

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re *Inter Partes* Review of:)
U.S. Patent No. 9,771,169)
Issued: Sep. 26, 2017)
Application No.: 13/257,669)
Filing Date: Sep. 20, 2011)

For: **Preconditioned Air Unit with Variable Frequency Driving**

**DECLARATION OF DR. STEVEN B. LEEB IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 9,771,169**

Table of Contents

I.	Introduction	10
II.	Qualifications	10
III.	Summary Of Materials Reviewed And Considered	15
IV.	Understanding of Legal Standards.....	18
	A. Claim construction.....	18
	B. Obviousness	19
V.	Person of Ordinary Skill in the Art (“POSITA”).....	23
VI.	The ’169 Patent (Ex. 1001).....	25
	A. Summary	25
	B. Overview of the File History (Ex. 1002).....	29
VII.	Claim Construction	33
VIII.	Overview of the Technology and Cited Prior Art.....	33
	A. Technology Background.....	33
	1. Air Conditioning and HVAC&R Systems	33
	2. Preconditioned Air Units.....	39
	3. Variable Frequency Drives.....	42
	B. Overview of Kreymer (Ex. 1005).....	45
	C. Overview of Taras (Ex. 1006)	48
	D. Overview of Takahashi (Ex. 1007).....	51
	E. Overview of Lechmotoren (Ex. 1008).....	54
	F. Overview of Carrier (Ex. 1040).....	63
IX.	A POSITA would have found claims 2-9 and 11-12 obvious in view of the combination of Kreymer and Taras	65
	A. A POSITA would have combined Kreymer and Taras	65
	B. Claim 2.....	73
	1. 2[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising.....	73

2. 2[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet..... 74
3. 2[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and..... 76
4. 2[c]: at least one variable frequency driver for power supply of the at least one compressor..... 78
5. 2[d]: and a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems, ... 79
6. 2[e]: wherein the central controller automatically adjusts the cooling performed by the preconditioned air unit according to at least one of: the selected type of aircraft, the ambient temperature, the humidity, the cabin temperature, or the outgoing airflow from the preconditioned air unit..... 82
- C. Claim 3: A preconditioned air unit according to claim 2, wherein the housing further accommodates at least one condenser fan positioned for generation of an airflow interacting with at least one of the condensers of the plurality of refrigeration systems. 84
- D. Claim 4: A preconditioned air unit according to claim 2, wherein the housing further accommodates at least one variable frequency driver connected for power supply of at least one condenser fan for generation of an airflow interacting with at least one of the condensers of the plurality of refrigeration systems. 88
- E. Claim 5: A preconditioned air unit according to claim 2, wherein the housing further accommodates a variable frequency driver connected for electrical power supply of the blower. 89

F.	Claim 6: A preconditioned air unit according to claim 2, wherein at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver.....	90
G.	Claims 7 and 8: A preconditioned air unit according to claim 6, wherein the controller is configured for variation of the output frequency of the at least one variable frequency driver above the frequency of the mains supply of the preconditioned air unit.	91
H.	Claim 9: A preconditioned air unit according to claim 2, wherein the housing further accommodates a rectifier connected to a mains supply input of the air unit for generation of a power DC voltage supply.	93
A.	Claim 11: A preconditioned air unit according to claim 2, further comprising at least one of: a user interface panel with input keys and a display, a remote control, a computer interface, a network interface, or a loudspeaker.....	94
A.	Claim 12: A preconditioned air unit according to claim 2, further comprising a heater in the flow duct.	95
X.	A POSITA would have found claims 14-22 obvious in view of the combination of Kreymer, Taras, and Takahashi.....	95
A.	A POSITA would have combined Kreymer, Taras, and Takahashi.	95
B.	Claim 16.....	103
1.	16[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising.....	103
2.	16[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet.....	103
3.	16[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and.....	104

4. 16[c]: at least one variable frequency driver for power supply of the at least one compressor, and..... 104
 5. 16[d]: a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems, ... 105
 6. 16[e]: wherein each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller..... 105
- C. Claims 17 and 22: A preconditioned air unit according to claim 16, wherein the central controller is further configured to automatically adjust the required amount of cooling among the remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal. 107
- D. Claim 18: A preconditioned air unit according to claim 16, wherein at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver..... 109
- E. Claim 19: A preconditioned air unit according to claim 18, wherein the controller of the variable frequency driver is further configured for adjustment of the output frequency in response to a sensor output connected to the controller. 110
- F. Claim 20: A preconditioned air unit according to claim 18, wherein the central controller is connected to at least one controller of at least one voltage frequency driver. 112
- G. Claim 21: A preconditioned air unit according to claim 16, wherein at least one variable frequency driver keeps the ratio between the output voltage and the frequency substantially constant to maintain a high motor torque throughout the entire output frequency range. 112
- H. Claim 14: A preconditioned air unit according to claim 2, wherein each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller. 113

I.	Claim 15.....	114
1.	15[a]: A preconditioned air unit according to claim 2, wherein: at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver;	114
2.	15[b]: the controller is configured for variation of the output frequency of the at least one variable frequency driver above the frequency of the mains supply of the preconditioned air unit;	114
3.	15[c]: at least one variable frequency driver is configured to keep the ratio between the output voltage and the frequency substantially constant;	115
4.	15[d]: each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller; and.....	115
5.	15[e]: the central controller is further configured to automatically adjust the required amount of cooling among the remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal.	115
XI.	A POSITA would have found claims 9-10 obvious in view of the combination of Kreymer, Taras, and Carrier	115
A.	A POSITA would have combined Kreymer, Taras, and Carrier	115
B.	Claim 9: A preconditioned air unit according to claim 2, wherein the housing further accommodates a rectifier connected to a mains supply input of the air unit for generation of a power DC voltage supply.	118
C.	Claim 10: A preconditioned air unit according to claim 9, wherein the rectifier is selected from the group consisting of a 12-pulse rectifier, an 18-pulse rectifier, and a 24-pulse rectifier.....	119
XII.	A POSITA would have found claims 1, 2, and 13 obvious in view of Lechmotoren and Taras.....	120

A.	A POSITA would have combined Lechmotoren and Taras	120
B.	Claim 1	124
1.	1[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising.....	124
2.	1[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet.....	125
3.	1[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and.....	127
4.	1[c]: at least one variable frequency driver for power supply of the at least one compressor, and.....	130
5.	1[d]: a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems	131
6.	1[e]: wherein the central controller has a power sharing control input for control of the preconditioned air unit power consumption	133
C.	Claim 2.....	136
1.	2[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising.....	136
2.	2[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet,.....	137
3.	2[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and.....	137

