

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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VERTIV CORPORATION

Petitioner

v.

VALTRUS INNOVATIONS LIMITED and KEY PATENT INNOVATIONS  
LTD.

Patent Owners

Patent No. 6,718,277  
Original Issue Date: April 6, 2004

Title: ATMOSPHERIC CONTROL WITHIN A BUILDING

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*Inter Partes* Review No. Unassigned

**DECLARATION OF JOHN P. ABRAHAM, PH.D.**

## TABLE OF CONTENTS

|       |                                                                   |    |
|-------|-------------------------------------------------------------------|----|
| I.    | INTRODUCTION .....                                                | 6  |
| II.   | MY BACKGROUND AND QUALIFICATIONS .....                            | 9  |
| III.  | MATERIALS REVIEWED .....                                          | 16 |
| IV.   | PERSON OF ORDINARY SKILL IN THE ART .....                         | 18 |
| V.    | RELEVANT LEGAL STANDARDS .....                                    | 20 |
| A.    | Claim Construction.....                                           | 20 |
| B.    | Prior Art.....                                                    | 23 |
| C.    | Anticipation .....                                                | 23 |
| D.    | Obviousness.....                                                  | 24 |
| VI.   | THE '277 PATENT .....                                             | 28 |
| A.    | Overview of the '277 Patent.....                                  | 28 |
| B.    | Prosecution History of the '277 Patent .....                      | 35 |
| VII.  | CLAIM CONSTRUCTION .....                                          | 39 |
| A.    | Petitioner's Constructions of the "Map" Claim Terms .....         | 41 |
| B.    | Patent Owner's Implied Constructions of the "Map" Claim Terms ... | 45 |
| VIII. | OVERVIEW OF THE PRIOR ART .....                                   | 46 |
| A.    | Technical Background.....                                         | 46 |
| B.    | Nakanishi.....                                                    | 52 |
| C.    | Bishop.....                                                       | 61 |
| IX.   | ANALYSIS OF THE PRIOR ART AND THE '277 PATENT CLAIMS ...          | 66 |
| A.    | GROUND 1: CLAIMS 1–21 ARE ANTICIPATED BY NAKANISHI .....          | 66 |
| 1.    | Claim 1 .....                                                     | 66 |
| a.    | 1[pre] .....                                                      | 66 |
| b.    | 1[a].....                                                         | 67 |
| c.    | 1[b] .....                                                        | 68 |
| d.    | 1[c].....                                                         | 69 |
| e.    | 1[d] .....                                                        | 72 |
| f.    | 1[e].....                                                         | 78 |

|     |                                                                         |     |
|-----|-------------------------------------------------------------------------|-----|
| 2.  | Claim 2 .....                                                           | 80  |
| a.  | 2[a].....                                                               | 80  |
| b.  | 2[b] .....                                                              | 82  |
| 3.  | Claim 3 .....                                                           | 82  |
| 4.  | Claim 4 .....                                                           | 83  |
| 5.  | Claim 5 .....                                                           | 85  |
| 6.  | Claim 6 .....                                                           | 85  |
| 7.  | Claim 7 .....                                                           | 87  |
| 8.  | Claim 8 .....                                                           | 88  |
| 9.  | Claim 9 .....                                                           | 89  |
| 10. | Claim 10 .....                                                          | 89  |
| 11. | Claim 11 .....                                                          | 92  |
| 12. | Claim 12 .....                                                          | 94  |
| 13. | Claim 13 .....                                                          | 96  |
| a.  | 13[a].....                                                              | 97  |
| b.  | 13[b] .....                                                             | 97  |
| 14. | Claim 14 .....                                                          | 97  |
| 15. | Claim 15 .....                                                          | 98  |
| 16. | Claim 16 .....                                                          | 99  |
| 17. | Claim 17 .....                                                          | 99  |
| 18. | Claim 18 .....                                                          | 100 |
| 19. | Claim 19 .....                                                          | 100 |
| 20. | Claim 20 .....                                                          | 101 |
| 21. | Claim 21 .....                                                          | 101 |
| B.  | GROUND 2: CLAIMS 1–6, 8–17 AND 19–21 ARE ANTICIPATED<br>BY BISHOP ..... | 102 |
| 1.  | Claim 1 .....                                                           | 102 |
| a.  | 1[pre] .....                                                            | 102 |
| b.  | 1[a].....                                                               | 103 |

|     |                                                                                                                                               |     |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------|-----|
| c.  | 1[b] .....                                                                                                                                    | 104 |
| d.  | 1[c].....                                                                                                                                     | 107 |
| e.  | 1[d] .....                                                                                                                                    | 109 |
| f.  | 1[e].....                                                                                                                                     | 115 |
| 2.  | Claim 2 .....                                                                                                                                 | 116 |
| a.  | 2[a].....                                                                                                                                     | 117 |
| b.  | 2[b] .....                                                                                                                                    | 118 |
| 3.  | Claim 3 .....                                                                                                                                 | 118 |
| 4.  | Claim 4 .....                                                                                                                                 | 122 |
| 5.  | Claim 5 .....                                                                                                                                 | 123 |
| 6.  | Claim 6 .....                                                                                                                                 | 124 |
| 7.  | Claim 8 .....                                                                                                                                 | 125 |
| 8.  | Claim 9 .....                                                                                                                                 | 127 |
| 9.  | Claim 10 .....                                                                                                                                | 127 |
| 10. | Claim 11 .....                                                                                                                                | 129 |
| 11. | Claim 12 .....                                                                                                                                | 131 |
| 12. | Claim 13 .....                                                                                                                                | 132 |
| a.  | 13[a].....                                                                                                                                    | 133 |
| b.  | 13[b] .....                                                                                                                                   | 133 |
| 13. | Claim 14 .....                                                                                                                                | 133 |
| 14. | Claim 15 .....                                                                                                                                | 134 |
| 15. | Claim 16 .....                                                                                                                                | 135 |
| 16. | Claim 17 .....                                                                                                                                | 135 |
| 17. | Claim 19 .....                                                                                                                                | 136 |
| 18. | Claim 20 .....                                                                                                                                | 136 |
| 19. | Claim 21 .....                                                                                                                                | 137 |
| C.  | GROUND 3: CLAIMS 1–21 ARE OBVIOUS OVER NAKANISHI<br>IN VIEW OF BISHOP AND THE KNOWLEDGE OF A PERSON<br>HAVING ORDINARY SKILL IN THE ART ..... | 137 |

|     |                |     |
|-----|----------------|-----|
| 1.  | Claim 1 .....  | 142 |
| a.  | 1[pre] .....   | 142 |
| b.  | 1[a] .....     | 142 |
| c.  | 1[b] .....     | 143 |
| d.  | 1[c] .....     | 143 |
| e.  | 1[d] .....     | 143 |
| f.  | 1[e] .....     | 148 |
| 2.  | Claim 2 .....  | 150 |
| a.  | 2[a] .....     | 150 |
| b.  | 2[b] .....     | 151 |
| 3.  | Claim 3 .....  | 152 |
| 4.  | Claim 4 .....  | 152 |
| 5.  | Claim 5 .....  | 153 |
| 6.  | Claim 6 .....  | 154 |
| 7.  | Claim 7 .....  | 155 |
| 8.  | Claim 8 .....  | 157 |
| 9.  | Claim 9 .....  | 158 |
| 10. | Claim 10 ..... | 158 |
| 11. | Claim 11 ..... | 159 |
| 12. | Claim 12 ..... | 160 |
| 13. | Claim 13 ..... | 161 |
| a.  | 13[a] .....    | 161 |
| b.  | 13[b] .....    | 162 |
| 14. | Claim 14 ..... | 162 |
| 15. | Claim 15 ..... | 163 |
| 16. | Claim 16 ..... | 163 |
| 17. | Claim 17 ..... | 164 |
| 18. | Claim 18 ..... | 164 |
| 19. | Claim 19 ..... | 165 |

20. Claim 20 .....165

21. Claim 21 .....166

X. CONCLUDING STATEMENTS.....166

I, John P. Abraham declare as follows:

**I. INTRODUCTION**

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

2. I have been engaged as an expert witness on behalf of Petitioner Vertiv Corporation. (“Petitioner” or “Vertiv”), and its counsel Nixon Peabody LP, in the above-captioned Petition for *Inter Partes* Review (the “Petition”). I am personally knowledgeable about the matters stated herein and am competent to make this declaration.

3. I am being compensated for my time in connection with this matter at my standard consulting rate. My compensation is in no way dependent on the outcome of this *Inter Partes* Review. The conclusions I present are based on my own judgement. I am not an employee of Vertiv, Nixon Peabody, or of any affiliated companies.

4. This Petition for *Inter Partes* Review involves U.S. Patent No. 6,718,277 (“the ’277 patent”) (Ex. 1001). The ’277 patent is titled, “Atmospheric Control Within a Building,” and lists Ratnesh Sharma as the inventor. The ’277 patent issued with 24 claims. Claims 1–21 are challenged (the “Challenged Claims”).

5. The '277 patent issued on April 6, 2004, from U.S. Application Serial No. 10/123,403, filed on April 17, 2002 (the "'403 application") Ex. 1001, cover.

6. For purposes of this *Inter Partes* Review, I have been instructed to assume that the effective filing date of the Challenged Claims is the earliest possible filing date, *i.e.*, the April 17, 2002, filing date of the '403 application.

7. I understand that according to the USPTO, the '277 patent is currently assigned to Valtrus Innovations Limited ("Valtrus" or "Patent Owner").

8. The '277 patent is directed to "a method and system for controlling atmospheric conditions within a building" that involves generating an "empirical atmospheric map . . . and compar[ing] to a template atmospheric map. Pattern differentials are identified therebetween and corrective action to reduce the pattern differentials is determined." Ex. 1001, Abstract. I am familiar with the technology described in the '277 patent as of the earliest possible priority date of April 17, 2002.

9. In preparing this Declaration, I have reviewed the '277 patent, the file history of the '277 patent (Ex. 1003), and each of the documents cited herein, and I have considered these documents in light of the general knowledge in the art as of April 17, 2002. In formulating my opinions, I have relied upon my experience in the relevant art. I have also considered the viewpoint of a person having ordinary

skill in the art (POSITA) in the design or evaluation of fluid flow systems for electronics cooling as of April 17, 2002.

10. I have been asked to provide my technical expertise, analysis, insights, and opinions regarding the '277 patent and relevant references, which form the basis of the grounds of rejection set forth in the accompanying Petition for *Inter Partes* Review of the '277 patent. As described in detail, I offer the following opinions in this Declaration:

- Claims 1–21 are anticipated by Nakanishi (Ground 1);
- Claims 1–6, 8–10, 12–17, and 19–21 are anticipated by Bishop (Ground 2);  
and
- Alternatively, Claims 1–21 would have been obvious over Nakanishi in view of Bishop and the knowledge of a POSITA (Ground 3).

11. In summary, and as will be explained in further detail below, a POSITA would have recognized that Nakanishi discloses every step of claims 1–21 arranged in the same way as claimed and that Bishop discloses every step of claims 1–6, 8–10, 12–17, 19–21 arranged as in those claims. Furthermore, using either of Nakanishi or Bishop as a starting point, a POSITA would have readily known and constructed a system for implementing methods having the functions and processes for the control of thermal conditions within a building as the Challenged Claims of the '277 patent. A POSITA would have performed these

processes by making simple modifications to the methods disclosed by those references because the references address the same or similar problems, the control technologies involved were predictable and well-known in the art, the modifications would have provided benefits that were understood, and the results of making the minor modifications were predictable and could be achieved with reasonable expectation of success.

## **II. MY BACKGROUND AND QUALIFICATIONS**

12. Throughout the remainder of this Declaration, I will refer to the field of atmospheric management in buildings, including thermal modeling and thermal management in buildings such as data centers, as the “relevant field” or the “relevant art.” In formulating my opinions, I have relied upon my training, knowledge, and experience in the relevant art. A copy of my current curriculum vitae is provided as Appendix A, and it provides a comprehensive description of my academic, project and employment history, including a list of relevant art publications for at least the last 20 years.

13. My expertise qualifies me to perform the type of analysis required in this case for the relevant field. Of particular relevance, I specialize in thermal sciences, which involves the science of flow (e.g., flow of heat, flow of fluids, etc.) and the physical processes that occur during these flows, as well as in thermodynamic cycles and processes. My experience encompasses heat transfer,

thermodynamics, and computational fluid dynamics. I have performed research and consulted for numerous companies on issues related to heat transfer and flow and electronics cooling. I have also consulted on the design, testing, and analysis of Heating, Ventilation, and Air Conditioning (HVAC) systems.

14. I started in the relevant art as a student at the University of Minnesota – Twin Cities where I earned a Bachelor of Science degree in Mechanical Engineering with a minor in Mathematics in 1997. In 1999, I earned a Master of Science (“MS”) degree from the University of Minnesota – Twin Cities, in the area of thermal-fluid sciences. My MS research project was in the areas of heat transfer, fluid flow, and thermodynamics. During my MS work, I designed, built, and tested heat exchangers for use in refrigeration and air conditioning applications.

15. I have taken numerous courses in thermodynamics, fluid mechanics, and heat transfer as part of my undergraduate and graduate degrees.

16. In 2002, I earned a Ph.D. degree in Mechanical Engineering in the area of thermal-fluid sciences, also from the University of Minnesota – Twin Cities, with my thesis on fluid and heat flows in enclosures such as buildings. During my doctoral program I served as a Teaching Assistant, then as a Graduate Teaching Fellow, and then as adjunct faculty.

17. In 2002, I joined the faculty of University of St. Thomas in St. Paul, Minnesota as an Assistant Professor in the Engineering Department. In 2008, I

became an Associate Professor at the University of St. Thomas in the Engineering Department. In 2013, I was promoted to a full professorship at the University of St. Thomas in the Engineering Department, where I currently teach topics associated with thermodynamics, heat transfer, and fluid mechanics, including the following classes: Heat Transfer (ENGR 384), Fluid Mechanics (ENGR 383), Advanced Thermal Design (ETLS 591), and Finite Element Analysis (ETLS 777). I have also taught courses that cover refrigeration and thermal management of electronics, and I have trained students to solve problems related to cooling of heat-generating devices, such as CPUs and cabinets that contain heat-generating components.

18. I have received several honors and awards during my teaching career, including the University of St. Thomas Engineering Professor of the Year in 2005; the University of St. Thomas John Ireland Award in 2009; and the University of St. Thomas Professor of the Year Award in 2016.

19. I have published peer-reviewed scientific papers detailing my work in heat transfer, fluid flow, thermodynamics, and temperature management of electronics. I have presented my work on these topics at technical conferences.

20. Over the past 20 years, I have served as a consultant to numerous companies to aid in the design or evaluation of fluid flow systems for electronics cooling. Examples of these companies include ADC Telecom (2000), MicroControl Company (2001), Lockheed Martin (2007–2009), Remmele

Engineering and Northrup Grumman (2002–2005). I have also performed my own studies of cooling of electronics, including computer systems and Central Processing Units (“CPUs”), as well as on cabinets that contain heat-generating components.

21. I have published numerous peer-reviewed studies on flow and distribution of fluids through manifolds and thermodynamic cycles (including heat exchangers and cold plates) and cooling of computer systems. I have produced approximately 500 publications, books, book chapters, conference presentations, and patents in areas including heat transfer, fluid flow, thermodynamics and analysis of the structures that convey fluids for heating and cooling. I am also a named inventor on multiple patents that deal with flow and heat transfer.

22. I have served as an editor of two highly rated series: *Advances in Heat Transfer* (Dr. John Abraham, Dr. John Gorman & Dr. Wolodymyr Minkowycz, eds., 2012 – Present) and *Advances in Numerical Heat Transfer* (W.J. Minkowycz, E.M. Sparrow & J.P. Abraham). These series bring together world leaders in the thermal sciences. I have been responsible for the curation, review, and editing of the submissions. I also served as Editor-in-Chief for the journals Numerical Heat Transfer Part A and Numerical Heat Transfer Part B. All of the studies published in these venues deal with heat transfer and/or fluid flow and the vast majority of them deal with the creation of thermal maps.

23. I have given numerous presentations and publications on atmospheric control techniques, such as cooling techniques and related heat transfer processes, as well as software tools for modeling heat transfer and fluid flow. Some examples include:

- *E.M. Sparrow, J.C.K. Tong, and J.P. Abraham, An Experimental Investigation on a Mass Exchanger for Transferring Water Vapor and Inhibiting the Transfer of Other Gases, International Journal of Heat and Mass Transfer, Vol. 44, pp. 4313-4321, 2001.*
- *E.M. Sparrow, G.L. Martin, J.P. Abraham, and J.C.K. Tong, Air-to-Air Energy Exchanger Test Facility for Mass and Energy Transfer Performance, Transactions of the ASHRAE, Vol. 107, (2) 2001.*
- *Sparrow, E.M., Martin, G.L., Abraham, J.P., and Tong, J.C., Air-to-Air Energy Exchanger Test Facility for Mass and Energy Transfer Performance. American Society of Heating, Refrigeration, and Air-Conditioning Engineers Annual Meeting, Inc., Cincinnati, OH, ASHRAE Symposium Paper, 2001.*
- *Ephraim M. Sparrow, John P. Abraham, and Paul Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, ASME International Mechanical Engineering Congress and R & D Expo, Washington, DC, November, 2003.*
- *John P. Abraham and Ephraim M. Sparrow, Methodologies to Enhance the Numerical Simulations of Electronic Cooling, Semi-Therm Conference, San Jose, CA, March 9-10, 2004.*
- *Ronald Major and John Abraham, The Application of Thermal Analysis on a Disk Array, Fluent's 2005 CFD Summit, Detroit, MI, June 7-8, 2005.*

- *E.M. Sparrow, J.P. Abraham, P.W. Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, Journal of Heat Transfer, Vol. 127, pp. 27-33, 2005.*
- *P.W. Chevalier, J.P. Abraham, and E.M. Sparrow, The Design of Cold Plates for the Thermal Management of Electronic Equipment, Journal of Heat Transfer Engineering, Vol. 27, pp. 6-16, 2006.*
- *J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, A Quasi-Analytical Method for Fluid Flow in a Multi-Inlet Collection Manifold, Journal of Fluids Engineering, Vol. 129, pp. 579-586, 2007.*
- *J.C.K. Tong, E.M. Sparrow, and J.P. Abraham, Attainment of Flowrate Uniformity in the Channels that Link a Distribution Manifold to a Collection Manifold, Journal of Fluids Engineering, Vol. 129 (9), pp. 1186-1192, 2007.*
- *J.C.K. Tong, E.M. Sparrow, and J. P. Abraham, Geometric Strategies for Attainment of the Identical Outflows Through all of the Exit Ports of a Distribution Manifold in a Manifold System, Applied Thermal Engineering, Vol. 29, 3552-3560, 2009.*
- *J.P. Abraham and G.S. Mowry, B.D. Plourde, Analysis of Thermal and Fluid Flow Problems, Thermal Packaging and Small Business Innovation Workshop, Eagan, MN, October 5-6, 2010.*
- *E.M. Sparrow, J.M. Gorman, K.S. Friend, and J.P. Abraham, Flow Regime Determination for Finned Heat Exchanger Surfaces with Dimples/Protrusions, Numerical Heat Transfer, Vol. 63, pp. 245-256, 2012.*
- *J.M. Gorman, EM. Sparrow, J.P. Abraham, and G.S. Mowry, Operating Characteristics and Fabrication of a Uniquely Compact Helical Heat Exchanger, Applied Thermal Engineering, Vol. 5, pp. 1070-1075, 2012.*

- *E.M. Sparrow, J. M. Gorman, and J.P. Abraham, Quantitative Assessment of the Overall Heat Transfer Coefficient U, Journal of Heat Transfer, Vol. 135, paper no. 061102, 2013.*
- *J.M. Gorman, M. Carideo, E.M. Sparrow, and J.P. Abraham, Heat Transfer and Pressure Drop Comparison of Louver- and Plain-finned Heat Exchangers Where One Fluid Passes Through Flattened Tubes, Case Studies in Thermal Engineering, Vol. 5, pp. 122-126, 2015.*
- *D. Nguyen, J. M. Gorman, E.M. Sparrow, and J.P. Abraham, Convective Heat Transfer Enhancement Versus Disenhancement: Impact of Fluid-Mover Characteristics, Applied Thermal Engineering, Vol. 90, pp. 242-249, 2015.*
- *J.M. Gorman, E., M. Sparrow, J.P. Abraham, W.J. Minkowycz, Heat Transfer Design Methodology Treating a Heat Exchanger Device and its Fluid-Mover Partner as a Single System, Heat Transfer Engineering, Vol. 38, pp. 841-852, 2017.*

24. A representative sample of the journals I have published in include the *International Journal of Heat and Mass Transfer*, the *International Journal of Heat and Fluid Flow*, *Numerical Heat Transfer*, *Advances in Heat Transfer*, the *Journal of Thermal Science and Engineering Applications*, *Frontiers in Heat Transfer*, *Applied Thermal Engineering*, the *Journal of Fluids Engineering*, the *Journal of Heat Transfer*, and the *Journal of Heat Transfer Engineering*.

25. I have also authored multiple publications on computational fluid dynamics (CFD), which involves mathematical modeling of heat transfer and fluid flow systems. I served as the principal investigator on a project dedicated to

performing CFD studies for the Supercomputing Institute from 2002–2012 and was a Research Fellow at that Institute for approximately the same time period.

26. A full list of my research works is provided in my CV, which is attached to this report as Appendix A.

27. The '277 patent concerns measuring, modeling, and controlling atmospheric conditions, such as temperature and flow, in buildings such as data centers. The '277 patent also discusses thermal maps created through the use of numerical simulation or through empirical measurements—both of which I am deeply familiar with. I recognize this technology as being well within the sphere of my experience and expertise, and I understand the technology described in the '277 patent fully. I believe my expertise and education in this field qualify me to explain this technology and to address the issues of patent validity from the perspective of a person of ordinary skill in the art. I am qualified to submit expert analyses in this proceeding.

### **III. MATERIALS REVIEWED**

28. I have relied upon my education, knowledge, and experience with control technology for building environments, as well as other materials discussed in this declaration in forming my opinions.

29. For this work, I have been asked to review the '277 patent, including the specification and claims and the '277 patent's prosecution history (file history).

In developing my opinions related to the '277 patent, I have considered the materials cited herein, including those items itemized in the Exhibit Table below:

| <b>Exhibit No.</b> | <b>Description</b>                                                                                                                                                                  |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ex. 1001           | U.S. Patent No. 6,718,277 (“the '277 patent”)                                                                                                                                       |
| Ex. 1003           | Prosecution History of the '277 patent                                                                                                                                              |
| Ex. 1004           | [RESERVED]                                                                                                                                                                          |
| Ex. 1005           | U.S. Patent No. 6,283,380 B1 (“Nakanishi”)                                                                                                                                          |
| Ex. 1006           | U.S. Patent Application Publication No. 2002/0149911 (“Bishop”)                                                                                                                     |
| Ex. 1007           | Infringement Claim Chart for the '277 Patent in <i>Valtrus Innovations Limited v. Digital Realty Trust, Inc. et al</i> , Case No. 2-24-cv-00139-JRG                                 |
| Ex. 1008           | U.S. Patent Publication No. 2003/0067745 A1 (“Patel”)                                                                                                                               |
| Ex. 1009           | U.S. Patent Publication No. 2003/0158718A1 (“Nakagawa”)                                                                                                                             |
| Ex. 1010           | U.S. Patent No. 6,188,189 (“Blake”)                                                                                                                                                 |
| Ex. 1011           | Tom Lee & Mali Mahalingam, <i>System Level Thermal Simulation of a Computer Chassis Using FLOTHERM Software</i> , 1993 FLOTHERM Int’l User Conf. Presentations 1 (May 1993) (“Lee”) |
| Ex. 1012           | 1979 Merriam-Webster’s New Collegiate Dictionary definition of “map”                                                                                                                |
| Ex. 1013           | 2002 MacMillian English Dictionary definition of “map”                                                                                                                              |

30. My review of these materials was informed by my education, my experience in and knowledge of industry, my work as a researcher, and my work as a consultant.

#### IV. PERSON OF ORDINARY SKILL IN THE ART

31. I have been asked to address the issues from the perspective of a person of ordinary skill in the art (“POSITA”) at the time ’277 patent was filed. The field of the invention of the ’277 patent relates to measuring and modeling of atmospheric conditions within a building environment containing heat generating sources such as computer equipment; thermodynamics; fluid dynamics; thermal management of heat generating systems; building cooling systems involving heat exchangers, cooling air, refrigerants or other fluids, piping, pumps, condensers, valves, compressors, fans, HVAC systems, and other equipment used in the above-referenced systems, among others.

32. I have been informed and understand that a POSITA is a hypothetical person who is presumed to be aware of all pertinent prior art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

33. I considered several factors, including the types of problems encountered in the art, the solutions to those problems, the pace of innovation in the field, the sophistication of the technology, and the education level of active workers in the field. In my opinion, a POSITA at the time of the alleged invention of the ’277 patent would have at least a bachelor’s degree in mechanical or chemical engineering or an equivalent discipline, together with two years of experience in the design and/or operations of atmospheric management systems for buildings or

electronics or computer systems; or a master's degree in mechanical or chemical engineering or an equivalent discipline, with two years of experience in design and/or operations of atmospheric management systems for buildings or electronics or computer systems.

34. A POSITA would have been familiar with the equipment, tools, principles and practices that the '277 patent admits as being part of the general knowledge of the art, including conventional cooling systems for computer rooms and data centers, as well as CFD software modeling tools, such as FLOVENT/AIRPACK. A POSITA would have understood and been familiar with a variety of types of cooling systems, including chilled water-based systems and refrigerant based systems, and associated components and subsystems such as cooling towers, condensers, compressors, and the like; and ventilation structures, connecting blowers, vents, etc. Ex. 1001, 5:18–24, 5:26–30, 6:43–46. I am very familiar with these systems, equipment components, tools, and the engineering and operating principles involved.

35. At all relevant times, I have had a level of skill at least that of a person of ordinary skill in the art. I am able to provide insight into the understanding of one of ordinary skill in this art at all relevant times by virtue of my education, training, and experience. All of my opinions expressed herein are as viewed through

the eyes of a person of ordinary skill in the art as of the April 17, 2002, filing date of the '277 patent.

## **V. RELEVANT LEGAL STANDARDS**

36. I have been asked to provide my opinions regarding whether the claims of the '277 patent are anticipated or 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. As a technical expert, I am not offering any legal opinions. Rather, I am offering technical assessments and opinions.

37. Although I am not a lawyer, 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 applied those standards in forming my opinions expressed herein.

### **A. Claim Construction**

38. The patent claims describe the invention made by the inventor and describe what the patent owner owns and what the owner may prevent others from using. I understand that an independent claim sets forth all the requirements that must be met to be covered by that claim. I further understand that a dependent claim does not itself recite all of the requirements of the claim, but refers to another claim and incorporates all of the requirements of the claim to which it refers.

39. I have been informed and understand that in order to properly evaluate the validity of the '277 patent, the terms of the claims must first be interpreted. I have also been informed and understand that during an *inter partes* review proceeding, the claims are to be given their plain and ordinary meaning for a person skilled in the art at the time of the invention. I have also been informed and understand that claim terms are given their ordinary and accustomed meaning as they would be understood by one of ordinary skill in the relevant art in view of the language of the claims, the written specification and figures, and the prosecution file history. I understand that an inventor may attribute special meanings to some terms by defining those terms or by otherwise incorporating such meanings in these documents.

40. I have followed these principles in my analysis throughout this declaration. In order to construe the claims, I have reviewed the entirety of the '277 patent and its prosecution history.

41. I also understand that the law allows patent applicants to claim a means for performing a particular function or step performed without having to recite those structures or acts in the language of the claims. I understand that such “means-plus-function” terms are limited to the specific structures or acts described in the patent’s specification that correspond to the claimed function, as well as any equivalent

structures or acts. I understand that if a term uses the word “means,” there is a presumption that it is a means-plus-function term.

42. I understand that determining whether a particular claim term is a means-plus-function term depends on how a POSITA would have understood the term. I understand that the question one must ask is whether the words of the claim would have been understood by a POSITA to have a sufficiently definite meaning as the name for structure. I understand that if the claim term itself does not recite sufficiently definite structure, or otherwise recites function without reciting sufficient structure for performing that function, the term is considered a means-plus-function term.

43. I understand that if a claim recites a means-plus-function term, then the specification must disclose sufficient structure that corresponds to the claimed function. I understand that a structure disclosed in the specification qualifies as corresponding structure if the intrinsic record clearly connects or associates that structure to the function recited in the claim.

44. I understand that one should engage in a two-step process to determine whether there is a structure in the specification that corresponds to the claimed function of a means-plus-function term. I understand that the first step is to identify what exactly the claimed function is. I understand that the second step is to determine what structure, if any, corresponds to the identified function.

**B. Prior Art**

45. I understand that a printed publication must be publicly available before the invention date of a particular patent claim in order to qualify as “prior art” under 35 U.S.C. § 102(a), that a printed publication must be publicly available more than one year before the applicable filing date for patent in the United States in order to qualify as “prior art” under 35 U.S.C. § 102(b), and that the invention by another must be described in an application for a patent filed in the United States before the invention date of a particular patent claim in order to qualify as “prior art” under 35 U.S.C. § 102(e).

**C. Anticipation**

46. I understand that a claim is invalid as anticipated if each and every claim element is identically disclosed, either explicitly or inherently, in a single prior art reference. I understand that a disclosure of an asserted prior art reference can be “inherent” if the element is necessarily present or is the inevitable outcome of the process and/or thing that is explicitly described in the asserted prior art reference.

47. I am also advised that, to serve as an anticipatory reference, the reference itself must provide enough information so that a person of ordinary skill in the art can practice the subject matter of the reference without undue experimentation.

## **D. Obviousness**

48. I understand that where a prior art reference does not disclose all of the elements of a given patent claim, that patent claim is invalid if the differences between the claimed subject matter and the prior art reference are such that the claimed subject matter as a whole would have been obvious at the time the 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.

49. 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.

50. 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. A person having ordinary skill in the art is presumed to be aware of all the relevant art at the time of the invention. The person of ordinary skill is not an automaton, and may be able to fit together the teachings of multiple patents employing ordinary creativity and the common sense that familiar items may have obvious uses in another context or beyond their primary purposes.

51. Obviousness may be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the patented invention. Obviousness may also be shown by demonstrating that it would have been obvious to combine the teachings of more than one item of prior art. I understand that a claimed invention may be obvious if some teaching suggestion or motivation exists that would have led a person having ordinary skill in the art to combine the invalidating references. I also understand that this suggestion or motivation may come from sources such as explicit statements in the prior art, or from the knowledge of a person having ordinary skill in the art. Alternatively, any need or problem known in the field at the time and addressed by the patent may provide a reason for combining elements of the prior art. I also understand that when there is a design need or market pressure, and there are a finite number of predictable solutions, a person of ordinary skill may be motivated to apply both his

skill and common sense in trying to combine the known options in order to solve the problem.

52. 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. I also understand that a claim can be determined obvious if the claimed combination would have resulted from common sense, would have been obvious to try (such as being one of a relatively small number of possible approaches to the problem that would have been reasonably expected to succeed), or would have been the predictable result of using prior art elements according to their known functions.

53. 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.

54. I understand that secondary considerations that may indicate non-obviousness 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; and the patentee proceeding contrary to the accepted wisdom of the prior art. For secondary considerations to be accorded substantial weight, I understand that there must be a nexus between the secondary considerations and the claimed

invention. For example, if a secondary consideration results from something other than what is claimed and novel, then there is no nexus. In addition, I understand that another potential factor of that can suggest that a claimed invention *was* obviousness is the independent simultaneous invention by others.

55. I also understand that secondary considerations of non-obviousness are inadequate to overcome a strong showing on the primary considerations of obviousness. For example, where the inventions represented no more than the predictable use of prior art elements according to their established functions, the secondary considerations are inadequate to establish non-obviousness.

## **VI. THE '277 PATENT**

### **A. Overview of the '277 Patent**

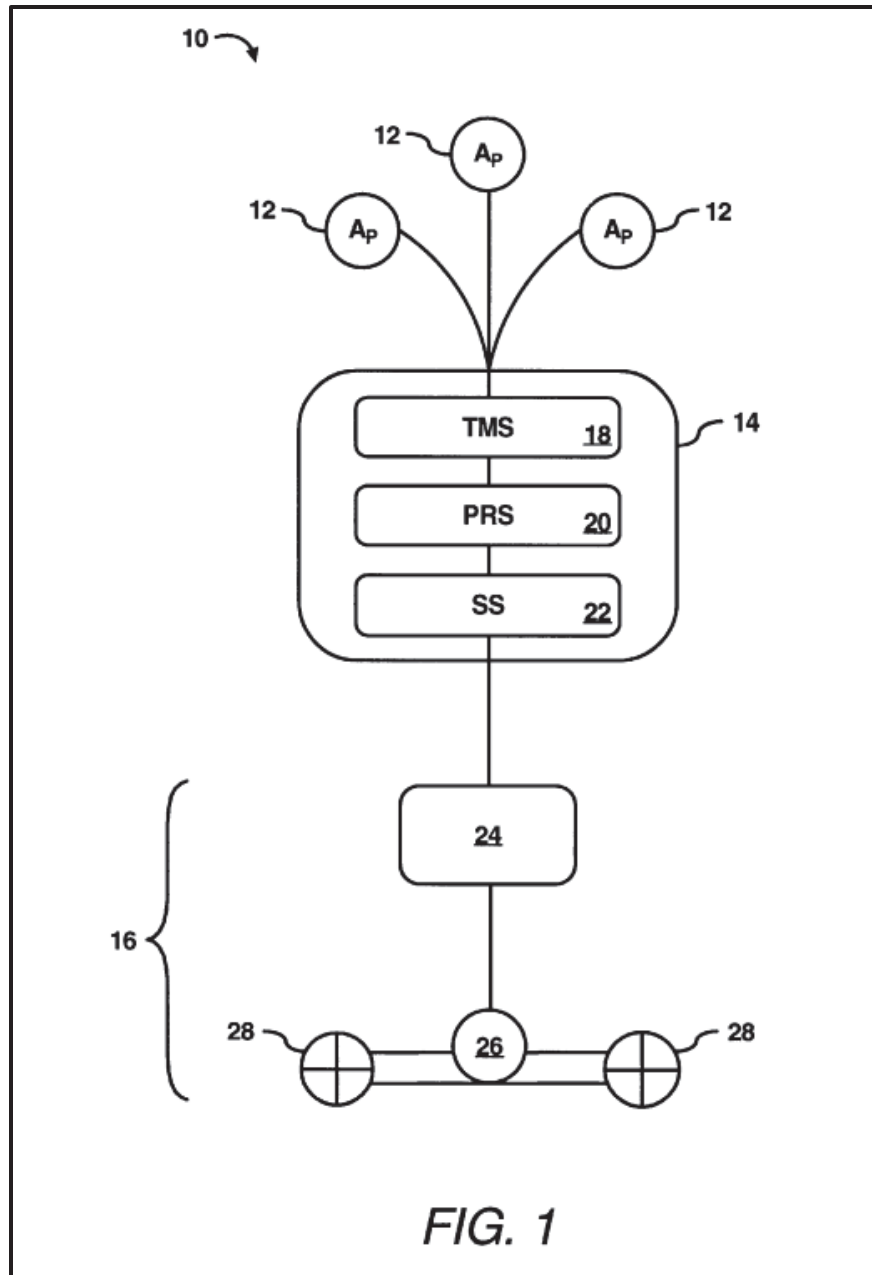
56. The '277 patent is directed to systems and methods for controlling atmospheric conditions within a building such as a data center. The '277 patent contends that the disclosed systems and methods can cool data centers more efficiently by varying the cooling output of air conditioning units “based on the distributed, location-specific needs of the data center.” *See* Ex. 1001, 2:20–39.

