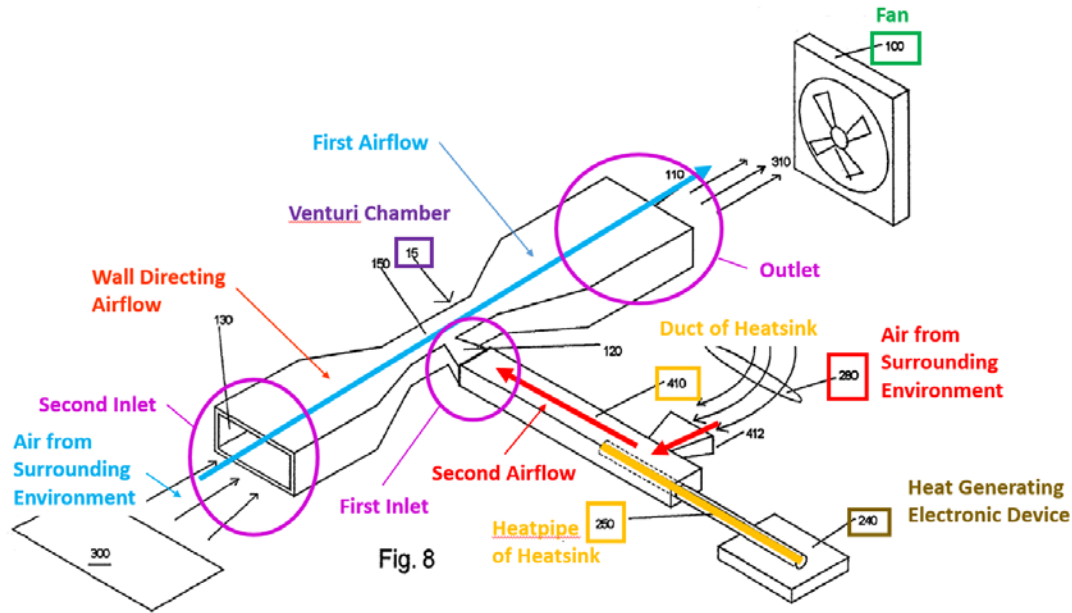
extending between exhaust manifold 110 and the intake of fan 100 constitutes a fan shroud as recited in element [1.1]. Thus, Sterner discloses element [1.1].

[1.2] a Venturi chamber having a first inlet for receiving a heated airflow from a heatsink, a second inlet for receiving an airflow from a surrounding environment, and an outlet coupled to the fan shroud, the fan drawing air from the Venturi chamber via the outlet when the fan is on;

77. Sterner discloses element [1.2]. FIG. 2 illustrates an air duct and FIG. 8 illustrates one embodiment of the arrangement and operation of components for removing heat generated by components 240, 300 within enclosures 230, 234 respectively.



EX-1004 FIG. 2.



EX-1004 FIG. 8

78. Sterner discloses that air duct 15 [*Venturi chamber*] comprises a venturi vent 120 having an opening 140 [*first inlet*] “that is preferably flared, and which helps to couple and operatively engage air external to the air duct 15 into the venturi vent 120.” EX-1004 3:10-13.

79. Sterner explains that heatpipe 250 (gold) is thermally coupled to heat producing component 240 (green). Heatpipe 250 (gold) [*heatsink*] is further coupled to second duct 410 [*heatsink*] such that the second airflow (red) flowing through duct 410 is heated by heatpipe 250 [*heated airflow from the heatsink*]. As illustrated in FIG. 8, venturi vent 120 is coupled to duct 410 such that opening 140 receives the second airflow (red) that has been heated by heatpipe 250 [*heatsink*]. EX-1004 5:18-21.

Thus, a POSA understood that opening 120 constitutes *a first inlet for receiving a heated airflow from a heat sink* as recited in element [1.2].

80. Sterner further discloses that air duct 15 [*Venturi chamber*] comprises “an intake manifold 130 in which air is drawn into the air duct 15.” EX-1004 3:13-14. As illustrated in FIG. 3A above, the airflow received into the intake manifold 130 of the air duct 15 is drawn from the surrounding environment through vents 260.

81. If PO argues that the air drawn into intake manifold 130 is not “drawn from the surrounding environment” because it passes over component 300, Sterner discloses that optionally air can be drawn directly from outside the device rather than drawing air over component 300 in order to cool the exhaust air. EX-1004 4:20-26. A POSA understood that this optional embodiment applies to the embodiment of FIG. 8 as well as the embodiment of FIG. 4.

82. Thus a POSA understood that intake manifold 130 constitutes *a second inlet for receiving an airflow from a surrounding environment* as recited in element [1.2].

83. Sterner discloses that air duct 15 [*Venturi chamber*] comprises exhaust manifold 110 [*outlet*] where air exits the air duct. EX-1004 3:33-35. As set forth above with respect to element [1.1] and with reference to

the partial blow-up of FIG. 3A, exhaust manifold 110 [*outlet*] is coupled to barrier 232 [*fan shroud*] such that fan 100 [*fan*] draws air from air duct 15 [*Venturi chamber*] via the exhaust manifold 110 [*outlet*]. Thus, a POSA understood that exhaust manifold 110 constitutes *an outlet coupled to the fan shroud, the fan drawing air from the Venturi chamber via the outlet when the fan is on* as recited in element [1.2].

84. Hence, Sterner discloses element [1.2].

[1.3] *wherein the Venturi chamber comprises a wall for directing the airflow air from the surrounding environment in from the second inlet and across the heated airflow from the heatsink in a manner as to draw the heated airflow through the heatsink using a Venturi effect, when the fan is on.*

85. Sterner discloses element [1.3]. Sterner discloses that air duct 15 (**purple**) [*Venturi chamber*] comprises one or more walls (**red-orange**) for directing a first airflow (**blue**) from the surrounding environment in from the intake manifold 130 (**lavender**) [*second inlet*] past a venturi vent 120 in a manner as to draw air through the venturi vent 120 using a Venturi effect when fan 100 is operating.

86. Specifically, Sterner discloses:

FIG. 2 illustrates an air duct 15 [*Venturi chamber*] that comprises a venturi vent 120. The venturi vent 120 has an opening 140, that is preferably flared, and which helps to couple and operatively engage air external to the air duct 15 into the venturi vent 120.

EX-1004 3:10-14.

87. A POSA understood from Sterner that air within the first volume is forced to increase its velocity as it leaves the intake manifold 130 and is coupled with first coupling 134 into restriction chamber 150. As the air velocity increases, its pressure must decrease to conserve the energy of air mass moving through the air duct 15 according to the principle of conservation of energy and Bernoulli's principle. When the velocity increases in the restriction chamber 150, the air pressure against the sidewalls of the air duct 15 in restriction chamber 150 reduces. This reduction in pressure as the air velocity increases is known as the Bernoulli principle, which is another form of the principle of conservation of energy or the simple form of the first law of thermodynamics. EX-1004 3:15-24.

88. Sterner further states that:

The restriction chamber 150 further has an opening or optionally a flared opening 140 on at least one sidewall to create a venturi vent 120. This venturi vent 120 then allows air outside of the air duct 15 to enter the opening thus allowing air outside of air duct 15 to mix with the air entering the intake manifold 130. This mixed air is operatively engaged by being coupled through a second coupling 152 to an exhaust manifold 110 where it exits air duct 15.

EX-1004 3:25-35.

89. Sterner further discloses that venturi vent 120 is coupled to duct 410 such that the second airflow (**red**) that has been heated by heatpipe 250 (**gold**) [*heated airflow through the heatsink*] is drawn into the venturi vent 120 using a venturi effect caused by the first airflow (**blue**) when fan 100 (**green**) is operating.

90. Thus, a POSA understood that each of the one or more walls forming the air duct 15 constitute *a wall for directing the airflow air from the surrounding environment in from the second inlet and across the heated airflow from the heatsink in a manner to as to draw the heated airflow through the heatsink using a Venturi effect, when the fan is on* as recited in element [1.3].

91. Hence, a POSA understood that Sterner discloses element [1.3].

Claim 3

The cooling unit of claim 1, wherein the at least one electrical fan includes a primary fan and a backup fan that becomes operational upon a failure of the primary fan.

92. It was obvious to a POSA to modify Sterner to include the additional limitations recited in Claim 3. It was well-known in the art of cooling enclosures housing electrical devices to include a back-up fan that becomes operational upon a failure of the primary fan. *See* EX-1006 4:46-51. Moreover, the '521 Patent does not ascribe any point of patentability

to the use of a second fan. To the contrary, the '521 Patent describes that a POSA “would appreciate that there are a number of methods to detect when the primary fan 260 has failed” to explain the addition of a backup fan. EX-1001 4:16-25.

93. A POSA was motivated to include a backup fan to provide redundancy and prevent damage to the electronics in the event of a failure of the primary fan. The fan in a forced convection cooling system is a critical component, and a POSA understood the desirability of providing redundancy for critical components. Moreover, it was within the knowledge and skill of a POSA to design the cooling system with appropriately sized fans to provide sufficient cooling using primary or backup fans such that a POSA understood that implementing redundancy would be successful.

94. Thus, it was obvious to a POSA to modify the teachings of Sterner to include one or more backup fans for redundancy as was well-known by a POSA. Hence, Claim 3 is obvious over Sterner.

Claim 4

The cooling unit of claim 1, wherein the Venturi chamber first inlet encircles one or more convective openings of the heatsink.

95. Sterner discloses Claim 4. As set forth for element [1.2], air duct 15 (**purple**) [*Venturi chamber*] comprises a venturi vent 120 having

an opening 140 (**lavender**) [*Venturi chamber first inlet*] “that is preferably flared, and which helps to couple and operatively engage air external to the air duct 15 into the venturi vent 120.” EX-1004 3:10-13. Also, as set forth for element [1.2], venturi vent 120 is coupled and operatively engaged with duct 410 [*convective opening of the heatsink*] to receive second airflow (**red**) from duct 410 into venturi vent 120 through opening 140 [*Venturi chamber first inlet*]. A POSA understood that in order for venturi vent 120 to be coupled and operatively connected to duct 410, that opening 140 [*Venturi vent first inlet*] encircles the opening of duct 410 [*encircles one or more convective openings of the heatsink*].

96. Further, as set forth for element [1.2], Sterner discloses that duct 410 is thermally coupled to heatpipe 250 (**gold**) such that second airflow (**red**) flowing through duct 410 receives heat from heatpipe 250. Thus, a POSA understood that the opening of duct 410 constitutes *one or more convective openings of the heatsink* as recited in Claim 4.

97. Hence, Sterner discloses Claim 4.

Claim 5

The cooling unit of claim 1, wherein the airflow from the surrounding environment is cooler than the heated airflow.

98. Sterner discloses the additional limitations recited in Claim 5.

As set forth for element [1.2], Sterner discloses *a first inlet for receiving a*

heated airflow from a heatsink, and a second inlet for receiving an airflow from a surrounding environment. Sterner discloses that the second airflow (**red**) [*heated airflow*] is drawn into duct 410 through opening 412 from “outside air 280, which is air external from electronic device 10.” EX-1004 5:23-25. A POSA understood that outside air 280 is drawn from the same surrounding environment and thus would be the same temperature as the air drawn into intake manifold 130 (the first airflow (**blue**)) [*airflow from a surrounding environment*]. Thus, a POSA understood that the airflow from the surrounding environment is cooler than an airflow from the same surrounding environment that has been heated by heatpipe 250 (the second airflow (**red**)).

99. Hence, Sterner discloses Claim 5.

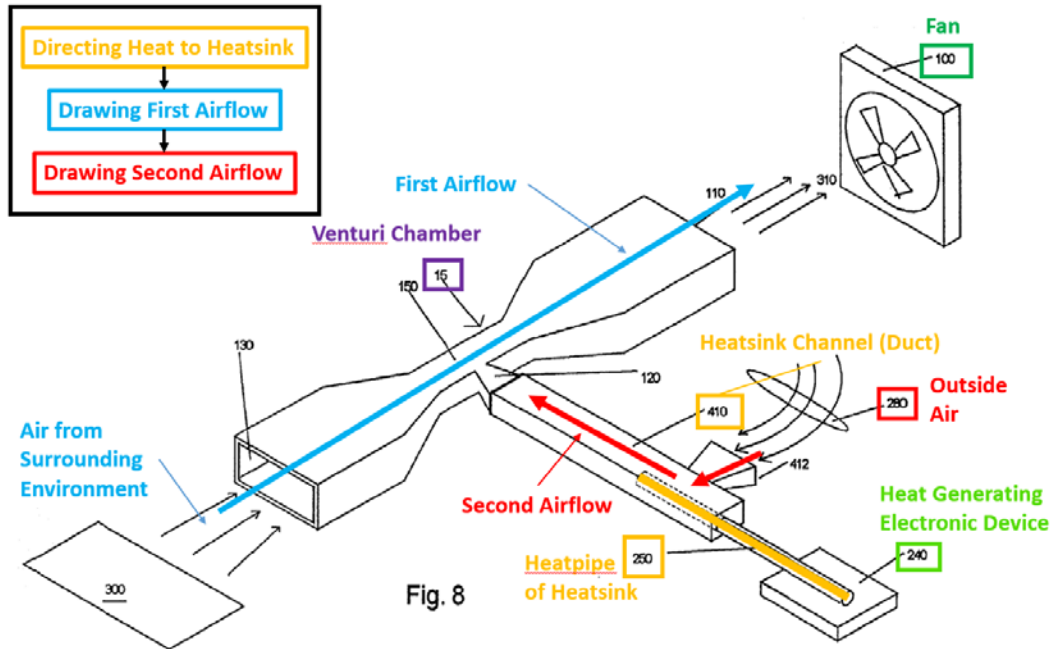
Claim 14

[14.0] *A method for cooling a sealed environment of an enclosure for housing electronics, the method comprising:*

100. To the extent the preamble is limiting, Sterner discloses element [14.0] for at least the reasons set forth for element [1.0].

101. Sterner provides FIG. 8 as illustrating one embodiment of the arrangement and operation of components for implementing a method for cooling a sealed environment of an enclosure housing electronics.

Annotated FIG. 8 below illustrates how Sterner discloses the following steps recited in Claim 14.



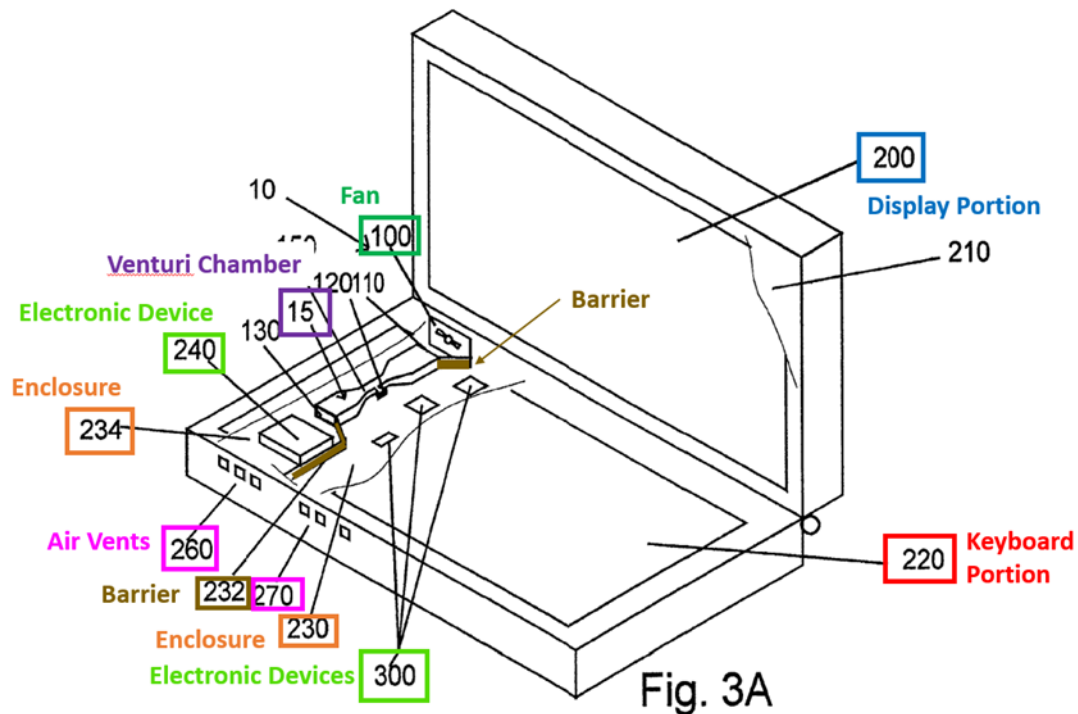
EX-1004 FIG. 8

102. A POSA understood enclosure (cavity) 230 (**orange**) housing electronic device 240 (**green**) constitutes *a sealed environment of an enclosure for housing electronics* as recited in element [14.0].

[14.1] directing heat generated by one or more electronic devices housed within a sealed environment of an enclosure to a heatsink thermally coupled to an external environment;

103. Sterner discloses element [14.1]. Sterner discloses that keyboard portion 220 (**red**) includes barriers 232 (**brown**) forming isolated enclosures or cavities 234, 230 (**orange**) that house heat producing

electronic devices 240, 300 (**green**) respectively.



104. Sterner provides FIG. 8 as illustrating one embodiment of the arrangement and operation of components for removing heat generated by components 240, 300 within enclosures 230, 234 respectively.

105. As set forth for element [1.2], Sterner discloses that heat producing electronic device 240 (**green**) [*electronics*] is housed in cavity 230 (shown in FIG. 3A) and “is preferably separated from system components 300 by a cavity or enclosure (not shown [in FIG. 8])” and that heat producing electronic device 240 is thermally coupled to heatpipe 250 (**gold**) which is thermally coupled to duct 410 [*directing heat generated by one or more electronic devices housed within a sealed environment of an*

enclosure to a heatsink]. EX-1004 5:20-28. During operation, the second airflow (**red**) is drawn into duct 240 through opening 412 from outside air 280, drawn into air duct 15 (**purple**) through venturi vent 120, and discharged from device 10 to the external environment by fan 100 (**green**) as part of exhaust air flow 380. Thus, a POSA understood that heatpipe 250 and duct 410 constitute *a heatsink thermally coupled to an external environment* as recited in element [6.1]. Hence, Sterner discloses element [14.1].

[14.2] *drawing a first airflow across one or more convective openings of the heatsink, wherein the first airflow does not flow into the one or more convective openings of the heatsink;*

106. Sterner discloses element [14.2] for at least the reasons set forth for element [1.3]. Sterner discloses a venturi chamber comprising *a wall for directing the airflow air from the surrounding environment in from the second inlet and across the heated airflow from the heatsink in a manner to as to draw the heated airflow through the heatsink using a Venturi effect, when the fan is on* as recited in element [1.3]. Sterner draws a first airflow (**blue**) through air duct 15 (**purple**) such that the first airflow flows through restriction chamber 15 and across venturi vent 120 that is coupled to an opening of duct 410 [*one or more convective openings of the heatsink*], thereby drawing the second airflow (**red**) into venturi vent 120

using a venturi effect. EX-1004 3:10-44, 5:18-20 . A POSA understood from the description of Sterner and the well-known behavior of venturis, that the first airflow (**blue**) does not flow into duct 410 [*one or more convective openings of the heatsink*], but rather, the first airflow draws the second airflow (**red**) from duct 410 and into venturi vent 120.

107. Thus a POSA understood that the operation of the embodiment described by Sterner with reference to FIG. 8 constitutes drawing a first airflow across one or more convective openings of the heatsink, wherein the first airflow does not flow into the one or more convective openings of the heatsink as recited in element [14.2]. Hence, Sterner discloses element [14.2].

[14.3] *drawing a second airflow of heated air from the one or more convective openings using a Venturi effect created by drawing the first airflow.*

108. Sterner discloses element [14.3] for at least the same reasons as set forth for element [14.2]. The first airflow (**blue**) [*first airflow*] flowing through air duct 15 draws the second airflow (**red**) [*second airflow*] from duct 410 (**gold**) [*one or more convective openings of the heatsink*] using a venturi effect. EX-1004 3:10-44, 5:18-20. A POSA understood that that the operation of the embodiment described by Sterner with reference to FIG. 8 constitutes *drawing a second airflow of heated air*

from the one or more convective openings using a Venturi effect created by drawing the first airflow as recited in element [14.3]. Thus Sterner discloses element [14.3].

Claim 15

[15.0] *The method of claim 14*

[15.1] *wherein drawing the first airflow further comprises drawing the first airflow into a Venturi chamber;*

109. Sterner discloses the additional limitations recited in element [15.1] for at least the reasons set forth above with respect to elements [1.2], [1.3], and [14.2].

[15.2] *wherein drawing the second airflow further comprises drawing the second airflow into the Venturi chamber;*

110. Sterner discloses the additional limitations recited in element [15.2] for at least the reasons set forth for elements [1.2], [1.3], and [14.3].

[15.3] *the method further comprising operating a fan to pull the first airflow and the second airflow out of the Venturi chamber.*

111. Sterner discloses the additional limitations recited in element [15.3] for at least the reasons set forth for elements [1.2], [14.2] and [14.3].

Claim 16

The method of claim 14, further comprising operating a fan to draw the first airflow and the second airflow.