4.	2[c]: at least one variable frequency driver for power supply of the at least one compressor, and.....	137
5.	2[d]: a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems, ...	138
6.	2[e]: wherein the central controller automatically adjusts the cooling performed by the preconditioned air unit according to at least one of: the selected type of aircraft, the ambient temperature, the humidity, the cabin temperature, or the outgoing airflow from the preconditioned air unit.....	138
D.	Claim 13: A preconditioned air unit according to claim 2, wherein the central controller has a power sharing control input for control of the preconditioned air unit power consumption.....	139
XIII.	A POSITA would have found claims 14-22 obvious in view of the combination of Lechmotoren, Taras, and Takahashi.....	140
A.	A POSITA would have combined Lechmotoren, Taras, and Takahashi	140
B.	Claim 16.....	145
1.	16[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising.....	145
2.	16[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet.....	146
3.	16[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and.....	146
4.	16[c]: at least one variable frequency driver for power supply of the at least one compressor, and.....	147

5.	16[d]: a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems	147
6.	16[e] wherein each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller.....	148
C.	Claims 17 and 22: A preconditioned air unit according to claim 16, wherein the central controller is further configured to automatically adjust the required amount of cooling among the remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal.....	150
D.	Claim 18: A preconditioned air unit according to claim 16, wherein at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver.....	152
E.	Claim 19: A preconditioned air unit according to claim 18, wherein the controller of the variable frequency driver is further configured for adjustment of the output frequency in response to a sensor output connected to the controller.....	154
F.	Claim 20: A preconditioned air unit according to claim 18, wherein the central controller is connected to at least one controller of at least one voltage frequency driver.....	155
G.	Claim 21: A preconditioned air unit according to claim 16, wherein at least one variable frequency driver keeps the ratio between the output voltage and the frequency substantially constant to maintain a high motor torque throughout the entire output frequency range.	156
H.	Claim 14: A preconditioned air unit according to claim 2, wherein each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller.....	159
I.	Claim 15.....	160

1.	15[a]: A preconditioned air unit according to claim 2, wherein: at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver;	160
2.	15[b]: the controller is configured for variation of the output frequency of the at least one variable frequency driver above the frequency of the mains supply of the preconditioned air unit;	160
3.	15[c]: at least one variable frequency driver is configured to keep the ratio between the output voltage and the frequency substantially constant;	161
4.	15[d]: each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller; and.....	162
5.	15[e]: the central controller is further configured to automatically adjust the required amount of cooling among the remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal.	162
XIV. CONCLUSION		163

I. Introduction

1. My name is Steven B. Leeb. I currently serve as a Professor of Electrical Engineering and Computer Science and Mechanical Engineering at the Massachusetts Institute of Technology.

2. I have been retained by Dabico Airport Solutions Inc. (“Dabico” or “Petitioner”) to provide my opinion concerning the validity of U.S. Patent No. 9,771,169 (attached to the accompanying Petition as Ex. 1001 and henceforth referred to as “the ’169 patent”) in support of this Petition for *inter partes* Review.

3. I am being compensated for my time in connection with this IPR at my rate of \$675. My compensation is not dependent in any way upon the outcome of this matter.

II. Qualifications

4. In this section, I summarize my educational background, work history, and other relevant background and qualifications. A copy of my curriculum vitae (“CV”) is found at Ex. 1004, and includes detailed information pertaining to my education, experience, and qualifications.

5. I am a tenured Professor in the Electrical Engineering and Computer Science Department at the Massachusetts Institute of Technology (“MIT”), and I have a joint appointment in the Department of Mechanical Engineering at MIT. In 2004, I was appointed as a MacVicar Faculty Fellow, a program honoring MIT

teachers and mentors who have made outstanding contributions to undergraduate education.

6. I earned a Bachelor of Science (S.B.) degree, a Master of Science (S.M.) degree, an Electrical Engineering (E.E.) degree, and a Doctorate (Ph.D.) degree from MIT in 1987, 1989, 1990, and 1993, respectively.

7. I have over 35 years of experience in the fields of electrical engineering, computer science, and mechanical engineering, with particular experience in the fields of power electronics, energy conversion systems, and motor drives. My work in the area of power electronics, energy conversion systems, and motor drives has included extensive research activities on the health and operation of refrigeration/air conditioning systems.

8. From 1987 to 1991, I worked part-time as a United States Air Force (“USAF”) Reservist at the Wright Research and Development Center at Wright Patterson Air Force Base in Ohio, in its avionics branch, developing and studying power supplies for use in advanced avionics systems. During my time on the MIT faculty from 1993 to present, I have designed several power electronic products that include microcontrollers and that employ advanced control techniques, including variable speed drives for motor control. My work in the area of power electronics has included extensive study, analysis, and use of control systems, electromechanical system monitoring, HVAC systems, power factor correction,

monitoring power consumption, electronic circuits, voltage regulation, and voltage regulators.

9. As part of my research at MIT, I have developed power electronic circuits for power supplies, motor drives, induction heating units, and charging systems, among numerous other applications.

10. Since 1995, I have taught several courses at MIT that cover the use of power electronics, microcontrollers, and electromechanical systems. I have taught graduate and undergraduate level courses at MIT in motor design, microcomputer control, power electronic circuit design, motor drives, field theory, circuit analysis, signal processing, feedback control, and power systems. In these courses, I have taught extensively regarding the design of electromechanical systems, converters and drives, and protection circuits. I also have supervised over 150 theses and advanced undergraduate projects since I joined the MIT faculty in 1993. I have won the MIT Edgerton and Bose awards for excellence in teaching and research, MIT's Spira teaching award, and several other recognitions, including a teaching award from an undergraduate student honor society (HKN).

11. I have authored or co-authored more than 200 technical publications and am a named inventor on over 25 U.S. patents, with others pending in the areas of power electronics and power systems design, analysis, monitoring, and control. My CV includes a sample list of these publications. *See* Ex. 1004. For example, a

paper that I co-authored, “*Current and Voltage Reconstruction from Non-Contact Field Measurements*,”16(15)IEEE SENSORS JOURNAL (2016), was recognized as one of the 25 most downloaded Sensors Journal papers in 2016. I have been invited to give plenary session papers and presentations, for example, at the IEEE Applied Power Electronics Conference (APEC) in 2004 for a paper I authored entitled “*Putting Profit into Power Electronic Products with Digital Control*.” Another recent paper that I co-authored, “*Capacitor-less Photovoltaic (PV) Cell-Level Power Balancing using Diffusion Charge Redistribution*,” received a “Best Presentation” award in its session at the APEC 2014 conference.

12. Some of my research work has been directed at systems involved with motors and drive systems for electric motors. Publications I have co-authored with examples of this work include, but are not limited to, “*A Comparison of Switched Doubly-Fed Machine Drive Topologies for High Power Applications*” presented at the 2015 IEEE International Electric Machines and Drives Conference, “*Adaptive Control of Power Electronic Drives for Servomechanical Systems*,”15(6) IEEE TRANSACTIONS ON POWER ELECTRONICS (2000), and “*Nonintrusive Induction Motor Speed Detection*,”9(5) IET ENERGY AND POWER APPLICATIONS JOURNAL(2015).

13. Examples of peer-reviewed publications resulting from my research in HVAC systems can be found, for instance, in “*Detection of HVAC Faults via*

Electrical Load Monitoring,” 8(1) INTERNATIONAL JOURNAL OF HVAC&R RESEARCH (2002), “*Monitoring HVAC Equipment Electrical Loads from a Centralized Location—Methods and Field Test Results*,” 108(1) ASHRAE TRANSACTIONS (2002), and “*Nonintrusive Ventilation System Diagnostics*,” in 21(17) IEEE SENSORS JOURNAL (2021).