57. More specifically, the '277 patent teaches “strategically distributing cooling fluid, or conditioned air, within the data center by substantially . . . increasing the cooling fluid flow to locations within the data center having racks that dissipate greater amounts of heat, and by substantially . . . decreasing the

cooling fluid flow to locations having racks that dissipate lesser amounts of heat.”

Ex. 1001, 3:43–49. The inventor apparently believed that there was something new about operating the cooling devices in a data center “according to the actual location and area specific cooling needs,” rather than operating “at substantially 100 percent of the anticipated heat dissipation from the racks.” Ex. 1001, 3:51–54.

58. The ’277 patent provides Figure 1 as an exemplary system that is capable of operating in a “strategic” manner with regard to the distribution of cooling fluid. Ex. 1001, FIG. 1.



59. As shown in Figure 1, the exemplary system can measure conditions of the atmosphere at various locations via atmospheric sensors 12, such as temperature sensors. Ex. 1001, 4:12–15. A CPU 14 keeps track of the measurements received from the atmospheric sensors 12 and the corresponding sensor locations. Ex. 1001, 4:29–34. The CPU has software for generating maps of atmospheric

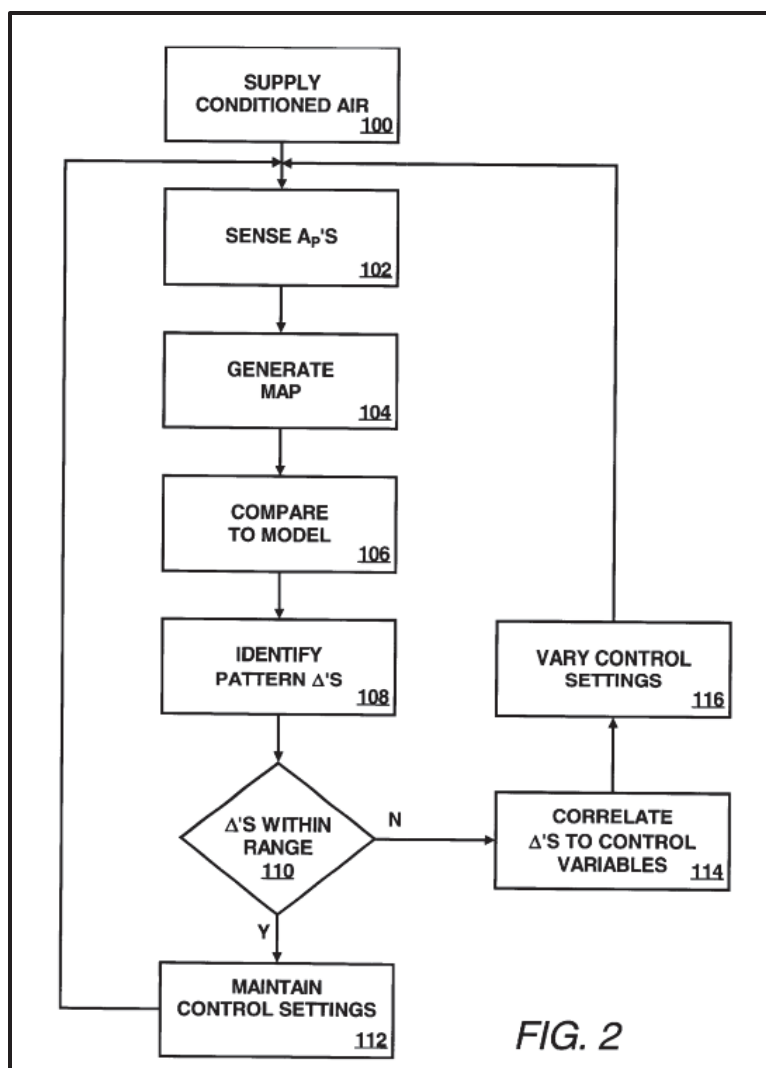
conditions, such as thermal mapping software 18 to generate thermal maps of the data center. Ex. 1001, 4:38–40. The specification acknowledges that such software tools were widely available and conventional. Ex. 1001, 6:43–53. The specification explains that conventional thermal mapping software can process numerous input sensed temperatures and output map-like information, for example, a thermal map composed of temperature contours that define various isothermal regions of distinct temperatures. Ex. 1001, at 4:41–46. The specification also highlights the capability of thermal mapping software to apply mathematical techniques the sensed temperature and sensor location data to calculate temperature gradients and locate “hot spots” including those located between various temperature sensors. Ex. 1001, 4:46–67.

60. The specification also refers to a “template thermal map” or “master” or “model” thermal map, which “basically represents a thermal map of an optimally operating data center cooling system.” Ex. 1001, 6:36–41. CPU 14 of the disclosed system also includes pattern recognition software 20 to identify pattern differences in the maps, and strategic software 22 to “determine a course of corrective action to minimize or eliminate the pattern differentials.” Ex. 1001, 5:1–10.

61. The ’277 patent discloses that when a pattern differential, such as a hot spot, is identified, the “cooling system 16 is used to vary one or more of the quantity, quality, and distribution of the cooling fluid used to cool the data center.” Ex. 1001,

5:16–18. For example, the quantity of cooling fluid may be varied by adjusting “the speed and/or baffling of the blower 26” or by varying “the percentage opening of the vents 28” of the cooling system 16. Ex. 1001, 5:38–41. The quality of cooling fluid (i.e., temperature, humidity, etc.) may be varied by increasing or decreasing the chiller cycle “between 0% and 100% of operating capacity.” Ex. 1001, 5:34–38. The distribution of the cooling fluid may be varied by the selection of or by adjusting one or more of the chillers (e.g., 24), blowers (e.g., 26), and vents (e.g., 28), such as “to target one or more hot spot locations within the data center.” Ex. 1001, 5:43–52.

62. The '277 patent also provides Figure 2, which is a flow chart of an exemplary method for strategically distributing cooling fluid. Ex. 1001, FIG. 2.



63. As shown in Figure 2, the '277 patent discloses supplying conditioned air 100 to a building, such as a data center, and then sensing “temperature within the data center . . . in various locations” 102. The location-specific temperature measurements are converted into the form of a “pictorially informative” empirical thermal map 104 which shoes thermal interdependencies across the data center landscape. Ex. 1001, 6:1–3, 6:33–35. The pattern recognition software then compares the empirical thermal map to a template thermal map 106. Ex. 1001,

6:36–38. The template thermal map is “a thermal map of an optimally operating data center cooling system.” Ex. 1001, 6:39–41. The ’277 patent discloses that the thermal maps may be generated using “[c]omputational fluid dynamics (CFD) software tools, such as FLOVENT/AIRPACK, [which] are widely available and known to those skilled in the art.” Ex. 1001, 6:43–46.

64. Next, pattern differentials between the empirical thermal map and the template thermal map are identified. Ex. 1001, 6:60–63. The identified pattern differentials are classified as either within or outside of “a predetermined range of temperature, size, etc.” Ex. 1001, 6:66–7:2. If the pattern differentials are within the predetermined range, then the cooling system “maintains current operating conditions and settings.” Ex. 1001, 7:3–6. However, if the pattern differentials are outside of the predetermined range, then the strategic software determines corrective action (i.e., changing one or more control variables) to “eliminate or at least reduce [the] pattern differentials.” Ex. 1001, 7:7–10. The strategic software evaluates control variables such as “the location of the vents, the capacity of the blower, and the capacity of the chiller.” Ex. 1001, 7:10–13. The software also considers the thermal map data such as the location, size, and intensity of isotherms to develop an optimally efficient course of action. Ex. 1001, 7:13–20.

65. The specification mentions some examples of the types of corrective actions contemplated:

For example, if the size and/or intensity of an [sic] hot spot isotherm is relatively small, then the cooling system can merely adjust the opening size of the vent closest to the location of the isotherm. If, on the other hand, the size and/or intensity of an isotherm is relatively large, then multiple vents can be adjusted in addition to increasing the chiller cycle. Similarly, if the cooling system included multiple chillers, the chiller most proximate the isotherm could be increased in cycle. In general, the quantity and/or quality of the cooling fluid can be decreased, or maintained, for locations of the data center that exhibit pattern differentials within a predetermined acceptable range. In contrast, the quantity and/or quality of the cooling fluid may be increased for locations of the data center that exhibit pattern differentials outside of a predetermined acceptable range.

Ex. 1001, 7:20–35.

## **B. Prosecution History of the '277 Patent**

66. As mentioned, the application for the '277 patent was filed on April 17, 2002. Ex. 1001, cover. A Non-Final Rejection was issued by the Office on June 16, 2003, rejecting all pending claims; there were twenty pending claims at this time. Ex. 1003, 339–40. Claims 1–5, 8–14, and 17–20 were rejected as being anticipated by U.S. Patent No. 5,290,200 (“Kiser”), claims 6 and 15 were rejected over Kiser in view of U.S. Patent No. 6,296,193 (“West”), and claims 7 and 16 were rejected over Kiser in view of U.S. Patent No. 5,506,768 (“Seem”). Ex. 1003, 341–44.

67. In a September 16, 2003, Response, the applicant, Hewlett-Packard Company (“Applicant”), did not amend any of the claims, but did add new claims 21–24. Ex. 1003, 278–83.

68. In the accompanying remarks, the applicant emphasized that the claimed invention involved sensing at least one atmospheric parameter in a plurality of locations followed by generating an empirical map from the results of the sensing step and comparing the atmospheric map to a template atmospheric map, and identifying pattern differentials between the two maps. Ex. 1003, 284–85. The Applicant argued that Kiser does not anticipate the claims because “there is no indication in Kiser that an empirical map is generated. Instead, in column 7, lines 20-24, Kiser merely states that current conditions noted by sensors are received by a control unit periodically.” Ex. 1003, 285–86.

69. The Applicant characterized Kiser as teaching that current conditions received from sensors are stored in memory and “compared to stored data representing the desired conditions at that location . . . .” Ex. 1003, 286. Applicant further distinguished Kiser by stating that “Kiser does not include a computer configured to generate the empirical map nor does Kiser disclose the step of generating the empirical map.” Ex. 1003, 286. The Applicant argued that “[t]he step of comparing current conditions to stored desired condition data is not equivalent to comparing a generated empirical map to a template atmospheric or thermal map”; and that “a comparison of noted conditions with desired parameters [] substantially differs from a comparison of pattern differentials from empirical maps.” Ex. 1003, 286, 288.

70. On December 24, 2003, the Office issued a Notice of Allowance, which included an Examiner's Amendment. Ex. 1003, 329–38. The Examiner's amendment amended application claims 1, 10, 15, and 18. Ex. 1003, 333–35. The amendments included adding language clarifying that the invention of the independent claims uses software for processing input from said sensing step and for producing output in the form of an empirical atmospheric or thermal map. Ex. 1003, 333–35. In the Reasons for Allowance, the Examiner indicated that independent claims 1 and 10 (now 12) were patentable because the prior art of record did not teach or suggest the combination of sensing temperatures or other atmospheric parameters at locations within a building; using software for processing input from the sensing step and for producing output in the form of an empirical thermal map or empirical atmospheric map; comparing empirical thermal/atmospheric map to a template thermal/atmospheric map; and identifying pattern differentials between the two maps. Ex. 1003, 335–37.

71. On September 30, 2004, Applicant submitted a Request for Certificate of Correction because the “Office failed to enter the amendments to Claims 1, 10 (now 12), 15 (now 17), and 18 (now 22) as set forth in the Examiner's Amendment dated December 24, 2003.” Ex. 1003, 270–71. On November 16, 2004, the Office issued a Certificate of Correction. Ex. 1003, 266–68.

72. Claim 1 was corrected as follows:

1. A method of controlling atmospheric conditions within a building, said method comprising the steps of:  
 supplying a conditioned fluid inside said building;  
 sensing at least one atmospheric parameter in a plurality of locations inside said building;  
 generating an empirical atmospheric map from the results of said sensing step using software for processing input from said sensing step and for producing output in the form of said empirical atmospheric map;  
 comparing said empirical atmospheric map to a template atmospheric map; and  
 identifying pattern differentials between said empirical and template atmospheric maps.

Ex. 1003, 268.

73. Claim 12 was corrected as follows:

12. A method of cooling a data center having equipment therein, said method comprising the steps of:  
 supplying a cooling fluid within said data center to cool said equipment within said data center;  
 sensing temperature within said data center in a plurality of locations;  
 generating an empirical thermal map of said data center from the results of said sensing step using software for processing input from said sensing step and for producing output in the form of said empirical thermal map;  
 comparing said empirical thermal map to a template thermal map;  
 and  
 identifying pattern differentials between said empirical and template thermal maps.

Ex. 1003, 268.

74. Claim 17 was corrected as follows:

17. The method as claimed in claim ~~10~~12, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical ~~atmospheric~~ thermal map, wherein said thermal

mapping software triangulates locations of hot spots.

Ex. 1003, 268.

75. Claim 22 was corrected as follows:

22. A system for controlling atmospheric conditions within a building, said system comprising:  
 means for supplying a conditioned fluid inside said building;  
 means for sensing at least one atmospheric parameter in a plurality of locations inside said building;  
 means for generating an empirical atmospheric map from said means for sensing, wherein the means for generating comprises software for processing input from said means for sensing and for producing output in the form of said empirical atmospheric map;  
 means for comparing said empirical atmospheric map to a template atmospheric map; and  
 means for identifying characteristics of pattern differentials between said empirical and template atmospheric maps, said characteristics comprising at least one of location, size, and intensity of said pattern differentials.

Ex. 1003, 268.

## VII. CLAIM CONSTRUCTION

76. It is my understanding that the claim construction standard includes construing the claim in accordance with the ordinary and customary meaning of the claim as understood by a person of ordinary skill in the art. As explained above, I was at least a person of ordinary skill in the art as of the April 17, 2002, filing date of the '277 patent.

77. It is my understanding that while Petitioner and the Patent Owner have not yet exchanged claim constructions in any of the related district court

proceedings, Patent Owner has served infringement contentions for the '277 patent in *Valtrus Innovations Limited v. Digital Realty Trust, Inc. et al*, Case No. 2-24-cv-00139-JRG (*"Digital Realty I"*). I have reviewed Patent Owner's infringement contentions from *Digital Realty I*. Ex. 1007 (Patent Owner's infringement chart regarding certain accused products). Those infringement contentions show that Patent Owner interprets the claims expansively for purposes of alleging infringement. The table below summarizes my understanding of Patent Owner's interpretation of the claims based on its infringement contentions, as well what I consider to be the more correct construction based on the claim language and the remainder of the intrinsic record.

78. I address each of Petitioner's proposed claim constructions below, and the claim constructions are summarized in the following table.

| <b>Claim Term</b>                                                | <b>Petitioner's Construction</b>                                                                                            | <b>Patent Owner's Implied Construction</b>                            |
|------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| "empirical atmospheric map"<br><br>(claims 1, 6, 10, 11, 20, 21) | "data displayable as a visual representation of an area showing measured atmospheric conditions corresponding to locations" | "a set of measured atmospheric conditions corresponding to locations" |
| "empirical thermal map"<br><br>(claim 12, 17)                    | "data displayable as a visual representation of an area showing measured temperature conditions corresponding to locations" | "a set of measured temperature conditions corresponding to locations" |

|                                                      |                                                                                                                          |                                                                    |
|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| “template atmospheric map”<br><br>(claims 1, 11, 21) | “data displayable as a visual representation of an area showing model atmospheric conditions corresponding to locations” | “a set of model atmospheric conditions corresponding to locations” |
| “template thermal map”<br><br>(Claim 12, 20)         | “data displayable as a visual representation of an area showing model temperature conditions corresponding to locations” | “a set of model temperature conditions corresponding to locations” |

### **A. Petitioner’s Constructions of the “Map” Claim Terms**

79. It is my opinion that, after reading the claims, specification and prosecution history, a POSITA would understand the plain and ordinary meaning of term “empirical atmospheric map” to mean “data displayable as a visual representation of an area showing measured atmospheric conditions corresponding to locations.” A POSITA would similarly understand the plain and ordinary meaning of the term “empirical thermal map” to mean “data displayable as a visual representation of an area showing measured temperature conditions corresponding to locations.”

80. The ordinary and well-established meaning of the term “map” in 2002 and through today is a visual representation showing the positions of features of an area. In the context of the ’277 patent, the relevant features include atmospheric conditions throughout a data center or other room. Although the wording of particular definitions will of course vary, the general understanding of the term

“map” to those skilled in the art is shown by the following representative dictionary references.

“**1a:** a representation usu[ally] on a flat surface of the whole or a part of an area.” Ex. 1012, 3 (definition of “Map” in Merriam-Webster’s New Collegiate Dictionary (1979)).

“**a.** used about other types of drawing that show the positions of things.” Ex. 1013, at 3 (definition of “Map” in MacMillian English Dictionary (2002)).

81. A POSITA who reviewed the contents of the ’277 patent would understand that the terms “atmospheric map” and “thermal map” connote the ordinary meaning and usage of “map.” The specification describes that the thermal map, which includes temperature information, “provides a powerful *visual* tool for a data center operator” and “also provides a *pictorially* informative way of identifying the thermal interdependencies across the data center landscape.” Ex. 1001, 6:28–29 (emphasis added). Thus, a POSITA would understand that these “maps” are displayable as visual or pictorial representation of a room.

82. The specification refers to well-known computational fluid dynamics (“CFD”) software tools for applying thermodynamic models to point specific sensed temperature data, as well as heat loads, air velocities, pressures, etc., to generate “map-like information” showing temperature contours and the locations of hot spots at various positions within a data center. Ex. 1001, 4:38–59, 6:1–6, and

6:43–54. It also mentions available software tools for “recognizing pattern differential in such maps” and adapted to “identify hot spots by pattern recognition.” Ex. 1001, 5:1–13. These related disclosures would lead a POSITA to understand that the plain and ordinary meaning of an “atmospheric map” visually represents an area and its associated atmospheric conditions and that a “thermal map” is a particular type of atmospheric map that visually represents an area and its associated temperature conditions.

83. Independent claim 1 recites using software to generate an “empirical atmospheric map” from the results of sensing at least one atmospheric parameter at multiple locations in a building. Independent claim 12 recites using software to generate an “empirical thermal map” from the results of sensing temperature at multiple locations in a data center. Empirical means that something is observed or measured. A POSITA would therefore understand that the recited “empirical” maps are generated from measured or sensed conditions.

84. The claims also refer to a “template atmospheric map” (Claim 1) or a “template thermal map” (Claim 12). The specification explains that this is a “master” map that “represents a thermal map of an optimally operating data center cooling system.” Ex. 1001, 6:38–41. A POSITA would therefore understand that a template map represents model or desired conditions.

85. These understandings are reinforced after reading the prosecution history of the '277 patent. The Applicant overcame anticipation and obviousness rejections based on Kiser by asserting that Kiser failed to disclose generating an empirical map and failed to disclose comparing a generated empirical map to a template atmospheric or thermal map. Ex. 1003, 285–86. Specifically, Applicant took the position that the empirical map of the '277 patent is not anticipated by Kiser's disclosure "that current conditions noted by sensors are received by a control unit periodically." Ex. 1003, 285–86. The Applicant also argued that "[t]he step of comparing current conditions to stored desired condition data is not equivalent to comparing a generated empirical map to a template atmospheric or thermal map;" and that "a comparison of noted conditions with desired parameters [] substantially differs from a comparison of pattern differentials from empirical maps." Ex. 1003, 286, 288. In other words, the Applicant emphasized that the claims require more than just comparing a set of data reflecting measured conditions to a set of data reflecting optimal conditions. The claims require generating two maps and then comparing two maps to identify differences in their patterns.

86. Based on all of the above, I agree with Petitioner that a POSITA would understand the plain and ordinary meaning of the "map" claim terms to require more than just temperature or other atmospheric data correlated to locations. The maps

recited in the claims are displayable as representation of an area showing the temperature or other atmospheric data corresponding to locations within the area.

### **B. Patent Owner's Implied Constructions of the "Map" Claim Terms**

87. Based on my review of Patent Owner's infringement contentions in the *Digital Realty I* case (Ex. 1007), I expect that Patent Owner may dispute that the "map" claim terms require data that is displayable as a visual representation of an area. For example, Patent Owner's infringement allegations involving Petitioner's iCOM<sup>TM</sup> control software focus on a capability to display current temperature sensor readings and to trigger alarm events when a sensed temperature exceeds a threshold value. Ex. 1007, 24, 30. According to Patent Owner's infringement position, claim limitation 1[e] of "identifying pattern differentials between said empirical and template atmospheric maps" (discussed more fully below) encompasses identifying "when sensors are reporting conditions that exceed template conditions" without regard for whether the identification results from comparing two visual maps of the monitored area. Ex. 1007, 25, 30. Patent Owner's implicit construction of "map" appears to encompass any atmospheric data that is correlated to locations within an area regardless of whether the information is displayable as a visual representation of the area.

88. While I do not agree that a POSITA would understand the map claim limitations to have the broad meanings implied in Patent Owner's infringement

theories, I have nevertheless considered and addressed Patent Owner's constructions as well as Petitioner's proposed constructions in my analysis.

## **VIII. OVERVIEW OF THE PRIOR ART**

### **A. Technical Background**

89. As recognized in the background section of the '277 patent, data centers are a type of building that house numerous electronic packages and personal computer (PC) boards containing processors, micro-controllers, video cards, memories, semi-conductor devices, etc. Ex. 1001, 1:21–29. The PC boards are arranged in a plurality of racks distributed throughout the data center. Ex. 1001, 1:22–27. The PC boards generate and dissipate significant amounts of heat during operation, which raises the temperature of the surrounding area. Ex. 1001, 1:29–31. However, higher temperatures in data centers are undesirable because operation of the PC boards at too high of a temperature “may result in irreversible damage” to the PC boards and their electronic packages and reduce their reliabilities. Ex. 1001, 1:61–65. Thus, “it is necessary to maintain the temperatures of the electronic packages [and PC boards] within predetermined safe operating ranges.” Ex. 1001, 1:57–60.

90. The '277 patent acknowledges that “[d]ata centers are typically cooled by operation of one or more air conditioning units.” Ex. 1001, 2:6–7. While the cooling system for a data center could include a chiller unit, “those skilled in the art

will recognize that multitudes of other types of cooling systems are generally well-known and available for use . . . including, for example, refrigeration systems, cooling tower systems, cooler-condenser systems, and the like.” Ex. 1001, 5:18–24. The well-known cooling systems also include variable-speed air movers or blowers and remotely controlled dampers or vents. Ex. 1001, 5:24–26. The specification also indicates that “[t]hose skilled in the art will recognize that ventilation structure connecting the blower, vents, etc. are well known in the relevant art of Heating, Ventilating, and Air Conditioning (HVAC).” Ex. 1001, 5:26–30.

91. The ’277 patent provides as an example of a known cooling system for data centers, a system disclosed in an earlier filed application, U.S. Patent Application No. 09/970,707, which is incorporated by reference. That application was filed on October 5, 2001, and published as U.S. Patent Publication No. 2003/0067745 A1 (Ex. 1008, “Patel”). Ex. 1001, 4:4–7.

92. Patel illustrates a conventional data center cooling system by reference to its Figure 1, reproduced below:

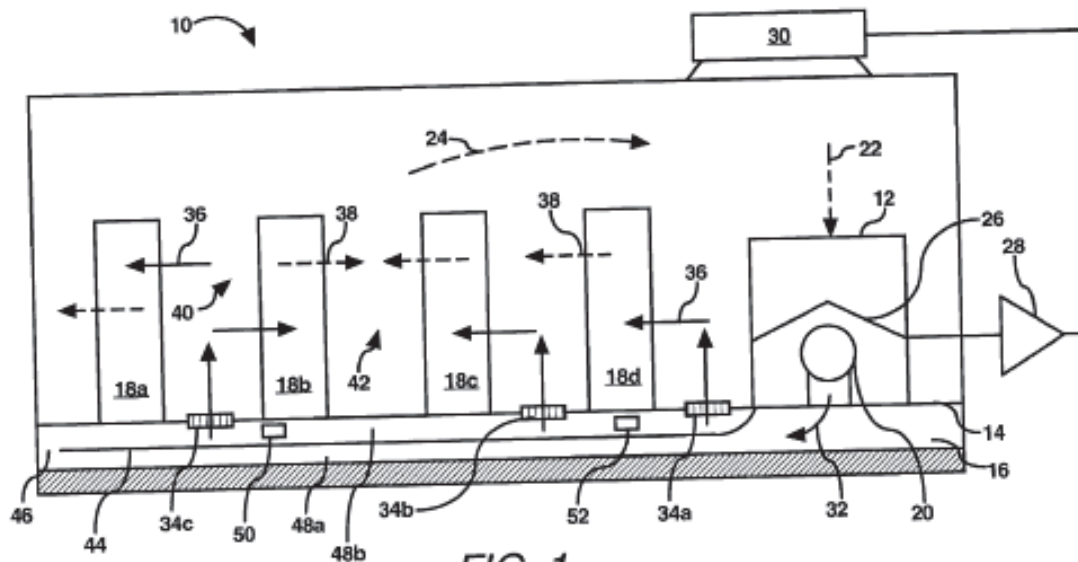


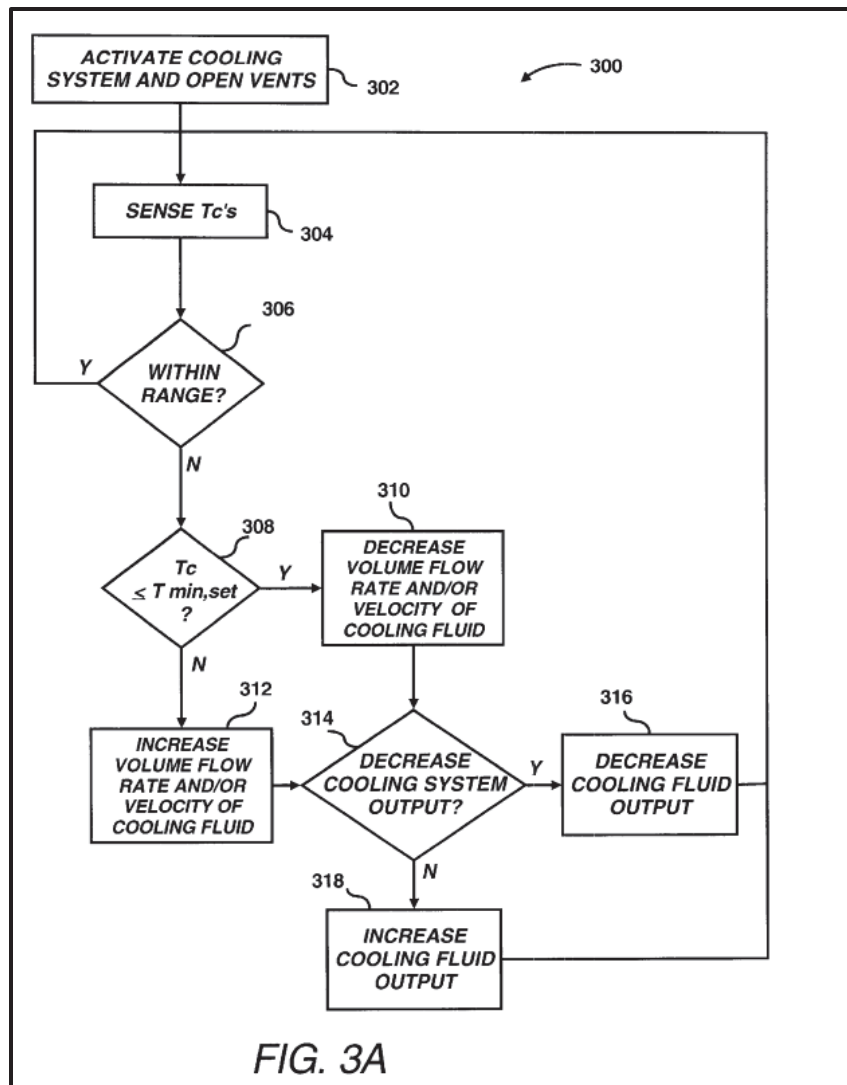
FIG. 1

93. The data center 10 includes a raised floor 14 with the space 16 beneath the floor serving as a plenum to deliver cooled air from cooling system 12 to racks 18 *a*-18 *d*. Ex. 1008, [0017]. The racks 18 *a*-18 *d* house electronic components such as processors, micro-controllers, high speed video cards, memories, semi-conductor devices, and the like. Ex. 1008, [0017]. A fan 20 supplies cooled air into the space 16. Ex. 1008, [0018]. Air is supplied into the fan 20 from the heated air in the data center 10 which enters the cooling system by arrow 22 and is cooled by a conventional refrigeration unit including a cooling coil 26, a compressor 28, and a condenser 30. Ex. 1008, [0018]. The cooling system 12 may be operated at various levels based on the heat loads in the racks 18 *a*-18 *d*. For example, the capacity (e.g., the amount of work exerted on the refrigerant) of the compressor 28 and the speed of the fan 20 can each be

modified to control the temperature and the amount of cooled air flow delivered to the racks 18 *a*-18 *d*. Ex. 1008, [0018].

94. The cooling fluid flows from the fan 20 and into the space 16 (e.g., plenum) as indicated by the arrow 32. Ex. 1008, [0019]. The cooled air flows out of the raised floor 14 through vents 34 *a*-34 *c* that generally operate to control the velocity and the volume flow rate of the cooled air to the racks. Ex. 1008, [0019]. This conventional arrangement of a data center and associated cooling system was well-known to those skilled in the art as April 2002.

95. The operation of the exemplary cooling system of Patel can be understood with reference to Figure 3A of Patel, reproduced below, which shows a “flow diagram 300 [that] may be embodied by a computer program.” Ex. 1008, [0040].



Ex. 1008, FIG. 3A.

96. Patel's disclosure reflects that, at the time of the filing of the '277 patent, it was known to activate a cooling system and then take temperature measurements via temperature sensors "located at various positions throughout the data center." Ex. 1008, [0042]. Patel further describes the conventional practice of determining "whether each of the measured temperatures are individually within a predetermined range of operating temperatures." Ex. 1008, [0043]. Patel discloses,

for example, that if a measured temperature of some locations is outside of the predetermined range, the cooling system would decrease or increase “either or both the volume flow rate and the velocity of the cooling fluid” accordingly. Ex. 1008, [0045-0046].

97. Patel also explains that because the temperatures of various racks and locations in the data center may differ, the changes in volume flow rate or velocity of the cooling fluid should be responsive to the individual needs of each rack or other monitored location in the data center. Ex. 1008, [0051]. Thus, Patel reflects the conventional practice, known at the time the '277 patent was filed, of varying the supply of cooling fluid to specific locations in a data center based on localized cooling needs rather than running the cooling system at or near full capacity all the time.

98. The '277 patent also acknowledges that at the time the '277 patent was filed, “[c]omputational fluid dynamics (CFD) software tools, such as FLOVENT/AIRPACK, are widely available and known to those skilled in the art.” Ex. 1001, 6:43–46. The '277 patent further confirms that known and available “CFD modeling can be used to output a master, template, or model thermal map.” Ex. 1001, 6:52–54. The '277 patent incorporates by reference U.S. Patent Application No. 10/076,635, which was filed on February 19, 2002, and published as U.S. Patent Publication No. 2003/0158718A1 (Ex. 1009, “Nakagawa”) as being

instructive on the use of CFD tools in the design and modeling of data centers. Ex. 1001, 6:54–59.

99. Nakagawa confirms that POSITAs were aware that CFD modeling tools could be used to create “a CFD simulation of the full IDC [(internet data center)].” Ex. 1009, [0033]. For example, Nakagawa discloses that when developing data center layout designs, “a full CFD simulation may be utilized to verify the solution” (i.e., layout design). Ex. 1009, [0046]. Nakagawa further teaches using CFD simulations to test the suitability of a data center layout based on whether “the calculated maximum temperature of the cells are below the maximum allowed operating temperature.” Ex. 1009, [0044]. The cells are different locations within a data center, such as “a cluster of racks, air conditioning units, ceiling, subfloor, and the like.” Ex. 1009, [0018]. Thus, the ’277 patent and Nakagawa confirm that it was known to use CFD modeling to generate thermal maps for evaluating the thermal characteristics and cooling needs of data centers.

## **B. Nakanishi**

100. U.S. Patent No. 6,283,380 B1 (“Nakanishi”) was filed on March 20, 2000, and issued on September 4, 2001. Ex. 1005, cover. I understand that Nakanishi qualifies as prior art to the ’277 patent.

101. Like the ’277 patent, Nakanishi is directed to the problem of operating data center cooling systems in an efficient manner that is responsive to localized

cooling needs. Nakanishi's approach involves monitoring temperatures at various locations, distributing cooled air through multiple strategically located fans, and controlling the speed and direction of the fans to distribute cooling throughout a computer room (i.e., data center) based on the temperature distribution to achieve a "uniform temperature" and "for power saving." Ex. 1005, 8:44–53.