112. Sterner discloses the additional limitations recited in Claim 16 for at least the reasons set forth for elements [1.2], [14.2] and [14.3].

B. Challenge 2: Claims 1, 2, 4-5 14-17 are obvious over Aakalu alone

1. Aakalu

113. Aakalu is titled “Enclosures for Heat Producing Devices” and, like the ’521 Patent, is directed to a method for cooling electronic devices housed in an enclosure using a fan-driven Venturi effect to draw air upward through a heat sink, and a system implementing the cooling method. EX-1005 Title, 3:30-34.

114. Aakalu explains that as of the late 1990’s, “in the development of wireless communication networks, it is desirable to provide a number of small base stations, called microcells” and that “[o]ne implementation of such microcells involves the packaging of electronic components associated with the base stations into small outdoor enclosures” but that “most enclosures tend to trap heat which may be detrimental to the electronic components, particularly to integrated circuits and microprocessor chips.” EX-1005 1:12-20. Aakalu further explains that “outdoor enclosures containing any electronic components are subject

to two forms of heat: heat generated by the electronic components and solar heat” and that it was known to dissipate the component generated heat using heat sinks and convection, and to cover the enclosures with a solar shield to shelter the enclosure from solar heat. EX-1005 1:21-34.

115. Aakalu then notes that “using the solar shields in combination with the heat sinks, in most cases, can significantly decrease the overall efficiency of the convection process. Accordingly, there exist a need for an enclosure with a cooling scheme for heat producing devices that shelters the enclosures from solar heat without significantly decreasing the efficiency of the convection process associated with heat sinks.” EX-1005 1:34-44.

116. Aakalu summarizes its solution as “an enclosure cooling scheme for cooling heat producing devices, such as electronic components, contained within the enclosure” wherein, in an embodiment, “[t]he enclosure comprises a housing and a solar shield.” EX-1005 1:48-56.

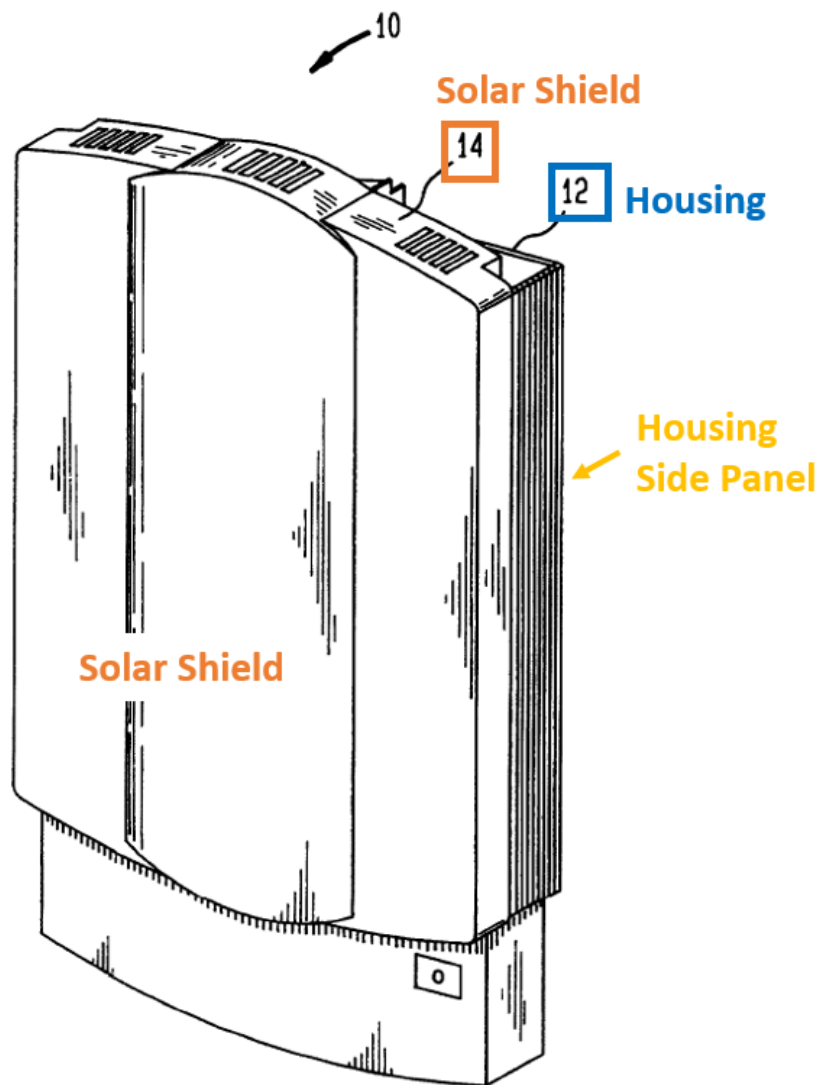
Aakalu further describes the enclosure:

The housing includes a plurality of heat sinks for absorbing and dissipating heat generated by the devices. Each heat sink has an interior side to which the devices are mounted and an exterior side with a plurality of fins that form first and second channels. In one embodiment, the first channels are aligned longitudinally

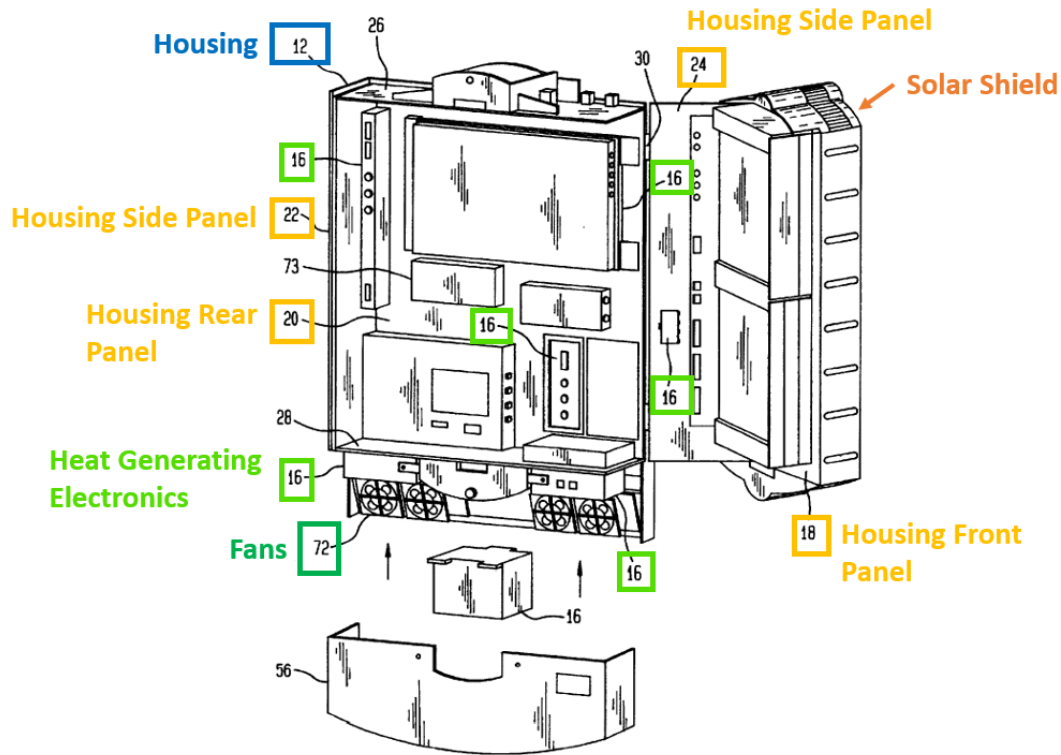
with the prevalent direction of airflow, and the second channels are aligned in a contrasting manner to the first channels to allow fresh air to be drawn into the first channels (through the second channels) during the convection process. Positioned over the heat sinks is the solar shield for sheltering the housing from solar heat. The solar shield includes ventilators which align with the first and second channels for allowing the passage of air into the heat sinks and heat absorbed by the heat sinks to be dissipated.

EX-1005 1:56-2:3.

117. Aakalu provides FIGs. 1 and 2 depicting the enclosure in the closed (FIG. 1) and open (FIG. 2) positions.



EX-1005 FIG. 1

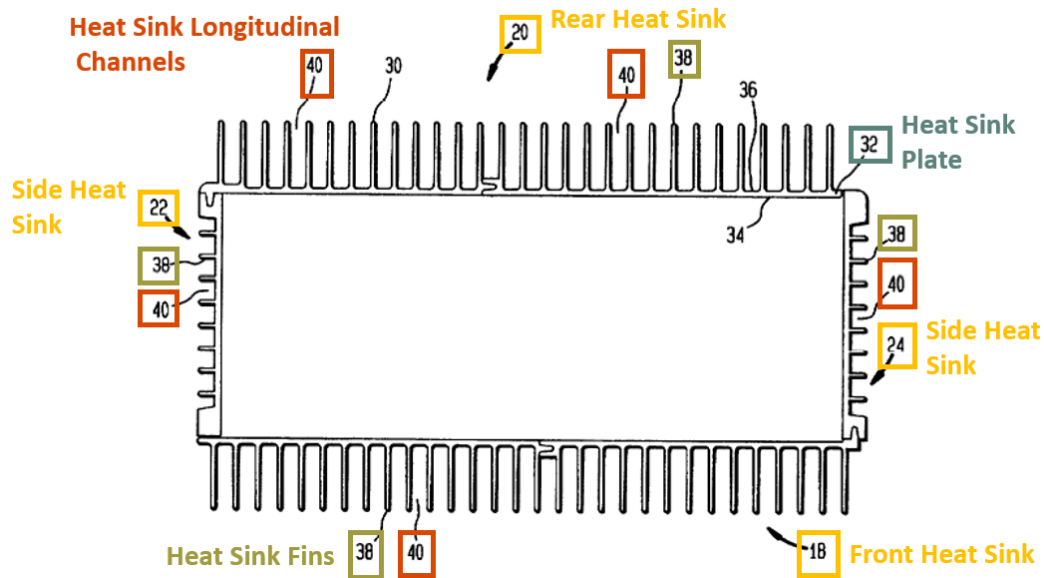


EX-1005 FIG. 2

118. Aakalu explains that enclosure 10 (referred to as a microcell) comprises housing 12 (blue) and solar shield 14 (orange). A plurality of electronic components 16 (green) are mounted to the interior of housing 12. Housing 12 comprises front panel 18 (gold), rear panel 20 (gold), and two side panels 22, 24 (gold), each of which form heat sinks for absorbing and dissipating heat generated by electronic components 16 (green). EX-1005 2:59-3:9.

119. Aakalu illustrates a top view of enclosure 10 with the solar shield removed in FIG. 5:

FIG. 5

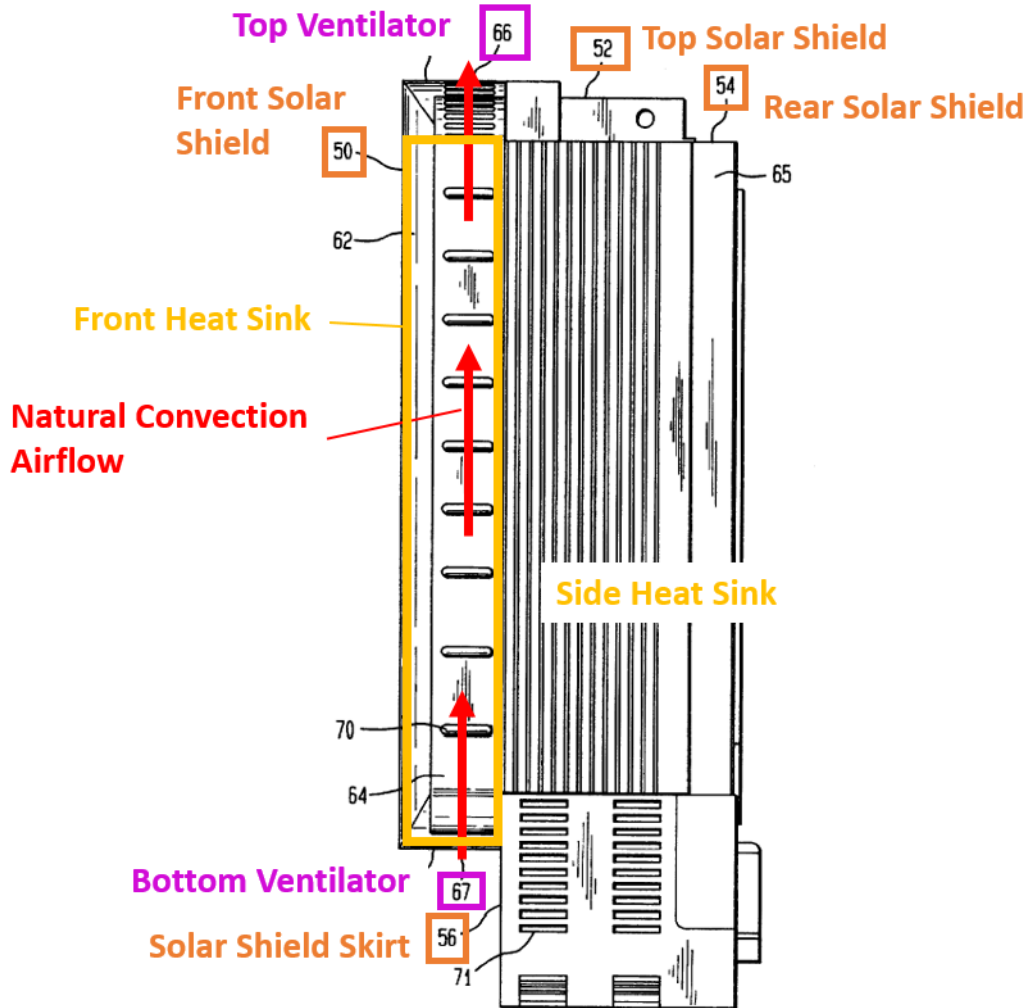


EX-1005 FIG. 5.

120. Aakalu explains that “[p]referably, the heat sinks [(gold)] are formed from a highly heat conductive material” and that each comprises “a heat sink plate 32 [(teal)] having an interior side 34 to which the base station electronic components 16 are mounted and an exterior side 36 having a plurality of fins 38 [(bronze)]” wherein “[t]he fins 38 project laterally outward from the exterior side 36 and form channels 40 [(red-orange)] (referred to herein as longitudinal channels) between through which cooling air may pass.” EX-1005 3:9-20.

121. Aakalu further explains that “solar shield 14 [(orange)](FIGs. 1, 2)] shelters the microcell 10 from solar heat” and “is adapted to fit over the front, rear, top and bottom panels 18, 20, 26, 28 of

the housing 12.” EX-1005 3:49-53. FIG. 7 illustrates a side view of enclosure 10 with the solar shield installed.

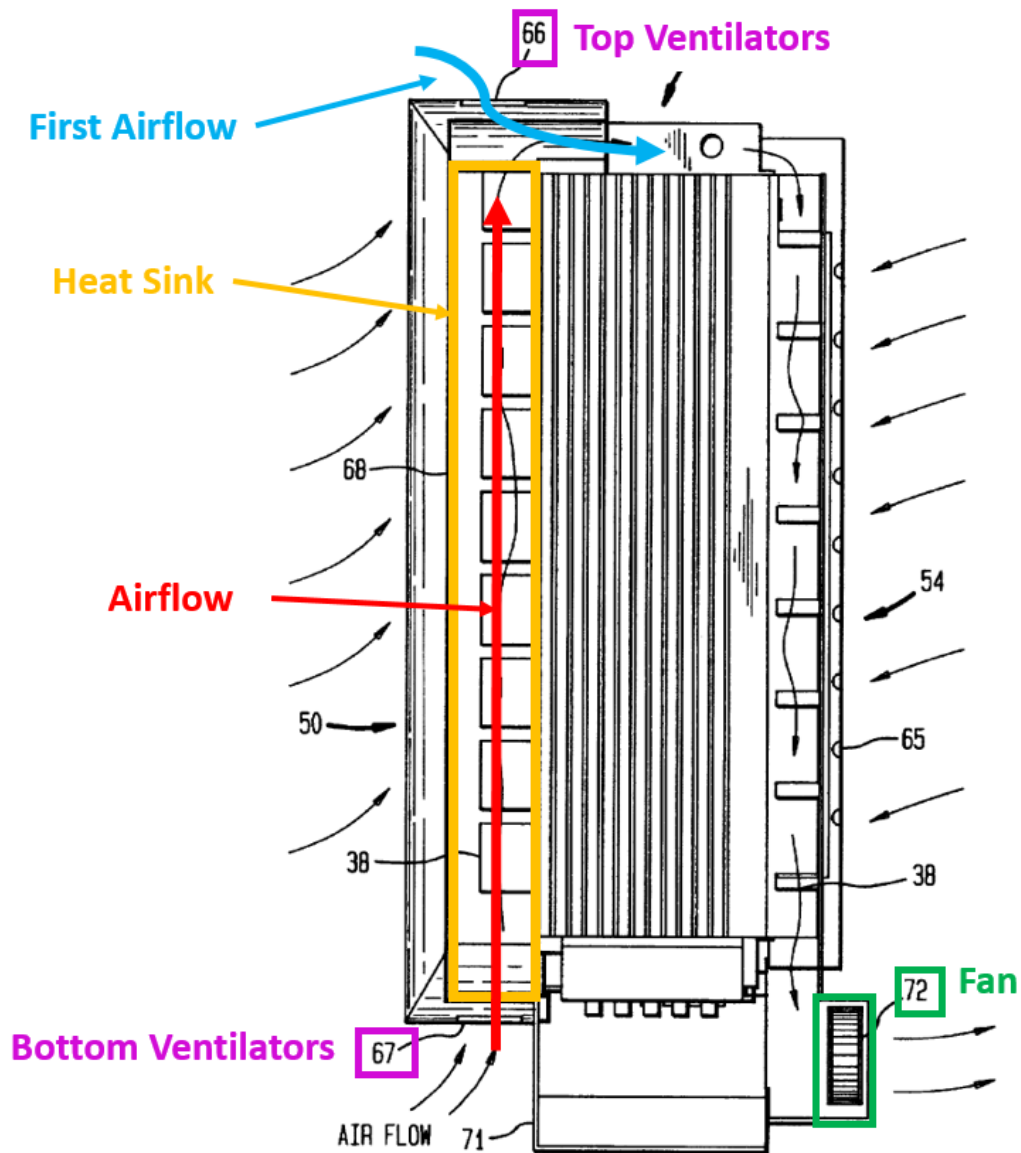


EX-1005 FIG. 7.

122. Solar shield 14 comprises front, top, rear, and skirt solar shields 50, 52, 54, 56 (**orange**). Front solar shield 50 top and bottom ventilators 66, 67 (**red-purple**) such as slots that align with the longitudinal channels 40 (**red-orange**)(FIG. 5) of the front heat sink (**gold**)

to thereby allow airflow passage (**red**) upward through the heat sink due to natural convection. EX-1005 3:63-4.

123. FIG. 10 depicts “a side cross-sectional view of microcell 10 illustrating the path of airflow through the microcell using forced convection” – i.e., by operating fans 72. EX-1005 4:56-58.



EX-1005 Fig, 10.

124. Aakalu explains that when fans 72 are operating during forced convection cooling of enclosure 10, “fresh air is drawn in through the top ventilators 66 and mixed with the old air as it passes over the top panel 26 and enters the longitudinal channels of the rear panel” and that “the fans draw air in through the ventilators.” EX-1005 4:64-67, 6:59-60. The air drawn in through the top ventilators 66 (**red-purple**) is depicted as the first airflow (**blue**). Air is also drawn in through the bottom ventilators 67 (**red-purple**) and “travels through the longitudinal channels dissipating heat absorbed by the heat sink (of the front panel)” as depicted by the second airflow (**red**). EX-1005 4:57-60. Aakalu further explains that the amount of air drawn up through the front heat sink (**second (heated) airflow**) is determined by the amount of air drawn in through the top ventilators 66 (**first airflow**) during the forced convection cooling operation: EX-1005 5:4-9:

125. A POSA understood that as the air is drawn in through the top ventilators (**first airflow**) flows into the constricted volume bounded by top panel 26 and top solar shield 52, the flow rate increases and the pressure decreases, and that this Venturi effect will increase the airflow upward through the front heatsink (**second (heated) airflow**).