14. In 1999, I co-founded Talking Lights, LLC, a company in Massachusetts. The company worked to commercialize inventions that I developed relating to a “Talking Lights” system. The system included electronic ballast circuits that modulated the arc in a fluorescent lamp and drivers that modulated the current in an LED lamp in order to transmit information and illumination to the blind or hard-of-hearing. As part of the design of these systems, I developed voltage regulators for these lighting ballasts. In 2003 and 2004, I co-developed commercial products that have passed regulatory approval with the Underwriters’ Laboratory and the Federal Communications Commission. The Talking Lights system has been sold commercially.

15. I received a National Science Foundation CAREER Award in 1996. I was named Technology Review’s TR100 Outstanding Young Innovator. I was also named the IEEE Outstanding Young Power Electronics Engineer in 1999. I have received two R&D 100 awards for products I developed at Talking Lights, LLC, a Massachusetts company that I co-founded.

16. In 2007, I was named a Fellow of the Institute of Electrical and Electronics Engineers (“IEEE”). The IEEE is the professional organization for electrical engineering in general, and for power electronic circuit designers. The rank of “Fellow” is granted to members of the IEEE judged by an extensive review process to have made “extraordinary accomplishments” in a field of IEEE’s interest.

17. In 2021, I was appointed as the chair holder of the Emanuel E. Landsman Professorship at MIT.

III. Summary Of Materials Reviewed And Considered

18. In forming my opinions herein, I have relied on my general and specific experience from my educational background and my years of work in the field.

19. I have also carefully reviewed documents and evidence as discussed throughout my report and listed in the table below. I have reviewed and considered any document or evidence discussed in this report, even if omitted from the table below.

Ex.	Description
1001	United States Patent No. 9,771,169 (“the ’169 patent”)
1002	File History for United States Patent No. 9,771,169 (“’169 FH”)
1004	<i>Curriculum Vitae</i> of Steven B. Leeb

Declaration for *Inter Partes* Review of USP 9,771,169

Ex.	Description
1005	U.S. Patent No. 5,715,701 (“Kreymer”)
1006	International Patent Publication No. WO 2007/046794 A1 (“Taras”)
1007	U.S. Patent No. 5,351,498 (“Takahashi”)
1008	German Patent Utility Model No. DE 296 22 089 U 1 (“Lechmotoren”) (English version of Exhibit 1021)
1010	Am. Soc’y of Heating, Refrigerating & Air-Conditioning Eng’rs, Inc. (ASHRAE), <i>2008 ASHRAE Handbook: HVAC Systems & Equipment</i> (2008) (“ASHRAE Systems Handbook”)
1011	Ross Montgomery & Robert McDowall, <i>Fundamentals of HVAC Control Systems</i> , ASHRAE (2008) (excerpts)
1012	Katherine B. Preston et al., Airport Coop. Rsch. Program (ACRP) Rep. No. 207: Optimizing the Use of Electric Preconditioned Air (PCA) & Ground Power Systems at Airports (2019), available at https://nap.nationalacademies.org/catalog/25623/optimizing-the-use-of-electric-preconditioned-air-pca-and-ground-power-systems-for-airports (“ACRP Rep. 207”)
1013	Benjamin Cromie, What is a Pre-Conditioned Air Unit,” PHL.org (July 6, 2023), https://www.phl.org/newsroom/PCAs (last visited Dec. 11, 2024, 5:40 p.m.)
1015	Solomon S. Turkel, “ <i>Understanding Variable Speed Drives (Part 2): A Thorough Understanding of How to Match the VFD to the Driven Load is the Key to a Successful Application</i> ,” EC&M (Apr. 1, 1999), https://www.ecmweb.com/basics/article/20897058/understanding-variable-speed-drives-part-2
1016	U.S. Patent No. 3,971,972 (“Stich”)
1017	U.S. Patent No. 4,272,967 (“White”)
1018	U.S. Patent No. 5,383,335 (“Anderson”)
1019	U.S. Patent No. 5,797,729 (“Rafuse”)
1020	U.S. Patent Application Publication No. US 2008/0174257 A1 (“Schnetzka”)

Declaration for *Inter Partes* Review of USP 9,771,169

Ex.	Description
1021	German Patent Utility Model No. DE 296 22 089 U 1 (Lechmotoren) (German version of Exhibit 1008)
1022	Declaration of Ingrid Hsieh-Yee
1034	A.E. Fitzgerald, Charles Kingsley, Jr., Stephen D. Umans, ELECTRIC MACHINERY (6th ed. 2003) (excerpt)
1036	Am. Soc’y of Heating, Refrigerating & Air-Conditioning Eng’rs, Inc. (ASHRAE), <i>2019 ASHRAE Handbook: Heating, Ventilating & Air-Conditioning Applications</i> (Inch-Pound ed. 2019) (“ASHRAE Applications Handbook”) (excerpts)
1037	AM. SOC’Y OF HEATING, REFRIGERATING & AIR-CONDITIONING ENG’RS, INC. (ASHRAE), About ASHRAE, https://www.ashrae.org/about (last visited Jan. 2, 2024)
1038	U.S. Patent No. 5,467,606 (“Sasaki”)
1040	Carrier Corp., <i>Variable Frequency Drive: Operation & Application of Variable Frequency Drive (VFD) Technology</i> (Oct. 2005) (“Carrier”), https://web.archive.org/web/20090718111829/http://www.docs.hvacpartners.com/idc/groups/public/documents/marketing/wp_varfreqdrive.pdf (last visited Jan. 4, 2025)
1041	Screenshot of portion of Exhibit 1040 as appears on browser, https://web.archive.org/web/20090718111829/http://www.docs.hvacpartners.com/idc/groups/public/documents/marketing/wp_varfreqdrive.pdf

20. My opinions are additionally guided by my appreciation of how a person of ordinary skill in the art (“POSITA”) would have understood the claims of the ’169 patent at the time of the alleged invention, which I have been asked to assume is March 20, 2009, for all claims.

IV. Understanding of Legal Standards

21. I am not an attorney, and I do not opine on matters of law. However, I have been informed by counsel of certain legal standards, which are set forth below. I have applied those standards in my analysis in this declaration. The material in this section has been supplied to me by counsel.

22. I have been informed by Counsel that the validity analysis is a two-step process. First, the patent claims are construed to ascertain their proper scope. Second, the construed claims are compared to the identified prior art to determine if the claims are valid over the prior art.

A. Claim construction

23. I have been informed by Counsel that the claims of a patent define the limits of the patentee's exclusive rights. I have been informed by Counsel that to determine the scope of the claimed invention, courts typically construe claim terms, the meaning of which the parties may dispute. I have been informed by Counsel that claim terms should generally be given their ordinary and customary meaning as understood by one of ordinary skill in the art at the time of filing of the patent application, after reading the patent and its prosecution history. I also have been informed by Counsel that a basic tenet of claim construction presumes that different words in a claim have different meanings, unless there is evidence to the contrary.