102. Nakanishi recognizes that computer rooms contain various computers and devices that generate heat, requiring air conditioning to maintain an optimal operating and working environment. Ex. 1005, 1:11–22. Nakanishi explains that because the amount of heat generated differs depending on the device and its current operating state, the temperature distribution within the computer room constantly changes. Ex. 1005, 1:23–43. These fluctuations can lead to stagnant high-temperature pockets "in a relatively narrow region" that are prone to move "unexpectedly," thus making uniform temperature distribution difficult to achieve. Ex. 1005, 1:32–34. Nakanishi therefore addresses the same problem as the '277 patent, i.e., a need "for an automatic control technique for quickly responding to the fluctuation of temperature distribution in a computer room, properly controlling a temperature, and keeping an optimum temperature state." Ex. 1005, 1:39–43.

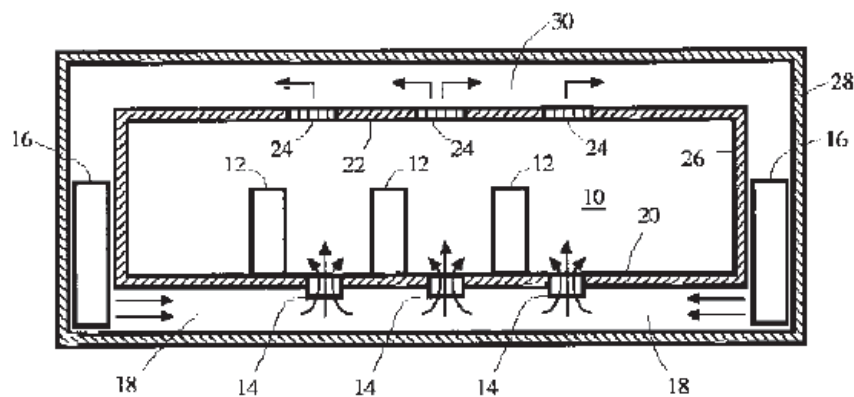
103. In particular, Nakanishi introduces the disclosed solution as follows:

An air conditioning system and an air conditioning method are disclosed for quickly and effectively controlling the temperature in a room requiring cooling and keeping the room at a uniform temperature. The present invention estimates a temperature distribution in a room

through a simulation and controls airflow rates and airflow directions of a plurality of fans on the basis of the simulation result. Temperature sensors are arranged at predetermined positions in a room such as a computer room. A simulation is performed on the basis of temperatures detected by the temperature Sensor Sn and the current airflow rates and airflow directions of a plurality of fans to obtain a temperature distribution in the room. It is determined whether obtained temperatures are in a predetermined temperature range. As the result of Such determination, at least one of airflow rate and airflow direction of a fan which covers a position being at a temperature out of the predetermined temperature range is controlled. It is preferable to use an underfloor fan that can be fitted into the floor of the computer room.

104. Ex. 1005, [Abstract]; *see also* 1:53–2:2. An exemplary air conditioning system for a computer room is shown in Nakanishi's Figure 1, reproduced below.

【図 1】

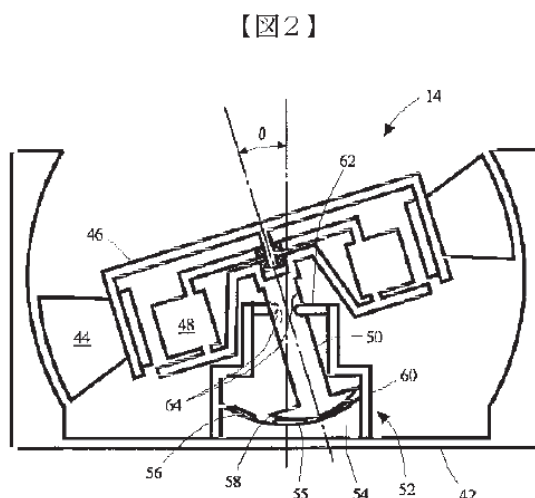


Ex. 1005, FIG. 1.

105. Computer units 12 are arranged on floor surface 20 and under-floor blower fans 14 are installed in the floor surface 20. Air conditioners 16 are located between an interior wall 26 and an exterior wall 28 of the computer room 10. The air conditioners deliver cooled air to the space 18 under the floor, which is directed

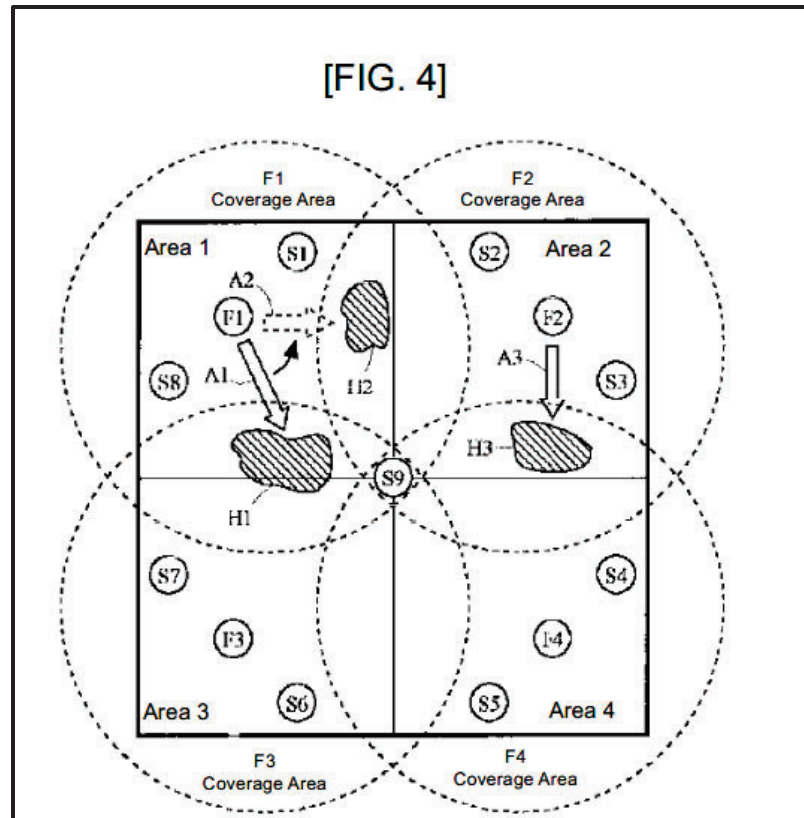
the computer room 10 by fans 14. Warmed air exits the computer room 10 through exhaust vents 24 provided in the ceiling 22 into a space 30 above the ceiling, and then circulates back to the air conditioners 16. Ex. 1005, 2:26–41.

106. A blower fan 14, adjustable in speed and direction, is illustrated in Figure 2:



Ex. 1005, FIG. 2. Direction control unit 52 controls the direction of air flow and air speed is controlled by controlling the fan motor. Ex. 1005, 2:54–3:20.

107. An overhead view of the computer room area managed by conditioning system is shown in Figure 4 of Nakanishi, reproduced below.

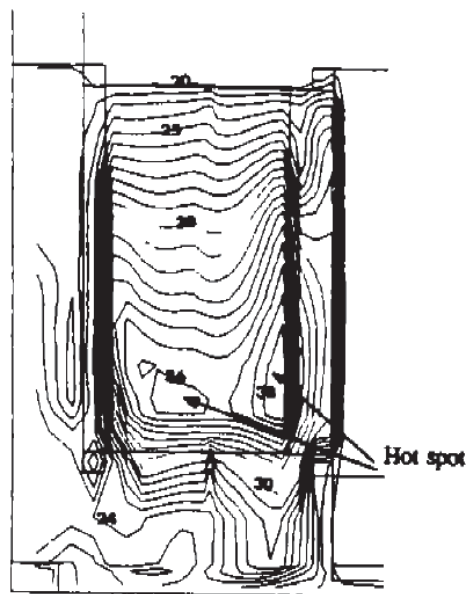


Ex. 1005, FIG. 4. As the figure illustrates, “[f]our fans F1 to F4 are set to the floor of [the] computer room” (Ex. 1005, 3:31–34) to deliver cool air to the computer room. Ex. 1005, 2:34–41. The disclosed system also includes “[a] plurality of temperature sensors S1 to S9 . . . arranged at selected positions of the computer room.” Ex. 1005, 3:42–44. This reflects the known approach of measuring temperatures at multiple locations in a data center.

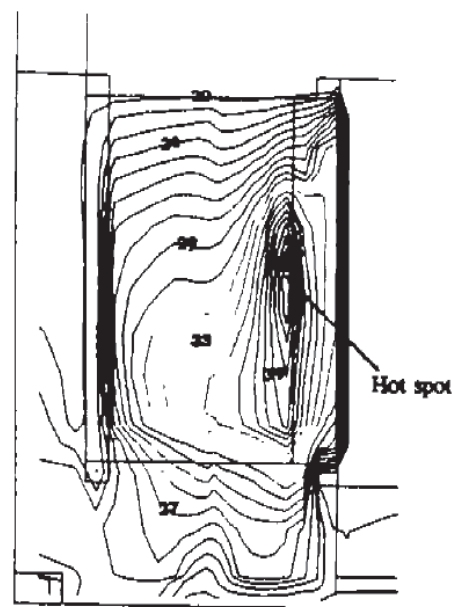
108. Once the temperatures at various locations of the computer room are measured, “[a] simulation is performed on the basis of the detected temperatures and the current airflow rates and airflow directions of the fans to obtain the temperature distribution in the computer room.” Ex. 1005, 3:46–50. The simulation

is performed on a computer that “includes a simulation program for monitoring a temperature distribution.” Ex. 1005, 4:37–39. The temperature distribution simulation program can be any suitable commercially available temperature distribution analysis program, such as “FLOTHERM.” Ex. 1005, 5:43–45.

109. I have extensive personal experience using temperature distribution analysis programs and have used these tools in my work for many years. In fact, I was creating such images in approximately 1996. Figures 10(a) and 10(b) from a 1993 conference paper on creating thermal simulations with FLOTHERM software are provided below as an example of the type of visuals that thermal mapping software could generate during the relevant time period. Ex. 1011, 13 (“Lee”).



(a) Air passage #1



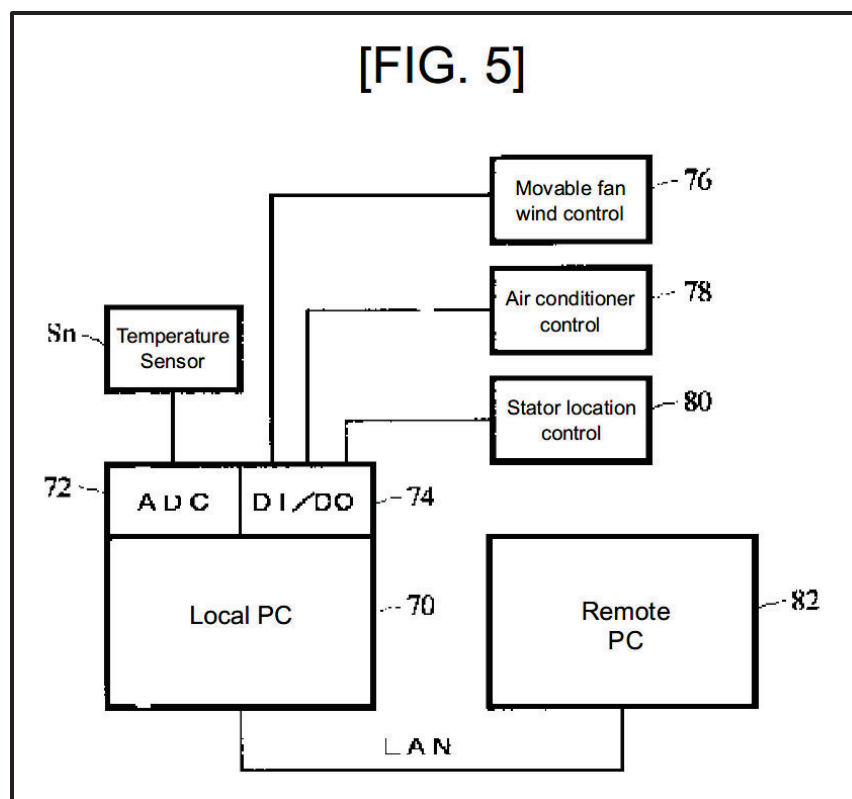
(b) Air passage #4

Lee, FIGs. 10(a) and 10(b). These figures show “[s]ide view[s] of the temperature field” (Ex. 1011, 13) and were generated in a “case study demonstrat[ing] the

capability of using FLOTHERM software in predicting flow field and heat transfer in an air-cooled computer system.” Ex. 1011, 6. As demonstrated by these figures, FLOTHERM software was capable of generating temperature distributions with temperature contour lines and facilitating the identification of hot spots.

110. Nakanishi’s stated goal is to maintain a “uniform temperature” in a data center. Ex. 1005, Abstract; 1:34–44; 8:44–53. Therefore, in Nakanishi’s system, the temperature distributions of the simulation are compared to preset temperature ranges to determine “high temperature region[s]” in the data center so that a corrective action may be taken Ex. 1005, 3:46–4:9. For example, Figure 4 of Nakanishi identifies three high temperature regions—labeled H1, H2, and H3—identified by the simulation. Ex. 1005, 3:46–4:9. These correspond to what the ’277 patent refers to as “hot spots.”

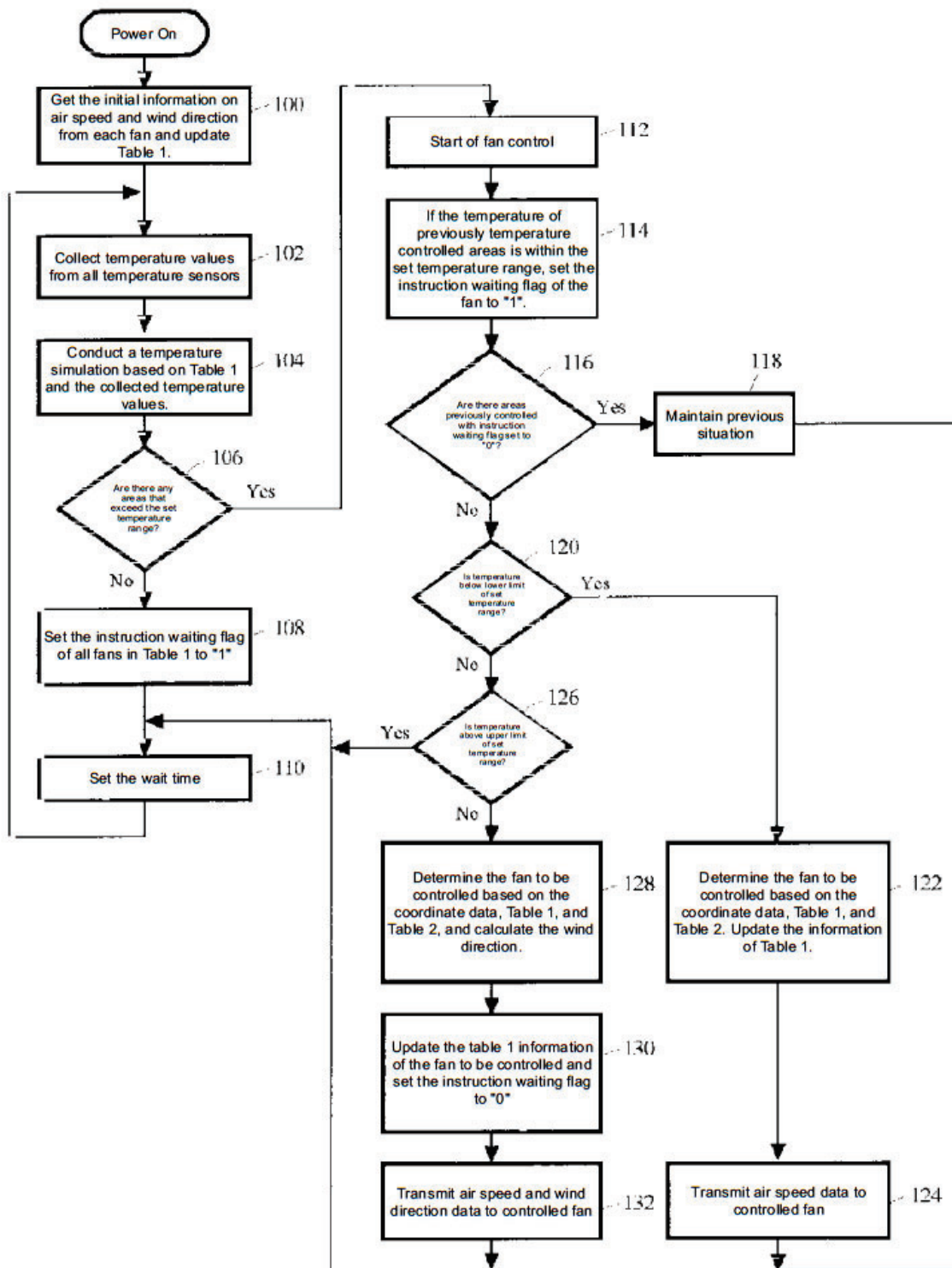
111. An exemplary system for taking a corrective action in response to high temperature regions is shown in Figure 5 of Nakanishi, reproduced below.



Ex. 1005, FIG. 5. As shown in Figure 5, Nakanishi discloses controlling the air speed and direction of the fans based on the results of comparing temperatures of simulated temperature distributions to preset temperature ranges. Ex. 1005, Abstract. For example, the “revolving speed of a designated fan 14” can be controlled by the “airflow-rate control circuit 76,” the power level of the air conditioner may be controlled by the “air-conditioner control circuit 78,” and the “airflow direction of the fan” can be controlled by “the stator-position control circuit 80.” Ex. 1005, 4:18–30.

112. Figure 6 of Nakanishi, reproduced below, provides a flow diagram for the control process logic to identify locations needing cooling and coordinate control of the distributed fans.

[FIG. 6]



Ex. 1005, FIG. 6.

113. The disclosed control method involves running simulations at regular time intervals to identify locations where the temperature falls outside of the preset temperature range. Ex. 1005, 3:56–4:9. A local PC 70 obtains information regarding air speed and direction of each fan, collects current values from the temperature sensors, and sends this data to a remote PC 82. Ex. 1005, 5:21–36. The remote PC performs a simulation from the data to generate a temperature distribution in the computer room and provides the temperature distribution along with coordinate location data back to PC 70. Ex. 1005, 5:36–56. The local PC 70 then assesses whether any temperature distribution values are outside a preset temperature range. Ex. 1005, 5:57–63. The process is repeated at a regular time interval. Ex. 1005, 6:8–34. If any out-of-range temperatures are detected during the cycle, the additional steps described in blocks 112 through 132 are executed to coordinate control of the speed and direction of each fan in a manner responsive to the location-specific cooling needs identified by the comparison of the simulated temperature distribution to the model preset temperature range. Ex. 1005, 6:25–7:67.

114. Additional relevant details about the disclosures of Nakanishi are set forth and discussed in Section IX below.

### **C. Bishop**

115. U.S. Patent Application Publication No. 2002/0149911 (“Bishop”) was published on October 17, 2002, and the underlying Patent Application (No.

09/833,722) was filed on April 12, 2001. Ex. 1006, cover. I am advised that Bishop qualifies as prior art to the '277 patent.

116. Bishop describes conventional critical environments having a raised floor supporting the computer racks and a source of cooling air pumped through floor tiles into the environment. Ex. 1006, [0012]. Bishop explains that prior cooling schemes for such environments involved monitoring temperatures “at various locations” of a data center such that “the cooling air temperature and/or volume [can be] adjusted to maintain the environment at the desired temperature. Ideally the environment temperature throughout the critical environment should be maintained at the same temperature.” Ex. 1006, [0012]. However, there are several challenges associated with managing heat generated in critical environment computing and warehousing rooms containing a variety of servers and other electronic modules arranged vertically within racks. Ex. 1006, [0005]–[0011].

117. One conventional approach mentioned in Bishop involves measuring temperatures throughout the critical environment at small spatial intervals and then adjusting air flows baffles in the raised floor tiles to even out the temperature. Ex. 1006, [0017]. Bishop describes performing this manual procedure with the aid of software “that generates a three dimensional map of temperature in the environment as a function of location within the environment.” According to this approach, baffles are adjusted near the location of identified hot spots. Next, the temperature

readings, map generation, and baffle adjustment steps are repeated until an acceptable temperature distribution is achieved. Ex. 1006, [0017].

118. As an example of a more automated known cooling scheme, Bishop discusses U.S. Patent No. 6,188,189 (Ex. 1010, “Blake”), which issued on February 13, 2001. Ex. 1006, [0029]. In the cooling scheme of Blake, temperature is measured at multiple locations and the measurements used to detect “hot spot[s] within an equipment enclosure” in a data center. Ex. 1010, 11:29–35. When hot spots are detected, a “fan speed control system can respond by speeding up its fans to full speed.” Ex. 1010, 11:29–35.

119. Bishop proposes, as a more efficient way to deliver cool air in critical computing environments, a system in which each cabinet or rack has its own controller equipped with air temperature, pressure and flow rate sensors and linked to temperature sensors associated with the cabinet and electronic modules. Ex. 1006, [0062], [0065]–[0066]. This is illustrated in Figure 2, reproduced below.

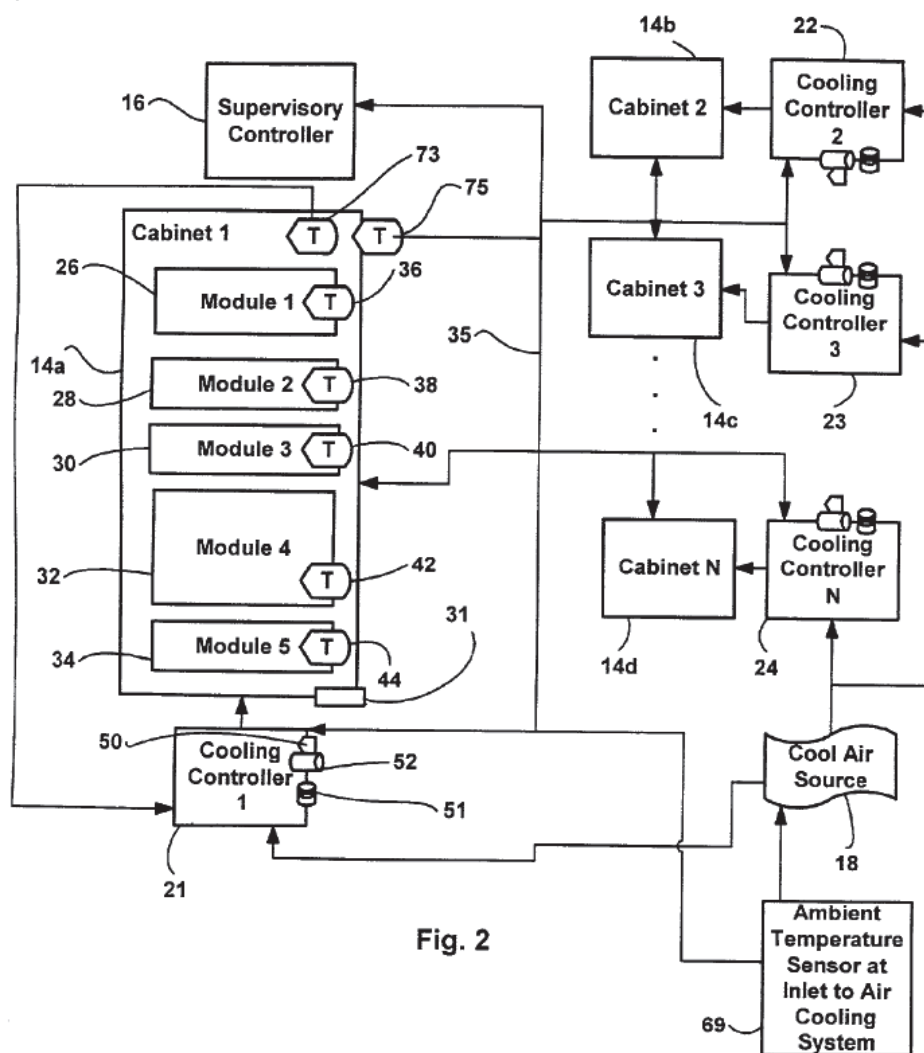
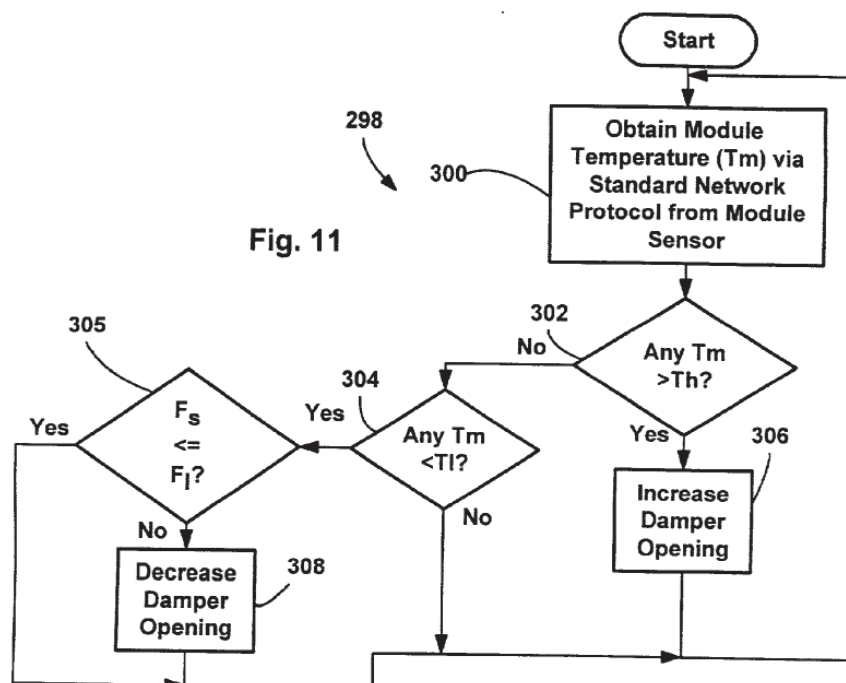


Fig. 2

Ex. 1006, Figure 2.

120. Cool air is provided through each controller 21 and associated air conduit into the cabinet space where it may be pulled by fans through each electronic module and over their heat generating components. Warm air expelled from the cabinets flows back into the critical environment and then recirculates to an air cooling system where its temperature is again reduced prior to delivery back into critical environment. Ex. 1006, [0080].

121. Each cabinet cooling controller, in coordination with a supervisory controller, can adjust operations in response to temperature readings from the electronics modules. Ex. 1006, [0082]. One “exemplary method” disclosed involves strategically cooling a data center by controlling the opening of a damper that controls the cooled air flow to each rack based on temperatures measured by sensors associated with electronic modules. Ex. 1006, [0082]–[0086]. This exemplary method is illustrated in Figure 11 of Bishop, which is reproduced below.



Ex. 1006, FIG. 11. When any module temperature is below a threshold temperature, a controller decreases a damper opening to reduce cooling air flow to the cabinet. Ex. 1006, [0084]. When a module temperature exceeds a high threshold, the damper opening is increased to provide more cooling air to the cabinet. Ex. 1006, [0085].

122. Bishop also discloses temperature sensors 75 outside of each cabinet, or averaging the individual module temperature readings, to provide temperature data at the cabinet location. Ex. 1006, [0106]. Bishop also teaches using temperature measurements associated with various cabinet locations in a data center to “generate a three dimensional temperature graph for observation by an environment administrator.” Ex. 1006, [0106].

123. Additional details about the disclosures of Bishop are set forth in Section IX below.

## **IX. ANALYSIS OF THE PRIOR ART AND THE '277 PATENT CLAIMS**

### **A. GROUND 1: CLAIMS 1–21 ARE ANTICIPATED BY NAKANISHI**

124. For the reasons set forth below, it is my opinion that Nakanishi discloses all of the limitations of claims 1–21 of the '277 patent.

#### **1. Claim 1**

125. I discuss each limitation of claim 1 in turn below, in conjunction with the relevant disclosures of each claim limitation by Nakanishi.

##### **a. 1[pre] – “A method of controlling atmospheric conditions within a building, said method comprising the steps of:”**

126. The preamble of claim 1 recites, “[a] *method of controlling atmospheric conditions within a building, said method comprising the steps of:*”

127. I have been informed that claim preambles are generally not limiting. In any case, even if the preamble here were a limitation, I believe that Nakanishi discloses the preamble in relation to a method for “quickly and effectively controlling the temperature in a room.” Ex. 1005, Abstract.

128. A POSITA would have understood that temperature is an atmospheric condition. The ’277 patent states that “atmospheric sensors 12 are used for measuring one or more atmospheric parameter and encompass temperature sensors.” Ex. 1001, 4:12–14. Thus, the controlling of temperature in a room as disclosed in Nakanishi discloses the preamble’s controlling of atmospheric conditions.

129. Additionally, Nakanishi is directed to air conditioning a computer room. Ex. 1005, Abstract, 1:11–1:50, FIGs. 1, 3, 4, and 7, for example. A POSITA would have understood that computer rooms exist within a building. Thus, Nakanishi discloses limitation 1[pre].

**b. 1[a] – “supplying a conditioned fluid inside said building;”**

130. Claim 1 further recites “*supplying a conditioned fluid inside said building.*” In my opinion, Nakanishi discloses this limitation.

131. Nakanishi discloses: “cooling air supplied from the air conditioners 16 is sent to the computer room 10 by fans 14.” Ex. 1005, 2:37–38. The conditioned fluid in Nakanishi is the cooled air that has been conditioned by the air conditioners.

Ex. 1005, 1:45–50. The '277 patent confirms that “cooling fluid” and “conditioned air” are interchangeable terms: “the amount of energy typically required to cool a data center may be relatively reduced by strategically distributing *cooling fluid*, or *conditioned air*, within the data center.” Ex. 1001, 3:42–44 (emphasis added). In fact, air is the only type of fluid conditioned by the cooling systems discussed throughout the '277 patent.

132. Additionally, the computer room of Nakanishi is inherently within a building, so the cooled air of Nakanishi is being supplied to the inside of the building.

133. Nakanishi therefore teaches supplying a conditioned fluid inside said building, as recited in claim limitation 1[a].

**c. 1[b] – “sensing at least one atmospheric parameter in a plurality of locations inside said building;”**

134. Claim 1 recites “*sensing at least one atmospheric parameter in a plurality of locations inside said building.*” In my opinion, Nakanishi discloses this limitation.

135. For example, Nakanishi teaches “[a] plurality of temperature sensors S1 to S9 are arranged at selected locations of the computer room.” Ex. 1005, 3:43–46, FIGs. 3 and 4. Nakanishi discloses performing a simulation “on the basis of the detected temperatures” and explains that the temperature sensors “supply temperature information to a local personal computer (PC) 70.” Ex. 1005, 3:47–55,

4:10–17. Nakanishi further teaches a method that includes a step of “detecting temperature at a plurality of predetermined positions in the room by a plurality of temperature arranged at the positions.” Ex. 1005, Claim 11.

136. Thus, Nakanishi teaches sensing at least one atmospheric parameter in a plurality of locations inside the building.

**d. 1[c] – “generating an empirical atmospheric map from the results of said sensing step using software for processing input from said sensing step and for producing output in the form of said empirical atmospheric map;”**

137. Claim 1 recites “*generating an empirical atmospheric map from the results of said sensing step using software for processing input from said sensing step and for producing output in the form of said empirical atmospheric map.*” In my opinion, Nakanishi discloses this limitation.

138. Nakanishi teaches that “local PC 70 collects temperature values from all the temperature sensors Sn. The local PC 70 sends the collected temperature values and data on the current airflow rate and airflow direction of each fan to the remote PC 82.” Ex. 1005, 5:31–35. Nakanishi also teaches that “the remote PC 82 performs a simulation on the basis of the temperature values” (as well as air speed and direction data for each fan) to “obtain a temperature distribution in the computer room.” Ex. 1005, 5:36–40. Nakanishi further teaches generating this temperature distribution of the computer room by using “any suitable temperature-distribution analysis program that is commercially available,” such as “FLOTHERM.” Ex.

1005, 5:40–45. Thus, Nakanishi teaches using software for processing the temperature measurements taken at various locations in the sensing step to generate a temperature distribution.

139. The temperature distribution of Nakanishi discloses the “empirical atmospheric map” recited in claim 1 of the ’277 patent under both Petitioner’s construction of this term and Patent Owner’s implied construction.

140. As discussed above, I agree with Petitioner’s proposed construction of “empirical atmospheric map” as referring to “data displayable as a visual representation of an area showing measured atmospheric conditions corresponding to locations.”

141. Nakanishi discloses this. For example, Nakanishi teaches “by *image-displaying* a simulated temperature-distribution state on a monitor . . . it is possible to monitor the temperature of an unattended computer room . . . .” Ex. 1005, 7:62–67 (emphasis added). The simulated distribution shows “the temperature distribution in the computer room.” Ex. 1005, 3:47–50. A POSITA would understand from these related teachings that the viewable image is a visual representation of the computer room showing temperatures corresponding to various locations in the room.

142. A POSITA’s understanding that Nakanishi discloses outputting a visual representation of an area showing measured temperatures corresponding to

locations would be reinforced by Nakanishi's disclosure of generating the temperature distribution using "any suitable commercially available temperature distribution analysis simulation program," such as "FLOTHERM." Ex. 1005, 5:40–45. A primary purpose of FLOTHERM and similar simulation programs is to create visual or pictorial representations of how atmospheric condition information corresponds to physical locations within an area.

143. The temperature distribution of Nakanishi also discloses claim limitation 1[c] under Patent Owner's implied construction of "empirical atmospheric map." As discussed in Paragraph 87 above, Patent Owner's infringement contentions suggest that Patent Owner applies this claim term to include any atmospheric condition data corresponding to physical locations within an area regardless of whether the information is displayable as a visual representation of the area.

144. Nakanishi teaches transferring "the obtained temperature distribution values to the local PC 70 together with coordinate position data for the temperature distribution values." Ex. 1005, 5:54–67. Therefore, the temperature distribution of Nakanishi correlates temperature data to corresponding locations. As discussed above, the temperature information in the temperature distribution of Nakanishi is one type of atmospheric information described and claimed in the '277 patent. Thus,

Nakanishi discloses the empirical atmospheric map under Patent Owner’s expected construction, which is broader than Petitioner’s construction.

145. Limitation 1[c] is therefore disclosed by Nakanishi under both Petitioner’s construction of “empirical atmospheric map” and Patent Owner’s expected construction of “empirical atmospheric map.”

**e. 1[d] – “comparing said empirical atmospheric map to a template atmospheric map; and”**

146. Claim 1 recites “*comparing said empirical atmospheric map to a template atmospheric map.*” In my opinion, Nakanishi discloses this limitation.