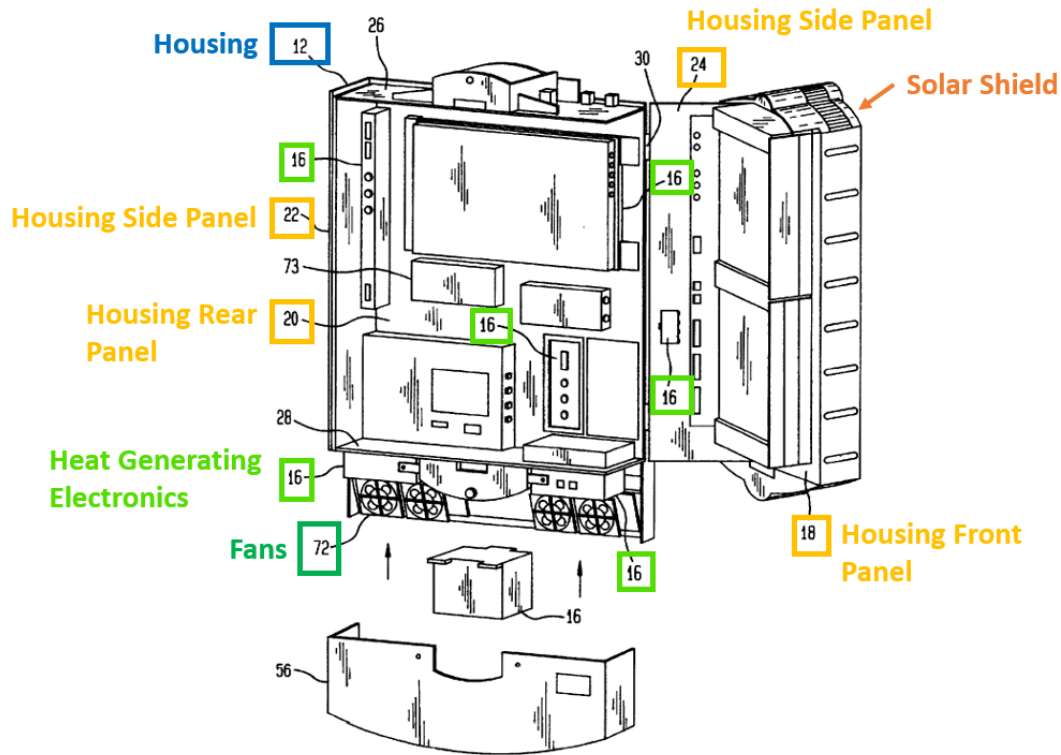
126. Aakalu also discloses that the cooling device may include a regulation device to automatically control the size of the ventilators to control the volume of air flowing through the microcell and hence control the temperature of the components housed within the microcell. EX-1005 5:21-29.

2. Detailed Application of Aakalu to the Challenged Claims

Claim 1

[1.0] *A cooling unit for an enclosure housing electronics, the cooling unit comprising:*

127. To the extent the preamble is limiting, Aakalu discloses element [1.0]. Aakalu is titled “Enclosures for Heat Producing Devices” and summarizes the disclosed invention as “an enclosure with a cooling scheme for cooling heat producing devices, such as electronic components, contained within the enclosure” and further states that “[t]he present invention is an enclosure with a scheme for convectively cooling heat producing devices, such as electronic components, housed within the enclosure.” EX-1005 1:48-50; 2:43-45. Aakalu illustrates the enclosure in an open position in FIG. 2:



EX-1005 FIG. 2

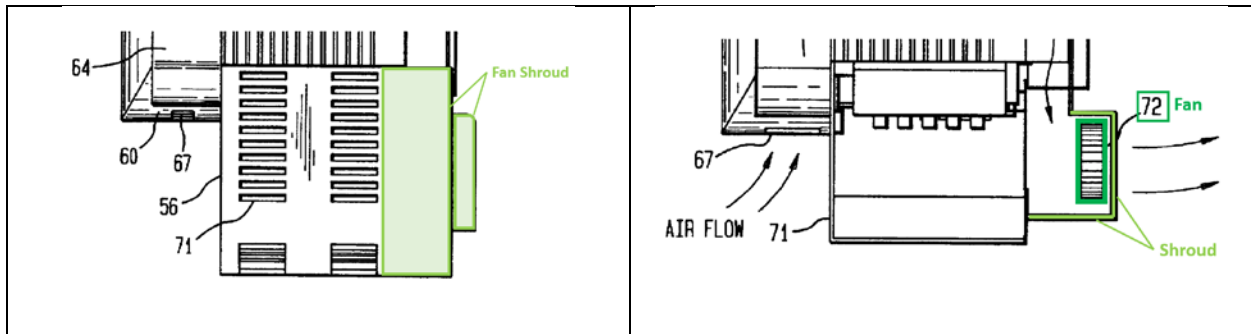
128. Aakalu explains that the enclosure 10 (microcell) comprises housing 12 (blue) and solar shield 14 (orange). A plurality of electronic components 16 (green) are mounted to the interior of housing 12 [*an enclosure housing electronics*]. Housing 12 comprises front panel 18 (gold), rear panel 20 (gold), and two side panels 22, 24 (gold), each of which form heat sinks for absorbing and dissipating heat generated by electronic components 16 (green). EX-1005 2:59-3:9. Aakalu discloses that, in one mode of operation, “forced convection is used to dissipate the heat absorbed by the heat sink” and that “microcell 10 includes fans 72

[(green)] which facilitate the flow of air through the heat sinks” [cooling unit for an enclosure] EX-1005 3:30-34.

129. Thus, Aakalu discloses element [1.0].

[1.1] *a fan shroud having at least one electrical fan; and*

130. Aakalu discloses element [1.1]. Partial blow-ups of a side view (FIG. 7) and side cross-sectional view (FIG. 10) are shown below:

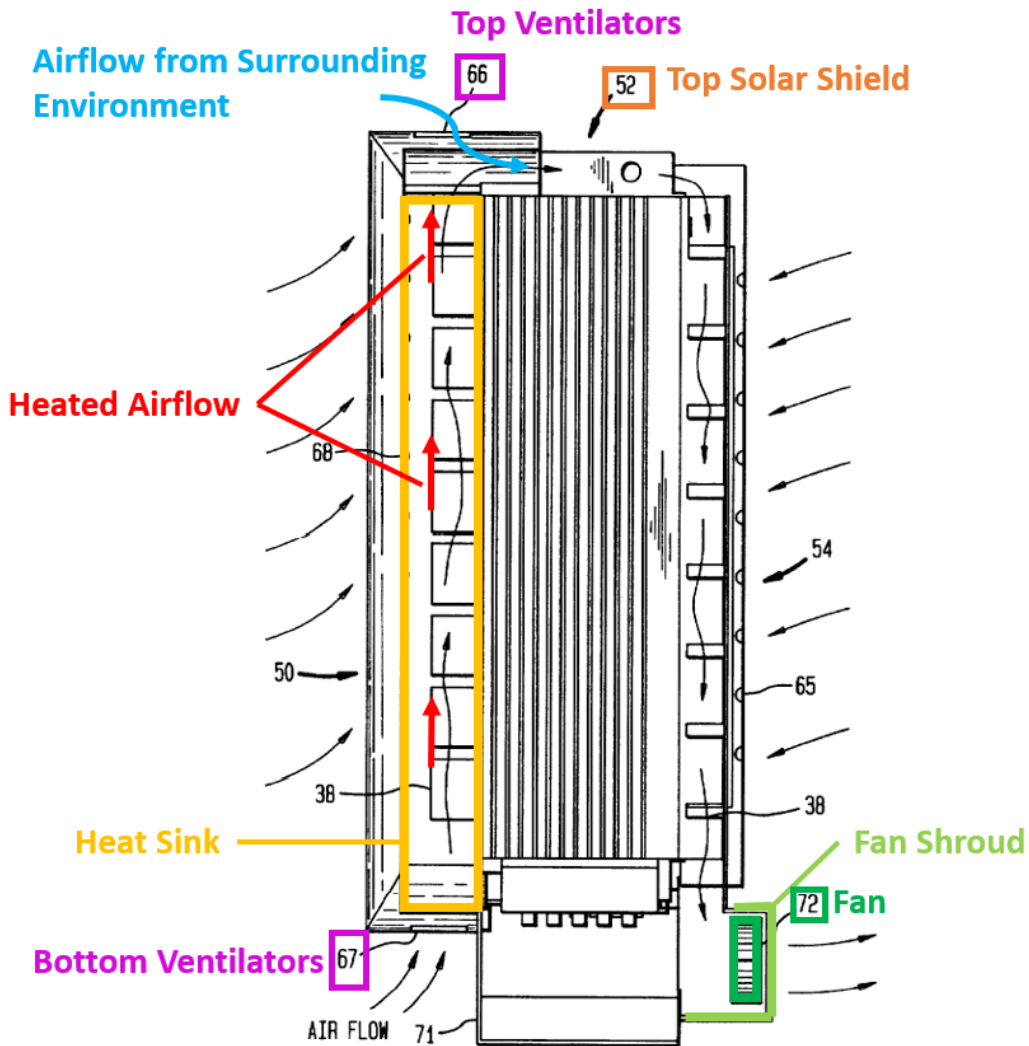


EX-1005 FIGs. 7, 10 (partial blow-ups).

131. As illustrated, “microcell 10 includes fans 72 [(green)] [at least one electrical fan] which facilitate the flow of air through the heat sinks.” EX-1005 3:30-34. A POSA understood that the structure surrounding each fan 72 constitutes a fan shroud (green) [fan shroud]. Thus, Aakalu discloses element [1.1].

[1.2] *a Venturi chamber having a first inlet for receiving a heated airflow from a heatsink, a second inlet for receiving an airflow from a surrounding environment, and an outlet coupled to the fan shroud, the fan drawing air from the Venturi chamber via the outlet when the fan is on;*

132. Aakalu discloses element [1.2]. Aakalu discloses that “forced convection is used to dissipate the heat absorbed by the heat sink” and that “microcell 10 includes fans 72 which facilitate the flow of air through the heat sinks,” and further that “the fans draw air in through the ventilators.” EX-1005 3:30-34, 6:59-60. FIG. 10 illustrates “the path of the airflow through the microcell using forced convection.” EX-1005 2:32-34.

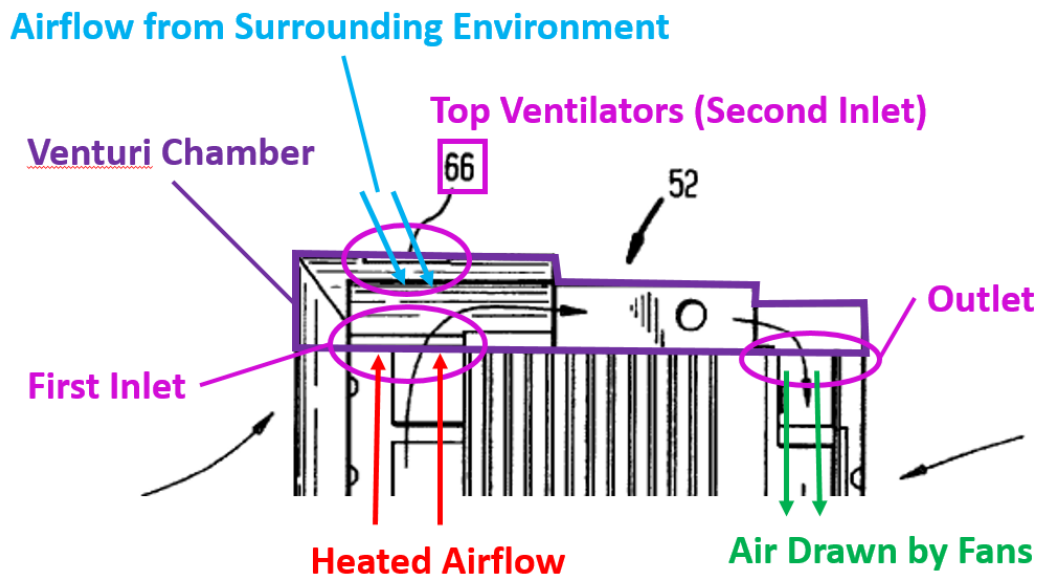


EX-1005 FIG. 10.

133. Aakalu explains that when fans 72 (**green**) are operating during forced convection cooling of enclosure 10, “fresh air is drawn in through the top ventilators 66 and mixed with the old air as it passes over the top panel 26 and enters the longitudinal channels of the rear panel.” EX-1005 4:64-67. A POSA understood that the air drawn in through the top ventilators 66 (**red-purple**) constitutes an *airflow from a surrounding environment* (**blue**) as recited in element [1.2].

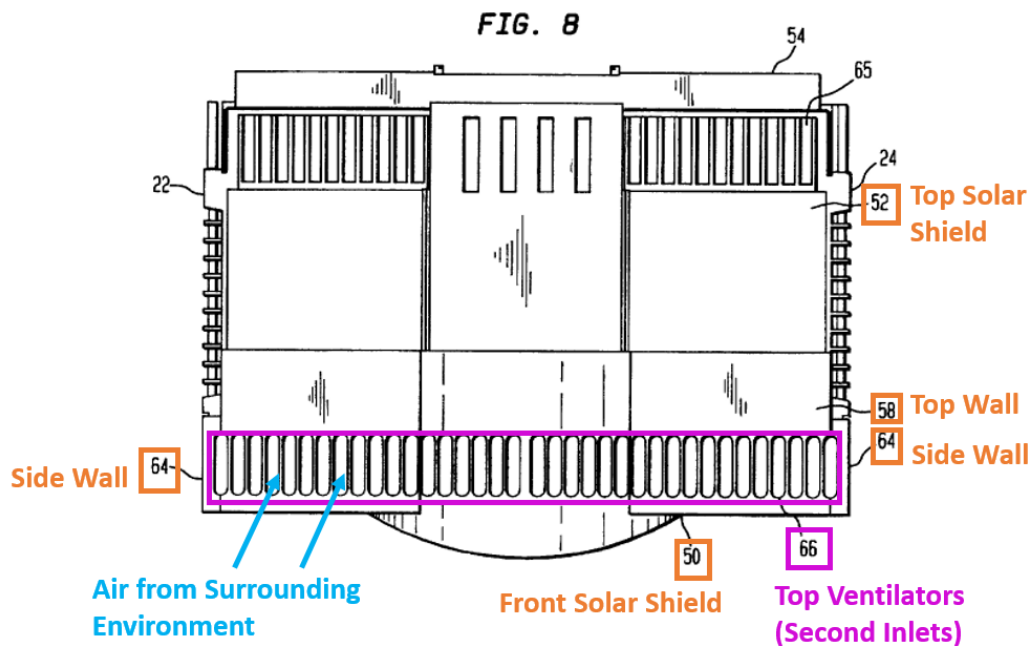
134. Air is also drawn in through the bottom ventilators 67 (**red-purple**) and “travels through the longitudinal channels dissipating heat absorbed by the heat sink (of the front panel).” EX-1005 4:57-60. A POSA understood that the airflow traveling through the heat sink (**gold**) constitutes a *heated airflow* (**red**) as recited in element [1.2].

135. A POSA further understood that the upper portions of the solar shields 50, 52 (**orange**) and top panel 26 of the enclosure form a Venturi chamber (**purple**) as shown in the partial blow up of FIG. 10 below:

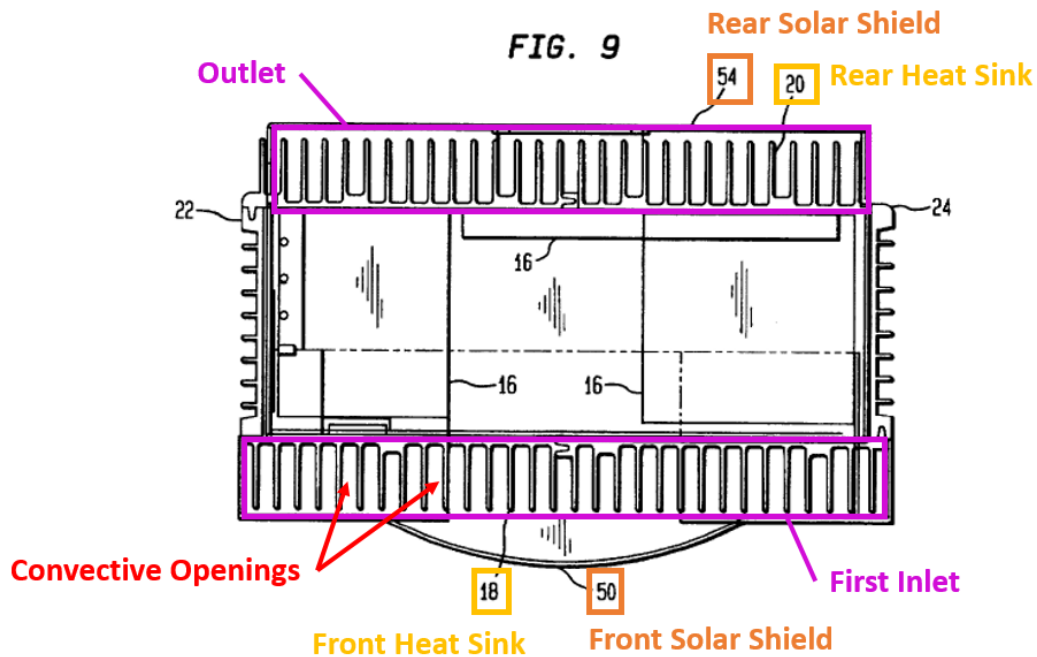


EX-1005 FIG. 10 (partial blow-up).

136. FIGs. 8 and 9 depict a top and top cross-sectional view:



EX-1005 FIG. 8.



EX-1005 FIG. 9.

137. The Venturi chamber (**purple**) in the device of Aakalu includes a first inlet (**red-purple**) positioned adjacent the convective openings (**red**) at the top of the longitudinal channels of the front heat sink (**gold**) such that the heated airflow (**red**) flowing upward through the front heat sink is received into the Venturi chamber through the first inlet and flows over the top panel 26 [*a first inlet for receiving a heated airflow from a heat sink*]. EX-1005 4:57-67.

138. The Venturi chamber also includes a plurality of top ventilators 66 (**red-purple**) forming an inlet where fresh air is drawn in

from the surrounding environment (**blue**) [*a second inlet for receiving an airflow from a surrounding environment*]. EX-1005 4:64-5:10.

139. Aakalu further discloses that air is drawn from the Venturi chamber by the operating fan(s) (**green**) through an outlet (**red-purple**) and downward through the longitudinal channels of the rear heat sink 20 to be exhausted by fan(s) 72 [*the fan drawing air from the Venturi chamber via the outlet when the fan is on*]. EX-1005 4:63-5:4. A POSA understood that the outlet (**red-purple**) is coupled to the fan shroud (**light green**) by rear heat sink 20 and rear solar shield 54 [*outlet coupled to the fan shroud*].

140. As discussed in the State of the Art section, a POSA understood as air is drawn in through the top ventilators 66 (**red-purple**) it is subject to a reduction in volume formed in the restriction chamber that guides the air to the outlets thereby producing venturi effect that draws heated air into the chamber from the convective openings of the heat sink. Thus, Aakalu discloses element [1.2].

[1.3] wherein the Venturi chamber comprises a wall for directing the airflow air from the surrounding environment in from the second inlet and across the heated airflow from the heatsink in a manner to as to draw the heated airflow through the heatsink using a Venturi effect, when the fan is on.

141. Aakalu discloses element [1.3]. The Venturi chamber (purple) includes at least side walls 64 (orange) and top wall 58 (orange) that direct the airflow (blue) [*airflow air from the surrounding environment*] in from the top ventilators 66 (red-purple) [*second inlet*] and across the convective openings containing the heated airflow (red) flowing from the front heat sink (gold) [*across the heated airflow from the heat sink*]. While Aakalu does not expressly use the term “Venturi effect” to describe the interaction between the airflow (blue) drawn in through ventilators 66 [*second inlet*] and the heated airflow (red), a POSA understood from Aakalu that the airflow (blue) is drawn across the convective openings (red) of the heat sink in a manner so as to draw the heated airflow through the heat sink using a Venturi effect.

142. Aakalu explains that fan(s) 72 draw the airflow (blue) in through the ventilators 66, and that the amount of air drawn up through the front heat sink (heated airflow) is determined by the amount of air drawn in through the ventilators 66 (first airflow) during the forced convection cooling operation:

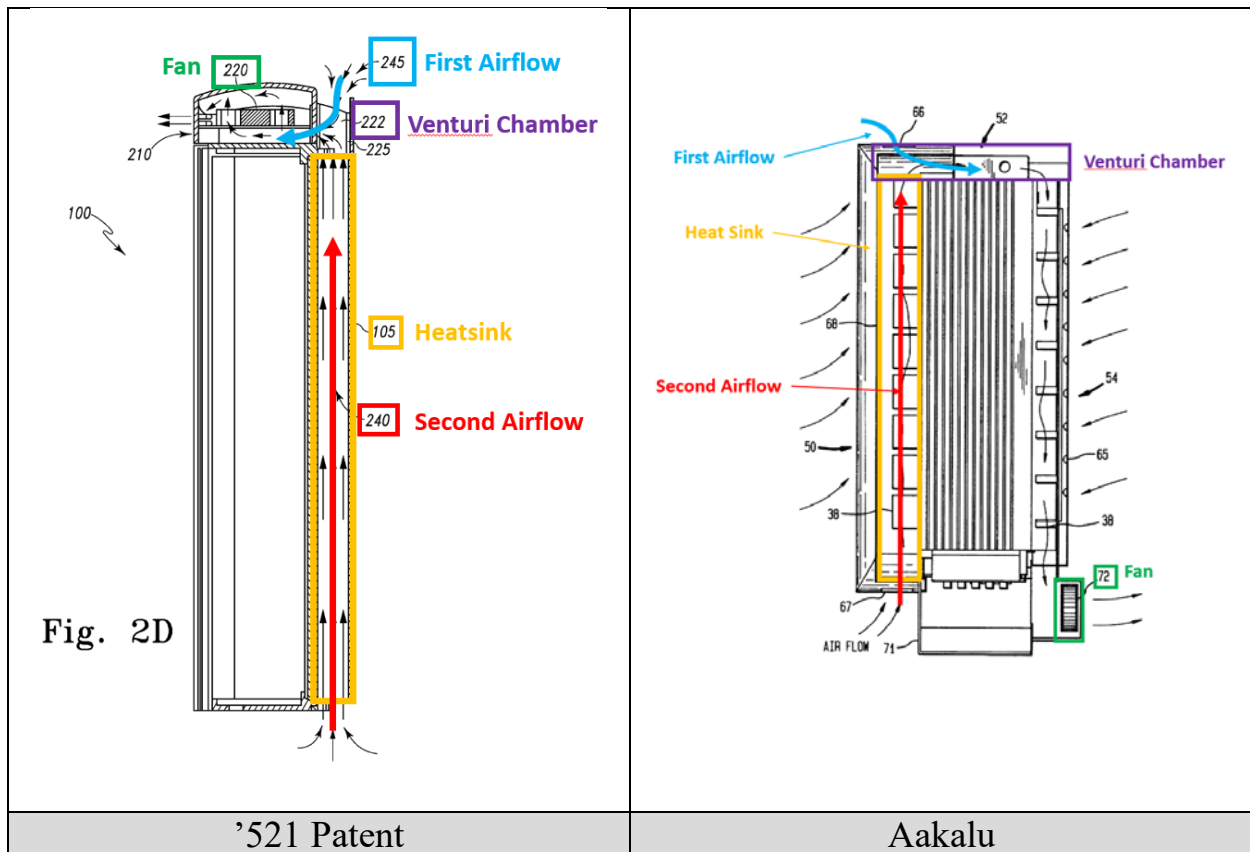
the top ventilators 66 also functions as a metering device for airflow during forced convection. The amount of fresh air drawn into the microcell during forced convection can be controlled by the size of the top ventilators 66 and the speed of the fans 72. In

other words, the ratio of air drawn in through the front solar shield 50 is determined, in part, by the size of the slots 66.