24. I have been informed by Counsel that claims must be construed in light of, and consistent with, the intrinsic evidence. In this context, I have been informed by Counsel that intrinsic evidence includes the claims themselves, the written disclosure in the specification, and the patent's prosecution history, including prior art that was considered by the United States Patent and Trademark Office ("USPTO"). I have been informed by Counsel that the specification is always highly relevant to the claim construction analysis and often is the single best guide to the meaning of a disputed term. I have been informed by Counsel that extrinsic evidence may also be considered when construing claims and may include, for example, technical dictionaries, technical publications and books, treatises, and expert testimony.

B. Obviousness

25. I have been informed by Counsel that patent claims can be deemed invalid if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the pertinent art. While such conclusions are often based on more than one piece of prior art, only one is required. It is not sufficient that a collection of prior art references merely recites the various elements of a challenged patent claim. Rather, as I have been informed by Counsel, the prior art must present the elements in a manner that is consistent

with their arrangement or use in the challenged claims. I have been informed by Counsel that obviousness cannot be based on the hindsight combination of components selectively culled from the prior art.

26. I have been informed by Counsel that a piece of prior art is considered analogous to a claimed invention if that piece of prior art is from the same field of endeavor as the claimed invention, regardless of the problem addressed or, if the piece of prior art is not within the inventor's field of endeavor, it is reasonably pertinent to the particular problem the inventor is trying to solve. The field of endeavor is determined from explanations of the invention's subject matter in the patent application, including the embodiments, function, and structure of the claimed invention. A reference outside an inventor's field of endeavor is reasonably pertinent if it is one a person of ordinary skill would have reasonably consulted and applied its teaching, based on the subject matter of the reference, in seeking a solution to the problem that the inventor was attempting to solve.

27. I have been informed by Counsel that a person having ordinary skill in the art ("POSITA") is a hypothetical person who is presumed to have known the relevant art at the time the invention was made. I have been informed by Counsel that the condition "at the time the invention was made" is imposed to rule out impermissible hindsight. I also have been informed by Counsel that an expert is to analyze the prior art from the perspective of a person of ordinary skill in the art at

the time the invention was made, and not simply to provide his/her own personal conclusions.

28. I also have been informed by Counsel that an obviousness determination includes several factual inquiries, including (1) determining the scope and content of the prior art; (2) ascertaining the differences between the claimed invention and the prior art; (3) resolving the level of ordinary skill in the pertinent art; and (4) taking into consideration any objective indicia of nonobviousness.

29. I have been informed by Counsel that obviousness must be determined as of the date of the invention (i.e., the effective filing date or priority date of the patent). Thus, in considering the reason or motivation to combine references, it is essential to avoid using hindsight. For example, the problem examined when considering obviousness is the general problem that confronted the inventor before the invention was made. Defining the problem in terms of its solution reveals improper hindsight in the selection of the prior art relevant to obviousness. Further, an overly narrow statement of the problem can represent a form of hindsight, because often the inventive contribution lies in defining the problem in a new revelatory way. Similarly, an assertion that a person of ordinary skill could combine the references, rather than that they would have been motivated to do so, is an impermissible form of hindsight. Moreover, knowledge of a problem

and motivation to solve it are entirely different from motivation to combine particular references to reach the particular claimed invention.

30. I have been informed by Counsel that a motivation to solve a problem (or issue) is not the same as a motivation to have combined references. I have been informed by Counsel that whether a skilled artisan would be motivated to make a combination includes whether he/she would select particular references in order to combine their elements.

31. I have been informed by Counsel that the analysis of the motivation to combine should be explicit. Additionally, it must include articulated reasoning with rational underpinnings to support the conclusion of obviousness. Providing a full explanation of the motivation to combine the references and the reasonable expectation of success is a necessary component of the obviousness inquiry, as inventions in most, if not all, instances rely upon building blocks long since uncovered, and claimed discoveries almost of necessity will be combinations of what, in some sense, is already known. However, conclusory statements fail to adequately explain why a person of ordinary skill would have a motivation to combine the potential prior art references.

32. I have been informed by Counsel that common sense, common wisdom, and common knowledge may be used to support a motivation to combine, so long as the use of common sense in the analysis is explained with sufficient

reasoning. But common sense can only be used to supply a limitation missing from the prior art where the technology is unusually simple and straightforward.

33. I also have been informed by Counsel that evidence suggesting reasons to combine cannot be viewed apart from evidence suggesting reasons not to combine. In analyzing motivation, both advantages and disadvantages must be considered. Teaching away, for example, is a statement in the prior art that either (i) discourages one from following the path of the claimed invention, or (ii) encourages one to follow a path that diverges from the path of the claimed invention. The concept of teaching away bears directly on whether there was a reason to combine prior art. Known disadvantages in prior art technology or devices which would naturally discourage a search for new inventions may also be taken into account in determining obviousness.

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

34. I understand that a person of ordinary skill in the art (“POSITA”) is a hypothetical person who is presumed to be aware of all pertinent art, possesses conventional wisdom in the art, is a person of ordinary creativity, and has common sense. I understand that this hypothetical person is considered to have the normal skills and knowledge of a person in a certain technical field (including knowledge of known problems and desired features in the field).

35. I have been asked to focus my analysis of the '169 patent, and prior art relating thereto, from the perspective of such a person at the time of the alleged inventions. I understand that the '169 patent claims priority to a Danish Patent Application filed on March 20, 2009. I have been asked to use March 20, 2009 as the date of the alleged invention.

36. It is my opinion that a person of ordinary skill in the art in the March 2009 timeframe would have had at least a Bachelor's degree in Electrical or Mechanical Engineering, or equivalent, and two years of work experience in heating, ventilation, air conditioning, and refrigeration (HVAC&R) engineering. It is my opinion that additional graduate education could substitute for work experience.

37. Such experience would have exposed the POSITA to the electrical, mechanical, electro-mechanical, and thermodynamic concepts and technology for air refrigeration systems, including concepts and technology for heat transfer, compression, and expansion in refrigerant circuits, control of air flows, control of motors, and automatic control of refrigeration systems. The experience would also have exposed the POSITA to well-known applications of HVAC&R engineering, including preconditioning air for aircraft.

38. As of March 20, 2009, I would have qualified as at least a POSITA, and my opinions herein are informed by my own knowledge based on my personal

experiences and observing others of various skill levels (including those above and below the level of a POSITA's experience).

39. My opinions below are not restricted to the precise definition of a POSITA above. The claims of the '169 patent are directed to preconditioned air units ("PCAs") for parked aircraft with multiple refrigeration units that employ automatic control and variable frequency drives for motors. The claimed limitations were well-known in the art and taught by numerous prior art references, including the references discussed below. Thus, my opinions below would apply under any reasonable definition of a POSITA.

VI. The '169 Patent (Ex. 1001)

A. Summary

40. I carefully reviewed the '169 patent (Ex. 1001).

41. The '169 patent is entitled "PRECONDITIONED AIR UNIT WITH VARIABLE FREQUENCY DRIVING." The patent describes embodiments for PCAs, a type of air-conditioning system that supplies parked aircraft with preconditioned air, e.g., refrigerated or heated air. *See* '169 patent at 1:13-15.