147. In addition to disclosing generating an “empirical atmospheric map,” Nakanishi also discloses the template atmospheric map recited in this claim limitation.

148. Regarding the term “template,” the ’277 patent explains (while referring to temperature as an exemplary atmospheric condition) that the “template thermal map could also be termed a master, or model thermal map. The template basically represents a thermal map of an optimally operating data center cooling system.” Ex. 1001, 6:38–41. Therefore, as discussed above, I agree with Petitioner that the “template atmospheric map” refers to “data displayable as a visual representation of an area showing model atmospheric conditions corresponding to locations.”

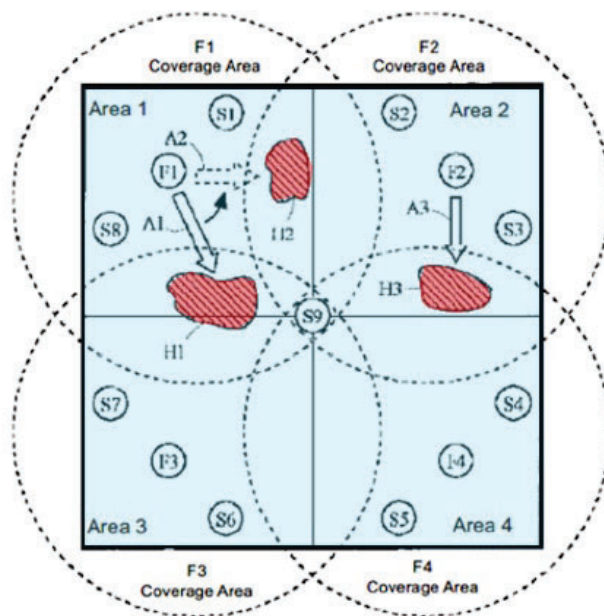
149. Nakanishi states that “uniform . . . temperature distribution in a computer room” is “an optimum temperature state” of the computer room. *See* Ex. 1005, 1:31–43. Nakanishi teaches achieving a uniform temperature distribution by controlling “at least one of the airflow rate and airflow direction of at least one selected fan covering a position being at a temperature out of the predetermined temperature range.” Ex. 1005, 1:33–2:1. To determine locations in which the air speed and wind direction of a fan should be modified, Nakanishi discloses comparing temperature values and corresponding location coordinates from the simulated temperature distribution (i.e., the empirical atmospheric map) to a corresponding prescribed temperature range for those locations. Ex. 1005, 6:8–24. In Nakanishi’s system, this assessment is repeated at set time intervals, “and it is possible to quickly and properly control all areas so that temperatures of the areas are kept in the set temperature range.” Ex. 1005, 7:60–63.

150. As mentioned, the system disclosed in Nakanishi includes the capability of displaying an image of the simulated temperature distribution on a monitor. Ex. 1005, 7:58–67. A POSITA would understand that the image displayed represents a template atmospheric map when all temperatures of the distribution are within the prescribed range. This understanding is consistent with the teachings of the ’277 patent specification, which indicates that “[t]he template can be dynamic, generated either in real-time from current operating conditions, or can be static,

generated prior to the comparing step 106” and further teaches that “CFD modeling can be used to output a master, template, or model thermal map to be emulated by adjusting cooling system variables.” Ex. 1001, 6:41–43 and 6:52–54.

151. The capability of Nakanishi’s system to generate both empirical and template atmospheric maps is also illustrated in its Figures 3 and 4. Figure 4, which depicts the “result of the simulation,” is a visual diagram showing the temperature distribution throughout the computer room. Ex. 1005, 3:51–53, FIG. 4; *see also* 4:32–43, 5:57–63. An annotated version of Figure 4 of Nakanishi is reproduced below.

[FIG. 4]



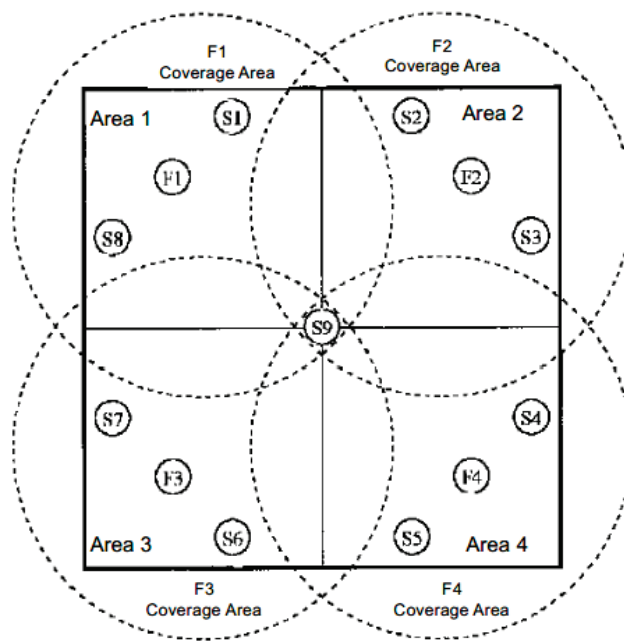
Ex. 1005, FIG. 4 (annotations added).

152. Figure 4 shows locations in the data center at which temperatures are within the prescribed temperature range (annotated in blue). Figure 4 also shows

regions where the temperature distribution is comparatively higher than the prescribed temperature range. Ex. 1005, FIG. 4; 3:47–4:9. These locations are termed “high-temperature region[s]” in Nakanishi and are displayed as shaded regions labeled H1, H2, and H3, respectively (annotated in red). Ex. 1005, FIG. 4; 3:47–4:9.

153. As discussed above, Nakanishi teaches that an optimal temperature state of the data center is when the temperatures at *all* locations are uniformly within the prescribed temperature range. A POSITA would immediately understand that when all temperatures are within the prescribed range the displayed image representing the temperature distribution throughout the computer room would lack any shaded regions. Figure 3 of Nakanishi, reproduced below, discloses such an optimal state and represents a template atmospheric map.

[FIG. 3]



Ex. 1005, FIG. 3. Therefore, Nakanishi discloses model temperatures for locations throughout an area and further discloses displaying this information as a visual representation of the area. I therefore conclude that Nakanishi discloses the template atmospheric map of this claim limitation 1[d] patent under Petitioner's proposed construction as informed by the plain and ordinary meaning as understood by a POSITA.

154. Nakanishi also discloses comparing the empirical atmospheric map (i.e., temperature and coordinate data of the generated temperature distribution) to a template atmospheric map (i.e., the temperature and coordinate data of the prescribed temperature range) under Petitioner's proposed construction as informed by the plain and ordinary meaning as understood by a POSITA of the "map" terms.

Figure 4 illustrates Nakanishi's capability to identify and display the location and size of hot spots as a result of this comparison.

155. Nakanishi also discloses the template atmospheric map under Patent Owner's expected construction of that term. As discussed above, Patent Owner appears to view this term to refer to a set of model atmospheric conditions corresponding to locations within an area regardless of whether the information is displayable as a visual representation of the area. As discussed above, Nakanishi teaches that an optimally operating data center has a temperature distribution that is within the prescribed temperature range at all locations in the data center. Ex. 1005, 1:45–2:2. Nakanishi describes evaluating temperatures at various coordinates of the simulated temperature distribution to determine whether they are within the prescribed temperature range. Ex. 1005, 5:57–63. A POSITA would understand that this necessarily entails storing data defining the prescribed temperature range at locations throughout data center. Thus, Nakanishi discloses the template atmospheric map of the '277 patent under Patent Owner's expected construction (and would do so even if Nakanishi had not disclosed displaying an image of the template atmospheric map).

156. Nakanishi discloses that PC 70 determines whether the simulated temperature distribution includes a temperature value outside a preset temperature range. Ex. 1005, 5:57–63. This is also performed for other locations to determine

relevant areas and the fans to be controlled based on identified coordinate locations where temperatures are outside of the set temperature range. Ex. 1005, 6:25–34, 6:41–58. 6:66–7:19. Thus, Nakanishi discloses comparing said empirical atmospheric map to a template atmospheric map under Patent Owner’s expected constructions of these terms, which are broader than Petitioner’s constructions.

157. Limitation 1[d] is therefore disclosed by Nakanishi under both Petitioner’s constructions of the “map” claim terms and Patent Owner’s expected constructions.

**f. 1[e] – “identifying pattern differentials between said empirical and template atmospheric maps.”**

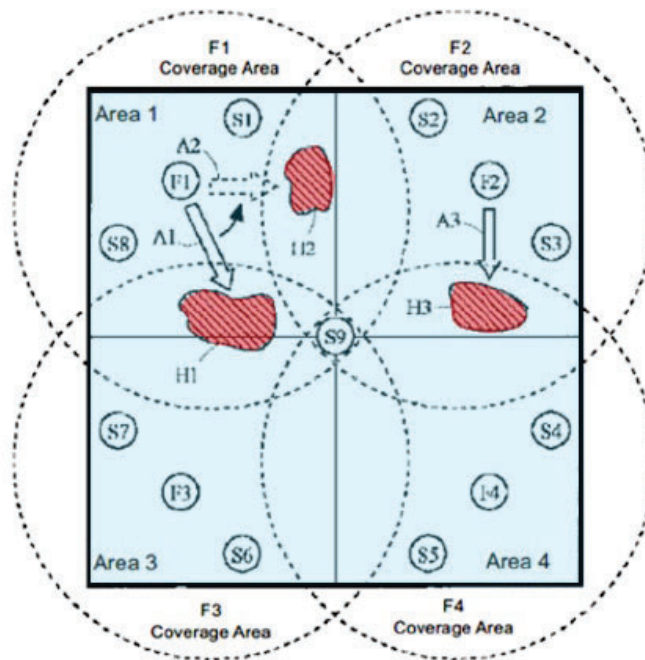
158. Claim 1 recites “*identifying pattern differentials between said empirical and template atmospheric maps.*” In my opinion, Nakanishi discloses this limitation.

159. As discussed above with respect to limitation 1[c], the simulated temperature distribution of Nakanishi, which correlates temperatures to coordinate locations and is displayable as an image, discloses the empirical atmospheric map of the ’277 patent. As discussed above with respect to limitation 1[d], the prescribed temperature range data for the coordinate locations, which is also displayable as a visual representation of the area, discloses the template atmospheric map of the ’277 patent.

160. The '277 patent explains that “thermal hot spots” are an example of pattern differentials that may be identified when comparing empirical and template atmospheric maps “in the case of data center cooling.” Ex. 1001, 6:64–66.

161. Nakanishi teaches identifying pattern differentials between the simulated temperature distribution and the corresponding prescribed temperature range for each location. Regions of the data center in which the temperature distribution rises above the prescribed temperature range are identified in Figure 4 of Nakanishi via shade lines and are labeled H1, H2, and H3, respectively. Ex. 1005, FIG. 4; 3:47–4:9. An annotated version of Figure 4 of Nakanishi is provided below, with H1, H2, and H3 annotated in red.

[FIG. 4]



Ex. 1005, FIG. 4 (annotations added).

162. Figure 4 depicts the “result of the simulation” and identifies regions H1, H2, and H3 as being “high temperature region[s].” Ex. 1005, 3:47–4:9. A POSITA would understand that a high temperature region is a pattern differential identified based on a comparison of Nakanishi’s disclosed empirical atmospheric map and template atmospheric map.

163. Nakanishi therefore discloses limitation 1[e].

## 2. Claim 2

164. I discuss each limitation of claim 2 in turn below, in conjunction with the relevant disclosures of each claim limitation by Nakanishi.

### a. 2[a] – “The method as claimed in claim 1, further comprising the steps of: determining corrective action to reduce said pattern differentials; and”

165. Claim 2 recites “[t]he method as claimed in claim 1, further comprising the steps of: determining corrective action to reduce said pattern differentials . . . .” In my opinion, Nakanishi discloses this limitation.

166. As explained above, Nakanishi discloses the method of claim 1.

167. As previously discussed, the “high temperature region[s]” of Nakanishi disclose the pattern differentials of the ’277 patent. Ex. 1005, 3:47–4:9.

168. Nakanishi teaches determining a corrective action to reduce these high temperature regions. Nakanishi’s disclosed system includes local PC 70 running an air conditioning control program “for controlling the entire cooling control process

on the basis of temperatures obtained by the simulation program. Ex. 1005, 4:39–42. With reference to Figure 6, Nakanishi discloses the control process flow in detail and explains how it coordinates adjusting the speed and/or direction of individual air fans in response to temperature conditions associated with designated areas. Ex. 1005, FIG. 6, 4:43–8:67. Fans are controlled to set their direction to the location of high temperature regions as determined by the simulation. Ex. 1005, 6:8–23. For example, Nakanishi teaches that “[w]hen a region H1 is determined to be a high-temperature region as the result of the simulation as shown in FIG. 4, the fan F1 covering the region H1 is controlled so as to supply cooling air toward the high temperature region H1.” Ex. 1005, 3:51–55. This discloses determining a corrective action as recited in claim 2.

169. The control system can detect when the temperature of a hot spot identified in a previous cycle has fallen back into the set temperature range such that it no longer requires temperature control. Ex. 1005, 6:8–23. For example, when the simulation is performed again and the temperature of region H1 falls within a preset temperature range and region H2 is determined to be a high temperature region, “fan F1 is then controlled so as to supply cooling air toward the region H2 . . .” Ex. 1005, 3:56–4:9. Because the temperature of region H1 falls within the preset temperature range, H1 is no longer a high temperature region. Thus, Nakanishi discloses reduction (and elimination) of identified pattern differentials.

170. Nakanishi therefore discloses claim limitation 2[a].

**b. 2[b] – “varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.”**

171. Claim 2 further recites “*varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.*” In my opinion, Nakanishi discloses this limitation.

172. Nakanishi discloses controlling the direction of fans such as “the fan F1 covering this region H1 . . . to supply cooling air toward the high-temperature region H1.” Ex. 1005, 3:47–55. A POSITA would understand that changing the direction of the fan F1 varies the distribution of conditioned fluid.

173. Nakanishi further discloses “control[ing] the airflow rate” as another corrective action that may be taken to cool high temperature regions. Ex. 1005, 4:18–30. A POSITA would understand that changing the air speed varies the quantity of conditioned fluid delivered to an area.

174. Nakanishi therefore discloses claim limitation 2[b].

**3. Claim 3 – “The method as claimed in claim 2, wherein said supplying step comprises the step of operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.”**

175. Claim 3 recites “[t]he method as claimed in claim 2, wherein said supplying step comprises the step of operating a system having at least one of a

*plurality of vents, at least one blower, and at least one source of conditioned air.”*

In my opinion, Nakanishi discloses this claim.

176. As explained above, Nakanishi discloses the method of claim 2.

177. Nakanishi discloses an “air conditioning system” for a computer room with a “plurality of under-floor fans 14 [] set to a floor 20.” Ex. 1005, 2:26–33. The air conditioning system also includes “[t]wo air conditioners [that] . . . supply cooling air to a space 18 under the floor. The cooling air from the air conditioners 16 is sent to the computer room 10 by fans 14. The air in the computer room 10 flows to a space 30 in a ceiling through exhaust ports 24 provided at the ceiling 22 . . . .” Ex. 1005, 2:34–41.

178. Accordingly, Nakanishi discloses supplying conditioned fluid by operating a system with at least one vent, at least one blower, and at least one source of conditioned air.

179. Claim 3 of the ’277 patent is therefore anticipated by Nakanishi.

**4. Claim 4 – “The method as claimed in claim 3, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”**

180. Claim 4 recites “[t]he method as claimed in claim 3, wherein said *determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality*

*of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”* In my opinion, Nakanishi discloses this claim.

181. As explained above, Nakanishi discloses the method of claim 3.

182. Nakanishi further discloses correlating the location of high and low temperature locations (i.e., pattern differentials) to the speed of at least one blower.

183. For example, in Nakanishi, “the air conditioning control application program identifies an area and a fan to be controlled, on the basis of the coordinate position being at a temperature higher than the set temperature range . . . .” Ex. 1005, 6:66–7:18. Areas where the temperatures are higher than the set temperature range are identified as high-temperature regions, and this corresponds to the pattern differentials recited in claims.

184. Nakanishi’s disclosed system includes variable speed fans. Ex. 1005, 5:22–30. Nakanishi further discloses: “[t]he local PC 70 supplies a signal for designating a fan to be controlled and a signal for designating raising an airflow rate to a level ‘middle’ to the airflow-rate control circuit 76 (FIG. 5).” Ex. 1005, 7:19–23. “Therefore, cooling air is supplied to the high-temperature region exceeding the set temperature range.” Ex. 1005, 7:25–27. If the temperature of a location falls below the set temperature range, the air speed of the relevant fan is reduced. Ex. 1005, 6:48–58. Both circumstances involve correlating the location of pattern differentials to the speed of at least one blower.

185. Claim 4 of the '277 patent is therefore anticipated by Nakanishi.

**5. Claim 5 – “The method as claimed in claim 4, wherein said varying step comprises adjusting at least one of the opening of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.”**

186. Claim 5 recites “[t]he method as claimed in claim 4, wherein said varying step comprises adjusting at least one of the opening of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.” In my opinion, Nakanishi discloses this claim.

187. As explained above, Nakanishi discloses the method of claim 4.

188. As discussed with respect to limitation 2[b], Nakanishi discloses varying the quantity of conditioned fluid delivered to an area by “control[ling] the airflow rate.” Ex. 1005, 4:18–30. The air speed is controlled by “[t]he airflow-rate control circuit 76,” which “controls the revolving speed of a designated fan 14.” Ex. 1005, 4:18–30.

189. Claim 5 of the '277 patent is therefore anticipated by Nakanishi.

**6. Claim 6 – “The method as claimed in claim 1, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical atmospheric map.”**

190. Claim 6 recites, “[t]he method as claimed in claim 1, wherein said generating step comprises using thermal mapping software to process input from

*said sensing step and to produce output in the form of said empirical atmospheric map.”* In my opinion, Nakanishi discloses this claim.

191. As explained above, Nakanishi discloses the method of claim 1.

192. The specification of the '277 patent describes thermal mapping software as functioning to process sensed data points into a thermal map composed of temperature contours that define various isothermal regions of distinct temperatures. Ex. 1001, 4:41–46. The specification explains that thermal mapping software is capable of locating “hot spots,” including those located between various temperature sensors. Ex. 1001, 4:46–67.

193. Nakanishi similarly discloses using thermal mapping software to process data from temperature sensors and produce a thermal map. According to Nakanishi’s teachings, local PC 70 collects temperature values from all temperature sensors and sends this data to a remote PC 82, which performs a simulation based on the temperature values to obtain a temperature distribution in the computer room. Ex. 1005, 5:31–56. Nakanishi recommends using “any suitable commercially available temperature distribution analysis program” and names FLOTHERM as an example. Ex. 1005, 5:41–45. A POSITA would understand that FLOTHERM and other thermal mapping programs process temperature sensor values to produce a thermal map, which the '277 patent recognizes as a type of empirical atmospheric map. Ex. 1005, 1:53–2:2; 3:47–4:10; 4:32–43; 8:23–36.

194. Claim 6 of the '277 patent is therefore anticipated by Nakanishi.

**7. Claim 7 – “The method as claimed in claim 1, wherein said identifying step comprises using pattern recognition software.”**

195. Claim 7 recites, “[t]he method as claimed in claim 1, wherein said identifying step comprises using pattern recognition software.” In my opinion, Nakanishi discloses this claim.

196. As explained above, Nakanishi discloses the method of claim 1.

197. As previously explained with respect to limitation 1[e], the high temperature regions of Nakanishi, which disclose the recited pattern differentials, are identified by comparing temperature values from the simulated temperature distribution (i.e., values from the empirical atmospheric map) to the prescribed temperature range for the corresponding locations (i.e., values from template atmospheric map). In Nakanishi, “the local PC 70 including an air conditioning control application program determines whether the temperature distribution values include a temperature out of a preset temperature range.” Ex. 1005, 5:57–63. Therefore, Nakanishi’s system uses software to recognize differences between the simulated temperature distribution pattern and the preset temperature distribution pattern.

198. Claim 7 of the '277 patent is therefore anticipated by Nakanishi.

**8. Claim 8 – “The method as claimed in claim 1, wherein said plurality of locations of said sensing step comprises locations at various elevations within said building.”**

199. Claim 8 recites, “[t]he method as claimed in claim 1, wherein said plurality of locations of said sensing step comprises locations at various elevations within said building.” In my opinion, Nakanishi discloses this claim.

200. As explained above, Nakanishi discloses the method of claim 1.

201. Nakanishi further discloses “[a] plurality of temperature sensors S1 to S9 are arranged at selected locations of the computer room. The temperature sensors are set at positions at a height of 1.3 m from the floor surface.” Ex. 1005, 3:43–45. A POSITA would understand that 1.3 m is one possible elevation only and that Nakanishi’s teachings include sensing temperatures at multiple elevations. Nakanishi states that “[t]hough the number of and positions of temperature sensors are not strict, it is generally preferable to set the sensors on the wall and poles of a computer room at an equal interval.” Ex. 1005, 8:33–36. Based on this guidance that sensors are preferably elevated above the floor at particular locations that are not critical, a POSITA would immediately understand that Nakanishi’s disclosure includes implementations in which temperature sensors are placed at various elevations..

202. Claim 8 of the ’277 patent is therefore anticipated by Nakanishi.

**9. Claim 9 – “The method as claimed in claim 1, wherein said sensing step comprises using at least one of temperature sensors, humidity sensors, pressure sensors, particle sensors, smoke sensors, and velocity sensors.”**

203. Claim 9 recites, “[t]he method as claimed in claim 1, wherein said sensing step comprises using at least one of temperature sensors, humidity sensors, pressure sensors, particle sensors, smoke sensors, and velocity sensors.” In my opinion, Nakanishi discloses this claim.

204. As explained above, Nakanishi discloses the method of claim 1.

205. Nakanishi discloses using temperature sensors for the sensing step. For example, Nakanishi teaches using “[a] plurality of temperature sensors Sn [to] supply temperature information to a local personal computer (PC) 70 through an analog- digital converter (ADC) 72.” Ex. 1005, 4:10–17.

206. Claim 9 of the ’277 patent is therefore anticipated by Nakanishi.

**10. Claim 10 – “The method as claimed in claim 1, wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.”**

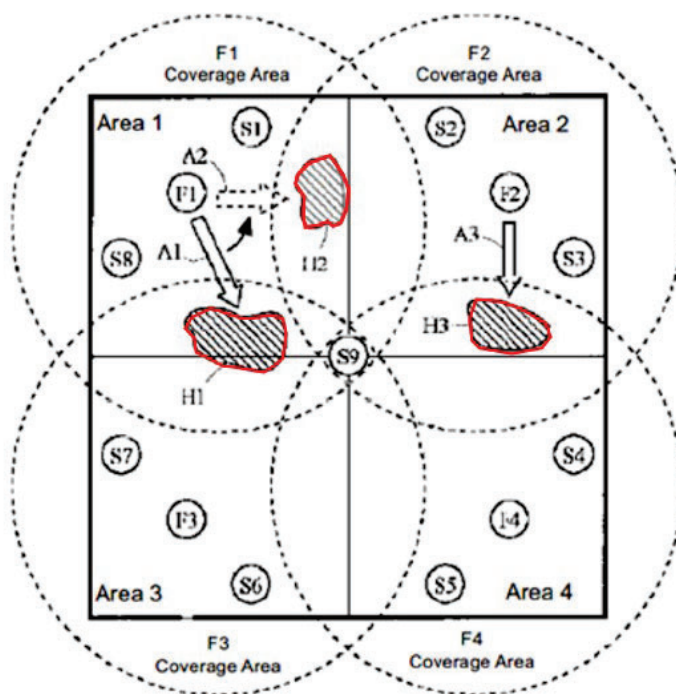
207. Claim 10 recites, “[t]he method as claimed in claim 1, wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.” In my opinion, Nakanishi discloses this claim.

208. As explained above, Nakanishi discloses the method of claim 1.

209. A POSITA in the field of thermal modeling would understand an isothermal region as a region having a distinct temperature or temperature range. Isotherms are typically shown as a curve on a diagram joining points representing conditions of equal temperature. The '277 patent reflects this conventional understanding: “a thermal map is composed of temperature contours that define various isothermal regions, or isotherms, of distinct temperatures. The most severe of these isotherms are commonly known as ‘hot spots.’” Ex. 1001, 4:44–47.

210. Nakanishi’s disclosed temperature distribution map includes temperature contours that define isotherms, such as hot spots. For example, high temperature regions (H1, H2, and H3) of a computer room are outlined by contour lines in Figure 4 of Nakanishi. Ex. 1005, FIG. 4; 3:47–4:9. These contour lines are annotated in red in the annotated version of Figure 4 of Nakanishi, provided below.

[FIG. 4]



Ex. 1005, FIG. 4 (annotated).

211. A POSITA would understand that the contour lines delineating the periphery of each high temperature region are temperature countour lines that identify isotherms.

212. Additionally, Nakanishi teaches generating the temperature distribution of the computer room using “any suitable temperature-distribution analysis program that is commercially available,” such as “FLOTHERM.” Ex. 1005, 5:42–45. A POSITA would understand that these programs produce maps showing temperature contours that define isothermal regions. The 1993 conference paper discussed above in Paragraph 109 shows an example of a temperature

distribution map produced by FLOTHERM showing temperature contour lines that define hot spots. Ex. 1011, 13.

213. Claim 10 of the '277 patent is therefore anticipated by Nakanishi.

**11. Claim 11 – “The method as claimed in claim 1, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.”**

214. Claim 11 recites, “[t]he method as claimed in claim 1, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.” In my opinion, Nakanishi discloses this claim.

215. As explained above, Nakanishi discloses the method of claim 1.

216. With reference to Figure 6 of Nakanishi, the figure indicates that “[i]n block 102, the local PC 70 collects temperature values from all the temperature sensors Sn. The local PC 70 sends the collected temperature values and the data of the current airflow rate and airflow direction of each fan to the remote PC 82.” Ex. 1005, 5:32–36. “In block 104, the remote PC 82 performs a simulation on the basis of the temperature values and the current airflow rate and airflow direction of each fan to obtain a temperature distribution in the computer room.” Ex. 1005, 5:37–40.

217. In an exemplary embodiment, Nakanishi describes using sensors S1 to S9 “arranged at selected positions in the computer room.” Ex. 1005, 3:42–45. Using

nine sensors provides only limited temperature information. The simulation program generates a more comprehensive evaluation of the temperature distribution throughout the computer room. A POSITA would understand that the simulation program uses techniques such as extrapolation or triangulation based on the temperature measurements to simulate the temperatures at additional locations within the computer room. Moreover, Nakanishi's disclosure that "the current airflow rate and airflow direction of each fan" are additional inputs sent to the remote PC 82 to simulate the temperature distribution confirm that Nakanishi discloses extrapolating or triangulating based on the empirical temperature measurements to simulate the temperatures of locations in the computer room that lack a temperature sensor. Ex. 1005, 5:31–36. A POSITA would understand that those additional inputs are used to thermodynamically model the effects of air circulation in the process of extrapolating from the measured information to estimate temperatures at locations away from the temperature sensor locations.

218. Nakanishi further discloses using these simulated temperatures in the temperature distribution to identify the locations of hot spots in the data room. For example, "[i]n block 106, the local PC 70 including an air-conditioning control application program determines whether the temperature distribution values include a temperature out of a preset temperature range." Ex. 1005, 5:57–63. "In block 126, it is determined whether there is a temperature higher than the upper limit of the set

temperature range.” Ex. 1005, 6:62–65. As explained previously, regions of the computer room where the temperature distribution is above the upper limit of the set temperature range are considered high temperature regions, i.e., hot spots.

219. The ’277 patent states that “thermal mapping software can extrapolate or triangulate the location of the actual hot spot from the known locations of the temperature sensors.” Ex. 1001, 4:50–52. This reflects the knowledge of a POSITA that a program, such as FLOTHERM, disclosed in Nakanishi, extrapolates or triangulates from a select number of measured temperatures to generate a comprehensive temperature distribution and identify the locations of hot spots.

220. Claim 11 of the ’277 patent is therefore anticipated by Nakanishi.

## **12. Claim 12**

221. Independent claim 12 corresponds closely to claim 1 with only minor relevant differences. Whereas claim 1 refers to cooling a building, claim 12 recites cooling “a data center.” The method of claim 1 involves sensing at least one “atmospheric parameter,” generating an “empirical atmospheric map” and comparing it to a “template atmospheric map.” The claim 12 recites essentially the same method with the atmospheric parameter being temperature. Claim 12 thus recites “sensing temperature,” generating an “empirical thermal map” and comparing it to a “template thermal map.”

222. As discussed above, Nakanishi discloses a system and method for monitoring and controlling the temperature distribution throughout a computer room equipped with various computer units arranged on floor surface. The terms “computer room” and “data center” have been used interchangeably in the field at all relevant times, and a POSITA would recognize that Nakanishi’s cooling system is intended and readily implementable for cooling data centers. The ’277 patent itself confirms that a data center is a type of computer room. Ex. 1001, 3:54–58 (“the racks may be positioned throughout the *data center* according to their anticipated heat loads to thereby enable *computer room air conditioning* (CRAC) units located at various positions throughout the *data center*”). The depiction of a computer room illustrated in Nakanishi’s Figure 1 is very similar to the data center illustrated in Figure 1 of Patel, incorporated by reference into the ’277 patent specification. (*See* Paragraphs 91–97 above.)

223. The relevant “atmospheric parameter” monitored and managed by the control system and method disclosed in Nakanishi is temperature, the disclosed simulation program generates temperature distribution maps, and Nakanishi’s method includes comparing the temperature map to a template temperature map.

224. Therefore, my analyses and opinions set forth in Paragraphs 125 to 220 above in relation to claims 1–11 apply equally to claims 12–21, because Nakanishi’s disclosure encompasses cooling of a data center.

225. The following table identifies where claim 12's limitations are analogous to limitations of claim 1 addressed above for assessing validity relative to Nakanishi's disclosed method of cooling a data center involving measuring temperatures and generating and comparing thermal maps:

| <b>Claim 12 Limitations</b>                                                                       | <b>Analogous Claim 1 Limitations</b>                                                                  | <b>Citations to Sections Above</b> |
|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------------------|
| a method of cooling a data center having equipment therein, said method comprising the steps of:  | a method of controlling atmospheric conditions within a building, said method comprising the steps of | <b>IX.A.1.1[pre]</b>               |
| supplying a cooling fluid within said data center to cool said equipment within said data center; | supplying a conditioned fluid inside said building,                                                   | <b>IX.A.1.1[a]</b>                 |
| sensing temperature within said data center in a plurality of locations,                          | sensing at least one atmospheric parameter in a plurality of locations inside said building,          | <b>IX.A.1.1[b]</b>                 |
| generating an empirical thermal map of said data center from the results of said sensing step;    | generating an empirical atmospheric map from the results of said sensing step;                        | <b>IX.A.1.1[c]</b>                 |
| comparing said empirical thermal map to a template thermal map;                                   | comparing said empirical atmospheric map to a template atmospheric map;                               | <b>IX.A.1.1[d]</b>                 |
| identifying pattern differentials between said empirical and template thermal maps.               | identifying pattern differentials between said empirical and template atmospheric maps.               | <b>IX.A.1.1[e]</b>                 |

226. Each of claim 12's limitations are disclosed by Nakanishi for the reasons provided above, and incorporated here. *Supra* Sections IX.A.1.1[pre]–[e]. In my opinion, claim 12 is anticipated by Nakanishi.

### **13. Claim 13**

227. I discuss each limitation of claim 13 in turn below, in conjunction with the relevant disclosures of each claim limitation by Nakanishi.

- a. **13[a] – “The method as claimed in claim 12, further comprising the steps of: determining corrective action to reduce said pattern differentials; and”**

228. Claim 13 recites, “[t]he method as claimed in claim 12, further comprising the steps of: determining corrective action to reduce said pattern differentials . . . .” In my opinion, Nakanishi discloses this limitation.

229. The subject of this claim limitation is analogous to claim limitation 2[a]. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.2.2[a].

- b. **13[b] – “varying at least one of the quantity, quality, and distribution of said cooling fluid in accord with said determining step.”**

230. Claim 13 further recites, “varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.” In my opinion, Nakanishi discloses this limitation.

231. The subject of this claim limitation is analogous to claim limitation 2[b]. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.2.2[b].

232. In my opinion, claim 13 is anticipated by Nakanishi.

- 14. Claim 14 – “The method as claimed in claim 13, wherein said supplying step comprises operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.”**

233. Claim 14 recites, “[t]he method as claimed in claim 13, wherein said supplying step comprises operating a system having at least one of a plurality of

*vents, at least one blower, and at least one source of conditioned air.”* In my opinion, Nakanishi discloses this claim.

234. The subject of this claim is analogous to claim 3. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.3.

235. Claim 14 of the ’277 patent is therefore anticipated by Nakanishi.

**15. Claim 15 – “The method as claimed in claim 14, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”**

236. Claim 15 recites, “[t]he method as claimed in claim 14, wherein said *determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.*” In my opinion, Nakanishi discloses this claim.

237. The subject of this claim is analogous to claim 4. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.4.

238. Claim 15 of the ’277 patent is therefore anticipated by Nakanishi.

**16. Claim 16 – “The method as claimed in claim 15, wherein said varying step comprises adjusting at least one of the opening of at least one of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.”**

239. Claim 16 recites, “[t]he method as claimed in claim 15, wherein said varying step comprises adjusting at least one of the opening of at least one of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.” In my opinion, Nakanishi discloses this claim.

240. The subject of this claim is analogous to claim 5. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.5.

241. In my opinion, claim 16 of the ’277 patent is anticipated by Nakanishi.

**17. Claim 17 – “The method as claimed in claim 12, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical thermal map, wherein said thermal mapping software triangulates locations of hot spots.”**

242. Claim 17 recites, “[t]he method as claimed in claim 12, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical thermal map, wherein said thermal mapping software triangulates locations of hot spots.” In my opinion, Nakanishi discloses this claim.

243. The subject of this claim is analogous to claim 6. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.6.

244. Claim 17 of the '277 patent is therefore anticipated by Nakanishi.

**18. Claim 18 – “The method as claimed in claim 12, wherein said identifying step comprises using pattern recognition software.”**

245. Claim 18 recites, “[t]he method as claimed in claim 12, wherein said identifying step comprises using pattern recognition software.” In my opinion, Nakanishi discloses this claim.