EX-1005 5:4-9.

143. A POSA understood that in order for the amount of airflow (blue) drawn in through ventilators 66 to “meter” the heated airflow (red) that the heated airflow is drawn through the heat sink using a Venturi effect caused by the first airflow.

144. Indeed, the configuration of the enclosure of Aakalu is functionally similar to that of the enclosure of the '521 Patent. A side-by-side comparison of the devices illustrating the airflow during operation of the fan is provided below:



145. The '521 Patent describes the operation of the cooling device with the fan operating:

the airflow flowing up from the heatsink's convective openings will be heated by the heat dissipated from high powered internal electronics and thus will be significantly more buoyant than the ambient first airflow. As a result, drawing the first airflow across the convective openings of the heatsink will establish a Venturi affect which will pull in more air through the heat sink than would flow naturally due to natural convention.

* * *

The combination of drawing both the heated airflow from the heatsink and the ambient airflow from above is what produces the Venturi effect that generates an increased airflow through the heatsink which in turn draws in relatively cool ambient air in from the bottom side convective openings of the heatsink.

EX-1001 5:66-6:6, 6:8-15.

146. Like the operation of the '521 Patent, a POSA understood in Aakalu that the combination of drawing both the heated airflow from the heatsink (red) and the ambient airflow from above (blue) is what produces the Venturi effect that generates an increased airflow through the heatsink which in turn draws in relatively cool ambient air in from the bottom side convective openings of the heatsink, Specifically, as the air drawn in through the top ventilators 66 (**first airflow**) flows into the constricted volume bounded by top panel 26 and top solar shield 52, the flow rate increases and the pressure decreases, and that this Venturi effect will increase the airflow upward through the front heatsink (**second (heated) airflow**).

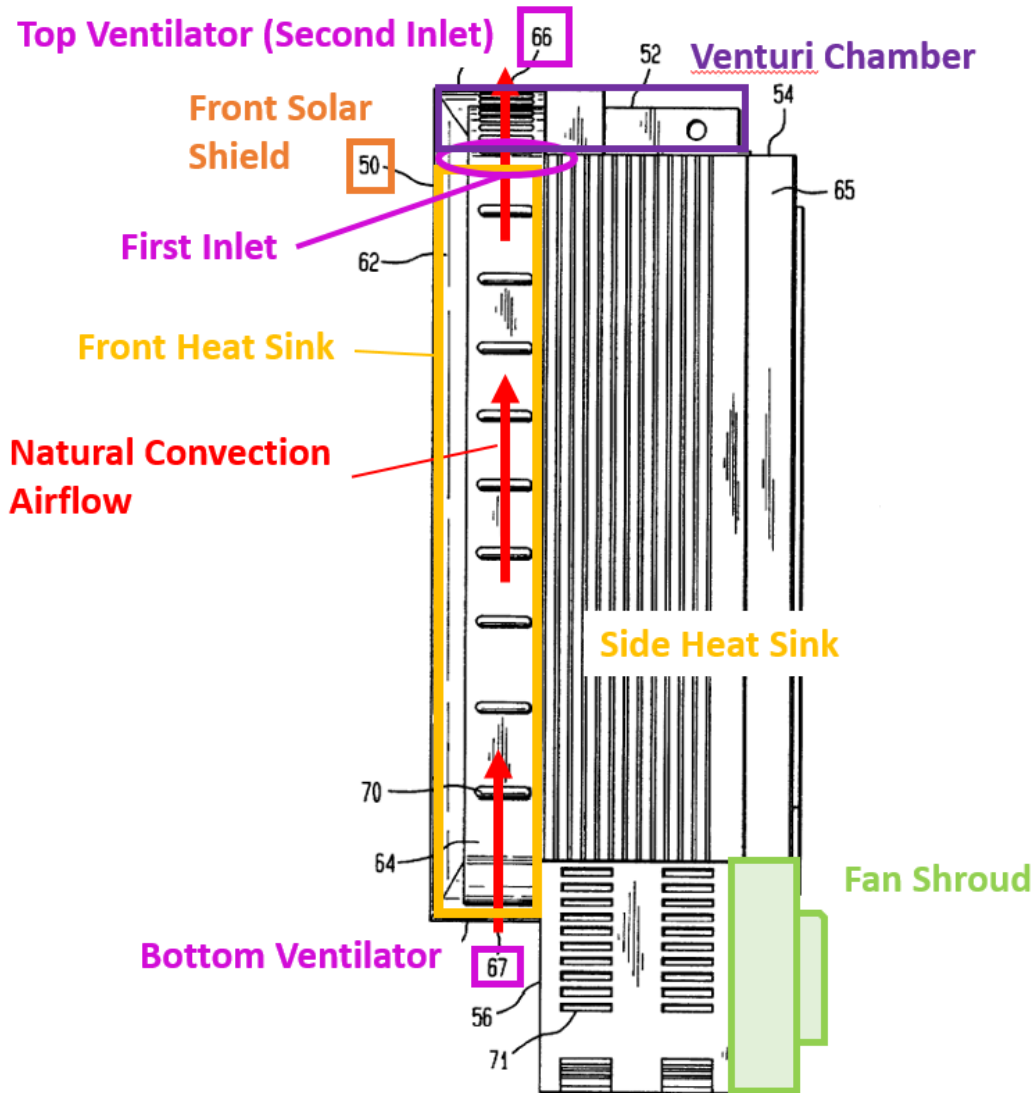
147. Thus, Aakalu discloses element [1.3].

Claim 2

The cooling unit of claim 1, wherein the fan shroud is offset from the Venturi chamber such that when the fan is not on, the fan shroud does not obstruct a natural circulation airflow

entering the first inlet and exiting the second inlet of the Venturi chamber.

148. Aakalu discloses Claim 2. Aakalu explains that, “[i]n one mode of operation, the heat absorbed by the heat sinks is dissipated by natural convection” when fan(s) 72 are not on as distinguished from the forced convection mode wherein “the fans facilitate the flow of air through the heat sinks.” EX-1005 3:26-34. Annotated FIG. 7 illustrates the natural convection mode described by Aakalu:



EX-1005 FIG. 7.

149. Aakalu explains that front solar shield 50 includes: top and bottom ventilators 66, 67, such as slots or openings, which align with the longitudinal channels 40 of the front panel 58, thereby allowing for the necessary airflow passage associated with the convection process (i.e., chimney effect) through the longitudinal channels 40.

EX-1005 4:2-7.

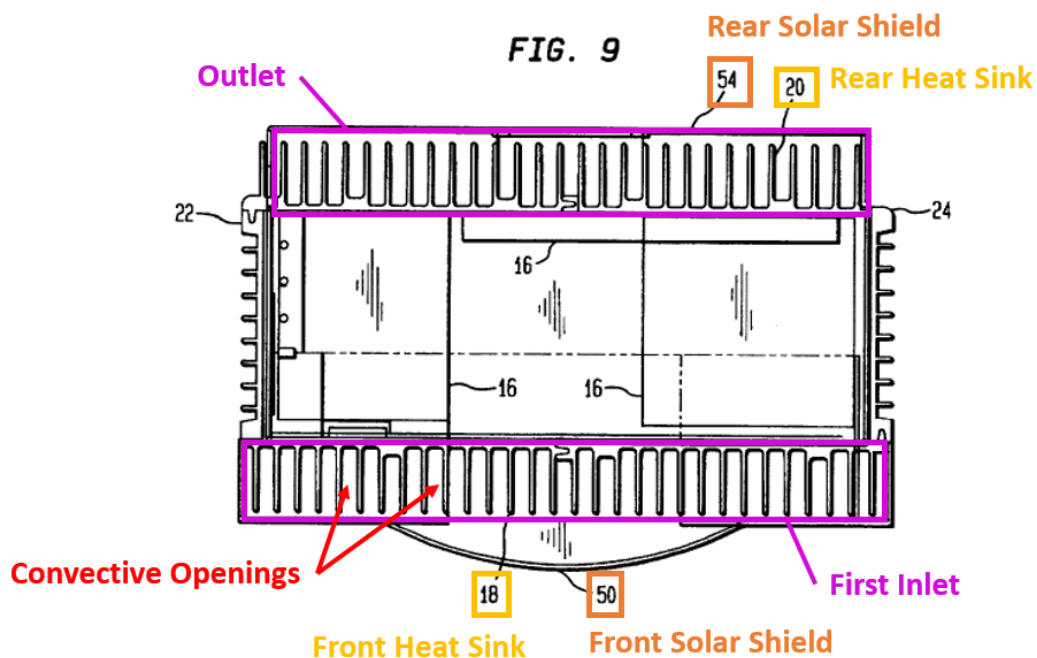
150. As illustrated, the fan shroud (**light green**) is offset from the Venturi chamber (**purple**) such that the shroud does not obstruct the natural convection airflow (**red**) [*natural circulation airflow*] flowing from the top of the heat sink (**gold**) and entering the adjacent opening (**red-purple**) [*first inlet*] and exiting the top ventilator 66 (**red-purple**) [*second inlet*] of the Venturi chamber.

151. Thus, Aakalu discloses Claim 2.

Claim 4

The cooling unit of claim 1, wherein the Venturi chamber first inlet encircles one or more convective openings of the heatsink.

152. Aakalu discloses Claim 4.



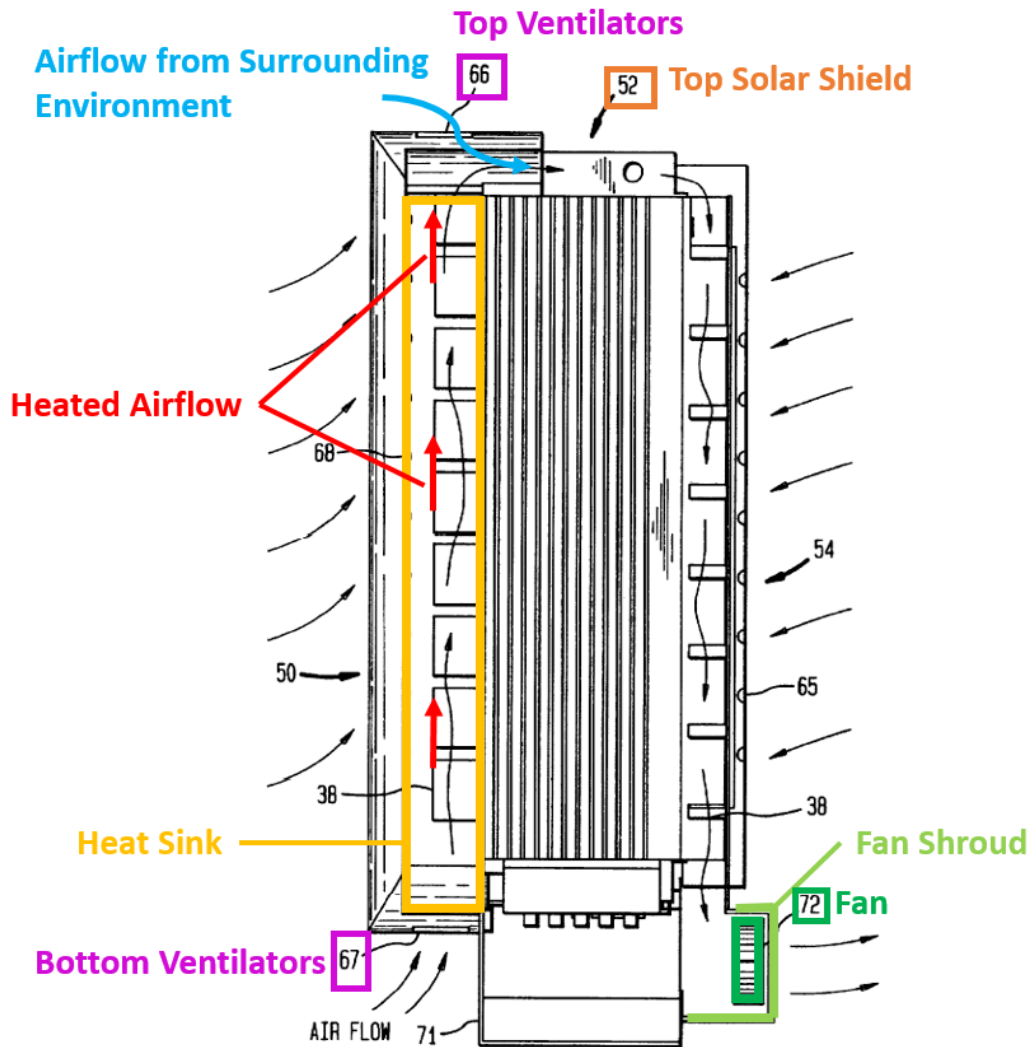
EX-1005 FIG. 9

153. As illustrated in FIG. 9, front heat sink 18 (**gold**) includes a plurality of convective openings (**red**) [*one or more convective openings*] at the top of the longitudinal channels 40 formed by adjacent fins of the heat sink. The heated airflow flows out of the convective openings through the inlet (**red-purple**) adjacent and surrounding the convective openings (**red**) and over panel 26 [*first inlet encircles one or more convective openings*]. Thus, Aakalu discloses Claim 4.

Claim 5

The cooling unit of claim 1, wherein the airflow from the surrounding environment is cooler than the heated airflow.

154. Aakalu discloses Claim 5.



EX-1005 Fig, 10.

155. As set forth for element [1.2], the heated airflow (**red**) is drawn into the heat sink through bottom ventilators 67 (**red-purple**) from the same surrounding environment as the airflow (**blue**) drawn into the top ventilators 66 (**red-purple**). The heated airflow absorbs heat as it flows through the heat sink. Thus, a POSA understood that the airflow from the

surrounding environment is cooler than the heated airflow that has absorbed heat from the heat sink. Hence, Aakalu discloses Claim 5.

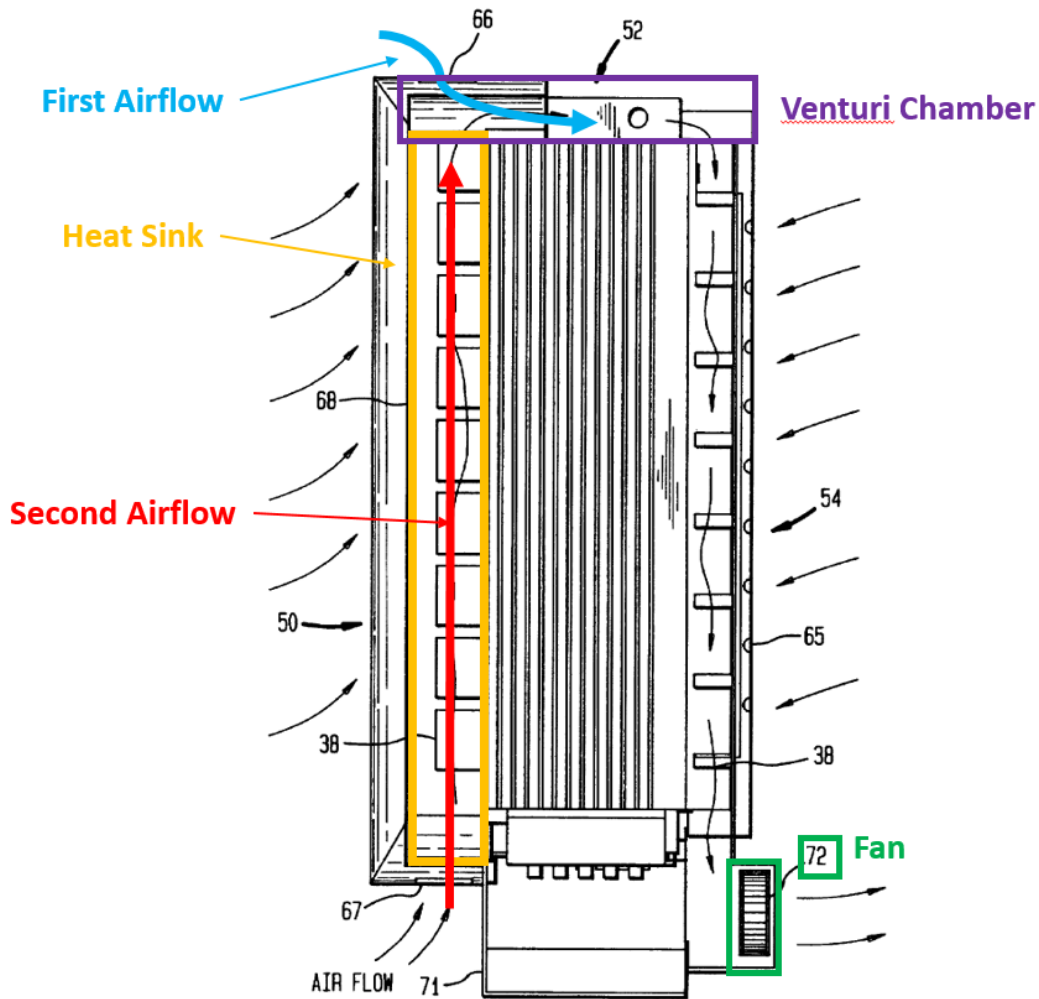
Claim 14

[14.0] *A method for cooling a sealed environment of an enclosure for housing electronics, the method comprising:*

156. To the extent the preamble is limiting, Aakalu discloses element [14.0] for at least the reasons set forth for element [1.0].

157. A POSA understood that microcell 10 constitutes *a sealed environment of an enclosure for housing electronics* as recited in element [14.0]. Aakalu states that its disclosure is particularly directed to “outdoor enclosures” and that its housing 12 comprises front panel 18 (**gold**), rear panel 20 (**gold**), and two side panels 22, 24 (**gold**), each of which form heat sinks for absorbing and dissipating heat generated by electronic components 16 (**green**) mounted to the interior of the housing panels. EX-1005 1:8-9, 2:59-3:9. A POSA understood that a sealed enclosure is formed when front panel 18 is closed to protect components 16 housed within the enclosure from the outdoor environment. Aakalu also explains that the convective cooling scheme for the housing includes airflow only on the exterior of the sealed housing 12 [*sealed environment*]. FIG. 10 illustrates the airflow through the microcell during the forced

convection method of cooling the electrical components housed within the sealed enclosure:



EX-1005 FIG. 10.

158. Thus, Aakalu discloses element [14.0].

[14.1] directing heat generated by one or more electronic devices housed within a sealed environment of an enclosure to a heatsink thermally coupled to an external environment;

159. Aakalu discloses element [14.1] for at least the reasons set forth for element [1.2]. Aakalu explains that a plurality of electronic components 16 (**green**) [*one or more electronic devices*] are mounted to the interior of the housing panels (**gold**) [*housed within a sealed environment*] that form heat sinks for absorbing and dissipating heat generated by the components 16 [*directing heat to a heat sink*]. EX-1005 2:59-3:9 .

160. Aakalu further discloses that air from the surrounding environment [*external environment*] is drawn into the heat sink (**gold**) through bottom ventilator 67 and is exhausted to the surrounding environment [*external environment*] by fan(s) 72. EX-1005 4:57-60, 5:3-4. Thus, a POSA understood that the heat sink is thermally coupled to an external environment. Hence, Aakalu discloses element [14.1].