42. An aircraft parked on the ground may require air-conditioning in the cabin to provide comfort to passengers and crew. An aircraft could employ its own auxiliary power unit (APU) to power the on-board air-conditioning system, but the APU consumes jet fuel, which has high costs and environmental drawbacks.

See '169 patent at 1:16-26. Instead, PCAs are usually made available at the airport to provide air-conditioning to parked aircraft. PCAs are powered from a power supply external of the aircraft and available at the airport. Using a PCA avoids unnecessary consumption of jet fuel on board an aircraft. *Id.* at 1:27-31.

43. The '169 specification describes particular PCA systems. For example, the described PCAs employ several “self-contained cooling modules.” *Id.* at 6:19-22. The use of multiple self-cooling modules purportedly allows for more efficient condensation of air humidity and “protects the last downstream evaporator 44 from freezing over.” *Id.* at 7:64-67.

44. “Each of the self-containing cooling modules 36 operates in accordance with *well-known refrigerator principles*.” *Id.* at 6:31-33 (emphasis added). Accordingly, “each of the self-contained cooling modules 36 comprises a refrigeration system including a compressor 38, a condenser 40, an expansion valve 42, and an evaporator 44 connected in series in a refrigerant flow circuit containing a refrigerant.” *Id.* at 6:23-27. Also in line with well-known refrigerator principles, an evaporator chills the air to be refrigerated and circulated by a blower fan for delivery to the aircraft. *See id.* at 7:49-58.

45. Another purported aspect described in the specification is the use of variable frequency drivers (“VFDs”) “in a way well-known in the art of variable frequency drivers. *Id.* at 8:23-25. As described in the patent, VFDs are devices

that can be controlled to vary their output voltage and frequency in order to drive a motor at different speeds, such as compressor motors, by varying the output voltage and frequency. *See id.* at 8:14-18. The embodiment employs its VFD to control the cooling capacity of the compressor in response, for example, to sensed temperatures. *Id.* at 8:33-40.

46. In addition to driving compressors, the specification describes the use of VFDs to drive the condenser fan. *Id.* at 8:56-9:1. Likewise, the specification also describes the use of a VFD to drive the blower. *Id.* at 9:1-10.

47. The specification describes a VFD that provides an operating output frequency range based on the rated frequency of the motors. For example, “the VFD-controller is capable of controlling the variable frequency driver 46 to output a variable output frequency, e.g., ranging from 0 Hz to the maximum rated frequency of the compressor 38.” *Id.* at 8:26-32. Similarly, “the output frequency [for variable frequency driver 54] may range from 0 Hz to the maximum rated frequency of the condenser fans.” *Id.* at 8:66-9:1. For the blower, “the controller of the variable frequency driver 56 is capable of controlling the variable frequency driver 56 to output a variable output frequency, e.g., ranging from 0 Hz to the maximum rated frequency of the blower.” *Id.* at 9:14-22.

48. Additional features of VFDs that were “well-known in the art of variable frequency drivers” are described in the specification. ’169 patent at 8:23-

25. For example, the '169 patent specification describes a control strategy for the VFD that keeps the ratio of the output voltage to the output frequency constant. This approach in principle maintains constant output torque throughout the output frequency, i.e., shaft speed, range. *See id.* at 8:28-22 (compressor VFD); 8:63-66 (condenser VFD); 9:10-13 (blower VFD). This is a decades-old well-known prior-art strategy to control VFDs known as “constant volts per Hz” operation. *See* Section X.G (claim 21).

49. Another feature discussed in the specification is the use of a “central controller 60 that is configured for controlling the operation of the preconditioned air unit 10.” '169 patent at 9:23-25. This central controller can adjust the cooling delivered by the PCA for different types of aircraft, ambient temperature, humidity, cabin temperature, or outgoing airflow from the PCA, among other things. *Id.* at 10:18-22. For example, the specification notes that “the central controller 60 is connected with all of the VFD-controllers . . . for individual control.” *Id.* at 9:30-46. The central controller controls each of the VFD controllers and thus the frequency of the power supplied to the motor (thereby setting the speed of the motor) based on the cooling capacity required by the system: “the central controller outputs an individual temperature setting to each of the VFD-controllers of the preconditioned air unit 10, and, in response to the individual temperature setting, each of the VFD-controllers controls the cooling capacity of the respective

compressor 38 to adjust the temperature of the airflow having interacted with the corresponding evaporator 44 as required.” *Id.* at 9:32-39. Further, in the event one of the cooling modules fails, the central controller receives “failure signals” transmitted by the failing cooling module, and “automatically adjust[s] the required amount of cooling among the remaining operating self-contained cooling modules 36.” *Id.* at 9:36-46.

50. A further feature discussed in the specification is the capacity of the PCA to share power with other equipment. *Id.* at 10:27-29. This feature is used to “lower the peak power requirement of the shared mains power outlet.” *Id.* at 10:30-39. To that end, “the preconditioned air unit 10 comprises a power sharing control input (not shown) for control of preconditioned air unit 10 power consumption. The power sharing control input may for example be operated to lower the preconditioned air unit 10 power consumption . . . by lowering the cooling capacity provided by the preconditioned air unit 10 during high load ground power unit operation.” *Id.*

51. As detailed below, all 22 claims in the patent were obvious to a POSITA at the time of the purported invention.

B. Overview of the File History (Ex. 1002)

52. I reviewed the File History for the patent application 13/257,669 (Ex. 1002), which issued as the ’169 patent, in addition to reviewing the ’169 patent.

53. The File History shows that patent application 13/257,669 was filed on September 20, 2011. The '169 patent claims priority to a Danish application filed March 20, 2009. '169 patent at Cover.

54. The application was filed with a set of claims that included an “as-filed” independent claim 13, reproduced below. Claim 13 would form the base limitations for independent claims 1, 2, and 16 of the issued patent. Claim 13 was directed to a PCA with a plurality of conventional refrigeration systems having, each, VFD-powered compressors.

13. A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet,

a plurality of refrigeration systems, each of which includes

at least one compressor,

at least one condenser,

at least one expansion valve,

at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and

at least one variable frequency driver for power supply of the at least one compressor, and

a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems.

55. The Examiner repeatedly rejected this claim as obvious, and the Applicant added additional features to gain allowance. The claim was repeatedly rejected because modifying a PCA to use a variable frequency driver to drive the compressor would have been obvious. As an example, the last Final Office Action relied on a combination of “Anderson” (Ex. 1018) disclosing PCAs without VFDs with “UVSD” (Ex. 1015) that “teaches that the variable frequency drive is the most effective motor controller in the industry.” Ex. 1002 at 502-04, 516-19; *see also id.* at 189-90, 269-71, 309-10, 361, 363, 432-34, 443-44, 551.

56. The applicant eventually amended the claim to form three separate claims that issued as independent claims 1, 2, and 16. *See id.* at 586-87, 590-92 (claim amendments leading to issuance). The three issued independent claims are reproduced in the table below. Each independent claim includes a “Base Claim” portion, that is identical to the above-discussed claim 13, and a distinct final limitation.