246. The subject of this claim is analogous to claim 7. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.7.

247. Claim 18 of the '277 patent is therefore anticipated by Nakanishi.

**19. Claim 19 – “The method as claimed in claim 12, wherein said plurality of locations of said sensing step comprises locations at various elevations within said data center.”**

248. Claim 19 recites, “[t]he method as claimed in claim 12, wherein said plurality of locations of said sensing step comprises locations at various elevations within said data center.” In my opinion, Nakanishi discloses this claim.

249. The subject of this claim is analogous to claim 8. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.8.

250. Claim 19 of the '277 patent is therefore anticipated by Nakanishi.

**20. Claim 20 – “The method as claimed in claim 12 wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.”**

251. Claim 20 recites, “[t]he method as claimed in claim 12 wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.” In my opinion, Nakanishi discloses this claim.

252. The subject of this claim is analogous to claim 10. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here.

*Supra* Section IX.A.10.

253. Claim 20 of the '277 patent is therefore anticipated by Nakanishi.

**21. Claim 21 – “The method as claimed in claim 12, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.”**

254. Claim 21 recites, “[t]he method as claimed in claim 12, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.” In my opinion, Nakanishi discloses this claim.

255. The subject of this claim is analogous to claim 11. Thus, Nakanishi discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.A.11.

256. Claim 21 of the '277 patent is therefore anticipated by Nakanishi.

**B. GROUND 2: CLAIMS 1–6, 8–17 AND 19–21 ARE ANTICIPATED BY BISHOP**

257. For the reasons set forth below, it is my opinion that Bishop discloses all the limitations of and anticipates claims 1–6, 8–17, 19–21 of the '277 patent.

**1. Claim 1**

258. I discuss each limitation of claim 1 in turn below, in conjunction with the relevant disclosures of each claim limitation by Bishop.

**a. 1[pre] – “A method of controlling atmospheric conditions within a building, said method comprising the steps of:”**

259. The preamble of claim 1 recites, “[a] *method of controlling atmospheric conditions within a building, said method comprising the steps of:*”

260. I have been informed that claim preambles are generally not limiting. In any case, even if the preamble here were a limitation, I believe that Bishop discloses the preamble.

261. A POSITA would have understood that temperature is an atmospheric condition. The '277 patent states that “atmospheric sensors 12 are used for measuring one or more atmospheric parameter and encompass temperature sensors.” Ex. 1001, 4:12–14. Bishop discloses a system for “cooling at least one

electronic module inside a module cabinet.” Ex. 1006, [0043]. The cooling system disclosed in Bishop discloses the preamble’s controlling of atmospheric conditions. *See also* Ex. 1005, 5:57–63; .

262. Additionally, Bishop teaches that these “electronic modules [are] in special ‘critical environment’ computing and warehousing rooms.” Ex. 1006, [0005]. Bishop’s improved cooling system is described with respect to “exemplary critical environment room 10.” Ex. 1006, [0062]. A POSITA would have understood that rooms exist within a building.

263. Thus, Bishop discloses limitation 1[pre].

**b. 1[a] – “supplying a conditioned fluid inside said building;”**

264. Claim 1 further recites “*supplying a conditioned fluid inside said building.*” In my opinion, Bishop discloses this limitation.

265. Bishop describes IT facilities in which large numbers of servers and other electronic modules are maintained in cabinets or racks. Ex. 1006, [0006]–[0008]. Bishop describes conventional cooling systems for such facilities in which “cooling air is pumped through floor tiles into the critical environment.” Ex. 1006, [0012]. Bishop explains that maintaining a constant temperature throughout the critical environment is ideal and describes challenges with achieving this, such as obstructed air flow paths and irregular amounts of heat being generated by different electronic modules as operating capacity changes. Ex. 1006, [0012]–[0014].

266. To address a need for a more efficient and effective cooling, Bishop discloses a system in which each cabinet or rack has its own controller equipped with air temperature, pressure and flow rate sensors and linked to temperature sensors associated with the cabinet and electronic modules. Ex. 1006, [0062], [0065]–[0066], FIG. 2. Warm air expelled from the cabinets flows back into a critical environment and then to an air-cooling system to reduce its temperature before being delivered back into the critical environment. Ex. 1006, [0080].

267. A POSITA would understand that cooling air is one type of conditioned fluid. Indeed, the '277 patent confirms that “cooling fluid” and “conditioned air” are interchangeable terms: “the amount of energy typically required to cool a data center may be relatively reduced by strategically distributing *cooling fluid*, or *conditioned air*, within the data center.” Ex. 1001, 3:42–44 (emphasis added).

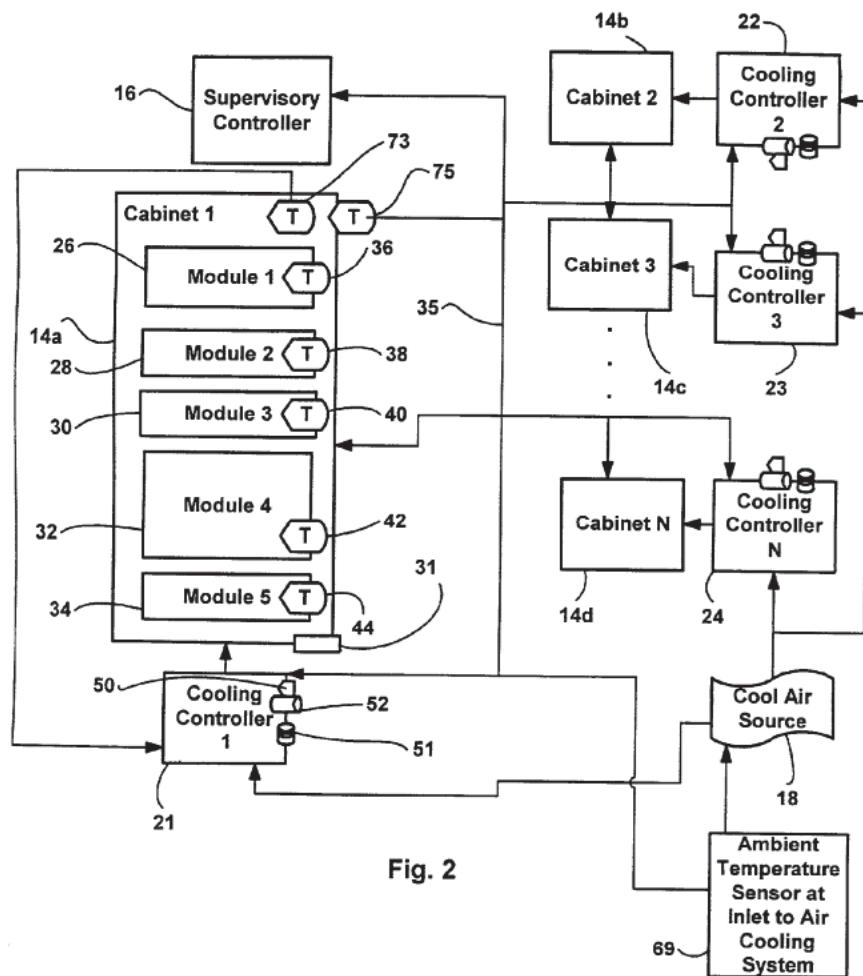
268. Bishop therefore teaches supplying a conditioned fluid inside a building, as recited in claim 1.

**c. 1[b] – “sensing at least one atmospheric parameter in a plurality of locations inside said building;”**

269. Claim 1 recites “*sensing at least one atmospheric parameter in a plurality of locations inside said building.*” In my opinion, Bishop discloses this limitation.

270. Bishop teaches electronic modules that “monitor their own operating temperatures and to that end have a module temperature sensor located at a critical area (e.g., proximate a heat sensitive component) within the module. In FIG. 2 the temperature sensors in modules 26, 28, 30, 32 and 34 are identified by numerals 36, 38, 40, 42 and 44, respectively.” Ex. 1006, [0081]. Additional temperature sensors are indicated by items 52, 73, 75, and 77. Collectively, these are “internal” and “external” temperature sensors (Ex. 1006, [0067]), and also sensors outside of cabinet 14a (Ex. 1006, [0106]) and in the air (Ex. 1006, [0066]).

271. Figure 2 of Bishop is reproduced below.



Ex. 1006, FIG. 2. As mentioned above, an additional temperature sensor 73 inside the cabinet 14a provides redundancy for the module sensors. Ex. 1006, [0105]. Temperature sensors 75 outside of each cabinet provide ambient temperature values at the cabinet location. Ex. 1006, [0106].

272. As discussed above, temperature is an atmospheric parameter, and a room is inherently within a building. Thus, Bishop teaches sensing at least one atmospheric parameter in a plurality of locations inside the building.

- d. 1[c] – “generating an empirical atmospheric map from the results of said sensing step using software for processing input from said sensing step and for producing output in the form of said empirical atmospheric map;”**

273. Claim 1 recites “*generating an empirical atmospheric map from the results of said sensing step using software for processing input from said sensing step and for producing output in the form of said empirical atmospheric map.*” In my opinion, Bishop discloses this limitation.

274. Bishop discloses generating the empirical atmospheric map recited in claim 1 of the ’277 patent under both Petitioner’s construction and Patent Owner’s expected construction of “empirical atmospheric map.”

275. As discussed above, a POSITA would understand the “empirical atmospheric map” to mean “data displayable as a visual representation of an area showing measured atmospheric conditions corresponding to locations.”

276. Bishop’s background discussion of conventional approaches for managing air flows and cooling within critical IT environments mentions an approach involving taking “a plurality of temperature readings” and feeding these temperature readings “into a computer that generates a three dimensional map of temperature in the environment as a function of location within the environment.” Ex. 1006, [0017]. As of the April 2002 filing date of the ’277 patent, a POSITA would have been familiar with CFD software capable of generating the type of three-dimensional temperature map described in Bishop.

277. Bishop's disclosed improved system for cooling critical environments includes such a mapping capability. In particular, the sensors 75 on the outside of each cabinet are linked to supervisory controller 16 and provide an ambient temperature reading at each cabinet location. Bishop describes that "the temperature readings from all of the external sensors (e.g., 75) may be used to generate a three dimensional temperature graph for observation by an environment administrator." Ex. 1006, [0106]. A POSITA would have understood that the three-dimensional temperature graph provides a visual representation of the critical space showing temperature information for at least the cabinet locations.

278. The relevant measured atmospheric information in the three-dimensional map of Bishop is temperature. Thus, under Petitioner's construction, the three-dimensional map of Bishop discloses the empirical atmospheric map of the '277 patent.

279. The three-dimensional map of Bishop also discloses the empirical atmospheric map recited in claim 1 of the '277 patent under Patent Owner's expected construction. As discussed above, Patent Owner appears to construe "map" to apply to any set of data that is correlated to locations. Bishop's disclosure of collecting temperature readings from cabinet temperature sensors to provide the "temperature at the cabinet location" discloses generating a set of temperature data correlated to locations. This is necessarily so, given Bishop's additional description

of using the collected data to generate a three-dimensional temperature graph for observation by an administrator. Because the measured temperature values and location data are required inputs to generate such a map, Bishop inherently discloses generating an index of the measured temperatures and the corresponding locations of those measured temperatures.

280. Limitation 1[c] of the '277 patent is therefore anticipated by Bishop under both Petitioner's construction of "empirical atmospheric map" and Patent Owner's expected construction of this term.

**e. 1[d] – “comparing said empirical atmospheric map to a template atmospheric map; and”**

281. Claim 1 recites “*comparing said empirical atmospheric map to a template atmospheric map.*” In my opinion, Bishop discloses this limitation.

282. As discussed above with respect to limitation 1[c], Bishop's cooling system measures and collects temperature at the location of each cabinet and produces a three-dimensional thermal map corresponding to the empirical atmospheric map of the '277 patent.

283. Bishop also discloses the template atmospheric map recited in claim 1 of the '277 patent under both Petitioner's construction of “template atmospheric map” and Patent Owner's expected construction of this term.

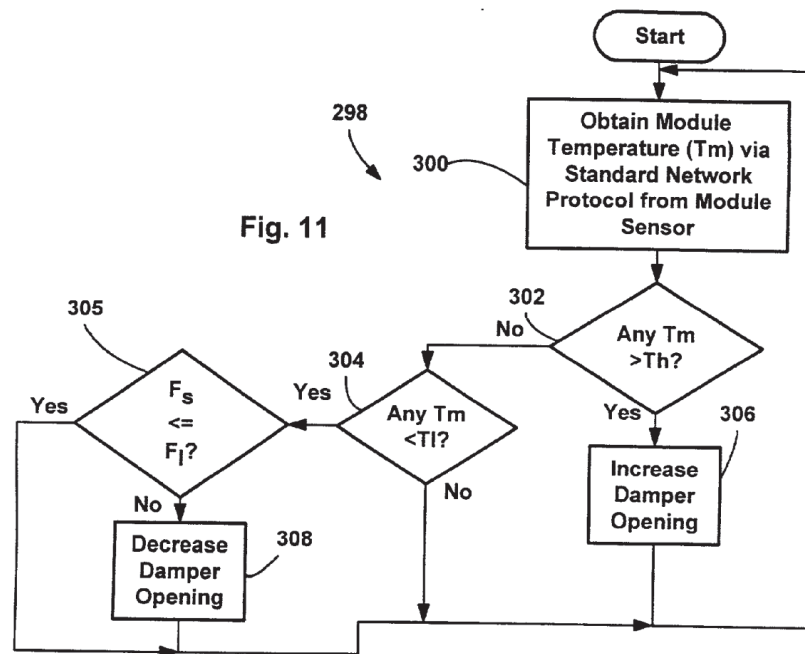
284. Regarding the term “template,” the '277 patent explains that while referring to temperature as the relevant atmospheric condition, the “template

thermal map could also be termed a master, or model thermal map. The template basically represents a thermal map of an optimally operating data center cooling system.” Ex. 1001, 6:38–41. As discussed above, a POSITA would understand the template atmospheric map as data that is displayable as a visual representation of an area showing model atmospheric conditions corresponding to locations. Patent Owner appears to apply this term more broadly to not necessarily require that the data be displayable as a representation of an area.

285. Bishop teaches that “[i]deally the environment temperature throughout the critical environment should be maintained at the same temperature so that if modules are swapped into or out of a cabinet the modules will always be exposed to the same optimal ambient temperature.” Ex. 1006, [0012]. Bishop’s control system receives temperature readings from multiple locations corresponding to electronics modules and cabinets and compares the measured temperature values to “threshold temperatures to determine if [the measured] temperatures are within an optimal range.” Ex. 1006, [0082]. The two threshold temperatures are the low threshold temperature ( $T_l$ ) and the high threshold temperature ( $T_h$ ). Ex. 1006, [0083]. Therefore, Bishop teaches that an optimally operating data center is one in which all the measured temperatures (and the corresponding three-dimensional map) are above the low threshold temperature ( $T_l$ ) and below the high threshold temperature ( $T_h$ ) at all locations. Therefore, Bishop discloses the template

atmospheric map under Patent Owner's expected construction of "template atmospheric map"—a data set of model atmospheric conditions (i.e., temperature range of  $T_l$ – $T_h$ ) corresponding to locations (i.e., all locations in a data center).

286. Bishop also teaches comparing said empirical atmospheric map to a template atmospheric map under Patent Owner's expected construction of the "map" terms. As shown in Figure 11 of Bishop (reproduced below), the control logic of Bishop's system involves comparing measured temperatures to the low threshold temperature ( $T_l$ ) and the high threshold temperature ( $T_h$ ) and adjusting damper openings until all measured temperatures are between the low threshold temperature ( $T_l$ ) and the high threshold temperature ( $T_h$ ). Ex. 1006, FIG. 11 (reproduced below).



Ex. 1006, FIG. 11. For example, Bishop teaches that when a measured temperature exceeds the high threshold temperature ( $T_h$ ), a damper opening should be increased “to increase the cooling air flow to the corresponding cabinet.” Ex. 1006, [0085]. When any module temperature is below a threshold temperature, a controller decreases a damper opening to reduce cooling air flow to the cabinet. Ex. 1006, [0084].

287. Therefore, limitation 1[d] of the ’277 patent is anticipated by Bishop under Patent Owner’s expected constructions of the “map” terms.

288. Bishop also anticipates limitation 1[d] of the ’277 patent under Petitioner’s constructions, which clarifies that the map data is displayable as a visual representation of an area.

289. Bishop’s system can generate a “three dimensional temperature graph for observation by an environment administrator.” Ex. 1006, [0106]. Bishop also mentions known-use thermal mapping software tools to identify where “hot spots” occur and to evaluate how cooling system adjustments affect the temperature distribution. Ex. 1006, [0017]. Based on these related teachings, a POSITA would immediately envision implementing Bishop’s three-dimensional thermal map feature to assess the impact of control actions taken to reduce or eliminate hot spots. A POSITA would understand that the displayed thermal map would lack any hot spots when all temperatures are between the low threshold temperature ( $T_l$ ) and the

high threshold temperature ( $T_h$ ). Thus, Bishop discloses displaying a three-dimensional thermal map that corresponds to the template atmospheric map recited in this claim limitation under Petitioner's construction of "map."

290. Bishop's system also discloses comparing measured temperatures from various locations to the model temperature range defined by the low threshold temperature ( $T_l$ ) and the high threshold temperature ( $T_h$ ). Ex. 1006, FIG. 11. This discloses the comparison step of this claim limitation 1[d].

291. Also, Claim 1 indicates that the step of generating an empirical atmospheric map is performed "using software." There is no corresponding language in limitation 1[d] requiring the use of software to compare the empirical and templates maps. This is also true of the final limitation 1[e] directed to identifying pattern differentials. Therefore, I have also evaluated Claim 1 from the standpoint of understanding that the last two recited steps can be performed manually.

292. As discussed above, Bishop describes the conventional practice of manually comparing computer-generated thermal maps as a way of evaluating corrective adjustments made to a cooling system. In particular, Bishop discloses: "a plurality of temperature readings . . . are then fed into a computer that generates a three dimensional map of temperature in the environment as a function of location within the environment. Where 'hot spots' occur the administrator then adjusts tile

baffles. Thereafter the administrator again collects temperature readings throughout the environment and causes the computer to generate the map to see the results.” Ex. 1006, [0017].

293. In Bishop, “hot spots” are areas where “the cooling air flow to the corresponding cabinet” should be increased, Ex. 1006, [0085], FIG. 6, such as by “adjust[ing] tile baffles.” Ex. 1006, [0017]. In order for an administrator to visually observe hot spots in the three-dimensional map of measured temperatures, Bishop necessarily discloses a visual or pictorial representation of the model temperature range that can be compared to the three-dimensional map of measured temperatures. A POSITA would understand the disclosed conventional approach as describing an administrator visually comparing a three-dimensional map of measured temperatures (i.e., empirical atmospheric map) to a three-dimensional map of model or optimal temperatures (i.e., template atmospheric map) for the purpose of identifying “hot spots.”

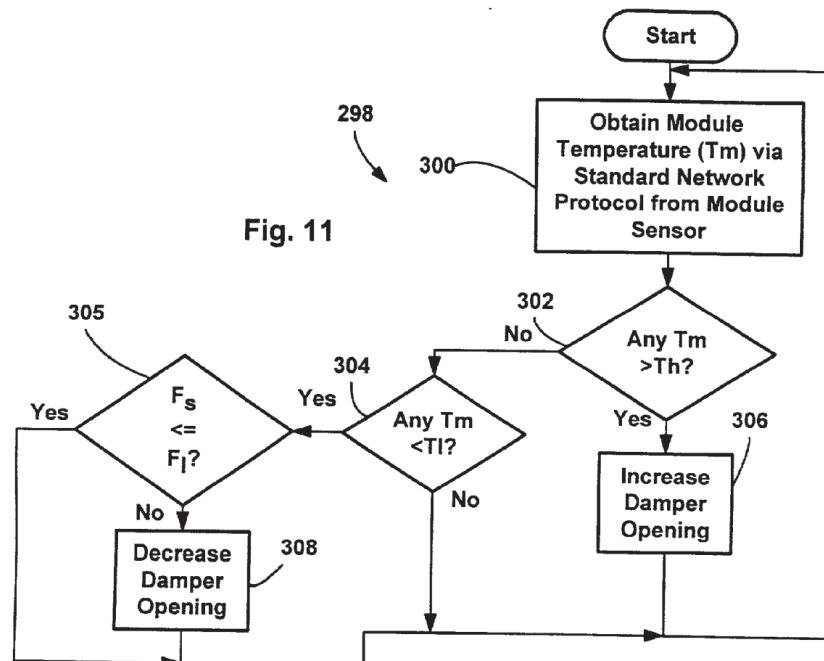
294. Limitation 1[d] of the ’277 patent is therefore anticipated by Bishop under both Petitioner’s constructions of the “map” terms and Patent Owner’s expected constructions.

**f. 1[e] – “identifying pattern differentials between said empirical and template atmospheric maps.”**

295. Claim 1 recites “*identifying pattern differentials between said empirical and template atmospheric maps.*” In my opinion, Bishop discloses this limitation.

296. The '277 patent explains that “thermal hot spots” are an example of pattern differentials that may be identified when comparing empirical and template atmospheric maps “in the case of data center cooling.” Ex. 1001, 6:64–66.

297. Bishop teaches identifying pattern differentials between the three-dimensional map and the optimal temperature range that is bounded by the low threshold temperature ( $T_l$ ) and the high threshold temperature ( $T_h$ ) and its visual representation. Bishop further discloses this identification of hot spots in block 302 of Figure 11 (reproduced below), in which the “supervising controller 16 compares each module temperature  $T_m$  to a threshold temperature that is at the high end of an acceptable temperature range.” Ex. 1006, [0083]. If the measured temperature of the module exceeds the high threshold temperature ( $T_h$ ), a damper opening is increased to “increase cooling air flow to the corresponding” module to diminish the hot spot. Ex. 1006, [0085].



Ex. 1006, FIG. 11. Similarly, at step 304, measured temperatures falling below the model range are identified. Ex. 1006, [0084].

298. Bishop also teaches the conventional technique of manually identifying pattern differentials between thermal maps generated at different times for the purpose of identifying hot spots and adjusting the cooling system operation to eliminate the hot spots. Ex. 1006, [0017].

299. Limitation 1[e] of the '277 patent is therefore anticipated by Bishop.

## 2. Claim 2

300. I discuss each limitation of claim 2 in turn below, in conjunction with the relevant disclosures of each claim limitation by Bishop.

- a. 2[a] – “The method as claimed in claim 1, further comprising the steps of: determining corrective action to reduce said pattern differentials; and”

301. Claim 2 recites “[t]he method as claimed in claim 1, further comprising the steps of: determining corrective action to reduce said pattern differentials . . . .” In my opinion, Bishop discloses this limitation.

302. As explained above, Bishop discloses the method of claim 1.

303. As previously discussed, Bishop discloses identifying pattern differentials when measured temperatures associated with the empirical atmospheric map are not within the preset optimal range. Ex. 1006, [0017], [0082]–[0085].

304. Bishop further teaches determining a corrective action to reduce these hot spots. For example, Bishop discloses that “where ‘hot spots’ occur the administrator then adjusts tile baffles” to increase the flow of cooling air towards the hot spots. Ex. 1006, [0017]. As another example, if the measured temperature of a module exceeds the high threshold temperature ( $T_h$ ), Bishop teaches “increas[ing] the damper opening to increase cooling air flow to the corresponding” module to diminish the hot spot. Ex. 1006, [0085].

305. Limitation 2[a] is therefore disclosed by Bishop.

**b. 2[b] – “varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.”**

306. Claim 2 further recites “*varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.*” In my opinion, Bishop discloses this limitation.

307. As explained above with respect to limitation 2[a], Bishop discloses increasing the flow of cooling air towards hot spots to diminish or eliminate the hot spots.

308. And as explained above with respect to limitation 1[a], a POSITA would understand that cooling air is one type of conditioned fluid. Thus, increasing the flow of cooling air discloses varying the quantity of conditioned fluid. The ability of Bishop’s system to control cooling air flow to individual cabinets discloses varying the distribution of conditioned fluid.

309. Limitation 2[b] of the ’277 patent is therefore disclosed by Bishop.

**3. Claim 3 – “The method as claimed in claim 2, wherein said supplying step comprises the step of operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.”**

310. Claim 3 recites “[t]he method as claimed in claim 2, wherein said *supplying step comprises the step of operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.*”

In my opinion, Bishop discloses this claim.

311. As explained above, Bishop discloses the method of claim 2.

312. Figures 2 and 5 of Bishop are reproduced below.

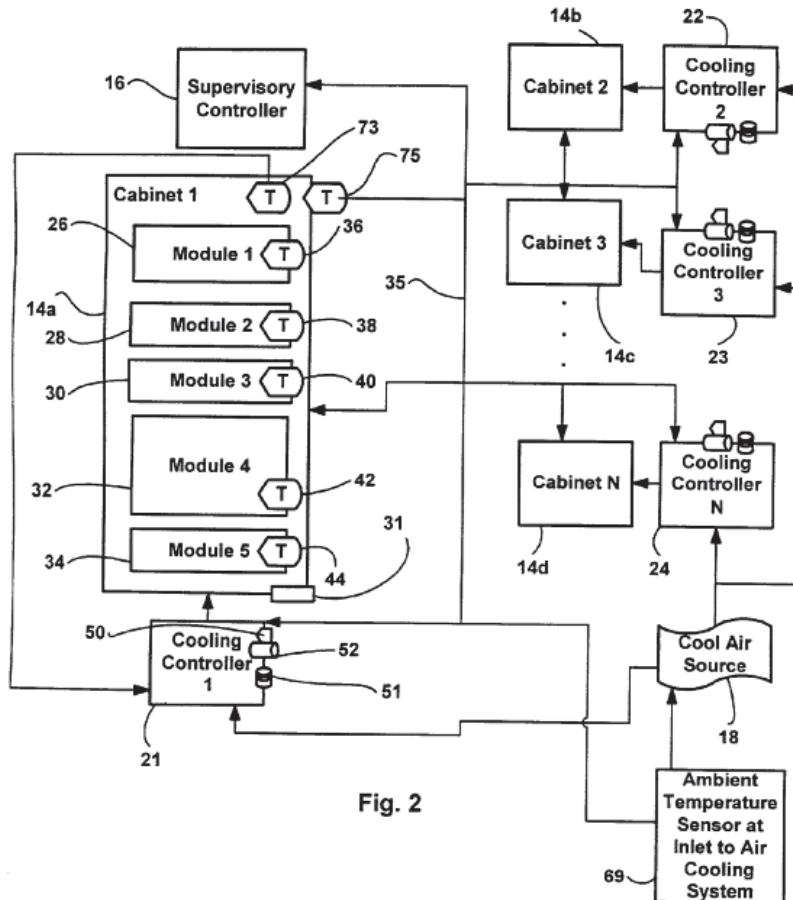
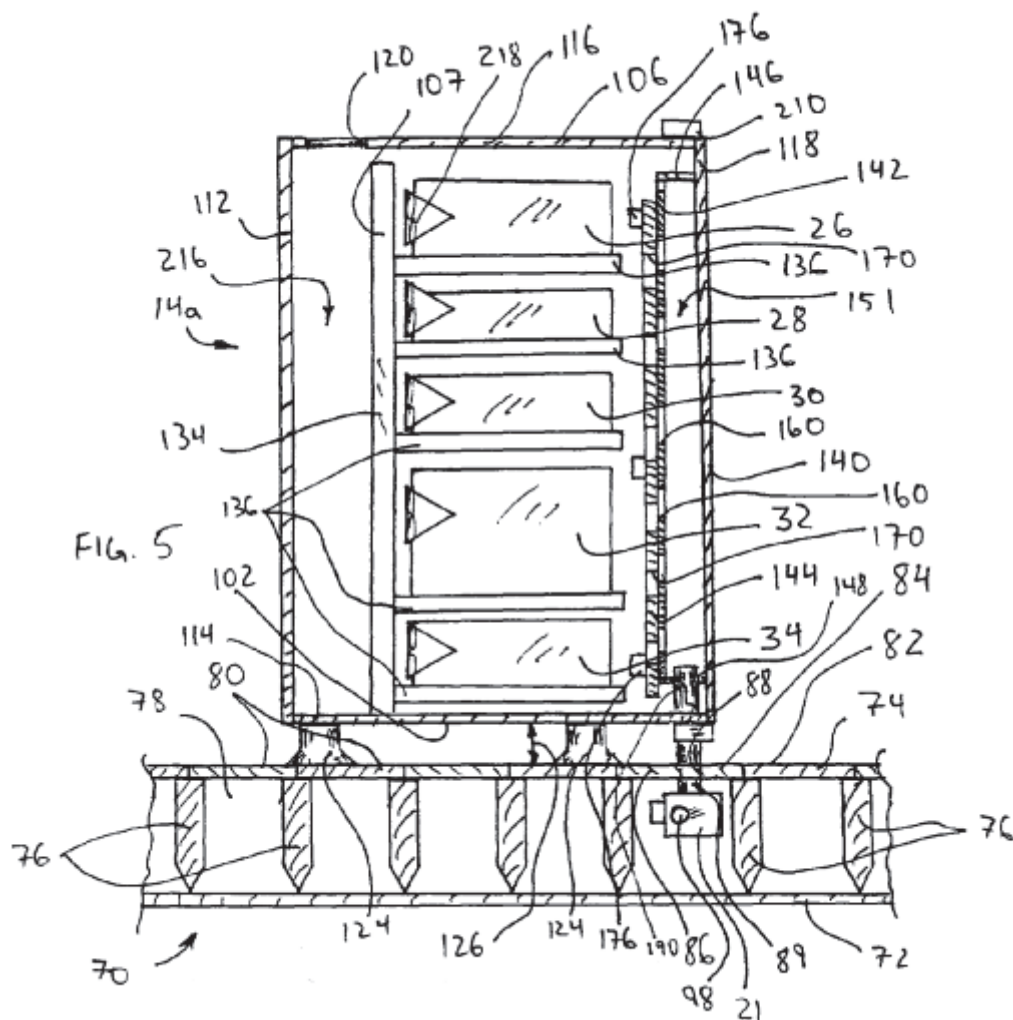


Fig. 2

Ex. 1006, FIG. 2.



Ex. 1006, FIG. 5. Bishop discloses: “[r]eferring to FIGs. 2, 3, 5 and 6, cabinet assembly 14 a includes a housing 106, a shelving unit 107, five electronic modules 26, 28, 30, 32 and 34, an internal temperature sensor 73 and an external temperature sensor 77. Housing 106 includes opposing lateral walls 108 and 110, a back wall 112 . . . , a bottom wall 114, a top wall 116 and plenum door assembly 118. . . . [A]lthough not illustrated, vent openings may be provided in any of these walls to allow venting of heat to the ambient.” Ex. 1006, [0067]. Other components include

a baffle wall 144 that “when assembled with other plenum components, is vertically arranged and forms a plurality of openings” and a plurality of brackets 176 that “cooperate to mount baffle assembly 144 against wall assembly 142 for slideable movement to any of several vertical positions.” Ex. 1006, [0071]–[0074]. Thus, Bishop discloses a system having a plurality of vents.

313. Bishop further discloses the system having at least one blower. For example, Bishop discloses that “although not illustrated, a fan may be provided within outlet 120 to draw warm air out of housing 106.” Ex. 1006, [0068]. Additionally, each of the “[e]lectronic modules 26, 28, 30, 32 and 34 . . . includes one or more small fans near a back end of the module and each module is arranged on its corresponding shelf so that the fan (e.g., 218) faces frame member 134 and air circulation space 216.” Ex. 1006, [0078]. “With fans 218 opposite the front faces of the modules, when the fans operate, cool air is pulled through each entire electronic module and over heat generating components therein prior to being expelled into space 216.” Ex. 1006, [0080]. A POSITA would understand that the terms “blower” and “fan” are synonymous. Thus, Bishop discloses a system having a plurality of vents, as well as at least one blower.

314. Bishop also discloses that a “cooling air source 18 provides cool air within space 78.” Ex. 1006, [0063]. The cooling air source 18 is shown in Figure 2

of Bishop, provided above. And as explained above with respect to limitation 1[a], a POSITA would understand that cooling air is one type of conditioned fluid.

315. I understand claim 3 to require operating a system having at least one of the three features mentioned – a plurality of vents, at least one blower, and at least one source of conditioned air. Bishop discloses operating a system having all three features.

316. Claim 3 of the '277 patent is therefore anticipated by Bishop.

**4. Claim 4 – “The method as claimed in claim 3, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”**

317. Claim 4 recites “[t]he method as claimed in claim 3, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.” In my opinion, Bishop discloses this claim.

318. As explained above, Bishop discloses the method of claim 3.

319. And as explained with respect to limitation 1[e], hot spots are an example of a pattern differential as recited in the '277 patent.

320. Bishop discloses the conventional approach of manually correlating the location of a hot spot to the location of baffles. For example, Bishop teaches,

“[w]here ‘hot spots’ occur the administrator then adjusts tile baffles.” Ex. 1006, [0017].

321. Bishop also discloses performing such a correlation automatically. In particular, the control logic summarized in Figure 11 identifies when a measured temperatures associated with a cabinet is outside of the optimal range and responds by manipulating the damper through which cooling air flows to that cabinet. The damper functions as a vent by controlling the amount of air that flows to the cabinet. This is an additional disclosure of correlating the location of hot spots to the location of vents.

322. Thus, Bishop discloses correlating a location of pattern differentials to a location of vents.

323. Claim 4 of the '277 patent is therefore anticipated by Bishop.

**5. Claim 5 – “The method as claimed in claim 4, wherein said varying step comprises adjusting at least one of the opening of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.”**

324. Claim 5 recites “[t]he method as claimed in claim 4, wherein said varying step comprises adjusting at least one of the opening of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.” In my opinion, Bishop discloses this claim.

325. As explained above, Bishop discloses the method of claim 4.

326. Additionally, Bishop teaches adjusting the opening of vents to vary the quantity of conditioned fluid delivered to an identified hot spot. For example, Bishop teaches, “[w]here ‘hot spots’ occur the administrator then adjusts tile baffles.” Ex. 1006, [0017].

327. Bishop’s improved cooling system performs this process automatically. “For example, controller 21 may control its corresponding damper simply as a function of one or more temperatures in cabinet 14 a. In the alternative, controller 21 may receive one or more temperature readings from within cabinet, determine a desired flow rate as a function of the temperatures and then modify damper position to achieve the desired flow rate.” Ex. [0108]; *see also* 1006, [0038], [0096], [0100], FIG. 11.

328. Claim 5 of the ’277 patent is therefore anticipated by Bishop.

**6. Claim 6 – “The method as claimed in claim 1, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical atmospheric map.”**

329. Claim 6 recites, “[t]he method as claimed in claim 1, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical atmospheric map.” In my opinion, Bishop discloses this claim.