[14.2] *drawing a first airflow across one or more convective openings of the heatsink, wherein the first airflow does not flow into the one or more convective openings of the heatsink;*

161. Aakalu discloses element [14.2] for at least the reasons set forth for elements [1.2] and [1.3]. Aakalu discloses that the first airflow (**blue**) is drawn in through top ventilators 66 (**red-purple**) and across the convective openings (**red**) of the longitudinal channels 40 of the heat sink (**gold**). Aakalu further discloses that the first airflow (**blue**)

mixes with the heated airflow (red) from the heat sink and is exhausted by fan(s) 72. EX-1005 4:63-5:4. Thus, a POSA understood that first airflow (blue) does not flow into the convective openings (red) of the heat sink. A POSA understood that the operation of the embodiment described by Aakalu with reference to FIGs. 8-10 constitutes *drawing a first airflow across one or more convective openings of the heatsink, wherein the first airflow does not flow into the one or more convective openings of the heatsink* as recited in element [14.2].

162. Hence, Aakalu discloses element [14.2].

[14.3] *drawing a second airflow of heated air from the one or more convective openings using a Venturi effect created by drawing the first airflow.*

163. Aakalu discloses element [14.3] for at least the reasons set forth for element [1.3]. The first airflow (blue) [*first airflow*] flowing in through top ventilator 66 and across the convective openings (red) [*one or more convective openings*] of the heat sink, draws the heat airflow (red) [*second airflow*] from the convective openings using a Venturi effect. A POSA understood that the operation of the embodiment described by Aakalu with reference to FIG. 10 constitutes *drawing a second airflow of heated air from the one or more convective openings using a Venturi effect created by drawing the first airflow* as recited in element [14.3].

164. Thus, Aakalu discloses element [14.3].

Claim 15

[15.0] *The method of claim 14*

[15.1] *wherein drawing the first airflow further comprises drawing the first airflow into a Venturi chamber;*

165. Aakalu discloses the additional limitations recited in element [15.1] for at least the reasons set forth for elements [1.2], [1.3], and [14.2].

[15.2] *wherein drawing the second airflow further comprises drawing the second airflow into the Venturi chamber;*

166. Aakalu discloses the additional limitations recited in element [15.2] for at least the reasons set forth for elements [1.2], [1.3], and [14.3].

[15.3] *the method further comprising operating a fan to pull the first airflow and the second airflow out of the Venturi chamber.*

167. Aakalu discloses the additional limitations recited in element [15.3] for at least the reasons set forth for elements [1.2], [14.2], and [14.3].

168. Thus, Aakalu discloses Claim 15.

Claim 16

The method of claim 14, further comprising operating a fan to draw the first airflow and the second airflow.

169. Aakalu discloses the additional limitations recited in Claim 16 for at least the reasons set for elements [1.2], [14.2], and [14.3].

Claim 17

The method of claim 15, wherein the fan is located offset with respect to the Venturi chamber to not impede a natural circulation of airflow through the Venturi chamber when the fan is not in operation.

170. Aakalu discloses the additional limitations recited in Claim 17 for at least the reasons set forth for elements [1.2], [14.2], and [14.3], and Claim 2.

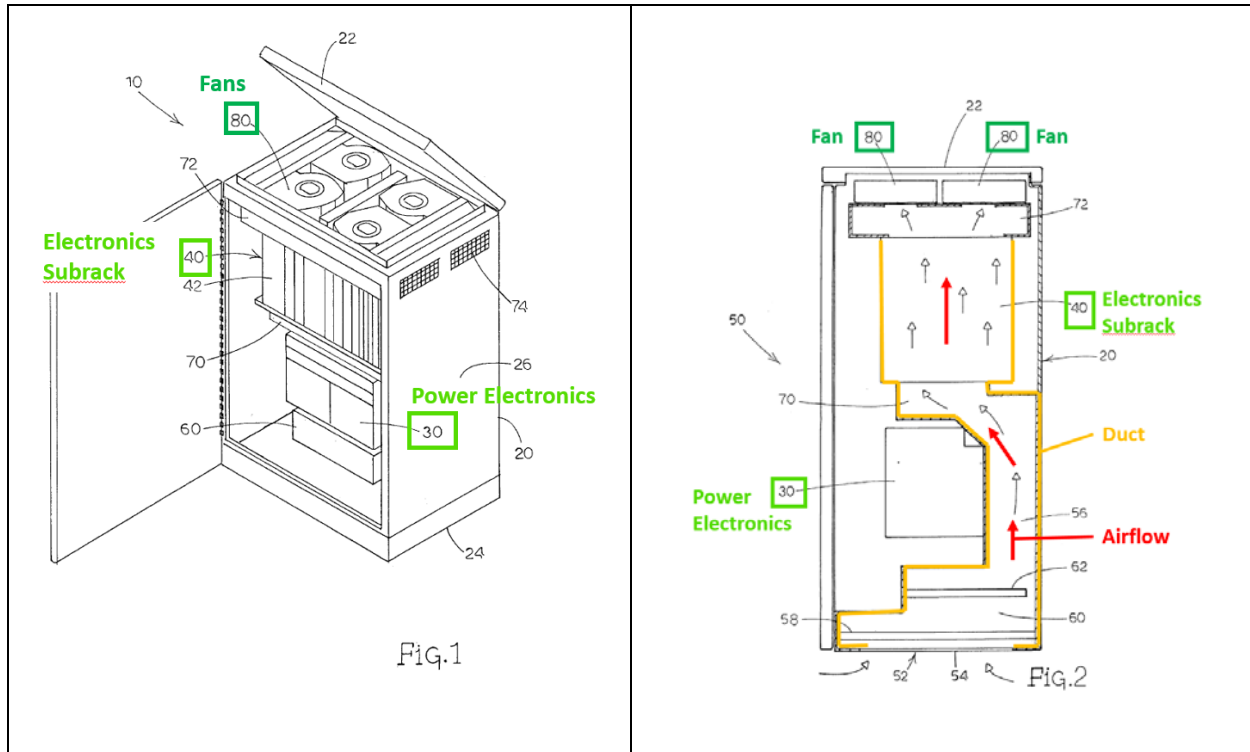
C. Challenge 3: Claims 3 and 18-20 are obvious over Aakalu in view of Jones

1. Jones

171. Jones is titled “Electronics Cabinet Cooling System” and discloses a “cabinet for housing telecommunications equipment in outdoor locations.” EX-1006 Title, Abstract. Jones explains that the cabinet includes an enclosure housing electronics and a cooling system including a duct having inlet and outlet plenums and one or more fans forming a segregated air routing system. EX-1006 2:15-38.

172. Jones further explains that the cooling system includes a thermal controller for monitoring the temperature within the cabinet and controlling operation of the fans and a heater. EX-1006 2:39-41.

173. FIGs. 1 and 2 illustrate a perspective view and section view of the cabinet.

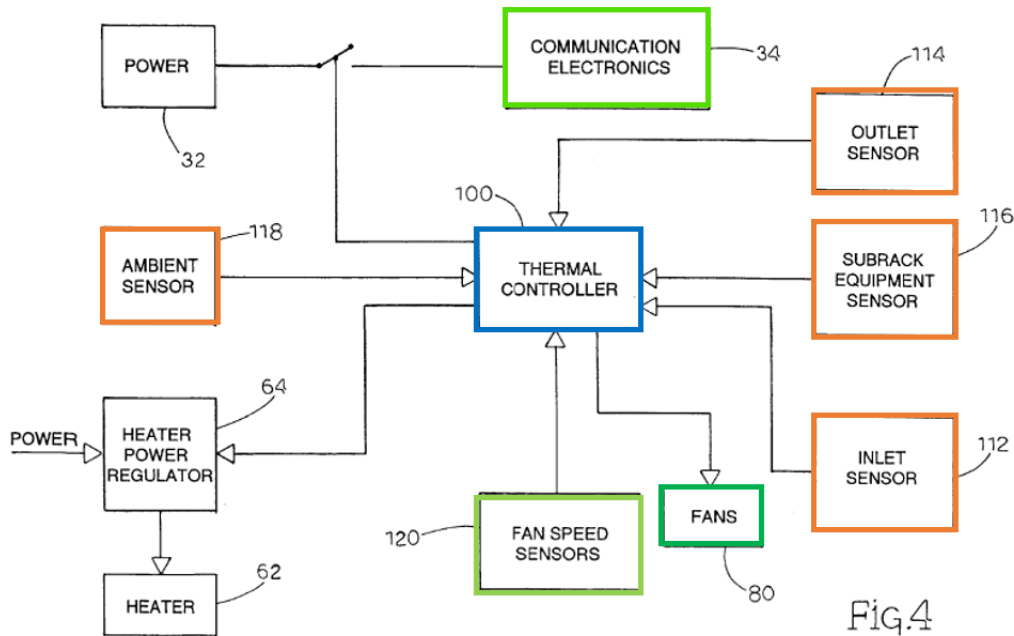


EX-1006 FIGs. 1, 2.

174. Jones explains that cabinet 10 includes cooling system 50 for cooling the electronics housed therein (e.g., communications electronics 34 in the subrack 40 (green)) by providing an airflow (red) through the ducting (gold) within the cabinet. A plurality of fans 80 (green) draw the air through the ducting. EX-1006 3:40-55.

175. Jones further explains that a thermal controller 100 (blue) controls the operation of the fans 80 (green) and a heater 82 responsive to input from temperature sensors (orange) and fan speed

sensors (light green). EX-1006 4:53-57. FIG. 4 is a block diagram of the thermal control system.



EX-1006 FIG. 4.

176. Jones explains that controller 100 controls the airflow through the cooling system and the power of the heater 62 to maintain the temperature of the cooling air supplied to the electronics (green). The on/off state of one or more of the fans, and the speed of the fans when on is controlled by controller 100 responsive to the sensed temperatures. EX-1006 5:5-42.

177. Jones also discloses that one fan 80 from the plurality of fans be held in reserve as a redundant backup. EX-1006 4:46-51.

2. Detailed Application of Aakalu and Jones to the Challenged Claims

Claims 3

[3] The cooling unit of claim 1, wherein the at least one electrical fan includes a primary fan and a backup fan that becomes operational upon a failure of the primary fan.

178. Aakalu in view of Jones renders Claim 3 obvious.

Aakalu discloses using a plurality of fans to affect a forced convection cooling scheme for an enclosure housing electronics, but does not expressly state that that one of the fans is a backup fan in the event of a failure of a primary fan. However, Jones expressly teaches using one of the plurality of fans as a backup.

179. Both Aakalu and Jones describe that communications electronics within the electronic equipment cabinet should be cooled to help prevent malfunctions or damage and this is particularly true for electronic equipment cabinets in locations that are not in temperature controlled environments, such as outdoor environments. EX-1005 1:15-30; EX-1006 3:40-45 . As a solution to prevent damage to electronic components, both Aakalu and Jones teach the use of variable speed fans to provided adequate air flow to maintain the temperature of the electronic components in a safe range. EX-1005 5:5-10; EX-1006 4:40-43. Jones discloses using a plurality of fans and expressly teaches that “[t]o provide a

redundant backup [*backup fan*], it is preferred that one fan 80 be held in reserve” so that if one of the main fans 80 [*primary fan*] is not operating properly, the reserve fan may be substituted for the malfunctioning fan [*backup fan that becomes operational upon a failure of the primary fan*]. EX-1006 4:46-51. A POSA would be motivated to modify the teachings of Aakalu to use a plurality of variable speed fans with the teachings of Jones to maintain at least one of the fans in reserve as a backup in order to provide redundancy and prevent damage to the electronics in the event of a failure of a primary fan. Thus, Jones provides the express motivation to provide redundancy to critical cooling systems like Aakalu by using one of the plurality of fans as a back-up fan. Moreover, it was within the knowledge and skill of a POSA to design the cooling system with appropriately sized fans to provide sufficient cooling using primary or backup fans such that a POSA understood that implementing redundancy would be successful.

180. Thus it was obvious to a POSA to modify the teachings of Aakalu to include one backup fan for redundancy as taught by Jones.

Hence, Claim 3 is obvious over Aakalu in view of Jones.

Claim 18

The method of claim 15, further comprising operating the fan when a temperature exceeds a predetermined threshold.

181. Aakalu alone or in view of Jones renders Claim 18 obvious. Aakalu teaches that its cooling system operates in two modes: (1) a natural convection mode with the fans not operating, or (2) a forced convection mode with the fans operating. EX-1005 3:25-34. Aakalu also teaches that the amount of fresh air drawn into the microcell may be controlled by the size of the ventilators and the speed of the fans. In one embodiment, the size of the ventilators is controlled to control the temperature of the cooling airflow. EX-1005 5:5-30.

182. Although Aakalu does not expressly describe transitioning from natural to forced convection mode by operating the fans when temperature exceeds a predetermined threshold, a POSA understood that temperature rising above a predetermined threshold in a natural convection mode indicates that natural convection is not adequate under the present conditions to prevent overheating the electronics such that forced convection is necessary by operating the fans. Specifically, Aakalu expressly teaches that the speed of the fan can be used to control the amount of fresh air drawn in and thus, if natural convection alone is not drawing in sufficient fresh air, a POSA would switch to forced convection mode to prevent damage to electrical components. EX-1005 5:5-30. Thus, a POSA understood that Aakalu discloses this limitation.

183. To the extent that PO argues that Aakalu does not expressly state that switching from natural convection mode to force convection mode is performed when a temperature exceeds a predetermined threshold, Jones discloses this limitation. Jones expressly teaches that the fans in a forced convection cooling system may be controlled based on sensed temperatures, including the on/off state of a fan. EX-1006 5:5-42. Jones teaches that the capacity and number of fans should vary depending on the desired capacity of the cooling system and that each fan should be variable speed over a wide range of speeds and that the speed of the fan was controlled by a thermal controller that received temperatures from a temperature sensor at the rack holding the electronic components based on predetermined temperature ranges. EX-1006 4:40-61; 5:20-42. Further, Jones describes that the fans can be turned on or off and each includes a backdraft damper to prevent recirculation of cooling air through any fans that are not in use. EX 1006 4:43-46. Thus, a POSA understood that fans could be turned on and off as necessary based on the sensed temperatures of the electronic components.

184. Thus, a POSA would be motivated to modify the teachings of Aakalu to operate a fan when the temperature exceeds a predetermined threshold as taught by Jones to prevent overheating the

electronics, e.g., to operate the fans when natural convection is no longer sufficient to maintain the temperature below a safe threshold. In addition, a POSA understood that operating the fan when a temperature exceeded a predetermined threshold conserved power and reduced wear on the fans when forced convection is not necessary. As demonstrated by Jones, it was well within the skill and knowledge of a POSA to sense the critical temperature(s) within the system of Aakalu, and control the fan(s) responsive to the sensed temperature(s).

185. Thus, it was obvious to a POSA to modify the teachings of Aakalu to include the temperature control of the fans as taught by Jones. Hence, Claim 18 is obvious over Aakalu alone and/or in view of Jones.

Claim 19

[19.0] *A method for cooling a sealed environment of an enclosure for housing electronics, the method comprising:*

186. Aakalu discloses element [19.0] for at least the reasons set forth for elements [1.0], [6.0], and [14.0].

[19.1] *directing heat generated by one or more electronic devices housed within a sealed environment of an enclosure to a heatsink thermally coupled to an external environment;*

187. Aakalu discloses element [19.1] for at least the reasons set forth for element [14.1].

[19.2] *when a temperature exceeds a first predetermined threshold, operating a fan to draw a first airflow across one or more convective openings of the heatsink and a second airflow of heated air from the one or more convective openings of the heatsink using a Venturi effect created by drawing the first airflow, wherein the first airflow does not flow into the one or more convective openings of heatsink;*

188. Aakalu discloses and/or renders obvious element [19.2] alone and/or in view of Jones for at least the reasons set forth for element [14.2] and Claim 18.

[19.3] *when the temperature does not exceed a second predetermined threshold, allowing a natural circulation airflow to flow from the one or more convective openings of the heatsink by not operating the fan.*

189. Aakalu discloses and/or renders obvious element [19.3] alone and/or in view of Jones for at least the reasons set forth for element [14.3] and Claim 18.

Claim 20

The method of claim 19, wherein the fan is located such as to not impede the natural circulation airflow when the fan is not in operation.

190. Aakalu discloses the additional limitations recited in Claim 20 for at least the reasons set forth for Claim 17.

CONCLUSION AND DECLARATION

My findings and opinions set forth in this Declaration are based on my work and examination to date. I may continue my examinations in view of additional documents or other factual evidence over the course of this proceeding that may necessitate supplementing and/or refining my opinions. I reserve the right to add to, alter, or delete my opinions and my Declaration upon discovery of additional information. I reserve the right to make such changes as necessary.

In signing this Declaration, I understand that the Declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I acknowledge that I may be subject to cross-examination in this case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001, of Title 18 of the United States Code.

[SIGNATURE ON FOLLOWING PAGE]

Date: 08/30/2024

By:

A handwritten signature in black ink, appearing to read "Emad Y. Tanbour", written over a horizontal line.

Emad Y. Tanbour Ph.D

APPENDIX A

Petitioner's Exhibit List

<i>Exhibit</i>	<i>Description</i>
1001	U.S. Patent No. 7,724,521 (the “’521 Patent”)
1002	Portions of prosecution history of the ’521 Patent (“File History”)
1004	U.S. Patent No. 7,028,753 (“Stern”))
1005	U.S. Patent No. 5,894,407 (“Aakalu”)
1006	U.S. Patent No. 6,104,003 (“Jones”)
1007	U.S. Patent No. 7,027,300 (“Lord”)
1008	U.S. Patent No. 7,450,382 (“Fischer”)
1009	U.S. Patent No. 7,245,485 (“Morrell”)

APPENDIX B

EMAD Y. TANBOUR, Ph.D.

CURRICULUM VITAE

Associate Professor

College of Engineering & Technology, School of Engineering, Eastern Michigan University

Cell 734-277-1644 etanbour1@gmail.com and etanbour@emich.edu

SUMMARY

EMAD Dr. Emad Tanbour has more than 33 years combined experience in Mechanical Engineering in both academia and industry. His industry experience spans over 18 years in the areas of product development, energy efficient appliances and sustainability, thermal systems design and engineering management. He is an expert researcher in industry and had been leading industry-academia funded research since 1997. Dr. Tanbour is an innovator with over 17 US pending and issued patents all of which resulted in products sold in North America. Most of his innovations are in the field of sustainable design of domestic and commercial appliances. Dr. Tanbour has advanced knowledge of computer aided engineering, CFD and computational mechanics. He is an expert user and trainer of computer aided design using solid modeling. He has conducted research in the areas of heat transfer, thermal-fluids, and energy systems and led many years of research and development projects in the interdisciplinary areas of Mechanical Engineering. He received his bachelor's degree in Mechanical Engineering and ranked third over his cohort and received full scholarship to pursue graduate studies towards his Ph.D. in Mechanical Engineering from the University of Iowa. During his studies at Iowa, Dr. Tanbour led the thermal design of all control circuits for NASA Cassini spacecraft that was launched to Saturn. Dr. Tanbour is the recipient of Arch T. Colwell Award from Society of Automotive Engineers and had served for five years as ABET industry consultant. He also received EMBA training courses at the University of Iowa.

In August 2016, Dr. Tanbour Joined Eastern Michigan University, School of Engineering As professor and coordinator of the Mechanical Engineering program. Dr. Tanbour also assumed coordinator position for Mechanical Engineering Technology upon joining EMU until fall 2017 when he assumed coordinator position for the Graduate Program in Engineering Management. Dr. Tanbour is teaching undergraduate junior and senior courses in Mechanical Engineering and has taught dynamics for Mechanical Engineering Technology. He also teaches graduate courses in Engineering Management. Dr. Tanbour currently serves as program coordinator for both Mechanical Engineering and Master of Engineering Management Program. Dr. Tanbour teaches the thermal fluid lab for the undergraduate mechanical engineering program in the USA and in the joint college in China (Joint College of engineering between BGU-China and Eastern Michigan University). While teaching the thermal fluid lab, Dr. Tanbour developed a set of experimental engineering program that includes, heat transfer, fluid flow, and refrigeration and air-conditioning systems. Students learn hand on experience of conducting experiments in heat conduction, convection, fluid flow, fluid statics, refrigeration cycles, refrigeration system evaporators, condensers and compressors among other thermal fluid experiments. Upon joining Eastern Michigan, Dr. Tanbour successfully designed and build a state of the art Virtual Reality (VR) lab. The VR lab consists of four-wall fully immersive active stereoscopic system that is 14ft by 14 ft floor plan. The VR lab successfully received funding from Ford Motor Company Fund. Dr. Tanbour is actively conducting research and

teaching using the VR lab and is supervising doctoral and undergraduate students conducting research and development in the VR field. The VR lab is also utilized as a design review and visualization facility for senior capstone design students in the School of Engineering.