Base Claim	A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with
------------	---

	the flow duct for generation of an air flow from the air inlet toward the air outlet, a plurality of refrigeration systems, each of which includes - at least one compressor, - at least one condenser, - at least one expansion valve, - at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and - at least one variable frequency driver for power supply of the at least one compressor, and a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems.
Additional limitation specific to cl. 1	wherein the central controller has a power sharing control input for control of the preconditioned air unit power consumption
Additional limitation specific to cl. 2	wherein the central controller automatically adjusts the cooling performed by the preconditioned air unit according to at least one of: the selected type of aircraft, the ambient temperature, the humidity, the cabin temperature, or the outgoing airflow from the preconditioned air unit
Additional limitation specific to cl. 16	wherein each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller.

VII. Claim Construction

57. In my analysis, I have applied the plain and ordinary meanings of the claim terms of the '169 patent as a POSITA would have understood them in the context of the patent at the time of its priority date.

58. However, my analysis does not depend on any particular or precise construction of a term, because I did not find that to be necessary to provide my opinions regarding the relationship between the prior art and the claims of the '169 patent. I have not been asked to evaluate any issues related to 35 U.S.C. § 112 and have not formed any opinions on those issues.

59. The opinions that I provide in this declaration would remain true under any reasonable construction of the claim terms in the '169 patent.

VIII. Overview of the Technology and Cited Prior Art

A. Technology Background

1. Air Conditioning and HVAC&R Systems

60. Heating, ventilating, air-conditioning and refrigeration (HVAC&R) engineering is generally concerned with the design, operation, and maintenance of HVAC&R systems designed to maintain desired environmental conditions in a space. *See* ASHRAE Systems Handbook (Ex. 1010) at 1.1. The most common HVAC&R systems for cooling have a refrigerant medium (e.g., “freon”) that cycles between a liquid and a gas state, similar to the change of liquid water to

steam and back again. The refrigerant medium circulates between a condenser, where the medium gives up heat and cools to a liquid state, and an evaporator, where the medium expands through an expansion valve and absorbs heat. An everyday demonstration of this effect occurs when we use a spray can of practically any type, and, while spraying a paint, hair spray, or other substance, the can becomes cold as the gas expands through the spray nozzle (the “thermal expansion valve”). A similar effect occurs on propane tanks connected to a barbecue, where the tank becomes cold as the propane is expended.

61. Absorption of heat in the evaporator causes the refrigerant medium to warm up and become a gas. In between the evaporator and the condenser, a compressor compresses the gas, allowing it to return to a liquid state in the condenser and begin the entire cycle again. Each time the refrigerant medium passes through the condenser, it gives up heat, and each time the medium passes through the evaporator, it absorbs heat, cooling the evaporator coils. The cold evaporator coils can be used to refrigerate or cool, e.g., food in a refrigerator or air blown by a blower over the evaporator coils for cooling a room or space. In an air conditioning application, the heat given off at the condenser is typically blown off by a condenser fan, e.g., outside of a house or building where a hot stream of air is blown off as waste to the outdoor environment.

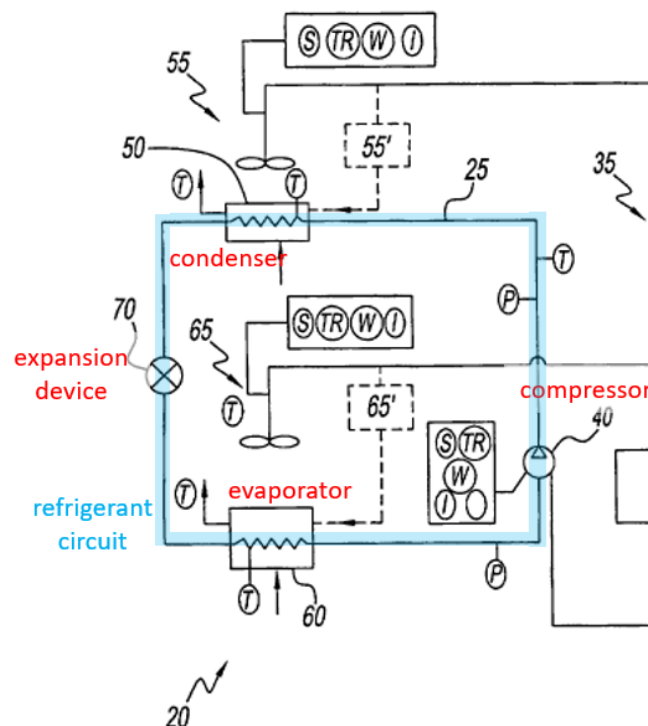
62. The entire system described above can also be used “in reverse” as a “heat pump,” which can warm a house or space in the winter, for example, by using the condenser air for heat in a building and rejecting the cold air to the outdoors. Alternatively, heat can be provided to a space by using the blower fan to blow over electrical heating coils or a hot set of metal fins warmed by combustion. The basic principles of the refrigeration cycle outlined above, and heating and cooling more generally, have been known since at least the 1800’s, and have served as the basis for modern refrigeration and air conditioning systems for over 100 years.

63. In the United States, ASHRAE is a professional society concerned with the design and construction of HVAC&R systems. *See* ASHRAE “About” page (Ex. 1037). Prior to a rebranding in 2012, ASHRAE stood for American Society for Heating, Refrigerating, and Air-Conditioning Engineers. *Id.*

64. Air-conditioning and air refrigeration equipment are examples of HVAC&R systems. These systems are used for heating, cooling, and/or controlling the humidity in an environment. *See* Ex. 1010 at 1.1. Heating, cooling, and/or controlling the humidity of an aircraft cabin are example applications of HVAC&R systems: the temperature inside an aircraft must be controlled by heating or cooling as needed to provide occupant comfort and safety in the enclosed space inside an aircraft. Aircraft require air-conditioning and air

refrigeration systems. *See e.g.*, ASHRAE Applications Handbook (Ex. 1036) at 13.1(discussing on-board air-conditioning systems in aircraft).

65. As described above, a typical, well-known, design for aircraft air conditioning is one which employs a refrigerant “circuit” carrying a compressible refrigerant like freon. This typical design will include a compressor, a condenser, an expansion valve, and an evaporator. An example of this design is illustrated in the excerpt from FIG. 3 of Taras, reproduced below. This type of design employs well-known thermodynamic principles for heating and/or cooling and uses the basic refrigeration cycle provided by a compressor, condenser, expansion valve,



and evaporator.