330. As explained above, Bishop discloses the method of claim 1.

331. And as explained above with respect to limitation 1[c], the three-dimensional maps described in Bishop disclose the empirical atmospheric map of the '277 patent. Bishop discloses that the maps are generated by a computer or a controller, which necessarily executes software to generate the thermal maps. Ex. 1006, [0017], [0106].

332. Claim 6 of the '277 patent is therefore anticipated by Bishop.

**7. Claim 8 – “The method as claimed in claim 1, wherein said plurality of locations of said sensing step comprises locations at various elevations within said building.”**

333. Claim 8 recites, “[t]he method as claimed in claim 1, wherein said plurality of locations of said sensing step comprises locations at various elevations within said building.” In my opinion, Bishop discloses this claim.

334. As explained above, Bishop discloses the method of claim 1.

335. Bishop teaches that “the temperature readings from all of the external sensors (e.g., 75) may be used to generate a three dimensional temperature graph for observation by an environment administrator.” Ex. 1006, [0106]. Bishop provides an exemplary schematic of where temperature sensors, including temperature sensor 75, are located on a cabinet in Figure 2 of Bishop, reproduced below.

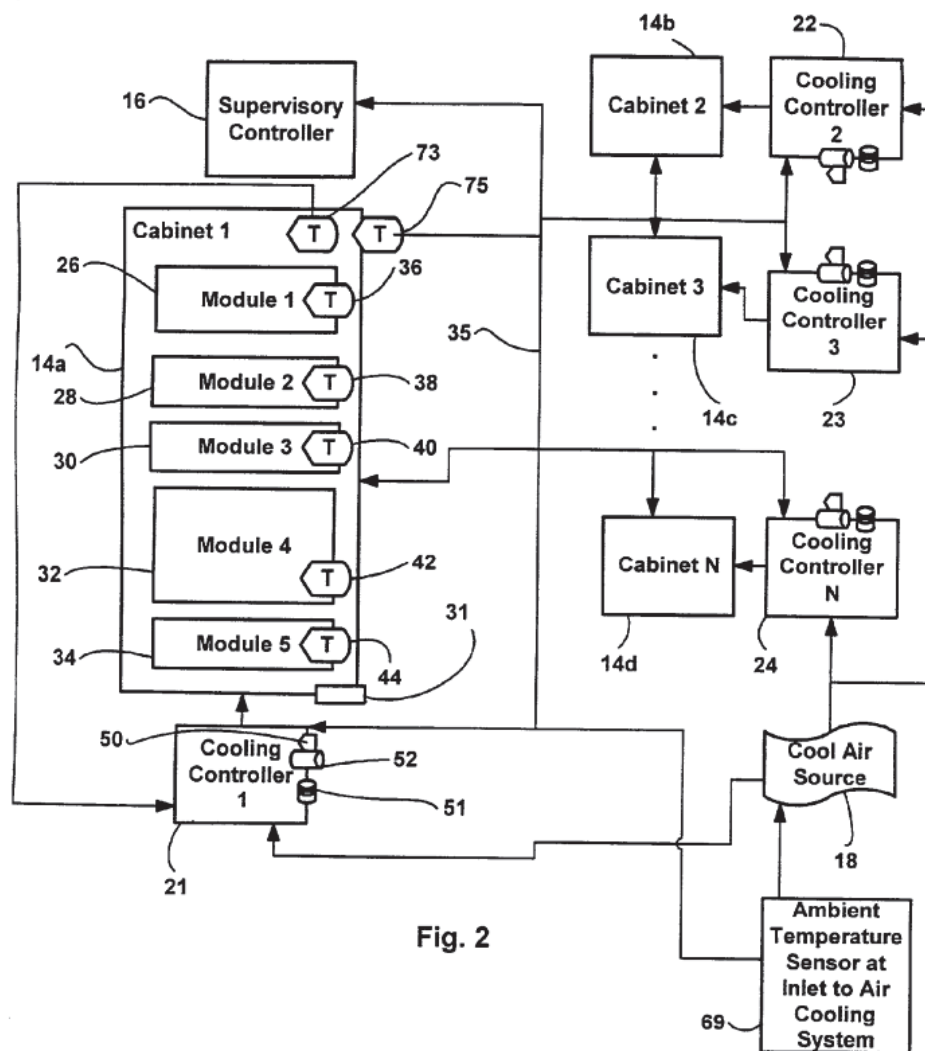


Fig. 2

Ex. 1006, FIG. 2.

336. “In FIG. 2 the temperature sensors in modules 26, 28, 30, 32 and 34 are identified by numerals 36, 38, 40, 42 and 44, respectively.” Ex. 1006, [0081]. And as can be seen with reference to Figure 2, above, the temperature sensors 36, 38, 40, 42, 44, and 75 of Bishop are at various elevations.

337. Claim 8 of the '277 patent is therefore anticipated by Bishop.

**8. Claim 9 – “The method as claimed in claim 1, wherein said sensing step comprises using at least one of temperature sensors, humidity sensors, pressure sensors, particle sensors, smoke sensors, and velocity sensors.”**

338. Claim 9 recites, “[t]he method as claimed in claim 1, wherein said sensing step comprises using at least one of temperature sensors, humidity sensors, pressure sensors, particle sensors, smoke sensors, and velocity sensors.” In my opinion, Bishop discloses this claim.

339. As explained above, Bishop discloses the method of claim 1.

340. Bishop discloses using temperature sensors for the sensing step, for example, the temperature sensors 36, 38, 40, 42, 44, and 75 shown in Figure 2 of Bishop.

341. Claim 9 of the ’277 patent is therefore anticipated by Bishop.

**9. Claim 10 – “The method as claimed in claim 1, wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.”**

342. Claim 10 recites, “[t]method as claimed in claim 1, wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.” In my opinion, Bishop discloses this claim.

343. As explained above, Bishop discloses the method of claim 1.

344. And, as previously explained with respect to limitation 1[c], the three-dimensional map of temperature in Bishop discloses the empirical atmospheric map of the '277 patent.

345. The '277 patent provides guidance as to what an isothermal region of a thermal map is: “a thermal map is composed of temperature contours that define various isothermal regions, or isotherms, of distinct temperatures. The most severe of these isotherms are commonly known as ‘hot spots’.” Ex. 1001, 4:44–47. Based on this excerpt from the '277 patent, a temperature contour that defines a hot spot would anticipate the temperature contours recited in claim 10.

346. Bishop teaches feeding measured temperatures “into a computer that generates a three dimensional map of temperature in the environment as a function of location within the environment. Where ‘hot spots’ occur the administrator then adjusts tile baffles.” Ex. 1006, [0017]. Bishop also teaches that the “three dimensional temperature graph [is] for observation by an environment administrator.” Ex. 1006, [0106]. A POSITA would understand that this refers to the same type of thermal map that defines where isothermal regions, such as hot spots, occur.

347. Claim 10 of the '277 patent is therefore anticipated by Bishop.

**10. Claim 11 – “The method as claimed in claim 1, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.”**

348. Claim 11 recites, “[t]he method as claimed in claim 1, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.” In my opinion, Bishop discloses this claim.

349. As explained above, Bishop discloses the method of claim 1.

350. Bishop further teaches determining the locations of hot spots by extrapolating or triangulating from measured temperature values. For example, Bishop teaches “identify[ing] temperatures throughout a critical environment at relatively small spatial intervals and then adjust[ing] air flow through baffled raised floor tiles within the environment to even out environment temperature. . . . [Temperature] readings are [] fed into a computer that generates a three dimensional map of temperature in the environment as a function of location within the environment. Where ‘hot spots’ occur the administrator then adjusts tile baffles.” Ex. 1006, [0017].

351. Because the temperature sensors in Bishop are spaced apart, a POSITA would understand that there are many locations on the three-dimensional map of temperature in Bishop where the temperature values on the map were not

empirically measured. As such, a POSITA would understand that for locations at which the temperature values were not empirically measured, the temperature values were determined based on extrapolating or triangulating from the measured temperature values. And since Bishop discloses that the three-dimensional map of temperature is used to determine where “‘hot spots’ occur,” Bishop discloses extrapolating or triangulating from the measured temperature values to determine locations of hot spots. Ex. 1006, [0017].

352. The '277 patent confirms that the thermal mapping software used by the computer to generate the three-dimensional maps of temperature in Bishop extrapolates or triangulates based on the measured temperature values to determine locations of one or more hot spots. For example, the '277 patent states that “thermal mapping software can extrapolate or triangulate the location of the actual hot spot from the known locations of the temperature sensors.” Ex. 1001, 4:50–52. Thus, the '277 patent acknowledges that the thermal mapping software used in Bishop extrapolates or triangulates the location of hot spots based on measured temperatures.

353. Claim 11 of the '277 patent is therefore anticipated by Bishop.

## 11. Claim 12

354. As discussed above, independent claim 12 is similar to claim 1 although refers to the building as being a data center and focuses on temperature as the atmospheric parameter.

355. Bishop addresses challenges of managing heat generated in critical environments equipped with a variety of servers and other electronic modules arranged vertically within racks. Ex. 1006, [0005]–[0012]. Bishop expressly refers to these environments as “data centers.” Ex. 1006, [0032] (“there is a need for a system that automatically tracks critical environment temperatures throughout a data center environment . . .”).

356. Bishop’s disclosed system and method operates to monitor and control the temperature distribution throughout a data center. Thus, the relevant “atmospheric parameter” monitored and managed by the control system and method disclosed in Bishop is temperature, the disclosed simulation program generates temperature distribution maps, and Bishop’s method includes comparing the temperature map to a template temperature map.

357. Therefore, my analysis and opinions set forth in Paragraphs 258 to 353 above in relation to claims 1–6 and 8–11 apply equally to claims 12–17 and 19–21, because Bishop’s disclosure encompasses cooling of a data center.

358. The following table identifies where claim 12's limitations are analogous to limitations of claim 1 addressed above for purpose of assessing validity relative to Bishop's disclosed method of cooling a data center involving measuring temperatures and generating and comparing thermal maps:

| <b>Claim 12 Limitations</b>                                                                       | <b>Analogous Claim 1 Limitations</b>                                                                  | <b>Citations to Sections Above</b> |
|---------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|------------------------------------|
| a method of cooling a data center having equipment therein, said method comprising the steps of:  | a method of controlling atmospheric conditions within a building, said method comprising the steps of | <b>IX.B.1.1[pre]</b>               |
| supplying a cooling fluid within said data center to cool said equipment within said data center; | supplying a conditioned fluid inside said building,                                                   | <b>IX.B.1.1[a]</b>                 |
| sensing temperature within said data center in a plurality of locations,                          | sensing at least one atmospheric parameter in a plurality of locations inside said building,          | <b>IX.B.1.1[b]</b>                 |
| generating an empirical thermal map of said data center from the results of said sensing step;    | generating an empirical atmospheric map from the results of said sensing step;                        | <b>IX.B.1.1[c]</b>                 |
| comparing said empirical thermal map to a template thermal map;                                   | comparing said empirical atmospheric map to a template atmospheric map;                               | <b>IX.B.1.1[d]</b>                 |
| identifying pattern differentials between said empirical and template thermal maps.               | identifying pattern differentials between said empirical and template atmospheric maps.               | <b>IX.B.1.1[e]</b>                 |

359. Each of claim 12's limitations are disclosed by Bishop for the reasons provided above, and incorporated here. *Supra* Sections IX.B.1.1[pre]–[e]. In my opinion, claim 12 is anticipated by Bishop.

## **12. Claim 13**

360. I discuss each limitation of claim 13 in turn below, in conjunction with the relevant disclosures of each claim limitation by Bishop.

- a. 13[a] – “The method as claimed in claim 12, further comprising the steps of: determining corrective action to reduce said pattern differentials; and”**

361. Claim 13 recites, “[t]he method as claimed in claim 12, further comprising the steps of: determining corrective action to reduce said pattern differentials . . . .”

362. The subject of this claim limitation is analogous to claim limitation 2[a]. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.B.2.2[a].

- b. 13[b] – “varying at least one of the quantity, quality, and distribution of said cooling fluid in accord with said determining step.”**

363. Claim 13 further recites, “varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.” In my opinion, Bishop discloses this limitation.

364. The subject of this claim limitation is analogous to claim limitation 2[b]. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.B.2.2[b].

365. In my opinion, claim 13 is anticipated by Bishop.

- 13. Claim 14 – “The method as claimed in claim 13, wherein said supplying step comprises operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.”**

366. Claim 14 recites, “[t]he method as claimed in claim 13, wherein said supplying step comprises operating a system having at least one of a plurality of

*vents, at least one blower, and at least one source of conditioned air.”* In my opinion, Bishop discloses this claim.

367. The subject of this claim is analogous to claim 3. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.B.3.

368. Claim 14 of the ’277 patent is therefore anticipated by Bishop.

**14. Claim 15 – “The method as claimed in claim 14, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”**

369. Claim 15 recites, “[t]he method as claimed in claim 14, wherein said *determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.*” In my opinion, Bishop discloses this claim.

370. The subject of this claim is analogous to claim 4. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.B.4.

371. Claim 15 of the ’277 patent is therefore anticipated by Bishop.

**15. Claim 16 – “The method as claimed in claim 15, wherein said varying step comprises adjusting at least one of the opening of at least one of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.”**

372. Claim 16 recites, “[t]he method as claimed in claim 15, wherein said varying step comprises adjusting at least one of the opening of at least one of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.” In my opinion, Bishop discloses this claim.

373. The subject of this claim is analogous to claim 5. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.B.5.

374. In my opinion, claim 16 of the ’277 patent is anticipated by Bishop.

**16. Claim 17 – “The method as claimed in claim 12, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical thermal map, wherein said thermal mapping software triangulates locations of hot spots.”**

375. Claim 17 recites, “[t]he method as claimed in claim 12, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical thermal map, wherein said thermal mapping software triangulates locations of hot spots.” In my opinion, Bishop discloses this claim.

376. The subject of this claim is analogous to claim 6. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here.

*Supra* Section IX.B.6.

377. Claim 17 of the '277 patent is therefore anticipated by Bishop.

**17. Claim 19 – “The method as claimed in claim 12, wherein said plurality of locations of said sensing step comprises locations at various elevations within said data center.”**

378. Claim 19 recites, “[t]he method as claimed in claim 12, wherein said plurality of locations of said sensing step comprises locations at various elevations within said data center.” In my opinion, Bishop discloses this claim.

379. The subject of this claim is analogous to claim 8. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here.

*Supra* Section IX.B.8.

380. Claim 19 of the '277 patent is therefore anticipated by Bishop.

**18. Claim 20 – “The method as claimed in claim 12 wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.”**

381. Claim 20 recites, “[t]he method as claimed in claim 12 wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.” In my opinion, Bishop discloses this claim.

382. The subject of this claim is analogous to claim 10. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.B.10.

383. Claim 20 of the '277 patent is therefore anticipated by Bishop.

**19. Claim 21 – “The method as claimed in claim 12, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.”**

384. Claim 21 recites, “[t]he method as claimed in claim 12, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.” In my opinion, Bishop discloses this claim.

385. The subject of this claim is analogous to claim 11. Thus, Bishop discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.B.11.

386. Claim 21 of the '277 patent is therefore anticipated by Bishop.

**C. GROUND 3: CLAIMS 1–21 ARE OBVIOUS OVER NAKANISHI IN VIEW OF BISHOP AND THE KNOWLEDGE OF A PERSON HAVING ORDINARY SKILL IN THE ART**

387. For the reasons stated above, it is my opinion that Nakanishi discloses all limitations of claims 1–21, thereby anticipating those claims. Section IX.A. It is also my opinion that Bishop discloses all limitations of at least claims 1–6, 8–17 and

19–21, thereby anticipating those claims. Section IX.B. To the extent that the Board does not find that Nakanishi anticipates claims 1–21, it is my opinion that Nakanishi as modified in view of Bishop discloses and renders obvious claims 1–21.

388. In particular, if independent claims 1 and 12, and their dependent claims, are interpreted to require comparing an empirical atmospheric/thermal map *image* to a template map *image*, it is my opinion that a POSITA familiar with Bishop’s teachings would have been motivated to modify the preferred embodiment of Nakanishi by comparing Nakanishi’s thermal map showing current temperature conditions to a thermal map showing optimal conditions to identify pattern differential between the two maps. Additionally, while I have already stated my opinion that Nakanishi anticipates the claims of the ’277 patent, *supra* Section IX.A, to the extent Nakanishi does not anticipate, a POSITA would have been motivated to perform such a comparison of map images manually or by implementing pattern recognition software into Nakanishi’s control system to automate the comparison, as in Bishop.

389. It would have been obvious to a skilled artisan to modify the system and methods of Nakanishi based on Bishop in view of their collective teachings, and based on a POSITA’s knowledge of the art. Nakanishi and Bishop are closely analogous references directed to cooling of environments containing computer equipment. Both were directed to solve a similar problem – i.e., to provide more

efficient and strategic cooling for varying heat loads generated by computer equipment to maintain the temperature distribution throughout the environment within an acceptable range. Both offer a similar solution. They each describe a cooling system that distributes cooling air from a central source to locations where cooling is needed, that continually monitors the temperature distribution in the environment, and that automatically adjusts the cooling air distribution in response to changing temperature conditions.

390. As discussed above, it is my opinion that all the limitations of claims 1–21 are disclosed in both Nakanishi and Bishop, alone as well as in their combination. This confirms how close the references are and confirms that a POSITA would look to modify Nakanishi based on Bishop, or combine the interrelated teachings of the two references to arrive at the claimed invention. The similarities between the two references would have suggested to a POSITA following the ordinary design process to combine their teachings. It further confirms that it would have been obvious for a POSITA to try to combine the teachings, choosing from a fine number of predictable solutions, and to substitute known techniques described in Bishop to obtain predictable results with a reasonable expectation of success.

391. Nakanishi and Bishop each teach comparing data representing current temperature conditions to desired temperature conditions to identify locations that

need more or less targeted cooling. A POSITA would understand that a limited number of ways exist to perform the comparisons. One known way was to compare the thermal map images that each system generates to a corresponding map image of the desired temperature distribution, either manually or using available image processing software. It would be obvious from a POSITA's knowledge of the art to look to another analogous reference in the cooling system space that specifically taught identifying and eliminating data center hot spots by generating and visually comparing thermal map images to detect pattern differences.

392. In my opinion and based on my knowledge and experience, generating empirical atmospheric/thermal maps and template maps using Nakanishi's system, and comparing the map images, would have been exceedingly straightforward using the existing features of Nakanishi's system and the capabilities of a POSITA. In fact, the creation and comparison of thermal maps is something I have personal knowledge of dating back to at least 1997, well before the priority date of the '277 patent. Furthermore, this approach would have predictably resulted in fast and reliable identification of hot spots and other deviations from optimal temperature conditions. A POSITA would have known to perform such an analysis at regular time intervals and then provide input to the control software for use in determining any necessary adjustments to the cooling air distribution.

393. A POSITA would also have been motivated to follow the similar alternative of incorporating additional software capabilities into Nakanishi's control system to automate the process of comparing map images. A POSITA would have had a reasonable expectation of success because, as the '277 patent specification confirms, it was a conventional practice to use pattern recognition software for processing images to identify differences between them. In fact, I have personal experience with this well before the priority date of the '277 patent. Furthermore, it would have been a routine and obvious matter for a POSITA to modify Nakanishi's system and methodology because the system already includes thermal map generating capabilities and algorithms for comparing a current temperature distribution to a desired temperature distribution and automatically implementing necessary adjustments to the cooling operation. The simple, routine and low-cost nature of incorporating available pattern recognition software into Nakanishi's control system, which would have ensured a reasonable expectation of success, would have further motivated a person of ordinary skill in the art.

394. The modifications and combinations discussed above shall be referred to herein as the "Nakanishi/Bishop Combination." Thus, in my opinion, ample motivation existed for a POSITA to make either of the above modifications to Nakanishi's control methodology (i.e., manual or automated comparison of map images) in order to arrive at the methods of the Nakanishi/Bishop Combination. I

further explain in the following discussion my reasons for concluding that if interpreted to require comparing two map images, the Nakanishi/Bishop Combination renders obvious claims 1–21.

# **1. Claim 1**

395. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 1.

## **a. 1[pre] – “A method of controlling atmospheric conditions within a building, said method comprising the steps of:”**

396. For the same reasons provided above in Section IX.A.1.1[pre], incorporated here, Nakanishi discloses limitation 1[pre]: “[a] *method of controlling atmospheric conditions within a building, said method comprising the steps of.*”

397. For the same reasons provided above in Section IX.B.1.1[pre], incorporated here, Bishop also discloses this limitation 1[pre].

## **b. 1[a] – “supplying a conditioned fluid inside said building;”**

398. For the same reasons provided above in Section IX.A.1.1[a], incorporated here, Nakanishi discloses limitation 1[a]: “*supplying a conditioned fluid inside said building.*”

399. For the same reasons provided above in Section IX.B.1.1[a], incorporated here, Bishop also discloses this limitation 1[a].

**c. 1[b] – “sensing at least one atmospheric parameter in a plurality of locations inside said building;”**

400. For the same reasons provided above in Section IX.A.1.1[b], incorporated here, Nakanishi discloses limitation 1[b]: “*sensing at least one atmospheric parameter in a plurality of locations inside said building.*”

401. For the same reasons provided above in Section IX.B.1.1[b], incorporated here, Bishop also discloses this limitation 1[b].

**d. 1[c] – “generating an empirical atmospheric map from the results of said sensing step using software for processing input from said sensing step and for producing output in the form of said empirical atmospheric map;”**

402. For the same reasons provided above in Section IX.A.1.1[c], incorporated here, Nakanishi discloses limitation 1[c]: “*generating an empirical atmospheric map from the results of said sensing step using software for processing input from said sensing step and for producing output in the form of said empirical atmospheric map.*”

403. For the same reasons provided above in Section IX.B.1.1[c], incorporated here, Bishop also discloses this limitation 1[c].

**e. 1[d] – “comparing said empirical atmospheric map to a template atmospheric map; and”**

404. For the same reasons provided above in Section IX.A.1.1[d], incorporated here, Nakanishi discloses limitation 1[d]: “*comparing said empirical atmospheric map to a template atmospheric map.*”

405. For the same reasons provided above in Section IX.B.1.1[d], incorporated here, Bishop also discloses this limitation 1[d] in relation to Bishop's disclosed preferred embodiment, as well as in Bishop's Background section discussing conventional practices for monitoring, assessing and adjusting data center cooling systems.

406. To the extent that the Board does not find that Nakanishi discloses this limitation, then the Nakanishi/Bishop Combination discloses this limitation.

407. In particular, to the extent that limitation 1[d] is interpreted to require comparing two visual map *images*, i.e., comparing an empirical atmospheric map *image* to a template atmospheric map *image*, this would have been obvious to a POSITA, based on the combined teachings of Nakanishi and Bishop and a POSITA's knowledge of conventional technologies, tools, and practices. In fact, I personally have compared multiple thermal maps since the 1990s and before the priority date of the '277 patent.

408. As discussed above, Nakanishi discloses sensing temperature at various locations of a computer room and generating a simulated temperature distribution throughout the room. Nakanishi teaches using a conventional temperature-distribution analysis program such as the commercially available FLOTHERM software and displaying the resulting temperature distribution as an image on a monitor. Ex. 1005, 5:36–56, 7:58–67. Like Nakanishi, Bishop discloses

a computer room cooling system that generates temperature maps. Ex. 1006, [0106] (“three dimensional temperature graph for observation by an environment administrator.”). Bishop also discloses known thermal mapping software tools for identifying where “hot spots” occur and to evaluate how cooling system adjustments affect the temperature distribution. Ex. 1006, [0017].

409. Whereas the preferred embodiment of Nakanishi teaches comparing the temperature and coordinate data of the generated temperature distribution (data that Nakanishi teaches is displayable as a map image) to temperatures and coordinate data of a prescribed temperature range (data that Nakanishi also teaches is displayable as a map image), the Board may find that Nakanishi does not expressly describe performing a visual comparison of the displayed simulated (empirical) map image to the displayed template map image.

410. As discussed above, Bishop describes the conventional practice of comparing computer generated thermal maps as a way of evaluating adjustments made to a cooling system. In particular, Bishop discloses: “a plurality of temperature readings . . . are then fed into a computer that generates a three dimensional map of temperature in the environment as a function of location within the environment. Where ‘hot spots’ occur the administrator then adjusts tile baffles. Thereafter the administrator again collects temperature readings throughout the environment and causes the computer to generate the map to see the results.” Ex. 1006, [0017]. Bishop

thus teaches generating and comparing thermal map images to identify hot spots and guide the process of adjusting the cooling system operations to eliminate the hot spots.

411. It would have been obvious to a POSITA, using Nakanishi's system, to compare an image representing the temperature distribution throughout the computer room (i.e., empirical atmospheric map) to an image representing the prescribed temperature range throughout the computer room (i.e., template atmospheric map) to identify locations where current temperatures are not within the prescribed range and determine the corrective actions.

412. Nakanishi teaches that displaying a simulated temperature distribution as an image on a computer is an effective way to monitor and quickly assess the temperature conditions of a computer room. Ex. 1005, 7:58–67. Thus, Nakanishi's system already has the capability to generate thermal map images. Nakanishi discloses in its Figure 4 a visual image of a computer room resulting from the simulation and showing temperature hot spots, and discloses a corresponding image in its Figure 3 showing no hot spots. Thus, Nakanishi's system has the capability to generate both an empirical atmospheric map and a template atmospheric map, as well to display both map images. It would have been a routine exercise to use Nakanishi's system to display both maps for comparison, and to then compare the map images to identify pattern differentials, such as the locations of hot spots. As I

previously observed, there is no indication that the “comparing” step of the limitation 1[d] or the “identifying” step of the final limitation 1[e] must be implemented by software or automated in some other way.

413. Bishop’s teachings of visually comparing thermal maps for the purpose of identifying hot spots and determining cooling system adjustments expressly motivates a POSITA to perform a visual comparison of the thermal maps generated by Nakanishi’s system for the same purpose. In modifying Nakanishi’s method to include a comparison of two visual map images, a POSITA would have looked to Bishop—an analogous prior art reference within the same field of endeavor as Nakanishi (cooling of computer rooms). Bishop would have motivated a POSITA to use Nakanishi’s system to capture an image of the simulated empirical atmospheric/thermal map and an image of the template map and to compare the two maps to identify differences.

414. Furthermore, the ’277 patent specification establishes that software, such as MATLAB, was commercially available for use “to generate thermal maps and identify hot spots by pattern recognition.” Ex. 1001, 5:9–14. For a POSITA electing to automate the process of comparing two thermal map images, although claim 1 does not require this, the available pattern recognition software would have been routine to implement in Nakanishi’s system to enhance its capabilities to detect hot spots and make responsive control adjustments.

415. Given the capabilities of both Nakanishi's disclosed system and Bishop's disclosed system to generate and display thermal maps of a computer room, their related teachings regarding the known use of commercial software for this purpose, as a POSITA's knowledge of available pattern recognition software (as confirmed by the '277 patent), a POSITA would have been motivated to undertake the simple, routine, and low-cost path of using Nakanishi's system to generate both map images followed by manual comparison, or, alternatively, to incorporate available pattern recognition software into Nakanishi's system to automate the comparison. Furthermore, given the known interchangeability of these approaches, a POSITA would have had a reasonable expectation of success in modifying Nakanishi's system and method in one or both ways.

416. The Nakanishi/Bishop Combination therefore discloses limitation 1[d], even if interpreted to require comparing an empirical atmospheric map image to a template atmospheric map image.

**f. 1[e] – “identifying pattern differentials between said empirical and template atmospheric maps.”**

417. For the same reasons provided above in Section IX.A.1.1[e], incorporated here, Nakanishi discloses limitation 1[e]: “*identifying pattern differentials between said empirical and template atmospheric maps.*”

418. For the same reasons provided above in Section IX.B.1.1[e], incorporated here, Bishop also discloses this limitation 1[e].

419. This limitation is closely related to the previous limitation 1[d] and the opinions I expressed regarding the Nakanishi/Bishop Combination for that limitation apply here as well. To the extent that the Board does not find that Nakanishi discloses this limitation, then the Nakanishi/Bishop Combination discloses this limitation.

420. In particular, to the extent that limitation 1[e] is interpreted to require identifying pattern differentials between an empirical atmospheric map *image* and a template atmospheric map *image*, this would have been obvious to a POSITA, based on the combined teachings of Nakanishi and Bishop and a POSITA's knowledge of conventional technologies, tools, and practices.

421. For the same reasons discussed in connection with the previous limitation, a POSITA familiar with the teachings of Nakanishi and Bishop would have been aware of the routine practice of inputting temperature measurements taken at various locations into a conventional software program to generate a thermal map of the temperature distribution throughout a computer room. In fact, as I stated above, it is my opinion that both Nakanishi and Bishop disclose this. *See supra* Sections IX.A.1 and IX.B.1.” A POSITA would have been aware from Bishop's teachings that thermal maps are an effective tool for quickly assessing the effectiveness of a cooling system and the impact of making operational adjustments to the cooling system. Bishop expressly teaches generating a thermal map when the operational state of the cooling system is adjusted and visually inspecting the thermal

maps to see how each adjustment affects the temperature distribution. Bishop teaches this approach as a way to identify “hot spots,” i.e., regions where current temperatures are above the desired temperature range.

422. For the reasons stated, it would have been obvious to a POSITA, using Nakanishi’s system, to compare an image representing the current temperature distribution throughout the computer room to an image representing the desired temperature range throughout the computer room to identify “hot spot” locations where current temperatures are not within the prescribed range so that corrective action can be taken. Hot spots are an example of “pattern differentials” recited in limitation 1[e], and therefore the Nakanishi/Bishop Combination discloses limitation 1[e].

## **2. Claim 2**

423. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 2.

- a. 2[a] – “The method as claimed in claim 1, further comprising the steps of: determining corrective action to reduce said pattern differentials; and”**

424. Claim 2 depends from claim 1. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claim 1.

425. For the same reasons provided above in Section IX.A.2.2[a], incorporated here, Nakanishi discloses limitation 2[a]: “*determining corrective action to reduce said pattern differentials.*”

426. For the same reasons provided above in Section IX.B.2.2[a], incorporated here, Bishop also discloses this limitation 2[a].

427. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses limitation 2[a].

**b. 2[b] – “varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.”**

428. For the same reasons provided above in Section IX.A.2.2[b], incorporated here, Nakanishi discloses limitation 2[b]: “*varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.*”

429. For the same reasons provided above in Section IX.B.2.2[b], incorporated here, Bishop also discloses this limitation 2[b].

430. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses limitation 2[b]. It is also my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 2 and renders claim 2 unpatentable as obvious.

**3. Claim 3 – “The method as claimed in claim 2, wherein said supplying step comprises the step of operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.”**

431. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 3.

432. Claim 3 depends from claim 2. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claims 1 and 2.

433. For the same reasons provided above in Section IX.A.3, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 2, wherein said supplying step comprises the step of operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.”

434. For the same reasons provided above in Section IX.B.3, incorporated here, Bishop also discloses this additional limitation of claim 3.

435. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 3 and renders claim 3 unpatentable as obvious.

**4. Claim 4 – “The method as claimed in claim 3, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”**

436. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 4.

437. Claim 4 depends directly from claim 3, and indirectly from claims 1 and 2. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claims 1, 2 and 3.

438. For the same reasons provided above in Section IX.A.4, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 3, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”

439. For the same reasons provided above in Section IX.B.4, incorporated here, Bishop also discloses this additional limitation of claim 4.

440. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 4 and renders claim 4 unpatentable as obvious.

**5. Claim 5 – “The method as claimed in claim 4, wherein said varying step comprises adjusting at least one of the opening of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.”**

441. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 5.

442. Claim 5 depends directly from claim 4, and indirectly from claims 1, 2 and 3. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claims 1–4.

443. For the same reasons provided above in Section IX.A.5, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 4, wherein said varying step comprises adjusting at least one of the opening of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.”

444. For the same reasons provided above in Section IX.B.5, incorporated here, Bishop also discloses this additional limitation of claim 5.

445. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 5 and renders claim 5 unpatentable as obvious.

**6. Claim 6 – “The method as claimed in claim 1, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical atmospheric map.”**

446. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 6.

447. Claim 6 depends from claim 1. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claim 1.

448. For the same reasons provided above in Section IX.A.6, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 1, wherein said generating step comprises using thermal mapping software to process input from

*said sensing step and to produce output in the form of said empirical atmospheric map.”*

449. For the same reasons provided above in Section IX.B.6, incorporated here, Bishop also discloses this additional limitation of claim 6.

450. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 6 and renders claim 6 unpatentable as obvious.

**7. Claim 7 – “The method as claimed in claim 1, wherein said identifying step comprises using pattern recognition software.”**

451. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 7.

452. Claim 7 depends from claim 1. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claim 1.

453. For the same reasons provided above in Section IX.A.7, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 1, wherein said identifying step comprises using pattern recognition software.”

454. As discussed in relation to claim 1, pattern recognition software was known and available to a POSITA (as acknowledged by the ’277 patent), and a POSITA would have been motivated to incorporate pattern recognition capabilities into Nakanishi’s thermal map generating features to automate the process of comparing empirical atmospheric map images to template map images. A POSITA

would have been motivated to undertake the simple, routine, and low-cost modification of Nakanishi's system to provide for more accurate and consistent comparisons and identification of hot spots indicating a need to adjust the cooling system operation. Cooling systems for data centers and other critical computing facilities typically operate on a continual basis, and a POSITA would recognize that automating the comparison of map images would reduce costs while allowing for the comparison to be performed more frequently so undesirable thermal conditions could be detected and corrected more quickly.

455. Furthermore, Nakanishi's cooling system is already automated with control software that compares simulated temperature values at various locations to desired temperature parameters and adjusts the fan operations to direct cooling air to where it is needed most. To the extent that the claims are interpreted to require a comparison of thermal map images, a POSITA would have been motivated to modify Nakanishi's system to use pattern recognition software that could provide input regarding identified pattern differences directly to the control software so that it could quickly execute necessary adjustments to the cooling fan operations. Furthermore, given the known interchangeability of these approaches, a POSITA would have had a reasonable expectation of success in modifying Nakanishi's system and using it to compare the generated empirical atmospheric/thermal map image to the template map image using pattern recognition software.

456. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 7 and renders claim 7 unpatentable as obvious.