Dr. Tanbour also teaches thermodynamics for the mechanical engineering program at Eastern Michigan University as well as at the Joint College of Engineering in China. During his tenure, Dr. Tanbour developed mechanical engineering curriculum in thermodynamics where refrigeration cycles, power cycles and heat pumps are taught in his courses. Dr. Tanbour also was instrumental in developing the heating, refrigeration and thermal fluids lab for the Joint College with BGU China. In his leadership of the joint mechanical engineering program with BGU China, Dr. Tanbour established the curriculum and specified all the components of the thermal fluids lab including heat transfer experiments, refrigeration unit test stands, heat pump test stands, fluid flow experiments and other mechanical engineering labs. In Jan 2014, Dr. Tanbour joined Central Michigan University (CMU) as a visiting scholar and served as tenure track assistant professor of Mechanical Engineering Technology in the School of Engineering and Technology (SET) since July 2014. During his first year at Central Michigan University, Dr. Tanbour taught engineering mechanics courses for both Engineering and Engineering Technology majors, Thermodynamic for ME major, Applied Fluid Mechanics, Machine Design and Capstone Projects for Senior Engineering Technology cohort. He also served on the SET Graduate Committee where he led the process to develop the Assessment Plan for the new Master of Science in Engineering (voted as best assessment plan in the history of CMU-currently used as a benchmark for new programs at CMU). Dr. Tanbour built a state of the art Virtual Reality laboratory at CMU, which employed several undergraduate, and two graduate students from SET. He contributed to MET Assessment Committee and was serving as MET Program Coordinator. During the spring of 2015 and 2016, Dr. Tanbour taught the Senior Capstone Industrial Design course for all BSET graduating seniors where he managed to attract several externally sponsored design projects and supervised four internally sponsored ones. Details of some of these Projects are added at the end of this CV. Dr. Tanbour is active in research and has published and presented engineering conference papers, and many journal papers.

In 2009, Dr. Emad Tanbour joined Prince Mohammad Bin Fahd University (PMU) faculty of Mechanical Engineering. He has led the university's strategic plans to achieve total quality assurance. He also led the university's compliance system with ABET (USA), NCAAA (National) and SACS (USA) accreditation. Dr. Tanbour served in several leadership capacities at the university including his membership of the University Council reporting to the Board of Trustees. He was also a member of the Senior Management Group of PMU and has served as a member of the University Deans' Council. He served also as a member of the University IT Council. All such councils were chaired by PMU Rector. He was a member of the College of Engineering Council and served as Senior Advisor to the Rector on Accreditation and was promoted to Dean of Quality and Accreditation reporting directly to the Rector. As Dean of Quality and Accreditation, Dr. Tanbour managed PMU's readiness works to successfully receive NCAAA national accreditation in 2013 (Equivalent to US regional university accreditation such as HLC). During five years at PMU, Dr. Tanbour taught many Mechanical and General Engineering courses more notably, the capstone graduation design projects. Dr. Tanbour brings to his classroom real-life industry experience especially in product design and development and interdisciplinary Mechanical Engineering. He was an instrumental member in the College of Engineering curriculum development committee for master's degrees in Mechanical Engineering and Energy Systems and has served for three years as member of the College Curriculum and Accreditation standing committee.

During 2005 to 2009, Dr. Tanbour managed product development engineering for Whirlpool and AO Smith-USA water heaters (a division of 45 engineers and technicians). He led the development of several energy efficient residential water heaters. He led the efforts to establish A O Smith Engineering

Department in Nanjing china to design and produce water heaters to the Chinese market under A O smith brand and quality. While working with A O Smith-China, Dr. Tanbour led the design and sourcing of all the components of heat pump water heaters. He established suppliers for condensers, evaporators, rotary compressors and other heat pump/refrigeration system components and systems. Dr. Tanbour also visited plants that manufactured evaporators, condensers, rotary compressors and other heat pump/refrigeration system components and managed design aspects and engineering drawings and manufacturing drawings and assembly activities to produce the heat pump components. Dr. Tanbour also has industry experience in designing compact heat pump/refrigeration systems that are mounted on the storage tank-type water heaters. He was successful in developing the world first ultra- low NOX water heater and the production of many DOE-rated Energy Star power-vented water heaters. His experience included utilization of CFD and state of the art CAD deployment through the industry. He also established industry-largest development & reliability labs for residential water heaters at Whirlpool-AO Smith. While at Whirlpool, Dr. Tanbour maintained industry-academia collaboration with Clemson University, Virginia Tech and University of Tennessee, Knoxville. His engineering department in industry-hosted internship program with these three universities and was home for doctoral and graduate student engineering fellows from Clemson and University of Toledo. During 1997 to 2005, Dr. Tanbour worked as R&D senior manager at HNI Corporate Technical Center, the second largest manufacturer of office furniture and hearth systems in North America. He led R&D projects utilizing computational mechanics and founded the Hearth Lab at the corporate center. His 8 years at HNI included numerous industry-academia funded research projects and strong collaboration relationship with the University Of Iowa College Of Engineering and the Center for Computer Aided Design. During the same period, Dr. Tanbour was active in service in the State of Iowa where he served as Co-Chair to Advanced Technical Training at the Iowa Department of Economic Development and several industry-academia service capacities.

During 1993 to 1997, Dr. Tanbour was leading Gail Industry's high pressure pumps manufacturing where he successfully developed hydrostatic testing piston pumps and mud pumps for oil and gas operations in California and Texas.

Dr. Tanbour has proven teaching and research record. He served as adjunct assistant professor at the University of Iowa (2000 to 2005) teaching undergraduate and graduate Mechanical Engineering curriculum and as full time faculty (2009 to Present). He was principal investigator in several HNI - U of Iowa funded research projects. He managed to secure \$300,000 seed funding of the Virtual Reality lab jointly at HNI/Allsteel and U of Iowa. This seed funding attracted over \$18 million in research grants over the past 19 years to the Center for Computer Aided Design at Iowa where he is still an affiliate research scholar. His record of service and research is evident in the list of publications in Thermo- Fluids and interdisciplinary Mechanical Engineering. Dr. Tanbour is still active in consulting projects for manufacturers in USA in the area of Mechanical Engineering design. Most recently, Dr. Tanbour was retained as expert infringement analyst in an ongoing litigation regarding intellectual property infringement case in water heater industry.

EDUCATION

Ph.D. in Mechanical Engineering

The University of Iowa, Iowa City, IA (1997)

M.Sc. in Mechanical Engineering

Jordan University of Science and Technology (1990)

B.Sc. in Mechanical Engineering

Jordan University of Science and Technology (1987)

EMBA, Executive MBA Program Training (courses only, no degree)

The University of Iowa, Iowa City, IA (2004-2005)

Courses completed: Managerial Economics, Managerial Accounting, Organizational Behavior, Data and Decision (Managerial Data, Decision and Statistical Analysis), Marketing Management, Human Resource Management and International Economic Environment of the Firm (Managerial Macroeconomics).

PROFESSIONAL EMPLOYMENT (MAJOR POSITIONS)

ACADEMIC APPOINTMENTS

Eastern Michigan University:

School of Engineering, College of Engineering & Technology

August 31, 2016 - Present:

- Full Professor of Mechanical Engineering (decision of promotion to full professor is made during April 2024, and will be effective July 2024)
- Associate Professor (tenured and promoted July 2019), and Chair of Mechanical Engineering, School of Engineering and Acting Director of the School of Engineering.
- School of Engineering ABET Coordinator (Summer 2018-present)
- Supervisor and Founder of EMU Virtual Reality lab.

Central Michigan University:

School of Engineering and Technology, College of Science and Technology.

Jan 2014 – August 15, 2016:

- Visiting Professor of Mechanical Engineering (Jan to Jun 2014)
- Tenure Track Assistant Professor of Mechanical Engineering Technology (July 2014-August 2016)
- Coordinator for MET Program
- Coordinator for the Master in Engineering Management Program.

Prince Mohammad Bin Fahd University (Al-Khubar, Saudi Arabia)

Aug 2009- Dec 2013 Dean of Quality and Accreditation and Professor of Mechanical Engineering

The University of Iowa, Iowa City, Iowa 52241, USA

2005-present Affiliate Research Scholar Center for Computer Aided Design

2000-2005 Adjunct Professor of Mechanical Engineering

1992-1997 Teaching/Research, College of Engineering, Department of Mechanical and Industrial Engineering

National College, Amman Jordan (Technical Community College)

1990-1992 Lecturer, Mechanical Engineering

Jordan University of Science & Technology, Irbid, Jordan

1987-1990 Teaching/Research Assistant. Taught and assisted in teaching undergraduate

Mechanical Engineering classes including manufacturing processes, fluid mechanics lab, heat transfer lab, instrumentation lab, Engineering and Mechanical Engineering Drawing.

INDUSTRIAL/MANUFACTURING APPOINTMENTS

2019-Present: Expert Witness Experience:

- 1- A. O. Smith vs Bradford White: Patent infringement case: Result: Winning the case of my client and favorable judgement. Was deposed and testified in court.
- 2- SPG vs Evapco: IPR Case in the US Patent Office. Was deposed and outcome was winning the US Patent validation of my client's patent
- 3- Confidential Case: serving as tech expert for a supplier of devices used in heat transfer appliances. Case resulted in mediation process in favor of my client.
- 4- Marine Air Conditioning Units. A case currently concluded with a favorable determination to my client at the US-ITC involving compact self-contained marine air conditioning products. Was deposed and testified in ITC court.
- 5- A case that is set for trial soon involving commercial icemakers. I am serving as the tech expert in the case representing the complainants. Was deposed and is scheduled to testify soon.

1993-1997 Director of Engineering
Gail Industries, Cedar Rapids, Iowa, USA
***Manufacturer** of high pressure pumps for hydraulic testing of pipelines*

1997-2005 Senior R&D Manager
S. M. Howe Tech Center, HNI Corporation, Muscatine, Iowa, USA
***Manufacturer** of office systems and hearth products*

2005- 8/2009 Manager, Product Development Engineering
A.O. Smith Corporation, Water Product Company, Johnson City, Tennessee, USA
*Second Largest **Manufacturer** of Residential and Commercial water Heaters and Heat Pump Water Heaters in North America with brands like Whirlpool and Sears Water Heaters.*

TEACHING EXPERIENCE

Eastern Michigan University

- EM 509 Engineering Project Management
- EM 649 Manufacturing Process Planning
- EM 520 Engineering Value and Economic Analysis
- EM 670: Design for Manufacture and Assembly
- ME 312: Dynamics
- ME 316: Thermodynamics
- ME 317: Fluid Mechanics
- ME 313: Mechanics of Materials
- ME 330: Machine Design

- ME 492: Senior Capstone I
- ME 493: Senior Capstone II
- MET 312: Applied Dynamics Principles

Central Michigan University

- IET 454 Machine Design

- IET 279 Applied Statics
- EGR 251 Engineering Statics
- IET 499 Industrial Projects Capstone
- EGR 356 Thermodynamics I
- IET 352 Applied Fluid Mechanics
- IET 501 Industrial Management (Graduate online)
- IET 524 Technology and the Environment (Graduate online)
- IET 680 Sustainability and Green Technology (Graduate online)

Prince Mohammad Bin Fahd University

- Fluid Mechanics
- Engineering Economy
- Power Generation
- Computer Aided Design (ME Senior year course)
- Mechanical Engineering Design I (Kinematics and dynamics of machinery)
- Mechanical Engineering Design II (Automatic control)
- Mechanical Engineering Design III (Machine Design)
- Assessment III (Mechanical Engineering Capstone Design Project)

The University of Iowa

Adjunct Faculty (2000-2005)

- Intermediate Thermodynamics (Graduate course)
- Dynamics
- Principles of Design 1 (Optimization)

Graduate Teaching Assistant (1992-1997)

- Thermodynamics 1
- Heat Transfer
- Fluid Mechanics
- Fluid Mechanics Lab
- Experimental Engineering

National College, Technical Community College

- | | |
|---|----------------------------------|
| • Air-Conditioning Engineering | • Heat Transfer |
| • Refrigeration Technology | • Strength of Materials |
| • Service of HRA System | • Engineering Drawing |
| • Fluid Mechanics and Hydraulic Machinery | • Calculus for Engineers |
| • Engineering Mechanics, Statics and Dynamics | • Mechanical Engineering Drawing |

PUBLICATIONS

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2. Barry, Oumar Rafiou, Tanbour, Emadeddin Y., Vaja, Nitish Kumar, and Tanbour; Hesham, Asymmetric Aeolian vibration damper, USA Patent Office, Patent No.: US 9,948,081 B1, Date of Patent: Apr. 17, 2018. <http://www.freepatentsonline.com/9948081.html>

3. Emadeddin Y. Tanbour, Moh'd-Eslam Dahdolan, Mahmoud R. AlOmari, Oumar R. Barry, Characterization of Aerogel Based Thermal Insulation Blankets, Economics, and Applications for Domestic Water Heaters, Journal of Thermal Engineering, 4-5-July, 2018. <http://eds.yildiz.edu.tr/journal-of-thermal-engineering/Submission/MyManuscripts>
4. M. Bukhari, Oumar Barry and Emadeddin Tanbour, On the vibration analysis of power lines with moving dampers, Journal of Vibration and Control, Published July 4, 2017. <http://journals.sagepub.com/doi/abs/10.1177/1077546317719194>
5. M. C. Greenfield, Emad Y. Tanbour, 2017, Gap Analysis of a Newly Developed Electrical Engineering Program using NCEES FE Exam, International Journal Of Engineering Research & Technology (IJERT) Volume 06, Issue 01 (January 2017).
6. Oumar Barry and Emadeddin Tanbour, Resonant Frequencies of Perforated Plates with Rectangular Slots, Journal of Mechanical Engineering Science, UK Institute of Mechanical Engineers, December 13, 2016, manuscript ID is JMES-16-0518.R1. <http://journals.sagepub.com/doi/10.1177/0954406216683974>
7. Nitish Kumar Vaja, Oumar Barry, Emadeddin Y. Tanbour, On the Dynamic Modeling and Analysis of an Asymmetric Stockbridge Damper, Proceedings of the Sixth International Conference on Structural Engineering, Mechanics and Computation, Cape Town, South Africa, 5-7 September 2016. <https://www.crcpress.com/Insights-and-Innovations-in-Structural-Engineering-Mechanics-and-Computation/Zingoni/p/book/9781138029279>
8. M. Freund, E. Joubaneh, O. Barry and E. Tanbour, Study Of Vibration Of Electric Power Steering Systems Using A Continuous System Model. International Mechanical Engineering Congress and Exhibition, ASME IMECE 2017, November 3-9, 2017, Tampa, Florida, USA. <https://mail.google.com/mail/u/0/#search/barry1o%40cmich.edu/WhctKHTKgrdpWgzdWsfKGjgqNldcqHgBhkZbdgLsQFwSPGnLRBfRDlJVbQxMKDSMFMPZpKQ?projector=1&messagePartId=0.2>
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10. Emadeddin Y. Tanbour and Oumar R. Barry, Free Vibration of flame Arrestors: Theoretical and Numerical Analysis, submitted to AMSE Journal of Vibrations and Acoustics, September 2015
11. Emad Tanbour and Suleiman Ashur, Gap Analysis of Engineering Course Learning Outcomes using NCEES FE Exam, accepted for publication and presentations ASME 2015 International Mechanical Engineering Congress and Exposition, Huston, Texas Nov.13-19, 2015

12. Emadeddin Y. Tanbour, Molu Olumolade and Oumar R. Barry, Newly Introduced Capstone Design Course for Mechanical Engineering Technology – Lessons Learned From Two Cohorts and Two Types of Projects, presented at the 123rd ASEE Annual Conference & Exposition. June 26 - 29, 2016 New Orleans, LA
13. E. Y. Tanbour, Design Optimization and Frequency Analysis of Blast Resistant Doors for 30 G-Force Rating, Canadian Journal on Mechanical Sciences & Engineering, vol. 2, No. 7, November 2011, pp. 157 - 162
14. M. F. Alzoubi, E. Y. Tanbour and R. Al-Waked, Compression and Hysteresis Curves of Nonlinear Polyurethane Foams under Different Densities, Strain Rates and Different Environmental Conditions. Accepted for publication and will appear in: Proceedings of IMECE11 2011 ASME International Mechanical Engineering Congress & Exposition November 11-17, 2011, Denver, Colorado, USA
15. E. Y. Tanbour, "Institutional Effectiveness, The Point Of View Of Southern Association Of Colleges And Schools (SACS)," Presented in the conference of the Vice Rectors for Quality in Saudi Universities, King Saud University, February 27-28, 2011
16. Emad Y. Tanbour, Rafat Al-Waked and Mohamed F. Alzoubi, Experimental Study of a Waste Heat Recovery System for Supplemental Heater, *proceedings of 3rd International Conference on Energy and Sustainability*, 11 - 13 April 2011, Alicante, Spain
17. Ramin K. Rahmani, Anahita Ayasoufi, Emad Y. Tanbour and Hosein Molavi, "Enhancement of Temperature Blending in Convective Heat Transfer by Motionless Inserts With Variable Segment Length" *Journal of Thermal Science and Engineering Applications*, September 2010, Vol. 2
18. Ramin K. Rahmani, Emad Y. Tanbour, Anahita Ayasoufi and Hosein Molavi, "Enhancement of Convective Heat Transfer in Internal Compressible Flows by Stationary Inserts" *Journal of Thermal Science and Engineering Applications* MARCH 2010, Vol. 2
19. Emad Y. Tanbour, Ramin K. Rahmani and Anahita Ayasoufi (2009), "Large-Eddy Simulation of Turbulent Flow Through Small Gage Gas Appliance Orifice," *Proceedings of IMECE 2009, 2009 ASME International Mechanical Engineering and Exposition, November 13-19, 2009, Lake Buena Vista, Florida, USA*
20. Emad Y. Tanbour and Ramin K. Rahmani, (2009), "Enhancement of Temperature Blending in Convective Heat Transfer by Motionless Inserts with Variable Segment Length," *Proceedings of IMECE 2009, 2009 ASME International Mechanical Engineering and Exposition, November 13-19, 2009, Lake Buena Vista, Florida, USA*
21. Emad Y. Tanbour and Ramin K. Rahmani, (2009), "A Numerical Study of The Thermal Performance of Two Stationary Insert Design in Internal Compressible Flow," *Proceedings of 2009 ASME Summer Heat Transfer Conference, HT2009, July 19-23, 2009, San Francisco, Ca, USA*

22. Emad Y. Tanbour and Ramin K. Rahmani, (2008), "Enhancement Of Natural Convection Heat Transfer Rate In Internal Compressible Flows By Inserting Stationary Inserts," *Proceedings of 2008 ASME Summer Heat Transfer Conference, HT2008, August 10-14, 2008, Jacksonville, Florida USA*
23. Emad Y. Tanbour and Ramin K. Rahmani, (2008), "Experimental Study Of Convective Heat Transfer In A Vertical Pipe With Stationary Inserts," *Proceedings of 2008 ASME Summer Heat Transfer Conference, HT2008, August 10-14, 2008, Jacksonville, Florida USA*
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25. Butler, P. B., Tanbour, E., Rahman, S., and Smith, T. F., "Virtual International Design Teams," *Proceedings of 2002 ASEE Midwest Section Meeting, Madison, WI, September 2002*
26. Abdel-Malek, K., Yang, J., Brand, R., and Tanbour, E., (2002), "Towards Understanding the Workspace of The Upper Extremities," 2001 SAE Transactions, *Journal of Passenger Cars: Mechanical Systems*, Vol. 110, Section 6, pages 2198-2206.
27. Mi, Z., Kim, J., and Abdel-Malek, K., Nebel, K., Tanbour, E., "Optimization Based Posture Prediction," *Seventh International Symposium on the 3-D Analysis of Human Movement*, Newcastle, United Kingdom, July 10 - 12 2002
28. Abdel-Malek, K., Yang, J., Brand, R., and Tanbour, E., "Towards Understanding the Workspace of the Upper Extremities," *Proceedings of SAE Digital Human Modeling for Design and Engineering*, 2001-01-2095, June 26-28, Arlington, VA, USA. [2001 Arch T. Colwell Merit Best Paper Award]
29. Abdel-Malek, K., Yu, W., Tanbour, E., Jaber, M., (2001), "Posture Prediction versus Inverse Kinematics," *Proceedings of the ASME 27th Design Automation Conference*, 2001 ASME Design Engineering Technical Conferences, Pittsburgh, Pennsylvania, U.S.A. September 9-12, 2001
30. K. Abdel-Malek, Y. Wei and E. Tanbour, "Inverse Kinematics using Cost Functions," *IASTED International Conference, Robotics and Manufacturing (RM 2001)*, Cancun, Mexico, May 2001
31. Tanbour, E. Y., and Ahmarow, M. E., "Design and Optimization of Fire-tube Boilers for Large Dairy Processing Plants," *Caroline Dairy Company, Amman, Jordan, Final Report*, ME Department, Yarmouk University, Irbid Jordan, 1987.
32. Tanbour, E. Y. and Ahmarow, M. E., "Design Calculations for Cooling Systems of Industrial Gas Turbines," *ME final Report*, Yarmouk University, Irbid, Jordan, 1987.
33. Tanbour, E. Y., "Pressure Distribution on Rotating Cylinders in Cross Flows," *ME final Report*, Graduation Project, ME department, Jordan University of Science and Technology, Irbid, Jordan, 1987.