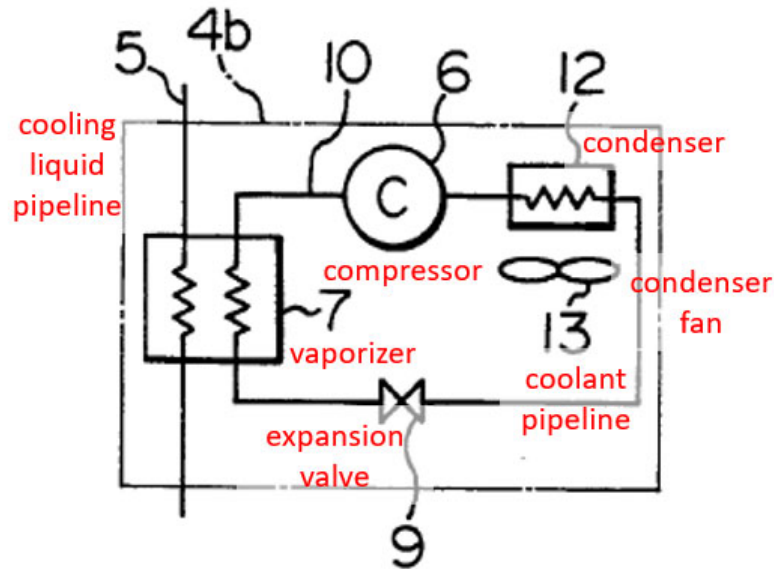
Taras, FIG. 3 (excerpted and annotated)

66. The compressor in Taras will compress a refrigerant in vapor form. When the compressed refrigerant passes through the condenser, it gives up heat and is cooled to a liquid phase. That is, the heat generated during compression is dissipated in the condenser. Next, the liquid refrigerant passes through the expansion device, and the fluid refrigerant is converted from liquid to a cold vapor that cools the evaporator. As the cold refrigerant vapor absorbs heat, the expanding (or “evaporating”) refrigerant cools the environment surrounding the evaporator. The refrigerant then returns to the compressor, completing the “circuit” and the thermodynamic cycle. Using the refrigerant circuit, this system is capable of drawing heat from the region surrounding the evaporator and transferring it to the region surrounding the condenser.

67. It is also well-known that this type of system, having a refrigerant circuit with a compressor, condenser, expansion device, and evaporator, can be configured to have the evaporator draw heat from any number of warm materials that need to be cooled. For example, air blown over the evaporator can be cooled. Similarly liquid flowing over or in communication with the evaporator can be cooled. An example of a system that uses the refrigerant circuit to cool a liquid is illustrated in FIG. 3 of Takahashi, reproduced below. As illustrated in this system, the refrigerant draws heat from a cooling liquid in an evaporator (i.e., “vaporizer”),

instead of cooling air. Different applications of the cooling provided by the evaporator for cooling air or liquids or solids were well-known. See Taras at ¶ 16.

FIG. 3



Takahashi, FIG. 3 (annotated).

68. Said another way, it is common for the “four basic components” of a refrigeration circuit (condenser, compressor, expansion valve, and evaporator) to heat or cool a variety of different “targets.” The targets can be liquids (e.g., a cooling liquid transported around a building or computer or other installation or device), solids (e.g., for cooling ice in a skating rink), or gases (e.g., building air in an air conditioning system). The details of the cooling “target” are essentially irrelevant, the basic “four component system” provides refrigeration in a similar manner in every case to any type of “target.”

69. Other well-known modifications to this system are commonly found in the relevant prior art. For example, as described above, the system can provide not only refrigeration but also heating in a variety of ways, including as a heat pump or with heat from other sources like electricity or combustion. *See, e.g.*, Ex. 1038 (“Sasaki”) at 4:18-27. The system of Sasaki, for example, employs a refrigerant circuit with a reversible flow operating as a heat pump. *Id.* Such modifications were well-known to a POSITA, as exemplified by Sasaki.

2. Preconditioned Air Units

70. During flight, aircraft may employ onboard air-conditioning equipment to heat and/or cool the cabin and provide comfort to the aircraft crew and its passengers. *See, e.g.*, Ex. 1036 at 13.1.

71. When on the ground, airplanes preferably employ external heating, cooling, and dehumidifying devices, instead of onboard systems. *See* Ex. 1013; *see also* Kreymer at 1:5-9, Ex. 1017 (“White”) at 1:18-23. These external systems are known as PCAs. Ex. 1013; Ex. 1012 at 15 (“[A]n air-conditioning unit—referred to as a PCA unit—is necessary to provide efficient heating and cooling to the aircraft [on the ground]”). In such systems, the air is “preconditioned” because it is heated or cooled before entering the aircraft. *Id.*

72. For decades prior to the ’169 patent’s priority date, electrical PCAs fixed to the jet bridge walkway or on mobile units on the ground heated and cooled

parked aircraft. These PCAs used a variety of power sources, including, for example, electrical supply lines from the electric utility or infrastructure at the airport, or diesel generators, or motor power. Lechmotoren at 1:23-2:1, 2:10-15; White at 1:24-28; Kreymer at 1:44-45, FIG. 1; Ex. 1013 at 1-2.

73. It was also well-known that the size of an interior space impacts the cooling or heating capacity required from an HVAC&R system. This problem is particularly relevant in designing PCAs for parked aircraft because each aircraft has a different interior cabin space and thus requires different heating and cooling capacities. Kreymer at 1:9-14; Lechmotoren at 3:37-4:7. It was also well-known that a solution for this problem is the use of multiple refrigeration circuits, or multi-stage air-conditioning packs. *Id.* An example of the use of multiple refrigeration circuits in a PCA is shown by Kreymer in its FIG. 3 reproduced below.

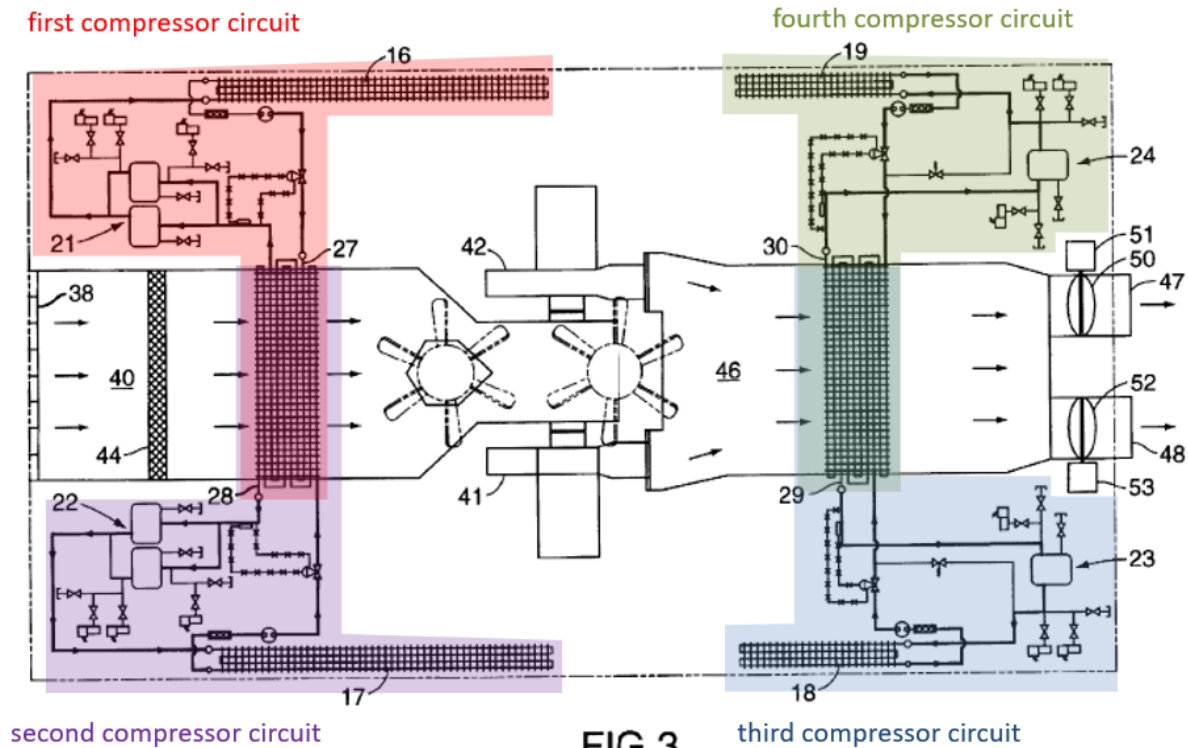


FIG 3

Kreymer, FIG. 3 (annotated).