**8. Claim 8 – “The method as claimed in claim 1, wherein said plurality of locations of said sensing step comprises locations at various elevations within said building.”**

457. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 8.

458. Claim 8 depends from claim 1. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claim 1.

459. For the same reasons provided above in Section IX.A.8, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 1, wherein said plurality of locations of said sensing step comprises locations at various elevations within said building.”

460. For the same reasons provided above in Section IX.B.7, incorporated here, Bishop also discloses this additional limitation of claim 8.

461. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 8 and renders claim 8 unpatentable as obvious.

**9. Claim 9 – “The method as claimed in claim 1, wherein said sensing step comprises using at least one of temperature sensors, humidity sensors, pressure sensors, particle sensors, smoke sensors, and velocity sensors.”**

462. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 9.

463. Claim 9 depends from claim 1. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claim 1.

464. For the same reasons provided above in Section IX.A.9, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 1, wherein said sensing step comprises using at least one of temperature sensors, humidity sensors, pressure sensors, particle sensors, smoke sensors, and velocity sensors.”

465. For the same reasons provided above in Section IX.B.8, incorporated here, Bishop also discloses this additional limitation of claim 9.

466. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 9 and renders claim 9 unpatentable as obvious.

**10. Claim 10 – “The method as claimed in claim 1, wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.”**

467. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 10.

468. Claim 10 depends from claim 1. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claim 1.

469. For the same reasons provided above in Section IX.A.10, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 1, wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.”

470. For the same reasons provided above in Section IX.B.9, incorporated here, Bishop also discloses this additional limitation of claim 10.

471. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 10 and renders claim 10 unpatentable as obvious.

**11. Claim 11 – “The method as claimed in claim 1, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.”**

472. As I explain below, the Nakanishi/Bishop Combination renders obvious claim 11.

473. Claim 11 depends from claim 1. For the reasons discussed above, Nakanishi alone and in combination with Bishop discloses and renders obvious all limitations of claim 1.

474. For the same reasons provided above in Section IX.A.11, incorporated here, Nakanishi discloses: “[t]he method as claimed in claim 1, wherein the step of

*identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.”*

475. For the same reasons provided above in Section IX.B.10, incorporated here, Bishop also discloses this additional limitation of claim 11.

476. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 11 and renders claim 11 unpatentable as obvious.

## **12. Claim 12**

477. As discussed above in Sections IX.A.12 and IX.B.11, independent claim 12 is similar to claim 1, although its preamble refers to the building as being a “data center” and the claim focuses on temperature as the atmospheric parameter. Claim 12 thus recites “sensing temperature,” generating an “empirical thermal map” and comparing it to a “template thermal map.”

478. Nakanishi discloses a system and method for monitoring and controlling the temperature distribution throughout a “computer room,” which is another term “data center.” Nakanishi monitors temperature, the disclosed simulation program generates temperature distribution maps, and Nakanishi’s method includes comparing the temperature map to a template temperature map.

Bishop's disclosed system and method also operates to monitor and control the temperature distribution throughout a data center.

479. Therefore, my analyses and opinions set forth in Paragraphs 395 to 422 above in relation to claim 1 apply equally to claim 12. Thus, for the same reasons discussed in relation to claim 1, to the extent that claim 12 is interpreted to require comparing an empirical thermal map image to a template thermal map image, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 12 under such an interpretation and renders claim 12 unpatentable as obvious.

### **13. Claim 13**

480. I discuss each limitation of claim 13 in turn below, in conjunction with the relevant disclosures of each claim limitation by Nakanishi.

#### **a. 13[a] – “The method as claimed in claim 12, further comprising the steps of: determining corrective action to reduce said pattern differentials; and”**

481. Claim 13 recites, “[t]he method as claimed in claim 12, further comprising the steps of: determining corrective action to reduce said pattern differentials . . . .”

482. The subject of this claim limitation is analogous to claim limitation 2[a]. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.2.2[a].

**b. 13[b] – “varying at least one of the quantity, quality, and distribution of said cooling fluid in accord with said determining step.”**

483. Claim 13 further recites, “*varying at least one of the quantity, quality, and distribution of said conditioned fluid in accord with said determining step.*”

484. The subject of this claim limitation is analogous to claim limitation 2[b]. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.2.2[b].

485. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 13 and renders claim 13 unpatentable as obvious.

**14. Claim 14 – “The method as claimed in claim 13, wherein said supplying step comprises operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.”**

486. Claim 14 recites, “[*t*]he method as claimed in claim 13, wherein said supplying step comprises operating a system having at least one of a plurality of vents, at least one blower, and at least one source of conditioned air.”

487. The subject of this claim is analogous to claim 3. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.3.

488. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 14 and renders claim 14 unpatentable as obvious.

**15. Claim 15 – “The method as claimed in claim 14, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”**

489. Claim 15 recites, “[t]he method as claimed in claim 14, wherein said determining step comprises correlating at least one of the location, size, and intensity of said pattern differentials to at least one of the location of said plurality of vents, the speed of said at least one blower, and the capacity of said at least one source of conditioned air.”

490. The subject of this claim is analogous to claim 4. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.4.

491. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 15 and renders claim 15 unpatentable as obvious.

**16. Claim 16 – “The method as claimed in claim 15, wherein said varying step comprises adjusting at least one of the opening of at least one of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.”**

492. Claim 16 recites, “[t]he method as claimed in claim 15, wherein said varying step comprises adjusting at least one of the opening of at least one of said plurality of vents, the speed of said at least one blower, and the output of said at least one source of conditioned air.”

493. The subject of this claim is analogous to claim 5. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.5.

494. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 16 and renders claim 16 unpatentable as obvious.

**17. Claim 17 – “The method as claimed in claim 12, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical thermal map, wherein said thermal mapping software triangulates locations of hot spots.”**

495. Claim 17 recites, “[t]he method as claimed in claim 12, wherein said generating step comprises using thermal mapping software to process input from said sensing step and to produce output in the form of said empirical thermal map, wherein said thermal mapping software triangulates locations of hot spots.”

496. The subject of this claim is analogous to claim 6. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.6.

497. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 17 and renders claim 17 unpatentable as obvious.

**18. Claim 18 – “The method as claimed in claim 12, wherein said identifying step comprises using pattern recognition software.”**

498. Claim 18 recites, “[t]he method as claimed in claim 12, wherein said identifying step comprises using pattern recognition software.”

499. The subject of this claim is analogous to claim 7. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.7.

500. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 18 and renders claim 18 unpatentable as obvious.

**19. Claim 19 – “The method as claimed in claim 12, wherein said plurality of locations of said sensing step comprises locations at various elevations within said data center.”**

501. Claim 19 recites, “[t]he method as claimed in claim 12, wherein said plurality of locations of said sensing step comprises locations at various elevations within said data center.”

502. The subject of this claim is analogous to claim 8. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.8.

503. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 19 and renders claim 19 unpatentable as obvious.

**20. Claim 20 – “The method as claimed in claim 12 wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.”**

504. Claim 20 recites, “[t]he method as claimed in claim 12 wherein the step of generating an empirical atmospheric map comprises generating a map composed of temperature contours that define various isothermal regions.”

505. The subject of this claim is analogous to claim 10. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.10.

506. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 20 and renders claim 20 unpatentable as obvious.

**21. Claim 21 – “The method as claimed in claim 12, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.”**

507. Claim 21 recites, “[t]he method as claimed in claim 12, wherein the step of identifying pattern differentials between said empirical and template atmospheric maps comprises performing at least one of extrapolation and triangulation to determine locations of one or more hot spots.”

508. The subject of this claim is analogous to claim 11. Thus, the Nakanishi/Bishop Combination discloses this limitation for the reasons provided above, and incorporated here. *Supra* Section IX.C.11.

509. Thus, it is my opinion that the Nakanishi/Bishop Combination discloses each limitation of claim 21 and renders claim 21 unpatentable as obvious.

## **X. CONCLUDING STATEMENTS**

510. In my opinion, all of claims 1–21 of the ’277 patent were anticipated by or at least obvious in view of the prior art addressed herein. As such, it is my opinion that claims 1–21 of the ’277 patent should be found unpatentable.

511. I declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true, and 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.

Executed on February 26, 2025 in Minneapolis, Minnesota.

DocuSigned by:  
  
7A860E4BA901415...

John P. Abraham, Ph.D.

## SUMMARY

Thermal science expert with experience in all aspects of heat transfer and fluid mechanics. Produced approximately 500 publications, books, book chapters, conference presentations, and patents in areas including biological heat transfer and fluid flow, biomedical device design, energy, burn injuries, climate change, fundamental heat transfer and fluid mechanics, and manufacturing processes. Author of approximately 350 popular press articles and has been in approximately 400 radio and television appearances.

## ACADEMIC APPOINTMENTS

*University of St. Thomas, St Paul, MN*

|                            |                     |
|----------------------------|---------------------|
| <b>Professor</b>           | <b>2013-Present</b> |
| <b>Associate Professor</b> | <b>2008-2013</b>    |
| <b>Assistant Professor</b> | <b>2002-2008</b>    |

## OTHER EMPLOYMENT

**WTS. LLC**

**Vice President of Research**

**2023-present**

Responsible for directing solar-electrical-thermal research activities

## EDUCATION

*University of Minnesota - Twin Cities, Minneapolis, MN*

|                                                                                |             |
|--------------------------------------------------------------------------------|-------------|
| <b>Ph.D.</b> , Mechanical Engineering (Thermal Sciences)                       | <b>2002</b> |
| <b>M.S.</b> , Mechanical Engineering, GPA 3.96/4.00                            | <b>1999</b> |
| <b>B.S.</b> , Mechanical Engineering, GPA 4.00/4.00, <b>Minor:</b> Mathematics | <b>1997</b> |

## PREVIOUS TEACHING EXPERIENCE

|                                                                                   |                  |
|-----------------------------------------------------------------------------------|------------------|
| <b>Adjunct Faculty</b> , <i>University of St. Thomas, St Paul, MN</i>             | <b>2000-2002</b> |
| <b>Graduate Teaching Fellow</b> , <i>University of Minnesota, Minneapolis, MN</i> | <b>2001-2002</b> |
| <b>Teaching Assistant</b> , <i>University of Minnesota, Minneapolis, MN</i>       | <b>1997-2001</b> |
| <b>Tutor</b> , <i>University of Minnesota, Minneapolis, MN</i>                    | <b>1993-1997</b> |

## HONORS/AWARDS

- Advances in Atmospheric Sciences Notable paper award (2024).
- Journal of Forensic Sciences, Noteworthy paper award (2023).
- AAS Esteemed News and Views Paper Prize, (2023)
- Editor's Choice Award, Journal of Forensic Sciences, (2022).
- AAS Esteemed News and Views Paper Prize, (2022)
- Journal of Atmospheric and Oceanic Technology, Editor award (2020)
- National Center for Science Education, Friend of the Planet Award (2016)
- University of St. Thomas, Professor of the Year (2016)
- USA Green Deal of the Year business excellence award (2013)
- Composites Sustainability Award, American Composites Manufacturers Association Award for Composite Excellence, (2013)

- Nominated, George Mason University, Center for Climate Change Communication, Climate Change Communicator of the Year (2011)
- University of St. Thomas, John Ireland Award (2009)
- University of St. Thomas, Distinguished Educator Award (2008)
- University of St. Thomas, Engineering Professor of the Year (2005)
- Graduate Teaching Fellowship (2001/2002)
- Institute of Technology Teaching Assistant of the Year, awarded by the Institute of Technology Student Board, University of Minnesota (1999/2000)
- Institute of Technology Teaching Assistant of the Year, awarded by the Institute of Technology Student Board, University of Minnesota (2000/2001)
- Institute of Technology Teaching Assistant of the Year, awarded by the Institute of Technology Student Board, University of Minnesota (2001/2002)
- Mechanical Engineering Teaching Assistant of the Year, Mechanical Engineering Department, University of Minnesota (1998/1999)
- Minnesota Professional Engineers Foundation Orion Buan Memorial Scholarship (1996)
- Walter and Margaret Pierce Endowment Fund Scholarship (1996)
- National Space Grant Consortium Scholarship (1996)
- Frank Louk Scholarship (1996)
- Citizens' Scholarship (1992-1995)
- Alfred O. Neir Scholarship (1994)
- Dean's List (1993-1997)

### OTHER POSITIONS

**Climate Blogger – Guardian Newspaper**

**2013-2020**

**Editorial Board Member – Handling Ethics Cases, Energies**

**2024-present**

### PUBLICATIONS

*(26 edited works, 4 books, 45 book chapters, 320 journal publications, 149 presentations, 26 granted patents, 7 patent applications, 2 granted trademarks)*

### TOP PUBLICATIONS BY ALTMETRIC

L. Cheng, J.P. Abraham, K.E. Trenberth, T. Boyer, M.E. Mann, J. Zhu, F. Wang, R. Locarnini, J. Fasullo, Y. Li, B. Zhang, L. Wan, X. Chen, D. Wang, L. Feng, X. Song, Y. Liu, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, A. Mishonov, J. Reagan, K. von Schuckmann, Y. Pan, Z. Tan, Y. Zhu, W. Wei, G. Li, Q. Ren, L. Cao, and Y. Lu, New Record Ocean Temperatures and Related Climate Indicators in 2023, *Advances in Atmospheric Sciences*, 2025, doi: 10.1007/s00376-024-3378-5. **Altmetric score = 1064, top 1% in all journals, January 2024. This altmetric score places the paper in the top 1% (top 168 out of 205963 papers) in all journals, and within the top 1% of papers in the publishing journal.**

L. Cheng, J.P. Abraham, K.E. Trenberth, J.T. Fasullo, T. Boyer, M.E. Mann, J. Zhu, F. Wang, R. Locarnini, Y. Li, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, A. Mishonov, J. Reagan, and G. Li, Another Year of Record Heat for the Oceans, *Advances in Atmospheric Sciences*, Vol. 40, pp. 963-974, 2023. **Altmetric score = 1438, top 1% in all journals, January 2023. This altmetric score places the paper in**

**the top 1% (top 100 out of 214000 papers) in all journals, and within the top 1% of papers in the publishing journal.**

L. Cheng, J.P. Abraham, K.E. Trenberth, J. Fasullo, T. Boyer, M.E. Mann, J. Zhu, F. Wang, R. Locarnini, Y. Li, B. Zhang, Z. Tan, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, A. Mishonov, J. Reagan, Another Record Ocean Warming Continues Through 2021 Despite La Nina Conditions, *Advances in Atmospheric Sciences*, Vol. 39, 373-385, 2022). **Altmetric score = 4686, top 1% in all journals, January 2022. This altmetric score places the paper in the top 0.02% (top 57 out of 287000 papers) in all journals, and within the top 1% of papers in the publishing journal.**

L. Cheng, J.P. Abraham, K.E. Trenberth, J.T. Fasullo, T.L. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, M.E. Mann, F. Reseghetti, S. Simoncelli, V. Gouretski, G. Chen, and J. Zhu, Upper Ocean Temperatures Hit Record High in 2020, *Advances in Atmospheric Sciences*, Vol. 38, pp. 523-530, 2021. **Altmetric score = 1439, top 1% in all journals, August 2021.**

G. Li, L. Cheng, J. Zhu, K.E. Trenberth, M.E. Mann and J.P. Abraham, Increasing Ocean Stratification Over the Past Half Century, *Nature Climate Change*, Vol. 10, pp. 1116-1123, 2020. **Altmetric score = 726, top 1%, July 2021.**

J.P. Abraham, B. D. Plourde, and L. Cheng, Using Heat to Kill SARS-CoV-2, *Reviews in Medical Virology*, Vol. 30, e2115, 2020. **Altmetric score = 392, top 1%, July, 2021.**

L. Cheng, J.P. Abraham, J. Zhu, K.E. Trenberth, J. Fasullo, T. Boyer, R. Locarnini, B. Zhang, F. Yu, L. Wan, X. Chen, X. Song, Y. Liu, and M.E. Mann, Record-Setting Ocean Warmth Continued in 2019, *Advances in Atmospheric Sciences*, Vol. 37, 1-6, 2020. **This paper was in the top 100 of all published scientific papers in the year 2020, ranked by Altmetric. Also, second of all 2020 papers in the subject area of climate. Altmetric score = 3957, top 1%, January 2021.**

L. Cheng, J. Zhu, J.P. Abraham, K. E. Trenberth, J. T. Fasullo, B. Zhang, F. Yu, L. Wan, Z. Chen, X. Song, 2018 Continues record global warming, *Advances in Atmospheric Sciences*, 36, pp. 249-252, 2019. **Altmetric score = 646, top 1%, January 2021.**

L. Cheng, J.P. Abraham, Z. Hausfather, and K.E. Trenberth, How fast are the oceans warming?, *Science*, Vol. 363, pp. 128-129, 2019. **Altmetric score = 2853, top 1%, January 2021.**

L.J. Cheng, K.E. Trenberth, T. Boyer, J. T. Fasullo, L. Zhu, J.P. Abraham, Improved Estimates of Ocean Heat Content from 1960-2015, *Science Advances*, Vol. 4, paper no. e1601545, 2017. **Altmetric Score = 753, top 1%, January 2021.**

J.P. Abraham, M. Baringer, N.L. Bindoff, T. Boyer, L.J. Cheng, J.A. Church, J.L. Conroy, C.M. Domingues, J.T. Fasullo, J. Gilson, G. Goni, S.A. Good, J. M. Gorman, V. Gouretski, M. Ishii, G.C. Johnson, S. Kizu, J.M. Lyman, A. M. Macdonald, W.J. Minkowycz, S.E. Moffitt, M.D. Palmer, A.R. Piola, F. Reseghetti, K. Schuckmann, K.E. Trenberth, I. Velicogna, and J.K. Willis, A Review of Global Ocean Temperature Observations: Implications for Ocean Heat Content

Estimates and Climate Change, *Reviews of Geophysics*, Vol. 51, pp 450-483, 2013. **Altmetric score = 178, top 5%, January 2024.**

### **Editing Activities (28 editorial activities)**

1. Editor, *Advances in Heat Transfer*, Vol. 60, (Forthcoming, 2025).
2. Editor, *Advances in Heat Transfer*, Vol. 59, (Forthcoming, 2025).
3. Editor, *Advances in Heat Transfer*, Vol. 58, 2024.
4. Editor, *Advances in Heat Transfer*, Vol. 57, 2024.
5. Editor, *Advances in Numerical Heat Transfer – Artificial Intelligence Methods*, (forthcoming 2024)
6. Editor, Special edition in *Numerical Heat Transfer B – AI methods in heat transfer* (2023)
7. Editor, *Advances in Heat Transfer*, Vol. 56, 2023.
8. Editor, *Advances in Heat Transfer*, Vol. 55, 2023.
9. Editor in Chief, *Numerical Heat Transfer A* (2022-2024).
10. Editor in Chief, *Numerical Heat Transfer B* (2022-2024).
11. Editor, *Advances in Atmospheric Sciences (AAS)*, 2022.
12. Editor, *Advances in Heat Transfer*, Vol. 54, 2022.
13. Editor, *Advances in Heat Transfer*, Vol. 53, 2021.
14. Editor, *Advances in Heat Transfer*, Vol. 52, 2020.
15. Editor, *Advances in Heat Transfer*, Vol. 51, 2019.
16. Editor, *Advances in Heat Transfer*, Vol. 50, 2018.
17. Editor, *Advances in Heat Transfer*, Vol. 49, 2017.
18. Editor, *Advances in Heat Transfer*, Vol. 48, 2016.
19. Editor, *Advances in Heat Transfer*, Vol. 47, 2015.
20. Editor, *Advances in Heat Transfer*, Vol. 46, 2014.
21. Editor, *Advances in Numerical Heat Transfer Vol. 5: Numerical Models of Heat Exchangers*, Taylor and Francis, New York, 2017.
22. Editor, *Small-Scale Wind Power – Design, Analysis, and Economic Impacts*, Momentum Press, 2014.
23. Editor, *Advances in Heat Transfer*, Vol. 45, 2013.
24. Editor, *Advances in Heat Transfer*, Vol. 44, 2012.
25. Editor, *Advances in Numerical Heat Transfer Vol. 4: Nanoscale Heat Transfer and Fluid Flow*, Taylor and Francis, New York, 2012.
26. Guest Editor, *Advances in Numerical Heat Transfer Vol. 3: Numerical Implementation of Biological Models and Equations*, Taylor and Francis, New York, 2009.
27. Guest Editor, Special Edition of the *International Journal of Heat and Mass Transfer: Bioheat and Biofluid Flow*, Elsevier, Vol. 51, 23-24, November, 2008.
28. Assistant Editor, *Handbook of Numerical Heat Transfer*, 2<sup>nd</sup> Ed. Editors: Sparrow, Minkowycz, and Murthy, John-Wiley & Sons, Inc., New York, 2006.

### **Editorial Board Member**

1. Water Eng. & Sciences, 2023-present
2. *Advances in Atmospheric Sciences*, 2022-present
3. *International Journal of Forensic Sciences*, 2023-present

4. International Society of Cardiovascular Translational Research, 2020-present
5. Energies, Thermal Management, 2019-present
6. Cardiovascular Revascularization Medicine, 2018-present
7. Stem Cell Biology and Transplantation, 2015-present
8. Associate Editor, National Center for Science Education, Climate Science, 2012-present
9. International Journal of Mechanics and Energy, 2012-present
10. Open Mechanical Engineering Journal, 2007-present
11. Open Mechanical Engineering Reviews, 2007-present
12. Open Mechanical Engineering Letters, 2007-present
13. Open Medical Devices Journal, 2008-present
14. Creative Engineering Journal, 2009-present
15. ISRN Applied Mathematics, 2011-present
16. International Journal of Sustainable Energy, 2012 - present
17. International Journal of Materials, Methods, and Technologies, 2012- present

### **Books**

1. K. Vajravelu, J.P. Abraham, S. Mukhopadhyay, and P. Lakshminarayana, Advances in Nanofluid Flow, Heat, and Mass Transfer at Moving/Stretching Surfaces, CRC Press, (in preparation).
2. J.P. Abraham and B.D. Plourde, Small-Scale Wind Power – Design, Analysis, and Environmental Impacts, *Momentum Press*, 2014.
3. J.P. Abraham, P.S. Ellis, M.C. MacCracken, and G.M. Woodwell, Climate controversy 2013. New York, NY: *AuthorHouse*, 2013.
4. J.P. Abraham, E.M. Sparrow, W.J. Minkowycz, R.Ramazani-Rend, and J.C.K. Tong, All Fluid-Flow-Regimes Simulation Model for Internal Flows, *Nova Science Publishers, Inc.*, Hauppauge, NY, 2011.

### **Book Chapters (author of 43 book chapters)**

1. F. Salmasi, J.P. Abraham, and B.O. Bakhshayesh, Numerical Study of Stability of Retaining Walls in the Presence of Horizontal and Chimney Drainage, *Engineering Research: Perspective on Recent Advances*, MDPI Publisher, 2025.
2. F. Salmasi and J.P. Abraham, Estimation of Energy Dissipation of Flow Over Stepped Spillways, *Energy Research: Perspectives on Recent Advances*, MPDI Publisher, 2025.
3. K. Vajravelu, J.P. Abraham, S. Mukhopadhyay, and P. Lakshminarayana, Advances in Nanofluid Flow, Heat, and Mass Transfer at a Moving/Stretching Surface, *Advances in Heat Transfer*, Vol. 58, 2024.
4. F. Salmasi and J.P. Abraham, New Perspectives on the Design of Stilling Basins, *Theory and Applications of Engineering Research*, 2024.

5. F. Salmasi and J.P. Abraham, Exploring Two-Phase Flow Dynamics: Experimental Investigations and Computational Modeling in Smooth and Stepped Chutes, *Theory and Applications of Engineering Research*, 2024.
6. F. Salmasi and J.P. Abraham, Ogee Crest Weir Head-Discharge Relationships, *Research Highlights in Science and Technology*, 2023.
7. F. Salmasi and J.P. Abraham, Hydraulic Performance of Sluice Gates: A Review of Head Loss Estimation and Discharge Coefficients for Optimal Flow Control and Design Considerations, *Dam Engineering – Design, Construction and Sustainability*, IntechOpen, 2023.
8. D.K. Vashwakarma, S. Bhattacharyya, M.L. Soni, and J.P. Abraham, Effect of Inlet Flat Obstruction on Thermohydraulic Characteristics in a Smooth Circular Tube in the Transitional Flow Regime, in Bhattacharya, Verma, Harikrishnan (eds), *Fluid Mechanics and Fluid Power, Vol. 3, Lecture Notes in Mechanical Engineering*, Springer, doi: 10.1007/978-981-19-6270-7\_76.
9. F. Salmasi and J.P. Abraham, On the Finite Differences Method Using MS Excel, *Research Highlights in Mathematics and Computer Science* Vol. 6, pp 140-186, 2023.
10. F. Salmasi and J.P. Abraham, Boundary of Transition Flow Regime on Stepped Spillways by Physical Modeling, *Current Overview on Science and Technology Research*, (in press).
11. F. Salmasi and J.P. Abraham, Determination of Stilling Basin Invert Elevation and its Effect on Controlling Hydraulic Jumps, Chapter 5, *Techniques and Innovation in Engineering Research*, Vol. 2, 2022.
12. F. Salmasi and J.P. Abraham. Energy Loss at the Base of a Free Straight Drop Spillway, *Current Overview on Science and Technology Research*, Vol. 6, 2, 2022.
13. F. Salmasi and J.P. Abraham, Computation of Optimal Cross Section of Gravity Dams Using Genetic Algorithms, *Current Overview on Science and Technology Research*, Vol. 6, Chapter 1, 2022.
14. F. Salmasi and J.P. Abraham, Flow Characteristics of Skimming Regime Flow Over Stepped Spillways with Attention to Optimum Step Size, *Current Overview on Science and Technology Research*, Vol. 6, Chapter 3, 2022.
15. R. Daneshfaraz, E. Aminvash, and J.P. Abraham, Hydraulic Characteristics of Fish-Passes on Inclined Drops, *Research Developments in Science and Technology*, Vol. 4, pp. 108-123, 2022.

16. F. Salmasi, J.P. Abraham, and A. Salmasi, Design Considerations for Pumping Stations Using Variable Speed Pumps, *Novel Perspectives of Engineering Research*, Vol. 10, pp. 98-118, 2022.
17. F. Salmasi, J.P. Abraham, Drainage Gallery in Concrete Gravity Dams and its Effect on Reduction of Uplift Forces, *Novel Perspectives of Engineering Research*, Vol. 10 pp. 43-62, 2022.
18. F. Salmasi, and J.P. Abraham, Numerical Simulation Using the Finite Element Method to Investigate the Effect of Horizontal Drains and Cutoff Walls on Seepage and Uplift Pressure in Heterogeneous Earth Dams, *Novel Perspectives of Engineering Research*, Vol. 9, pp. 58-85, 2022.
19. F. Salmasi, J.P. Abraham, B. Nourani, Determining the Analysis of the Stability of Embankments Against Sliding and Prediction of Sliding and Critical Factor of Safety, *Novel Perspectives of Engineering Research*, pp. 98-125, 2022.
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2. E. Wells, B.D. Plourde, J. Lyons, J.P. Abraham, G. Pauly, G. Riche, L. Purdum, C. Armstrong, K. Rice, T. Decker, K. Nowlan, M. Story, T. Solider Wolf, Electrification and Job Development for Rural Applications in the USA: Case Study – Wind River Reservation: Impacts on Tribal Capacity, Resiliency, Access to Power, and Jobs, *Microgrid Global Innovation Forum*, San Francisco, September 24-25, 2024.
3. J.P. Abraham, Heat Transfer in Forensics, VCU Forensics Seminar, December 6, 2022.
4. L. Cheng, and J.P. Abraham, Perspectives on Ocean sand Their Role in the Global Energy Budget and Water Cycle, *American Meteorological Society 102<sup>nd</sup> Annual Meeting, Houston, Kevin Trenberth Symposium*, January 23-27, 2022 (invited).
5. L. E. Olsen and J.P. Abraham, New correlations for convective coefficients over square and cubical bodies, *48<sup>th</sup> National Conference on fluid mechanics and fluid power*, December 27-29, 2021.
6. D. Vishwakarma, S. Bhattacharyya, M. Soni and J.P. Abraham, Effect of Inlet Flat Obstruction on Thermohydraulic Characteristics in a Smooth Circular Tube in the Transition Flow Regime, *48<sup>th</sup> National Conference on fluid mechanics and fluid power*, December 27-29, 2021.
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10. L. Cheng, K. Trenberth, K. von Schuckmann, J.P. Abraham, V. Gouretski, Oceanic Responses to the Climate: Recognizing Changes and Extremes, *AAAS Annual Meeting*, February 11, 2021.
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12. J.P. Abraham, L. Cheng, Kevin Trenberth – A Life of Research and Impact, *Trenberth Symposium*, Denver, CO, March 16, 2020.
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60. J.P. Abraham, Thawing Out Climate Science, IEEE 2013 Awards Banquet, St. Paul, MN, February 23, 2013.

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78. I. Enting, J.P. Abraham, Detailed Debunking of Denial, *AGU Winter Meeting 2012*, December 3-7, San Francisco, 2012.
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97. N.N. Johnson, K. L. McCaffrey, K.M. Rose, and J.P. Abraham, Cryosurgical Treatments for Uterine Fibroids, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.
98. R.D. Lovik, K. J. Kelly, E.M. Sparrow, and J.P. Abraham, Effect of Misalignment of Implant and Antenna on Heat Generation of Externally Recharged Neuromodulation Implants, *North American Neuromodulation Society 14<sup>th</sup> Annual Meeting*, Las Vegas, NV, December 2-5, 2010.
99. J.P. Abraham and S. Mandia, An Emerging Ethic of Responsibility: A Case Study for Engaging the Public, *American Geophysical Union Fall Meeting*, San Francisco, CA December 13-17, 2010.
100. J.P. Abraham and G.S. Mowry, B.D. Plourde, Analysis of Thermal and Fluid Flow Problems, *Thermal Packaging and Small Business Innovation Workshop*, Eagan, MN, October 5-6, 2010.
101. N.N. Johnson, J.P. Abraham, Z.I. Helgeson, and M.P. Hennessey, Numerical Simulation of Blood Flow in the Presence of Embolizing Agents, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.
102. N.N. Johnson, J.P. Abraham, and Z.I. Helgeson, Calculations of Scald Burns: Effects of Water Temperature, Exposure Duration, and Clothing, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.
103. N.N. Johnson, M.P. Hennessey, and J.P. Abraham, Swept Arc Length Measure of Abrasive Wear, *ASME 2010 International Congress and Expo*, Vancouver, CA, November 12-18, 2010.
104. K.L. McCaffrey, K.M. Rose, and J.P. Abraham, Numerical Simulation of Cryosurgery as a Potential Treatment for Uterine Fibroids, *14<sup>th</sup> International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.
105. J.P. Abraham, E.M. Sparrow, J.C.K. Tong, and W.J. Minkowycz, Intermittent Flow Modeling. Part 1: Hydrodynamic and thermal Modeling of Steady, Intermittent Flows in Constant Area Ducts, *14<sup>th</sup> International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.

106. J.P. Abraham, E.M. Sparrow, J.C.K. Tong, and W.J. Minkowycz, Intermittent Flow Modeling. Part 2: Time-Varying Flows and Flows in Variable Area Ducts, *14<sup>th</sup> International Heat Transfer Conference*, Washington, D.C., August 8-13, 2010.
107. K.L. McCaffrey, K.M. Rose, and J.P. Abraham, Cryosurgery as an Alternative Treatment for Menorrhagia and Uterine Fibroids, *ASME Summer Biomedical Engineering Conference*, Naples, FL, June 16-19, 2010.
108. J.M. Gorman, N.K. Sherrill, J.P. Abraham, Analysis of Drag-Reducing Techniques for Olympic Skeleton Helmets, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.
109. B. D. Plourde, J.P. Abraham, G.S. Mowry, Numerical Simulation of Vertical Axis Wind Turbines, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.
110. J.P. Abraham, Z.I. Helgeson, N.N. Johnson, G.S. Mowry, Numerical Simulations and Medical Device Design, *ANSYS Users Conference*, Minneapolis, MN, June 11, 2010.
111. J.M. Gorman, N.K. Sherrill, J.P. Abraham, Drag-Reducing Vortex Generators and Olympic Skeleton Helmet Design, *ANSYS Users Conference*, Chicago, IL, June 7, 2010.
112. J.P. Abraham, Z.I. Helgeson, N.N. Johnson, G.S. Mowry, (Keynote), Numerical Simulations in Biomedical Design, *ANSYS Users Conference*, Chicago, IL, June 7, 2010.
113. J.P. Abraham, E.M. Sparrow, Y. Bayazit, R.D. Lovik, and D.S. Smith, Numerical and Experimental Simulations as Symbiotic Tools for Solving Complex Bio-Thermal Problems, *Design of Medical Devices Conference*, Minneapolis, MN April 13-15, 2010.
114. E.M. Sparrow and J.P. Abraham, Numerical Solutions of Biological Heat Transfer, *Design of Medical Devices Conference*, Minneapolis, MN April 13-15, 2010.
115. J.P. Abraham, R.D. Lovik, D.S. Smith, E.M. Sparrow, and K.J. Kelly, Heat Generation Measurements of Revised Neuromodulation Devices and Calculations of Tissue Temperatures, *North American Neuromodulation Society 13th Annual Meeting*, Las Vegas, December 3-6, 2009.
116. J.P. Abraham and E.M. Sparrow, Numerical Simulation as a Tool for Assessing Thermal- and Fluid-Based Processes and Therapies, *Institute for Engineering in Medicine Innovation Showcase*, Minneapolis, MN, September 22, 2009.
117. J.P. Abraham, E.M. Sparrow, and R.D. Lovik, An Investigation of Tissue-Temperature Elevation Caused by Recharging of Transcutaneous Neuromodulation Devices, *31<sup>st</sup> Annual International Conference of the IEEE Engineering in Medicine in Biology Society*, Minneapolis, MN, September 2-7, 2009.