34. Tanbour, E. Y., "Design and manufacturing of new pressure measurement mechanism on rotating bodies in cross flows," Final Report, ME Department, Jordan University of Science and Technologies, Irbid, Jordan, 1988.
35. Tanbour, E. Y., "Wind Energy in Jordan," Department of Energy, Jordan, and Jordan University of Science and Technology, Irbid, Jordan, 1989. Project was funded by United Nations
36. Tanbour, E. Y., "Heat Transfer to Gas-Solid Suspension Flows in Vertical Pipes," M.S. Thesis, Jordan University of Science and Technologies, Irbid, Jordan, 1990.
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39. Tanbour, E. Y., "CFD and Heat Transfer Simulation of flow in co-axial elbows with internal baffles. Application to venting of zero-clearance fireplace chimney pipes." Hearth and Home Inc., Lakeville, MN, USA, 2000
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41. Tanbour, E. Y., Hu, J. and Smith T., "*Waste Heat Recovery Heat Exchanger for Supplemental Heaters*," Technical Report ME-01-006, Department of Mechanical Engineering, The University of Iowa, Iowa City, Iowa, 52242, USA, July 2001
42. Tanbour, E. Y., Yu, X. and Smith, T., "*Literature Review of Flexible and Adaptive HVAC Distribution Systems for Office Buildings*," Technical Report ME-01-005, Department of Mechanical Engineering, The University of Iowa, Iowa City, Iowa, 52242, USA, July 2001
43. Tanbour, E. Y., "Prince M. Bin Fahd University, Strategic Plan for National Commission for Academic Accreditation and Assessment". August 2009
44. Tanbour, E. Y., "Prince M. Bin Fahd University, College of Engineering Strategic Plan for ABET Accreditation". August, 2009 to February 2011
45. Tanbour, E. Y., "Prince M. Bin Fahd University, College of Engineering Academic Catalog, Revision". August, 2009 continuing
46. Tanbour, E. Y., "Prince M. Bin Fahd University, Strategic Plan for (Sothern Association of Colleges and Schools) SACS Accreditation". August, 2009 continuing.
47. Tanbour, E. Y. (Joint author with Professor Jamal Nayfeh, Dean of College of Engineering)," Master of Science in Mechanical Engineering, Program Specifications, Courses Specification and Syllabi in compliance with National Commission for Academic Accreditation and Assessment (NCAAA). Prince M. Bin Fahd University, December 2011.

48. Tanbour, E. Y. (Joint author with Professor Jamal Nayfeh, Dean of College of Engineering),” Master of Science in Energy Systems Engineering, Program Specifications, Courses Specification and Syllabi in compliance with NCAAA. Prince M. Bin Fahd University, December 2011.
49. Tanbour, E. Y. (contributing author with Professor Jamal Nayfeh, Dean of College of Engineering),” Master of Science in Electrical Engineering, Program Specifications, Courses Specification and Syllabi in compliance with NCAAA. Prince M. Bin Fahd University, December 2011.

USA AND INTERNATIONAL PATENTS

Total 11+ issued and pending patents and a total of 17+ prior arts and patents:

No.	US Patent Ref. Number	Patent Title
1	US 2019/0145507 A1	Slider-Crank Mechanism For Eliminating Side Forces
2	D607094	Air Intake For A Water Heater
3	US20090308332	Water Heater With Forced Draft Air Inlet
4	US20100065203	Sealable Water Heater Manifold Doors
5	D614680	Sight Glass And Frame
6	US20100101510	Water Heaters With Sealed Door Assembly
7	US20100154724	Water Heater Burner Tube And Door Assembly
8	8490580	Water Heaters With Sealed Door Assembly
9	US20100101508	Water Heaters With Sealed Door Assembly
10	US20130284118	Water Heaters With Sealed Door Assembly
11	US20100101509	Water Heaters With Sealed Door Assemblies
12	US20100101507	Water Heaters With Fuel Line And Door Assembly
13	8596226	Water Heater Burner Tube And Door Assembly
14	US20090084328	Water Heaters With Combustion Air Inlet
15	US20040011348	Apparatus And Method For Cooling A Surface Of A Fireplace
16	6848441	Apparatus And Method For Cooling A Surface Of A Fireplace
17	9,948,081	Asymmetric Aeolian Vibration Damper

COMPUTING AND CAD SKILLS

CAD: Advanced in: SolidWorks (2005-present), PRO/ENGINEER (CREO 1995-2005), PolyWorks (2016-Present). Working experience in AutoCAD, Inventor, Bentley and Revit.

SIMULATION: Advanced in: SolidWorks Simulation (SimulationWorks), Lab View (Core 1 and Core 2 certified, National Instruments® 2011), Unity 3D and Middle VR

FEA: ANSYS (1996-present), SimulationWorks (2005-present), Cosmos Works (2005-2009), PRO/MECHANICA (1997-2005)

CFD: ANSYS-FLOTTRAN (1997) and ANSYS (Fluent) (2003-present)

PROGRAMMING: FORTRAN Programming 1984-present

MICROSOFT: Microsoft Office (Word, Excel, Power Point, Outlook and Visio), Microsoft Project (1997-present)

MANAGEMENT: Product Data Management (PDM), PDM Works, Enterprise Software, production mainframe software, strategic planning and implementation.

MANAGERIAL FINANCE:

Advanced practical experience in financial analysis for project management and departmental budgeting and planning. Completed Advanced Financial Analysis Executive MBA course work with Professor John Spitzer, Senior Analyst-Board of Governors, Federal Reserve, at the University Of Iowa-Tippie School of Business.

LEARNING (LMS): Blackboard®, SMART Notebook for SMART interactive whiteboard, Banner (Academic ERP system)

Panopto® for online course development and delivery

Wiley Plus® by Wiley, McGraw-Hill Connect® and Pearson Mastering Engineering ®

CANVAS: 2016-present: self-trained-Using Canvas on all my online and in-class courses

OTHERS: Certified Training on FARO® Arm Laser Scanner (2016), 3DSTUDIO MAX, Maya and LaTeX® (introductory)

PROFESSIONAL ACTIVITIES AND CERTIFICATIONS

LICENSES AND OTHER TRAINING

- Engineer-in-Training State of Iowa, 1998
- Certificate of Completion: Failure Mode and Effect Analysis
- Apples and Oranges (Corporate Finance Training)

ACTIVE MEMBERSHIP

- Member of the founding body at Aramco Combustion Institute - Chapter, 2010-present
- Professional Member of the American Society of Metals (ASM), 2004-present.
- Member of Combustion Institute, 1998-present.
- Member of the American Society of Mechanical Engineers (ASME) 1992-present.

- Member of Jordan Society of Engineers, Mechanical Engineering, 1987-present.
- Member of the Pioneers' Committee, American Institute of Sustainable Science and Technology, UI Oakdale Research Campus, Iowa City, Iowa, 1999-present
- Member of the Advisory Board of the Digital Human Lab-Center for Computer Aided Design (CCAD), The University of Iowa, Iowa City, Iowa, 2000-present

CERTIFICATION

- OSHA Certified Safety Manager, 2001-present.
- First Aid Certified, American Red Cross 1999-present.
- CPR Certified, American Red Cross 1999-present.

HONORS & AWARDS

- *Arch T. Colwell Merit Award*, Society of Automotive Engineers (SAE) USA: Author of best paper voted among over 3000 papers in the field of dynamics and ergonomics in the proceedings of SAE.
- *Ph.D. Scholarship Award*, Jordan University of Science and Technology, 1992-1997.
- *Teaching/Research assistantship*, 1990-1997 through M.Sc. and Ph.D. programs.
(This was concurrent with my Ph.D. Scholarship Award from Jordan University of Science and Technology)

SERVICE ACTIVITIES

Eastern Michigan University, Mt. Pleasant, Michigan, USA

- Serving as Program Coordinator for Mechanical Engineering Technology, starting the fall of 2016 until Fall 2018
- Serving as Program Coordinator for Mechanical Engineering, starting the fall of 2017
- Serving as Program Coordinator for Master of Engineering Management, starting the fall of 2017
- Representing CET at the University Budget Council, Eastern Michigan University-Faculty Senate, 2-years Appointment (2016-2018) - Still serving as alternate member.
- Serving member of the SET Strategic Planning committee, 2016-2018 cycle
- Serving member SET Finance Committee, 2016-2018 cycle
- Serving member School of Engineering Personnel Committee (2018-present)
- Serving member College of Engineering and Technology Assessment Committee (2018-present)
- Serving member of Faculty Council, College of Engineering and Technology (2018-present)
- ABET coordinator for SE (Summer 2018-present)

- Chaired faculty search committee for Mechanical Engineering resulted in hiring Dr. Andrew Mansfield
- Served as member of search committee for Information Assurance

Central Michigan University, Mt. Pleasant, Michigan, USA

Served as Program Coordinator for MET starting the fall of 2015 - Summer 2016

Served as Member of the MET Assessment Committee

Served in the School of Engineering and Technology Graduate Committee September 2014 until present. In charge of developing the assessment plan for the MSE program. Presented the assessment plan to the CMU Assessment Council

Assisted SET in the preparation for ABET accreditation visit for the Mechanical Engineering Technology Program.

Conducted semester-long weekly training session on SolidWorks for Graduating Cohort of MET students (Spring 2014 and Spring 2016)

Conducted semester-long weekly training session on SolidWorks for MET and ME Sophomore students (Fall 2014)

Conducted Weekly training session on SolidWorks for CMU-Art Department Faculty and Students (Fall 2014)

Served in search committee resulted in hiring Dr. Oumar Barry and Dr. Ernur Karadogan for the MET program.

Prince M. Bin Fahd University, KSA

- 1) Department of Mechanical Engineering
 - Member of Curriculum Review Committee, 2009-2013
 - Member, Assessment Committee, 2009-2013.
- 2) College of Engineering
 - Member of College of Engineering Council, 2009-2013
- 3) University
 - Member of University Council, 2010-2013.
 - Member of Senior Management Board, 2009-2013.
 - Member of several University-wide committees in Quality, Accreditation, Internationalization and Research, 2009-2013
 - Director of Quality Center and Institutional Relations, 2010

- Member of Rector's advisory committee, 2010-2013

Department of Economic Development, State of Iowa, USA

- Co-Chair, Advanced Technology Board, 1999-2001

University of Iowa: Center for Computer Aided Design, Iowa City, Iowa, USA

- Member of the Advisory Board, 2001-present

ABET, Accreditation Board of Engineering and Technology, USA

- Industry Consultant, 2000-2005-Worked closely with Dr. George Peterson, ABET Emeritus President. Continuing to work with Dr. Peterson during his international accreditation activities.

Conferences and Processional Meetings

- Chair of "Practical Combustion" session of the Combustion Institute, George Washington University, Washington DC 1998
- Session Chair, Engineering Criteria 2000 workshop of ABET EC2000, Accreditation Board of Engineering and Technology, Newton, Iowa, Sept. 23-24, 2000 – This workshop was funded by Maytag Corporation.
- Keynote Speaker, Davinci Conference, Iowa Department of Economic Development, Des Moines, Iowa Feb 2001

Habitat for Humanity

- Volunteer Home Builder, Muscatine, Iowa 1998.

TALKS, SEMINARS AND PRESENTATIONS:

1. **Emad Tanbour**, The Faculty Forum Seminar on Sunday "Computer Aided Engineering," Sunday, December 20, 2009, Learning Resource Center Room, Prince M. Bin Fahd University, Al-Khobar, KSA
2. **Emad Tanbour**, Al-Zamil Company: Design of Quick-Connect floor-to-wall partition system for Saudi Aramco, 2011

3. **Emad Tanbour**, Design of Penstock and Sluice Gates Using SolidWorks and SolidWorks Simulation®, Presentation to Al-Kuhaimi Metal Industries, Special Projects Division, Second Industrial City, Dammam, KSA, Feb 5, 2011
4. **Emad Tanbour**, “Overview of Prince M. Bin Fahd University and an Update on Accreditation Projects,” A Short lecture presented to the Annual Meeting of Vice Rectors for Quality and Development in Saudi Universities, King Saud University, Riyadh, KSA, Feb, 27, 2011
5. **Emad Tanbour**, Eight introductory workshops on “Requirements of National Commission for Academic Accreditation and Assessment,” presented to Faculty of All departments at Prince M. Bin Fahd University during Spring 2010 and Fall, 2010/2011
6. Represented Prince M. Bin Fahd University (PMU) during the Summer Annual Conference of Accreditation Board of Engineering and Technology (ABET) during the Month of July 2011 in Washington DC, USA
7. Attended 20-hours Workshop on Business Planning at Saudi Aramco During the Month of October 2011
8. Represented PMU in the pre-applicant workshop for Southern Association of Colleges and Schools (SACS), held in Decatur, Georgia, USA, April 2010

HIGHLIGHTS OF DESIGN AND MANUFACTURING EXPERIENCE

Energy Systems Experience

- Over 19 years of experience managing cross-functional teams of product development engineering, serving residential energy efficient fireplaces, stoves, water heaters (Gas fired, wood fired and Electric).
- Development of new generation of FVIR (flammable vapor ignition resistant) Water Heaters.
- Experience in developing and manufacturing of Power-Vented residential water heaters and methods of improved combustion.
- Managed and implemented the production of the world first Ultra Low NOX residential water heater compliant to California, USA emission requirements.
- Managed and designed a high efficiency Combustion Water Heater. US DOE designated Energy Star ® water heater.
- Developed a patented combustion air diverting system for power vented residential water heaters. System is in production and successfully achieved cost effectiveness and performance improvement goals. System was recently qualified for the Department of Energy program of Energy Star designation for meeting high energy factor required for water heating equipment.
- Managed and implemented into production the Energy-Smart Gas® water heater. An intelligent gas water heater that utilizes control algorithms enabling water heaters to adapt to household hot water consumption pattern. This product is in production and is sold under Whirlpool Brand throughout North America.

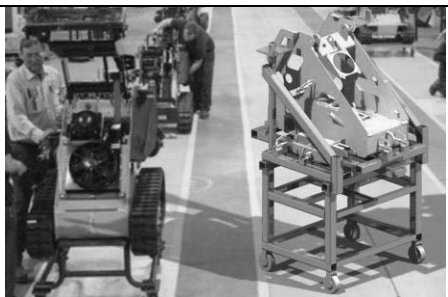
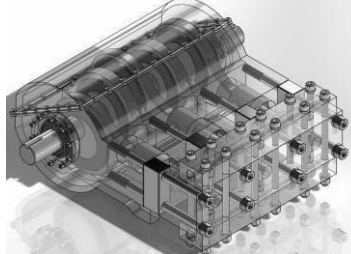
- Designed and implemented into production a new manifold door and burner assemblies for sealed combustion flammable vapor resistant water heaters.
- Thermal Analyst, NASA Cassini Space Mission to Saturn, Physics Department, The Univ. of Iowa, Iowa City, Iowa (1993-1996)

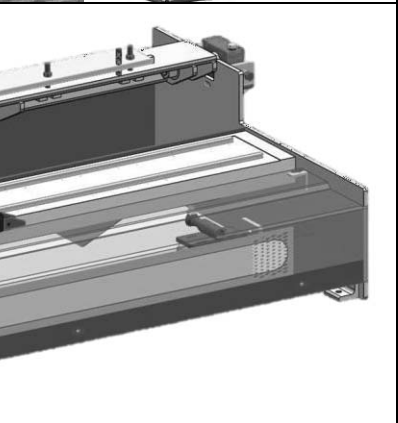
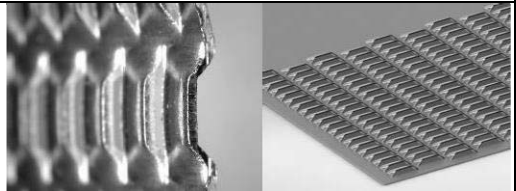
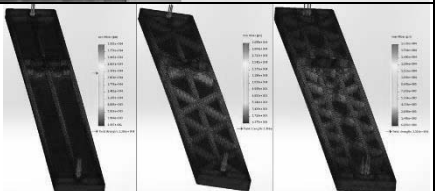
Interdisciplinary Mechanical Engineering Experience:

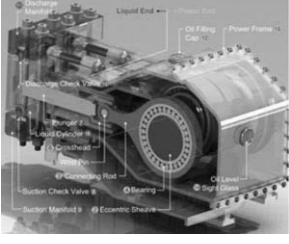
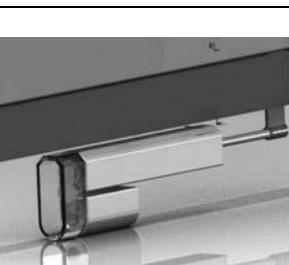
- Seating design, seating mechanism design, seating structural optimization, seating comfort and ergonomics applications in seating. Major seating projects: Allsteel #19 Chair ® (award winning signature product) and Allsteel Sum® Chair (award winning ergonomic signature office product).
- Storage systems design and sheet-metal applications in office storage systems. Alternative materials for office furniture.
- Office system design and development. Major projects: Allsteel Concensys®, Terrace 2.6, Reach and HON Initiate systems.
- Finite Element Analysis of seating, storage and office systems.
- Acoustics testing and optimization of office systems.
- Material development and inventiveness for green buildings of the future. A major project to utilize sustainable and renewable natural fiber to develop paneling alternative materials for construction applications. This panel system is in production since 2005.

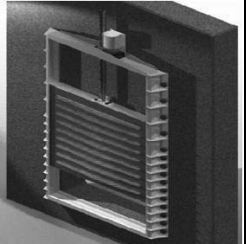
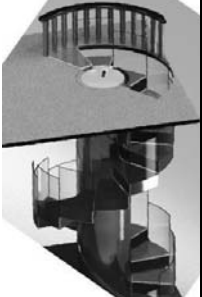
SELECTED SENIOR CAPSTONE PROJECTS SUPERVISED

I have utilized my solid industrial background in senior design courses. The following are samples of students' designs:

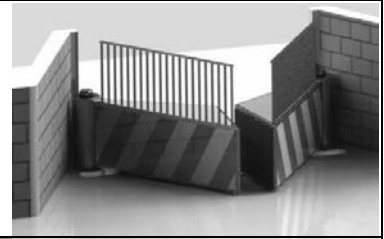
Project title	Presentation
1. CMU- Morbark Corporation, Winn, MI, Design of Robotic Welding Fixture for Morbark Boxer Ride-on earth movement machines. Spring 2016	
2. CMU- Gail Industries, Cedar Rapids, Iowa, Design and rapid prototyping of bearing-size-driven triplex plunger pump, Spring 2016	

3. CMU- Vantage Plastics, Standish, MI, Design and testing of toggle mechanism clamping system for rotary thermoforming process, Spring 2016	
4. CMU- SAE Baja and SAE Formula team (co- advised with Oumar Barry), Spring 2016	
5. CMU - Redesign of Morbark knife grinding machine. (Spring 2015) Senior MET and IET senior students	
6. CMU - Reverse Engineering of Flame Traps used in flammable vapor resistant water heaters – Sponsored by A. O. Smith – Milwaukee, WI (Spring 2015) 5- MET and IET senior students	
7. CMU - Converting machined steel office furniture components into die cast aluminum design and simulation of failure. Sponsored by Valley Design – Iowa (In progress)	2 MET senior students 
8. CMU Baja Project: Redesign and building of new suspension system (Spring 2015 – In progress)	5 MET and IET senior students 
9. CMU Formula One Car: Redesign and manufacturing of the differential system for Formula One car. (Spring 2015 – In progress)	5- MET and IET senior students 

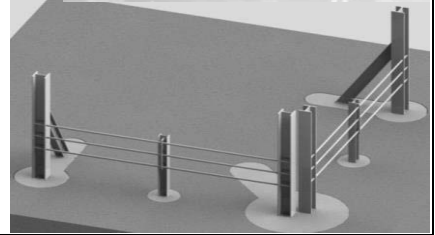
10. Design of High Pressure Triplex Pump, Spring 2010 Objective: Students to design a triplex plunger pump to be used for high pressure washing in a country where fresh water is not abundant. The team to come up with a crank shaft design concept that does not need forging which is not widely available in the country.	
11. Design of a 30 KW Wind Turbine, Spring 2010 Objective: Students to design a 30 kW wind turbine to generate electricity in rural farms of eastern province of the country utilizing the Shemal wind corridor of continuous 7 m/s wind across the half-moon bay area of the country.	
12. Single Passenger Solar Car, Spring 2010 Objective: Students to design a single passenger solar car frame that can reach 25 km/hr. speed.	
13. Design of Highway Sand Scoop, Fall 2010 Objective: Students to design implement that can be hooked to power-take-off drive of an off-road vehicle to scoop drifted sand from highways in the Gulf countries	
14. Design of Rain/Dust storm-sensitive window, Fall 2010 Objective: Students to design a mechanism driven by linear actuator and sensors to automatically shut windows upon rain or sand storms.	
15. Design of Aluminum Can Crushing Mechanism for recycling beverage cans, Fall 2010 Objective: Students to design a compaction mechanism that is capable of crushing aluminum beverage cans for purposes of recycling in a country where recycling is not widely utilized. Design animation was utilized to optimize and synchronize compaction and ejection mechanisms.	
16. Design of Solar Car II, Spring 2011 Objective: This is a continuation to Spring 2010 solar car project. Students to enhance suspension system of the solar car frame and to design a light weight body.	

17. Design of a 4m² Penstock-Dam Door, Spring 2011 Objective: Students to utilize fluid statics along with mechanical engineering design knowledge to design a remotely operated penstock dam-door (sluicgate). This project was aimed at using such gates to control flash flooding and prevent catastrophic cases repeated at the second largest city in the country (Jeddah)	
18. Design of a New Concept Wheelchair, Spring 2011 Objective: Students to design a new concept wheelchair where ratchet-driven wheels are replacing traditional wheel operated chairs. The project was led by one of senior students whose father is handicapped and received excellent sponsorship from a local manufacturer who is conducting feasibility studies on the design outcome.	
19. Design of a Date-Picking elevator, Spring 2011 Objective: Students to design an elevator to be used to harvest and serve palm trees in Al-Hasa oasis region (12 million palm trees). The aim is to expedite harvesting and improve safe handling of dates done manually most of the time. The elevator to be easy to operate using hydraulic actuators and maneuvered via farm tractors.	
20. Design of a Spiral Escalator, Spring 2011 Objective: Students to design and virtually prototype a spiral escalator system to be used in application where space is limited.	
21. Design of a Low Cost Hospital Bed, fall 2012: Students to design a low cost hospital be to be used in the field hospitals serving in disaster areas.	
22. Design of a truck-mounted Date Harvesting Implement, fall 2012: Students to design implement that can be mounted on a flatbed truck to be used to harvest dates from palm trees.	

23. Design of a road blocker, fall 2012: Students design a road blocker used to prevent unauthorized vehicles from entering high security areas.



24. Design of a Crash Resistant Fence, Fall 2012: Students designed a crash resistant fence according to US Department of State requirements to prevent crashing of hostile vehicles intruding into industrial, petrochemical and defense installations.



25. Characterization of drive belt tensioner for Ford Company. Team of four senior Mechanical engineering students.



26. Design and build of a lifting walker. Team of four Mechanical Engineering Seniors.



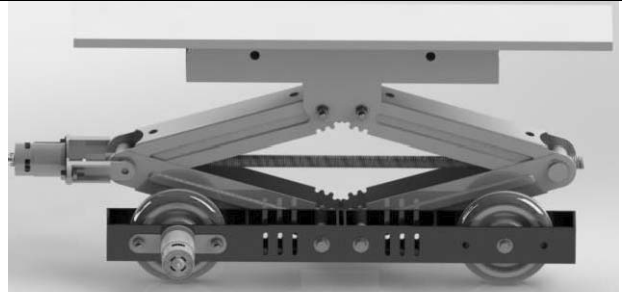
27. Design and build of a drone mounted gutter cleaner. Team of three senior Mechanical Engineering students.



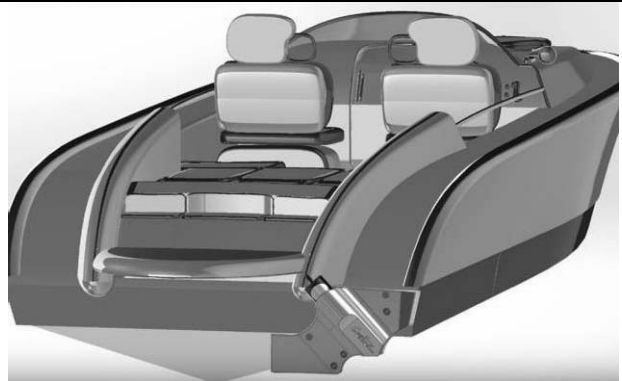
28. Design and build of a wearable charging system.



29. Design and build of Under-Vehicle Parallel Parking System (UVPPI). Team of 4-Senior ME students.



30. Design and build of a surf-wave generator mounted on a surf boat.



ASSESSMENT & QUALITY IN HIGHER EDUCATION (HIGHLIGHTS):

- Currently serving as member of the Graduate Committee of the School of Engineering and Technology, Central Michigan University. I was in charge of developing the Assessment plan for the newly developed Master of Science in Engineering planned to start fall 2015.
- Currently serving in the MET Assessment Committee which is focused on improving program level and course level assessment for the MET program as well as prepare for the readiness to ABET ETAC Commission accreditation
- Served for 5 Years in the State of Iowa, USA as industry consultant to ABET (Accreditation board of Engineering and Technology). Chaired training sessions on ABET criteria in the State of Iowa.
- Designed and implemented ABET readiness program for the college of engineering (Mechanical, civil and electrical engineering)
- Strong experience in outcome-based assessment, curriculum development and course/program specification to comply with accreditation standards.
- 14+ Years' experience leading strategic implementation of ABET, NCAAA and SACS compliance at Prince M. Bin Fahd University (PMU) (NCAAA is National Commission for Academic Accreditation & Assessment). Trained university-wide faculty and staff on NCAAA protocol. Developed strategic plans to comply with NCAAA and is leading the process to Quality and Accreditation at PMU

DETAILED INDUSTRIAL EXPERIENCE

1. (1988-1989) **Technical Support Engineer**, Dar-Al-Riyadh Engineering, Dhahran. Conducted field-training sessions for customers on instrumentations and gas detection equipment. Held weekly seminars at customer locations on gas detection technology, maintenance and operation of various gas detection instruments. Collaborated with manufacturers of equipment to enhance, develop and troubleshoot gas detection equipment.
2. (1993-1997) **Director of Engineering**, Gail Industries, Cedar Rapids, Iowa, USA. Managed the engineering department of Gail Industries, a major manufacturer of light weight, energy efficient high-pressure triplex pumps. Implemented CAD introduction and applied CAM to three new generation high-pressure light weight pumps. Top-down designed and managed the launch of Model 10000 and Model 20000 high-pressure triplex pumps for oil drilling applications. Designed a new-concept injection pump for the use in process applications. Designed and managed the manufacturing of 500hp mud pumps (Gail model 80) for the use in oil-well service applications and oil drilling industry in Bakersfield, California. Model 80 is a light weight and high efficiency family of mud pumps designed for helicopter delivered pumps for offshore oil drilling applications.
3. (1997-2005) **Senior Project Manager (R&D)**, HNI Technologies, Stanley M. Howe Technical Center. Muscatine, Iowa, USA. Managing research and development projects for six company divisions (Allsteel[®], Hon Company[®], Gunlocke[®], Maxon[®], Quadra Fire[®], Heat-N-Glo[®] and Heatilator[®])
4. (2005-2009): **Manager, Product Development Engineering**, A. O. Smith Corporation, Johnson City, Tennessee, USA. A. O. Smith is the second largest manufacturer of residential and commercial high efficiency energy star[®] water heaters in North America with global operations in USA, Mexico, Canada, Europe and China. I was managing the product development engineering department for residential water heater division. My department group is responsible for designing new water heaters and improvement/development projects for existing water heating technologies. The department is responsible for providing design and engineering leadership to 4.5 million residential water heating products produced annually across the globe. The group employs the state of the art experimental lab and cutting edge computational fluid dynamics and computational mechanics techniques. Computer Aided Design and CAM is fully deployed for all product platforms. Company produces energy star[®] water heaters for industry under the brand names of Whirlpool[®], A. O. Smith[®], State[®] and American Water Heaters[®] and other brands. A. O. Smith is a mid-cap blue chip company with annual revenue of over \$2.3 Billion

CAREER EXPERTISE AND SKILLS

<i>Technical</i>	<i>Industrial, Business & Management</i>
• Design and Product Development • Failure Mode and Effect Analysis (FMEA) • Engineering Change Request/Notice (ECN/ECR) • Sheet Metal Forming and Production Processes • Manufacturing Engineering • Finite Element Analysis: Structural and Thermal/Fluids applications. • Computational Fluid Dynamics • Virtual Reality Engineering Applications • Digital Human Modeling • Alternative materials/sustainability • Engineering Education • Computer Aided Design/Consumer Products • Engineering mechanics and materials • Industrial Applications of Thermo-fluids • <u>Data and Decision (Statistical Analysis)</u>	• Design and Manuf. Of Mud Pumps • Project Management • Managerial Financial Analysis • R&D Project Management • Strategic planning, Institution Building • New product end user research • Engineering-Marketing interfacing • Presentation/public speaking • Competitive strategies/cost effectiveness • Product launch and introduction • Business negotiation skills • Coaching/Mentoring and training • Organizational Behavior • Engineering/Business supervision • Managing product development cross-functional teams • GD&T ASME Y14.5-2009 revision

MAJOR CONSULTING EXPERIENCE:

1. Energy and sustainability assessment of thermoforming machines, Vantage Plastics, Standish, MI, Summer 2016
2. Design of Vibration Testing Platform for ISTA standards shipping testing, Vantage Plastics, Standish, MI, summer 2016
3. Design of heat transfer enhancement baffle system for EF models of high efficiency triple pass water heaters, Bradford White Corporation, Middleville, MI, summer 2016
4. Delivered short course (two-weekend days) in strategic planning for Oman Department of Dams (held in LA, CA, 2015)
5. (1993-1996) Thermal analyst, Cassini Spacecraft, NASA's Mission to Saturn, Jet Propulsion Lab and The University of Iowa Physics and Astronomy Department. Applied my Ph.D. thesis research code to simulate cooling of electronic components of Cassini Spacecraft. Won JPL's Award of outstanding thermal analysis application to electronic packaging. Cassini was launched in 1998. This is a three-year consulting work conducting electronic packaging (cooling) of components under vacuum conditions for space applications. Theoretical and experimental approaches were utilized. This work spanned over three years during my Ph.D. study at the University of Iowa. While working as a consulting graduate engineer at the physics department. The work was funded by NASA to develop electronic controls for the CASSINI probe that was launched to Saturn in the

late 1998. My responsibilities were in the area of thermal management of electronic controls under vacuum. I engineered experimental heat transfer (conduction and radiation) under vacuum conditions. I also utilized FORTRAN numerical code to simulate heat dissipation in electronic controls of CASSINI spacecraft.

6. 1994 Swirling Mixer Design, MiT-M Corporation, Peosta, IA, USA. This was a design and development of a swirling pre-mixer for oil-fired portable boilers that are used on pressure washing equipment. Flame stabilization mechanisms were optimized to provide customer needs.
7. 1998 Combustion Aerodynamics Design of Water Boilers for High Pressure Washers, MiT-M Corporation, Peosta, IA, USA. This was another design consultation for another MiT-M pressure washing system.
8. Several consulting services for Gail Industries (former employer) since 1997 in the areas of high-pressure triplex water pumps.
9. Structural analysis and failure diagnosis of aluminum extrusions for use in high-end office tables. The Gunlocke Company, New York , May-August 2005
10. CAD design of sheet metal and plastic components and assemblies of residential water heaters, using Solid Works®Design and failure analysis of sluice gates for flood control applications, Kuhaimi Metal Industries, KSA, 2009-present.
11. Design of Channel type sluice gates for Dammam Port Authority and Water Treatment Plants, , Kuhaimi Metal Industries, Dammam, KSA 2009-present
12. Design, failure and frequency analysis of explosion-proof doors for petrochemical, defense and security applications, Kuhaimi Metal Industries, SPD-Division, Dammam, KSA 2010-present
13. Design and Implementation of Parametric CAD assemblies for Hollow-Metal doors and Specialty Doors, Kuhaimi Metal Industries, SPD-Division, Dammam, KSA August 2011-in progress. Most Notable design achievements are: Design of fire exit doors for Al-Haramain Railroad Line between Medina and Mecca, design of fire-rated doors for Riyadh Metro, design of swing gates for Aramco-Bgaig Water Treatment Plant, design of explosion-proof doors for petrochemical plants in Jubail, and design of crash resistance barriers for residential compounds.

INDUSTRY-ACADEMIA COLLABORATIVE ACHIEVEMENTS

1. Co-chair of Advanced Technology Board, Department of Economic Development, State of Iowa, USA. The board mission is to deploy mechanisms and establish clusters of collaboration within the State of Iowa manufacturers to enable advanced technologies utilization. Board leadership constitutes of representatives from major Iowa industry and research and development institutions. The outcome of the Board efforts was translated into many successful establishments of rapid prototyping clusters within the state. These clusters were operated by major Iowa industry players but were made available to all regional manufacturers. Board has also succeeded in leading regular

advanced manufacturing training programs with the state that targeted industry leadership to deploy state of the art manufacturing and process techniques. The outcome of these programs was translated into collaborative efforts between major industry players to disseminate the know-how of Rapid Continuous Improvement (RCI) process. RCI is a version of the TOYOTA production system tailored for small to medium manufacturers that is solely based on Lean Manufacturing principles. The Board provided leadership and strategic planning services to industry clusters and established metrics to measure the progress of each initiative within the state.

2. Leading the research and development efforts at HNI Corporation in the areas related to Virtual Reality (VR) Simulation and Ergonomic Design of Consumer Products/Office Furniture. VR Projects were collaborated with the Digital Human Modeling Lab at the University of Iowa (2001-2005)
3. Collaborative research in the area of energy optimization of hearth systems (fireplaces and stoves) was conducted with Iowa Energy Center, Ankeny, Iowa (1999-2000)
4. Lead Engineer, Program for Enhanced Design Experience (PEDE), a collaboration program between HNI Corporation and The University of Iowa College of Engineering Senior Design Projects. (1998-2002)
5. Leading research projects at HNI Corporation related to personal climate control in office spaces and systems. Lead engineer from HNI Corporation in the Virtual International Design (VID) program collaborated between HNI Corporation, The University of Iowa and IUSTI – France (1999-2001)
6. Several lead engineer role in University-Industry initiatives and undergraduate senior design projects (1997-2005)
7. Project Manager of Allsteel Virtual Reality Facility (2001-2003). Allsteel, a division of HNI Corporation, Collaborated with The University of Iowa Center for Computer Aided Design to build the industry first virtual reality facility. The facility is used for visualization applications for product development and for marketing purposes.
8. Delivered a 40 hrs. Intermediate SolidWorks® training program for 15 engineers in Industrial City 1 – Dammam, KSA, March 2012
9. Delivered a 32 hrs. Advanced SolidWorks® training program for 15 engineers in Industrial City 1 – Dammam, KSA, April 2012
10. During spring 2015 Supervising three industry-sponsored Capstone Design Projects for undergraduate students in Mechanical Engineering Technology.
 - a. Redesign of a knife grinding machine for Morbark (Michigan)
 - b. Converting machined steel office furniture components into lower cost die cast aluminum design in compliance with BIFMA standards
 - c. Reverse Engineering and frequency analysis of flame traps used in Flammable

Vapor Ignition Resistant gas-fired water heaters.

11. Virtual Reality Design and Optimization of the Ambulance Patient Compartment. A Ford Motor Company sponsored project in collaboration with Huron Valley ambulance organization - Ann Arbor Michigan, July 2017 – August 31, 2018 (\$50,000 equipment funding)
12. Developed collaborative research relationship with EMU School of Nursing. Currently (2020) pursuing funding to develop EMU 1st Virtual Patient Room for School of Nursing teaching and research application. Proposal was jointly submitted with College of Nursing faculty Dr. Meriam Caboral-Stevens.

RECENT AND PAST R&D PROJECTS AND RESEARCH INTERESTS (1997-present)

1. Free Vibration of Flame Arrestors: A theoretical and numerical study of perforated plate flame arrestors used in domestic appliance to enable flammable vapor ignition resistance (FVIR). This research resulted in one journal publication in Sept 2015 and one more journal publication where the square pattern of perforation is examined. An indirect goal of this research is to enhance interdisciplinary Mechanical Engineering collaborative research between thermal fluids and Engineering Mechanics within the SET faculty.
2. Integrating Unity 3D game development software with Middle VR virtual reality content development software in a multiwall VR environment. This is an on-going effort in the VR lab at SET and currently employs three undergraduate students who are conducting system integration under the supervision of Dr. Emad Tanbour.
3. Enhancement of Machine Design teaching for MET seniors using project-based learning. This effort started in the spring of 2014 and continues to be utilized in teaching IET 454, the machine design course for MET seniors. The research is planned to be published in the upcoming ASEE 123rd annual conference in New Orleans, LA, USA, in 2016
4. Mechanism Designs for Seating Products: This project was conducted during my past industry experience at HNI Technical Center. The research was aimed at developing highly featured alternative chair mechanisms made of die-cast aluminum alloy. Finite element analysis and CAD using Pro-Engineer was used to develop the optimal chair mechanism. Mechanism provided features to allow ergonomic adjustment of the office chair for height, back tilt, seat tilt and slide and an innovative mechanism to adjust lumbar support in the back. The mechanism is based on user-weight activation principle developed at HNI and utilized in family of high-end office chairs.
5. Large-scale deformation modeling of irregular shaped cast aluminum parts. ANSYS® commercial finite element analysis software was utilized to predict failure and optimize components of office and storage mechanisms and platforms.
6. Computational modeling of fluid flow and heat transfer in 3D complex passages and applications

to fireplace venting. FLOTTRAN module of ANSYS software was used to predict flow and heat transfer in co-axial vent pipe and vent connections of stoves and fireplaces. Experimental measurements were used to validate modeling. This project developed a baffled co-axial vent elbow for direct-vented fireplaces that meets building standards for zero-clearance construction requirements.

7. Waste heat recovery from supplemental heating system. This project was sponsored in part by the Iowa Energy Center, Energy Research Station in Ankeny, Iowa.
8. Design, prototyping and testing of cross-flow compact heat exchangers for waste heat recovery from gas-fired fireplaces. This research developed a finned-tube heat exchanger that recovers waste heat from residential heating devices such as gas fired fireplaces and stoves. The recovery heat exchanger reduces flue temperature and allows the utilization of PVC/CPVC as venting pipe material.
9. Heat transfer and fluid flow in co-axial fireplace chimney pipes. Experimental work that was conducted in the HNI heart lab in Muscatine, Iowa. The work was aimed at characterizing flow and heat transfer in co-axial vent pipes for direct vent fireplaces and stoves. This experimental testing utilized the state-of-art data acquisition software and hardware to develop minimum and maximum vent lengths. Wind effect on direct-vented stoves was also studied and venting guidelines were established and used for agency certification and product literature development.
10. Optimal design of insulated flue pipes for fireplaces and stoves. Ceramic fiber blanket material was utilized to provide insulation for vent pipes.
11. The use of recycled engineered plastic to replace aluminum components for office systems applications. Connectors traditionally used for office cubical walls were replaced by plastic components that were extruded from recycled materials. The project aimed at cost reduction that achieved \$4 million annual savings during my industrial experience at HNI in Iowa.
12. Design and manufacturing of integrated mobile data acquisition systems for industrial hearth systems testing and applications. Data acquisition kiosks that houses hardware to enable large number of data logging channels and equipped with PC were manufactured for HNI hearth divisions Heatilator® and Heat-N-Glo®. These kiosks were used in agency certification labs and production lines to test fireplaces and stoves in real installation simulations.
13. Numerous FEA studies and applications to optimize the design of various industrial mechanical components. During my work at HNI (1997-2005) I led numerous finite element analyses of components used in office systems and hearth products. These simulations treated stress analysis due to mechanical loading and thermal effects. This represented a day-to-day design support activity and hundreds of FEA cases were completed annually.
14. CFD and heat transfer field applications for office environment
15. Virtual Reality (VR) Simulation and applications to ergonomic design of office furniture. This

project was in collaboration with the University of Iowa Center for computer Aided Design (CCAD). The technology of virtual reality was utilized for product development visualization as well as for marketing purposes. The outcome of this project was a joint effort that built two VR facilities, one at HNI and one at CCAD. Each VR facility provided a 3-wall environment that enabled immersive VR experience. Work included developing stereoscopic CAD models of office equipment that was VR enabled and animated in these VR facilities. The HNI facility is still used to date as a product development and visualization tool and a powerful marketing demonstration tool for showing future products to major customers. Photo-realistic and high fidelity renderings enabled the company to show future products to customers before going into production. The University of Iowa facility was used as a seed to attract funding for VR research. This seed attracted a multimillion (\$17million) grant that was awarded to CCAD over 5 years. The VR facility at the CCAD now houses the world first 6-wall PC-based VR environment.

16. Digital Human Modeling for ergonomic studies. This effort was in collaboration with the University of Iowa and HNI Technical Center. Digital human modeling was utilized to optimize workplace ergonomics and VR technology was used to visualize designs.
17. Thermal and acoustical simulation of comfort in office spaces. Thermal comfort experimental studies were conducted on HNI cubical workplaces. The testing was conducted by engineering interns from the University of Iowa College of engineering inside the university offices. Acoustical testing of noise propagation inside cubical office systems was conducted inside the labs of HNI Technical Center.
18. Finite Element Analysis of hydrostatically pressurized water heater tanks. This work is aimed at simulation of pressurization of water heater tanks to meet ANSI requirements on one hand and to optimize vessel wall thickness achieving cost reduction on the other hand.
19. Fatigue analysis of pulsation loaded water heater tanks. This work utilized Solidworks® COSMOS® FEA module to conduct fatigue analysis of water heater tanks. Water heater tanks experience pressure spikes due to water hammering and the use of other household devices that generate sudden pressure waves. This study provided in-depth analysis and characterization of the behavior of water heater tanks under cyclic loading. The outcome was implemented to predict reliability and to establish life expectancy of water heaters for warrantee purposes.
20. CAD design of sheet metal and plastic components and assemblies of residential water heaters, using Solid Works®
21. Design and failure analysis of sluice gates for flood control applications, Kuhaimi Metal Industries, KSA, 2009-present.
22. Design of Channel type sluice gates for Dammam Port Authority and Water Treatment Plants, , Kuhaimi Metal Industries, Dammam, KSA 2009-present
23. Design, failure and frequency analysis of explosion-proof doors for petrochemical, defense and security applications, Kuhaimi Metal Industries, SPD-Division, Dammam, KSA 2010-present

24. Design and FEA analysis of Crash Rated Fence (CRF) for Saudi Aramco, Kuhaimi Metal Industries, SPD-Division, Dammam, KSA 2011-present
25. Design and FEA analysis of Road Blockers, Kuhaimi Metal Industries, SPD-Division, Dammam, KSA 2011-present

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