118. R.D. Lovik, J.P. Abraham, and E.P. Sparrow, Pulsating Fluid Flows Undergoing Transitions Between Laminar, Transitional, and Turbulent Regimes, *ASME 2009 Summer Bioengineering Conference*, Lake Tahoe, CA, June 17-21, 2009.
119. E.M. Sparrow, and J.P. Abraham, Case Studies on the Use of Numerical Simulation for design and Optimization of Medical Devices, *Design of Medical Devices Conference*, Minneapolis, MN April 14-16, 2009.
120. F. Hoover and J. Abraham Assessment of the Carbon Dioxide and Energy Balances of Biofuels, *Climate Change Technology Conference 2009*, Hamilton, Ontario, May 12-15, 2009.
121. J.P. Abraham, G.S. Mowry, and R.E. Erickson, Design and Analysis of a Small-Scale Vertical-Axis Wind Turbine for Rooftop Power Generation, *Climate Change Technology Conference 2009*, Hamilton, Ontario, May 12-15, 2009.
122. F. Hoover and J.P. Abraham, A review: Comprehensive Comparison of Corn-based and Cellulosic-based Ethanol as Biofuel Sources, *Clean Technology Conference and Expo 2009*, Houston, TX, May 3-7, 2009.
123. J.P. Abraham, G.S. Mowry, and R.E. Erickson, Design and Analysis of a Small-Scale Vertical-Axis Wind Turbine, *Clean Technology Conference and Expo 2009*, Houston, TX, May 3-7, 2009.
124. J.P. Abraham, R.D. Lovik, and E.M. Sparrow, Tissue Temperature Rises Due to Heat Generation in Neuromodulation Implants, North American Neuromodulation Society 12th Annual Meeting, Las Vegas, December 4-7, 2008.
125. G. Nelson, A. Majewicz, and J.P. Abraham, Numerical Simulation of Thermal Injury to the Artery Wall During Orbital Atherectomy, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.
126. J.P. Abraham, Integrating Integration of ANSYS/CFX into Classrooms, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.
127. J.P. Abraham, Pressure Drop and Heat Transfer Calculations for Laminar-Turbulent Intermittent Flows, *ANSYS International*, Pittsburgh, PA, August 26-29, 2008.
128. J.P. Abraham, J.C.K. Tong, and E.M. Sparrow, Prediction of Laminar-Turbulent Transition and Friction Factors in Transitional Flows, *ASME International Congress and Expo*, Boston, MA, October 31 – November 5, 2008.
129. R.D. Lovik, J.P. Abraham, and E.M. Sparrow, Assessment of Possible Thermal Damage of Tissue Due to Atherectomy by Means of a Mechanical Debulking Device, *ASME 2008 Summer Bioengineering Conference*, Marco-Island, FL, June 25-29, 2008.

130. J.P. Abraham and A.P. Thomas, Numerical Simulation of Induced Co-Flow and Laminar-to-Turbulent Transition Associated with Synthetic Jets, *Fluconome 2007*, Tallahassee, FL, September 16-19, 2007.
131. J.P. Abraham and C.M. George, An Investigation of Radiation Shields for Full-Building Cooling in Desert Climates, *Solar 2007*, Cleveland, OH July 7-12, 2007.
132. A. Marchese, J.P. Abraham, C.S. Greene, L. Kizenwether, and J. Ochs, Toward a Common Standard Rubric for Evaluating Capstone Design Projects, *National Capstone Design Course Conference*, Boulder, CO June, 13-15, 2007 (Best Paper Award).
133. John Abraham, Chris Greene, Anthony Marchese, External Assessment Through Peer-to-Peer Evaluation of Capstone Projects, *Frontiers in Education*, Milwaukee, WI, October, 10-13, 2007.
134. John Abraham, Computation Fluid Dynamics Using ANSYS CFX, presented at the University of Minnesota Digital Technology Center, Sept. 12 and 14, 2006.
135. John Abraham, Application of the Finite Element Method, *LifeSciences Conference*, Minneapolis, October 5, 2006.
136. John Kim and John Abraham, Design of Experiments in the Medical Device Industry, *LifeSciences Conference*, Minneapolis, October 5, 2006.
137. Ephraim Sparrow, Nick Whitehead, and John Abraham, Fluid Flow Dynamics in the Urinary Tract – Impact on Device Design, Presented to the Department of Urologic Surgery, April 17, 2006.
138. John Abraham, Nick Whitehead, and Ephraim Sparrow, Numerical Simulation of Thermal Therapies, Presented to the Department of Urologic Surgery, April 17, 2006.
139. John Abraham, Nick Whitehead, and Ephraim Sparrow, Biomedical Applications Simulations/Experimental Investigations, *Biomedical Focus 2006*, Brooklyn Center, MN, March 20-21, 2006.
140. Nick Whitehead, Ephraim Sparrow, and John Abraham, A Role for Engineering in Medical Simulations, *Simulation in Healthcare*, Minneapolis, MN, November 28, 2005.
141. Ronald Major and John Abraham, The Application of Thermal Analysis on a Disk Array, *Fluent's 2005 CFD Summit*, Detroit, MI, June 7-8, 2005.
142. Camille George and John Abraham, A Sustainable Low-Energy Cooling System for Hot Dry Climates, *Sustainability as Security*, Austin, TX, October 5-9, 2005.

143. John P. Abraham and Ephraim M. Sparrow, Irrelevance of the Relative Velocity as the Characteristic Velocity When Both a Fluid and its Bounding Surface are in Motion, *Lorenz G. Straub Award*, Minneapolis, MN, November 13, 2004.
144. John P. Abraham and Ephraim M. Sparrow, An Unexpected U-Turn After an Eckert Straight Start, *Eckert Symposium*, Minneapolis, MN, September 13-14, 2004.
145. John P. Abraham and Ephraim M. Sparrow, Methodologies to Enhance the Numerical Simulations of Electronic Cooling, *Semi-Therm Conference*, San Jose, CA, March 9-10, 2004.
146. Ephraim M. Sparrow, John P. Abraham, and Paul Chevalier, A DOS-Enhanced Numerical Simulation of Heat Transfer and Fluid Flow Through an Array of Offset Fins with Conjugate Heating in the Bounding Solid, *ASME International Mechanical Engineering Congress and R & D Expo*, Washington, DC, November, 2003.
147. J. P. Abraham, Ephraim M. Sparrow, Student-Related Research “Thermal Design Capstone Projects”, *ASME International Mechanical Engineering Congress and R & D Expo*, Washington, DC, November, 2003.
148. Sparrow, E.M., Martin, G.L., Abraham, J.P., and Tong, J.C., Air-to-Air Energy Exchanger Test Facility for Mass and Energy Transfer Performance. *American Society of Heating, Refrigeration, and Air-Conditioning Engineers Annual Meeting*, Inc., Cincinnati, OH, ASHRAE Symposium Paper, 2001.
149. Tamma, K.K., Zhou, X., Abraham, J., and Anderson, C.V.D.R., Constitutive Model Theories and Plausible Propositions/Challenges to Heat Transport Characterization. *ASME/JSME Joint Thermal Engineering Conference*, March, 1999.

#### **Granted Patents (author of 26 patents)**

1. Robert Monson and John Abraham, “Dual-phase thermal electricity generator”, U.S. Patent # 8,484,974.
2. Robert Monson and John Abraham, “Variable Orifice Valve”, U.S. Patent # 7,559,485
3. Robert Monson, John Abraham, Joseph Crimando, Joel Farley, Matthew Linder, and Joel Seipel, "Vehicle Energy Absorption Apparatus", US Patent # 8,118,255.
4. B.D. Plourde and J.P. Abraham, “Rotor Blade for Vertical Axis Wind Turbine”, US Patent # 9,482,204/ WO 2011150171.
5. B.D. Plourde, J.P. Abraham, D.R. Plourde, A. Gikling, R. Pakonen, “Dual-Axis Tracking Device”, US Patent # 10,168,412.
6. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, “Control Valve Assembly for Fluid Heating System”, US Patent # 10,495,720.

7. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, “Dual Axis Tracking Device”, China National Intellectual Property Administration, Patent number ZL201580075224.1, 2020.
8. B.R. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, “Dual Axis Tracking Method”, U.S. Patent 10,890,645.
9. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, U.S. Patent 10,989,420.
10. B.D Plourde, J.P. Abraham, D. Plourde, R. Pakonen, A. Gikling, N. Naughton, “Fluid Heating System”, European Patent, EP 3227618.
11. B. D. Plourde, J. P. Abraham, D.R. Plourde, R. Pakonen, “Method of Calculating Pathogen Inactivation for a Fluid Heating System”, US Patent, 11,255,804.
12. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, China National Intellectual Property Administration, Chinese Application Number 201780083752.0
13. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, African Regional Intellectual Property Organization (ARIPO), (patent granted, number forthcoming).
14. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, European Union number EP 4,080,134.
15. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, European Union number EP3,542,107.
16. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, Columbia, Application number NC 2019/00006027, (*number to be issued*).
17. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, and D. Plourde, Solar Heating for Refrigeration and Fluid Heating Devices, Colombian Application No. 2019/0011368, (*number to be issued*).
18. B.D. Plourde, A. Gikling, J.P. Abraham R. Pakonen, and D. Plourde, Digital Fluid Heating System, US Patent no. 11,920,801
19. B.D. Plourde, J.P. Abraham, D. Plourde, R. Pakonen, A. Gikling, N. Naughton, “Fluid Heating System”, US Patent no. 11,946,886.
20. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Solar Heating for Refrigeration and Fluid Heating Devices”, filed March 2018. Brazil Application No. BR1120190190414, (patent number forthcoming).

21. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, filed November 2017. Brazil Application No. BR112019009923-9, (patent number forthcoming).
22. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Fluid Heating System”, Peru, Application Number 001011-2019 (patent number forthcoming).
23. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, India, Patent no. 478824.
24. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Dual-Axis Tracking Method”, India, 522,368, 2024.
25. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Solar Heating for Refrigeration and Fluid Heating Devices”, Peru, (patent number forthcoming).
26. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Dual Axis Tracking Device”, European Application, No. 15816974.8

#### **Pending Patents**

1. B.D. Plourde, J.P. Abraham, “Solar Heating System”, US Patent Application No. 62/423,814 (filed November 18, 2016).
2. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Solar Heating for Refrigeration and Fluid Heating Devices”, filed March 2018. US Application number 20180266712.
3. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Dual-Axis Tracking Method”, US Application number 2019/0107598, filed November 2018.
4. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, US Application number 2018/0142905, filed November 2017.
5. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Fluid Heating System”, Chinese National Intellectual Property Administration, Application number 2022105305045.8.
6. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Fluid Heating System”, India, Application number 201737018679.
7. B.D. Plourde, A. Gikling, J.P. Abraham, R. Pakonen, “Digital Fluid Heating System”, Brazil, Application number BR112019009923-9.

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**Granted Trademarks**

1. US Trademark Registration Number 5656322, assignee: WTS LLC, Minnesota, USA. Trademark granted, January 15, 2019.
2. US Trademark Registration Number 5656323, assignee: WTS LLC, Minnesota, USA. Trademark granted, January 15, 2019.

**Editorial Board Member**

18. International Society of Cardiovascular Translational Research, 2020-present
19. Energies, Thermal Management, 2019-present
20. Cardiovascular Revascularization Medicine, 2018-present
21. Stem Cell Biology and Transplantation, 2015-present
22. Associate Editor, NCSE, Climate Science, 2012-present
23. International Journal of Mechanics and Energy, 2012-present
24. Open Mechanical Engineering Journal, 2007-present
25. Open Mechanical Engineering Reviews, 2007-present
26. Open Mechanical Engineering Letters, 2007-present
27. Open Medical Devices Journal, 2008-present
28. Creative Engineering Journal, 2009-present
29. ISRN Applied Mathematics, 2011-present
30. International Journal of Sustainable Energy, 2012 - present
31. International Journal of Materials, Methods, and Technologies, 2012- present

**CONSULTANTSHIPS**

**GRANTS (funding \$24.02 million)**

|                                     |                  |
|-------------------------------------|------------------|
| <i>Bold Alliance</i>                | <b>2023-2024</b> |
| <i>Varian Medical Systems</i>       | <b>2023</b>      |
| <i>Flotherm</i>                     | <b>2021-2023</b> |
| <i>LEMA, LLC, MN</i>                | <b>2016-2023</b> |
| <i>HRST, Inc., MN</i>               | <b>2021</b>      |
| <i>Biotronik</i>                    | <b>2021</b>      |
| <i>Starky</i>                       | <b>2020</b>      |
| <i>Marvin Windows</i>               | <b>2020-2022</b> |
| <i>Cardiovascular Systems, Inc.</i> | <b>2019-2021</b> |
| <i>ALS Consulting</i>               | <b>2019</b>      |
| <i>Medivator, MN</i>                | <b>2018-2019</b> |
| <i>Medivators, MN</i>               | <b>2014-2015</b> |
| <i>EKOS, MN</i>                     | <b>2018</b>      |
| <i>Marcor</i>                       | <b>2018</b>      |
| <i>Marvin Windows</i>               | <b>2018</b>      |
| <i>Medtronic, Fridley, MN</i>       | <b>2017-2020</b> |
| <i>Orbital ATK</i>                  | <b>2017-2018</b> |
| <i>Pride Engineering, MN</i>        | <b>2017-2018</b> |
| <i>Cargill, MN</i>                  | <b>2016-2017</b> |
| <i>EKOS, MN</i>                     | <b>2016-2017</b> |
| <i>Precision Air, MN</i>            | <b>2016</b>      |

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Minneapolis, MN 55406

## John P. Abraham

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612-963-2169

|                                                |            |
|------------------------------------------------|------------|
| 3M, MN                                         | 2015-2017  |
| Flourescence, Inc., MN                         | 2015       |
| Smiths Medical, MN                             | 2014-2015  |
| WTS LLC, MN                                    | 2014-2022  |
| Somnetics, MN                                  | 2014       |
| Lake Region Medical, MN                        | 2013-2014  |
| Amphora Medical, MN                            | 2013-2014  |
| ALS Consulting, MN                             | 2013-2016  |
| Medtronic, Fridley, MN                         | 2013-2016  |
| Devicix, MN                                    | 2012-2013  |
| CriticCare, MN                                 | 2012       |
| HRST, Inc., MN                                 | 2012-2015  |
| QIG Group, OH                                  | 2011-2013  |
| Phraxis, MN                                    | 2011-2012  |
| Cardiovascular Systems, Inc., Roseville, MN    | 2007-2015  |
| Translational Biologic Infusion, AZ            | 2011-2013  |
| Galil Medical, Roseville, MN                   | 2011       |
| Imation, Oakdale, MN                           | 2010       |
| Medtronic, Fridley, MN                         | 2008-2011  |
| R4 Engineering, India                          | 2008-2009  |
| Horizontal Winds,                              | 2008-2009  |
| Lockheed Martin, Eagan, MN                     | 2007-2009  |
| St. Jude Medical, Minnetonka, MN               | 2007-2009  |
| Arizant Medical, Eden Prairie, MN              | 2006       |
| Johnson and Johnson, Newark, NJ                | 2004-2005  |
| Cortron/XeteX, Fridley, MN                     | 2005       |
| MicroControl Company, MN                       | circa 2001 |
| Donaldson Co., Bloomington, MN                 | 1999-2003  |
| Augustine Medical, Eden Prairie, MN            | 2000-2003  |
| Midmac Systems Inc., St Paul, MN               | 2002       |
| Remmele Engineering Inc., St Paul, MN          | 2002-2005  |
| Urologix, Minneapolis, MN                      | circa 2004 |
| Restore Medical, Minneapolis, MN               | circa 2002 |
| Jennio, Minnesota                              | circa 2001 |
| Caterpillar, Minneapolis, MN                   | circa 2000 |
| ADC telecom, Minneapolis, MN                   | circa 2000 |
| Entropy Solutions                              | circa 2000 |
| XeteX, Inc., Minneapolis, MN                   | 1996-2000  |
| Pneuseal, St. Paul, MN                         | 1996-1998  |
| Los Alamos National Laboratory, Los Alamos, NM | 1994       |

### GRANTS (funding \$24.783 million)

#### Energetics Technology Center

2025

\$477,000 Funding for development of solar-powered towers with sensors

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <b>Energetics Technology Center</b>                                                                                                                                                                                                                                                                                           | <b>2025</b>      |
| \$50,000 Funding for development of solar-powered towers with sensors                                                                                                                                                                                                                                                         |                  |
| <b>USAID</b>                                                                                                                                                                                                                                                                                                                  | <b>2024</b>      |
| \$145,900 Funding through USAID's Health Electrification and Telecommunications Alliance (HETA program)                                                                                                                                                                                                                       |                  |
| <b>Department of Interior</b>                                                                                                                                                                                                                                                                                                 | <b>2024</b>      |
| \$130,000 Funding for electrification of Wind River Reservation                                                                                                                                                                                                                                                               |                  |
| <b>Bold Alliance</b>                                                                                                                                                                                                                                                                                                          | <b>2023</b>      |
| ~\$12K For research on pollution plumes from a rupture pipeline                                                                                                                                                                                                                                                               |                  |
| <b>Varian Medical Systems, Inc.</b>                                                                                                                                                                                                                                                                                           | <b>2023</b>      |
| Brain thermal transport, oncology applications                                                                                                                                                                                                                                                                                |                  |
| <b>LEMA, LLC</b>                                                                                                                                                                                                                                                                                                              | <b>2016-2022</b> |
| \$20m for development and deployment of solar-power off grid systems.<br>Part of Consolidated Appropriations Act, 2023                                                                                                                                                                                                        |                  |
| <b>HRST, Inc.</b>                                                                                                                                                                                                                                                                                                             | <b>2021</b>      |
| \$34,000 for analysis of flow patterns in power plants                                                                                                                                                                                                                                                                        |                  |
| <b>Biotronik</b>                                                                                                                                                                                                                                                                                                              | <b>2021</b>      |
| \$44k for simulation of heating caused by implanted medical devices                                                                                                                                                                                                                                                           |                  |
| <b>Flotherm (SBIR award FAIN 2034065)</b>                                                                                                                                                                                                                                                                                     | <b>2020-2023</b> |
| \$20k for simulation of body-heating devices<br>\$48k for simulation of body-heating devices<br>SBIR funding, NSF Small Business Innovative Research project                                                                                                                                                                  |                  |
| <b>Starky</b>                                                                                                                                                                                                                                                                                                                 | <b>2019-2020</b> |
| \$6k for thermal modeling of hearing aid batteries                                                                                                                                                                                                                                                                            |                  |
| <b>National Science Foundation (Co-PI, FAIN = 2018403)</b>                                                                                                                                                                                                                                                                    | <b>2020-2021</b> |
| \$424k for engineering PIV instrumentation                                                                                                                                                                                                                                                                                    |                  |
| <b>Intertek</b>                                                                                                                                                                                                                                                                                                               | <b>2019-2020</b> |
| \$13k for study of tissue surrogates for biological heating                                                                                                                                                                                                                                                                   |                  |
| <b>Cardiovascular Systems, Inc.</b>                                                                                                                                                                                                                                                                                           | <b>2019-2021</b> |
| \$13k for thermal model of blower impellor for a dialysis pump<br>\$9k for thermal model of blower impellor for a dialysis pump<br>\$4k for thermal model of blower impellor for a dialysis pump<br>\$20k for flow model of blower impellor for a dialysis pump<br>\$5k for flow model of blower impellor for a dialysis pump |                  |

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|-------------------------------------------------------------------------------|------------------|
| <b>ALS Consulting</b>                                                         | <b>2019</b>      |
| \$15k for thermal model of power plant                                        |                  |
| <b>Medivators</b>                                                             | <b>2019</b>      |
| \$12k for thermal model of thermal sterilization                              |                  |
| <b>Marvin Windows</b>                                                         | <b>2019-2022</b> |
| \$4k for thermal analysis of a tiny home                                      |                  |
| \$5k for thermal model of manufacturing line                                  |                  |
| \$4k for thermal model of manufacturing line                                  |                  |
| <b>Medtronic</b>                                                              | <b>2019</b>      |
| \$22k for simulation of tissue temperatures during transcutaneous recharge    |                  |
| \$25.5k for simulation of tissue temperatures during transcutaneous recharge  |                  |
| <b>Medivators</b>                                                             | <b>2018</b>      |
| \$18k to research airflow in medical sterilization equipment.                 |                  |
| <b>Marvin Windows</b>                                                         | <b>2018-2020</b> |
| \$6k to research thermal processes during window ventilation                  |                  |
| \$4k to research thermal processes of natural lighting                        |                  |
| \$4k to research thermal processes of natural lighting                        |                  |
| <b>Medtronic</b>                                                              | <b>2018</b>      |
| \$3k to research battery heating rates                                        |                  |
| \$8k to research thermal tolerance of brain tissue                            |                  |
| <b>EKOS</b>                                                                   | <b>2018</b>      |
| \$14k for analysis of flow distribution within stents                         |                  |
| <b>Marcor</b>                                                                 | <b>2018</b>      |
| \$10k for fluid and heat transfer analysis                                    |                  |
| <b>Pride Engineering</b>                                                      | <b>2017</b>      |
| \$3k to calculate a metal stamping machine process                            |                  |
| <b>Orbital ATK</b>                                                            | <b>2017-2018</b> |
| \$30k to simulate fluid flow                                                  |                  |
| \$12k to simulate fluid flow                                                  |                  |
| <b>Medtronic</b>                                                              | <b>2017</b>      |
| \$5k to research thermal tolerance of brain tissue                            |                  |
| \$14k to calculate cranial temperature increases during transcranial recharge |                  |
| <b>3M</b>                                                                     | <b>2017</b>      |
| \$14k to simulate airflow in ultra-clean operating rooms.                     |                  |

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| <b>Zoll Engineering</b>                                                    | <b>2017</b>      |
| \$5.5k for design of flow through a ventilation medical device             |                  |
| <b>Cargill</b>                                                             | <b>2016-2017</b> |
| \$14k for analysis of food frier                                           |                  |
| \$15k for analysis of a food processing device                             |                  |
| <b>EKOS</b>                                                                | <b>2017</b>      |
| \$14k for analysis of flow distribution within stents                      |                  |
| \$14k for analysis of flow distribution within stents                      |                  |
| \$12k for analysis of flow distribution within stents                      |                  |
| <b>ALS Consulting</b>                                                      | <b>2016</b>      |
| \$15k for analysis of fluid flow in power plants                           |                  |
| <b>Precision Air</b>                                                       | <b>2016</b>      |
| \$1600 for simulation of airflow in operating rooms                        |                  |
| <b>Medtronic</b>                                                           | <b>2016</b>      |
| \$12k for simulation of tissue temperatures during transcutaneous recharge |                  |
| <b>3M</b>                                                                  | <b>2015</b>      |
| \$12k to simulate airflow in ultra-clean operating rooms.                  |                  |
| <b>Cardiovascular Systems, Inc.</b>                                        | <b>2015-2016</b> |
| \$8,000 for the study of deformable arteries                               |                  |
| \$6,000 for biological flows and impellor design                           |                  |
| <b>AF Energy</b>                                                           | <b>2015</b>      |
| \$3000 wind turbine calculations                                           |                  |
| <b>Intellectual Ventures Laboratory</b>                                    | <b>2015</b>      |
| \$2000 wall condensation calculations                                      |                  |
| <b>Medivators</b>                                                          | <b>2015</b>      |
| \$4000 for flow and pressure calculations medical chamber.                 |                  |
| <b>Flourescence, Inc.</b>                                                  | <b>2015</b>      |
| \$2,000 designing biological heater for cell environments                  |                  |
| <b>Mador Technologies</b>                                                  | <b>2015</b>      |
| \$20,000 analyzing a liquid nitrogen water condensation device             |                  |
| <b>Koronis Biomedical Technologies</b>                                     | <b>2015</b>      |
| \$5,000 simulation of fluid flow                                           |                  |

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| <b>Mador Technologies</b>                                                                    | <b>2014-2015</b>    |
| \$8,000 analyzing a liquid nitrogen water condensation device                                |                     |
| <b>National Resources Defense Council</b>                                                    | <b>2015</b>         |
| \$10k for climate education work                                                             |                     |
| <b>Medtronic</b>                                                                             | <b>2014</b>         |
| \$12k for simulation of tissue temperatures during transcutaneous recharge                   |                     |
| <b>Smiths Medical</b>                                                                        | <b>2014</b>         |
| \$9.5k for design and optimization of medical warming blankets                               |                     |
| \$10k for the design and improvement of medical fans                                         |                     |
| \$12k for the design and analysis of human thermal analogs                                   |                     |
| <b>WTS LLC</b>                                                                               | <b>2014-present</b> |
| \$1.5m for the design of solar pasteurization systems                                        |                     |
| <b>Medivators</b>                                                                            | <b>2014</b>         |
| \$4000 for flow and pressure calculations medical chamber.                                   |                     |
| \$3000 for flow and pressure calculations medical chamber.                                   |                     |
| <b>Somnetics</b>                                                                             | <b>2014</b>         |
| \$6000 for flow and pressure calculations in CPAP devices.                                   |                     |
| <b>Lake Region Medical</b>                                                                   | <b>2013-2014</b>    |
| \$4500 for simulations of a guidewire manufacturing oven                                     |                     |
| <b>Amphora Medical</b>                                                                       | <b>2013-2014</b>    |
| \$55.5k for design of RF probes for ablation of bladder tissue                               |                     |
| <b>ALS Consulting</b>                                                                        | <b>2013-2014</b>    |
| \$17.5k for analysis of fluid flow in power plants                                           |                     |
| <b>Medtronic, Inc.</b>                                                                       | <b>2012-2013</b>    |
| \$13k for analysis of subdermal heating associated with recharge of neuromodulation systems. |                     |
| <b>Phraxis</b>                                                                               | <b>2013</b>         |
| \$2,250 for the analysis of blood flow through an AV shunt                                   |                     |
| <b>Translational Biologic Infusion Catheter</b>                                              | <b>2011-2013</b>    |
| \$21.5k for the study of flow and pressure drop in a stem-cell delivery catheter             |                     |
| <b>Advanced Circulatory Systems, Inc.</b>                                                    | <b>2013</b>         |
| \$4200 for fluid flow modeling of medical-device blowers                                     |                     |
| <b>HRST, Inc.</b>                                                                            | <b>2012-2015</b>    |

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| \$11,250 for analysis of flow patterns in manifolds                                            |  |                  |
| <b>Devicix</b>                                                                                 |  | <b>2012</b>      |
| \$2000 for the analysis of medical-fluid injection devices                                     |  |                  |
| <b>Helical</b>                                                                                 |  | <b>2012-2013</b> |
| \$18,200 for the design and analysis of rooftop wind turbines                                  |  |                  |
| <b>QiG Group</b>                                                                               |  | <b>2012</b>      |
| \$7000 for study of thermoelectric technologies to power implants                              |  |                  |
| <b>HRST, Inc.</b>                                                                              |  | <b>2012</b>      |
| \$4300 for analysis of perforated plates for flow uniformity                                   |  |                  |
| <b>Energy Foundation</b>                                                                       |  | <b>2012-2013</b> |
| \$30k developing climate-science communication strategies                                      |  |                  |
| <b>CriticCare</b>                                                                              |  | <b>2012</b>      |
| \$4,275 for numerical modeling of accelerated aging of medical devices.                        |  |                  |
| <b>HRST, Inc.</b>                                                                              |  | <b>2012</b>      |
| \$5,540 for research study on mixing efficiency in heat recovery plants.                       |  |                  |
| <b>Windstrip, LLC</b>                                                                          |  | <b>2009-2013</b> |
| \$1m for development of vertical axis wind turbines to power cellular communication equipment. |  |                  |
| <b>QiG Group</b>                                                                               |  | <b>2011-2012</b> |
| \$20k for study of implant heating of biological tissue                                        |  |                  |
| <b>Phraxis</b>                                                                                 |  | <b>2011-2012</b> |
| \$8,000 for the analysis of blood flow through an AV shunt                                     |  |                  |
| <b>Energy Foundation</b>                                                                       |  | <b>2011-2012</b> |
| \$71k developing climate-science communication strategies                                      |  |                  |
| <b>Cardiovascular Systems, Inc.</b>                                                            |  | <b>2011</b>      |
| \$23k for the study of paclitaxel distribution techniques.                                     |  |                  |
| <b>Cardiovascular Systems, Inc.</b>                                                            |  | <b>2011</b>      |
| \$5,000 for the study of temperature management in palleted products                           |  |                  |
| <b>Galil Medical</b>                                                                           |  | <b>2011</b>      |
| \$9,000 for the kidney tumor cryosurgical devices.                                             |  |                  |
| <b>Multiple groups</b>                                                                         |  | <b>2010</b>      |
| \$13,000 for installation of solar panels in Uganda                                            |  |                  |

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| <b>Imation</b>                                                                                                                                                |                  |
| \$10k for the design of a polymeric extrusion die                                                                                                             | <b>2010</b>      |
| <b>Cypress Wind</b>                                                                                                                                           |                  |
| \$30.6k for the development of a vertical axis, small-footprint wind turbine.                                                                                 | <b>2010</b>      |
| <b>Cypress Wind</b>                                                                                                                                           |                  |
| \$27k for the development of a vertical axis, small-footprint wind turbine.                                                                                   | <b>2009</b>      |
| <b>Cardiovascular Systems, Inc.</b>                                                                                                                           | <b>2009</b>      |
| \$80k for the study of cavitation and bolus formation during orbital atherectomy procedures.                                                                  |                  |
| <b>Medtronic, Inc.</b>                                                                                                                                        |                  |
| \$65k for analysis of subdermal heating associated with recharge of neuromodulation systems.                                                                  | <b>2008-2011</b> |
| <b>University of St. Thomas Faculty Development Grant</b>                                                                                                     | <b>2009</b>      |
| \$4,200 for the purchase of a high-performance computer for numerical simulations.                                                                            |                  |
| <b>CSUMS: A computational Training and Interdisciplinary Research Program for Undergraduates in the Mathematical Sciences at the University of St. Thomas</b> | <b>2008-2013</b> |
| Served as Senior Personnel on a \$716,836 NSF award for the development of applied research projects for undergraduates in mathematics.                       |                  |
| <b>Lockheed Martin Innovative Program - Advanced Cooling Technology grant</b>                                                                                 | <b>2009</b>      |
| \$19.5k for the improvements to avionics heat pipe applications.                                                                                              |                  |
| <b>Horizontal Winds</b>                                                                                                                                       | <b>2008-2009</b> |
| \$11k for research on vertical-axis wind turbines                                                                                                             |                  |
| <b>R4 Engineering</b>                                                                                                                                         | <b>2008-2009</b> |
| \$10k for analysis of building-support insulation systems                                                                                                     |                  |
| <b>Lockheed Martin Innovative Program - Advanced Cooling Technology grant</b>                                                                                 | <b>2007</b>      |
| \$53k for the development of advanced electronic-cooling methodologies.                                                                                       |                  |
| <b>Arizant Medical</b>                                                                                                                                        | <b>2006</b>      |
| Characterization of a forced-air patient warming device                                                                                                       |                  |
| <b>Johnson and Johnson, Newark, NJ</b>                                                                                                                        | <b>2004-2005</b> |
| Analysis of a uterine fibroid embolization device                                                                                                             |                  |
| <b>Urologix</b>                                                                                                                                               | <b>2004</b>      |
| Design of thermoelectric device for heating/cooling of urological catheter fluids                                                                             |                  |

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**John P. Abraham**

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| <b>Donaldson Co.</b>                                                                                                                                                                                                   | <b>1999-2003</b> |
| Analysis and characterization of a filter-manufacturing device                                                                                                                                                         |                  |
| <b>Augustine Medical</b>                                                                                                                                                                                               | <b>2000-2003</b> |
| Characterization of a forced-air patient warming device                                                                                                                                                                |                  |
| <b>Midmac Systems Inc.</b>                                                                                                                                                                                             | <b>2002</b>      |
| Thermal analysis of a polymeric sealing machine                                                                                                                                                                        |                  |
| <b>Restore Medical</b>                                                                                                                                                                                                 | <b>2002</b>      |
| Characterization of sleep apnea treatment                                                                                                                                                                              |                  |
| <b>Remmele Engineering Inc.</b>                                                                                                                                                                                        | <b>2002-2005</b> |
| Thermal analysis of a polymeric sealing machine for insulin packaging                                                                                                                                                  |                  |
| Thermal analysis of liquid-based cold plates for cooling naval radar                                                                                                                                                   |                  |
| <b>MicroControl Company</b>                                                                                                                                                                                            | <b>2001</b>      |
| Analysis of burn-in board devices                                                                                                                                                                                      |                  |
| <b>Jenni-O</b>                                                                                                                                                                                                         | <b>2001</b>      |
| Analyzed devices that handle, transport, and cool turkeys during processing.                                                                                                                                           |                  |
| <b>Caterpillar</b>                                                                                                                                                                                                     | <b>2000</b>      |
| Analysis of a screed heating machine                                                                                                                                                                                   |                  |
| <b>ADC Telecom</b>                                                                                                                                                                                                     | <b>2000</b>      |
| Optimization of an AC/DC power converter                                                                                                                                                                               |                  |
| <b>Viracon Glass</b>                                                                                                                                                                                                   | <b>2000</b>      |
| Design and analysis of glass thermal processing method                                                                                                                                                                 |                  |
| <b>Entropy Solutions</b>                                                                                                                                                                                               | <b>2000</b>      |
| Design and Analysis of insulation and phase change thermal management for shipping containers                                                                                                                          |                  |
| <b>XeteX, Inc</b>                                                                                                                                                                                                      | <b>1996-2000</b> |
| Design of an air-to-air heat exchanger                                                                                                                                                                                 |                  |
| Creation of a film processing machine for coating heat exchangers                                                                                                                                                      |                  |
| Construction and operation of a full-sized HVAC test facility                                                                                                                                                          |                  |
| <b>Pneuseal</b>                                                                                                                                                                                                        | <b>1996-1998</b> |
| Operation and optimization of a polymeric sealing device for medical packaging                                                                                                                                         |                  |
| <b>Principal Investigator – Supercomputing Institute</b>                                                                                                                                                               | <b>2002-2012</b> |
| Served as PI for multi-year project dedicated to performing computational fluid dynamic studies. This grant awarded computing resources at the Supercomputing Institute for Digital Simulation and Advanced Computing. |                  |

**Principal Investigator – ASHRAE Project Grant Program** **2003**

Awarded a \$5,000 grant funded by ASHRAE to investigate the efficacy of rotating-wheel heat and moisture exchangers.

**Faculty Advisor – Bush Grant, Young Scholars Program** **2002**

Faculty advisor for a \$3,000 grant for undergraduate research of air-jet heat transfer for surgical applications.

**Faculty Advisor – Bush Grant, Young Scholars Program** **2002**

Faculty advisor for a \$3,000 grant for undergraduate research to encourage American Indian students to pursue careers in science and technology.

**A Multi-Function Heat Exchanger for Control of Temperature, Moisture,  
and Air Quality** **1997-2000**

Project Engineer for \$475K SBIR grants awarded by NSF, grant nos. 9660900 and 9801062