74. It was also well known that adjustment of the cooling capacity of an air-conditioning or refrigeration system can be achieved by having air-conditioning systems with variable outputs. *See* Lechmotoren at 3:37-4:7. This may be achieved by varying the frequency of electrical waveforms applied to motors driving, among other things, the compressor, the condenser fans, and/or the evaporator fans. *See* Taras at ¶19. A well-known way to alter the frequency and voltage of the power provided to a motor is through the use of a power electronic circuit called a Variable Frequency Drive (VFD). *Id.*

75. Several designs for PCAs have been published prior to the '169 patent's priority date and were known to a POSITA. A non-exhaustive list of

designs, attached to this petition, include White, Lechmotoren, Kreymer, and Anderson. *See* Exs. 1005, 1008, 1017-18; *see also* Ex. 1012 (discussing use of PCAs in airports).

3. Variable Frequency Drives

76. VFDs use power electronics to vary the frequency of electrical waveforms applied to a motor in order to control motor speed and torque. Ex.1040 (“Carrier”) at 2.

77. As described, VFDs have a power line input that could be AC or DC (e.g., 3-phase, AC 60 Hz in the US), which then goes through a rectifier that “convert[s] incoming ac power into direct current (dc) power.” *Id.* at 3. The number of phases in an AC line determines the number of rectifiers the VFD will have. Specifically, “[o]ne rectifier will allow power to pass through only when the voltage is positive. A second rectifier will allow power to pass through only when the voltage is negative. Two rectifiers are required for each phase of power.” *Id.* at 3. Thus, for three-phase power applications common in US commercial and industrial environments, there will be a minimum of six rectifiers but may have more. *Id.* at 3. After the input current goes through the rectifiers, electrical power is stored on capacitors on a dc bus, where that power can then be delivered to an inverter, which “contains transistors that deliver power to the motor” in the form of a bespoke AC signal. *See id.* at 3.

78. The proliferation of VFDs to control motor speed in HVAC&R systems is easy to understand. There are many advantages of using VFDs to control capacity in refrigeration systems that were well-known, including, “energy savings, low motor starting current, reduction of thermal and mechanical stresses on motors and belts during starts, simple installation, high power factor, and lower KVA[kilo-volt-amperes].” Carrier at 4. By 2009, the use of VFDs in refrigeration systems was commonplace, as demonstrated by textbooks and industry manuals. *E.g.*, ASHRAE Fundamentals of HVAC Control Systems (Ex. 1011) at 56 (describing VFDs as “[o]ne of the most important developments in recent years and describing “VFDs used in HVAC applications”); Ex. 1010 at 42.9-42.10 (use of VFD to drive compressors); *id.* at 4.13 (use of VFD to drive air handlers); *id.* at 44.9-44.14 (detailed description on the electrical implementation of VFDs in HVAC systems); *see also id.* at 3.2-3.4, 3.8, 5.3, 39.8-39.9 (other applications). Installing them into HVAC&R applications is as simple as “connecting them to the power supply” and the motor. Carrier at 10.

79. VFDs were used in air-conditioning and refrigeration devices that operated in the same “conventional” manner as the refrigeration units in a PCA. ’169 patent at 6:23-34. Specifically, VFDs are used to control the motor speed on components in the devices. In other words, VFDs are not inherently part of the thermodynamic cycle in a HVAC&R cycle—it’s rather a method of

controlling components in that cycle. For example, Ex. 1006 (“Taras”) provides an example of VFDs used in a refrigeration system using “power electronics . . . known in the art.” Taras at ¶19. Taras discloses air-conditioning and refrigeration systems operating using well-known refrigeration techniques. Taras at ¶16 (“Such refrigeration components are known by a person of ordinary skill in the art.”). The system includes a motor-operated compressor, a condenser, an expansion device, and an evaporator connected in a refrigerant circuit—the exact same architecture as described in the ’169 patent. Compare Taras at ¶17 with ’169 patent at 6:23-34. Taras further discloses the use of several VFDs to drive the compressor motors, condenser fans, and evaporator fans in such systems. Taras at ¶31.

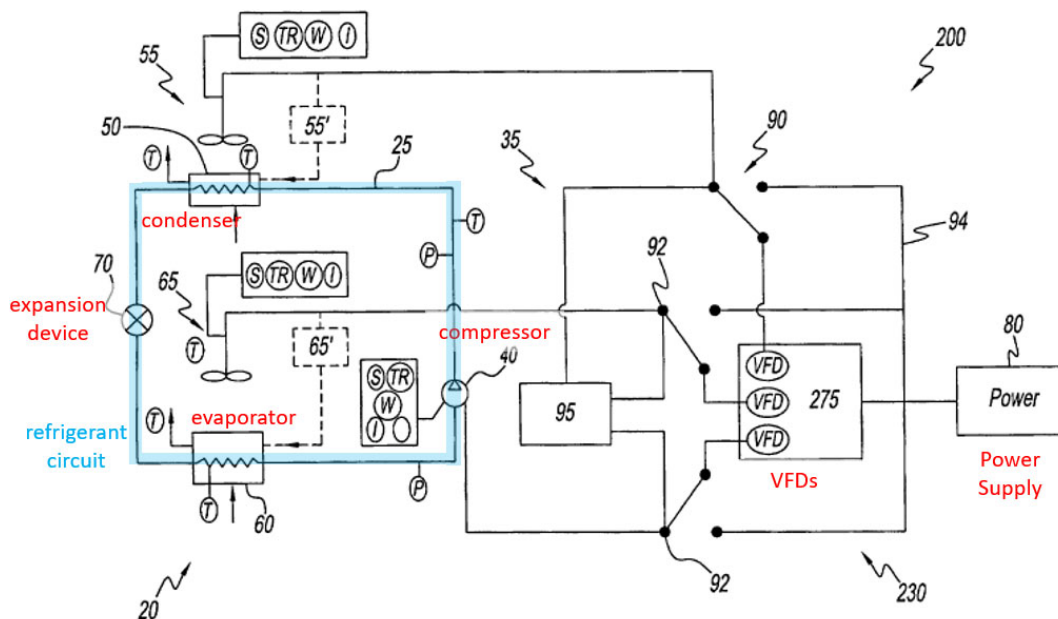


Fig. 3

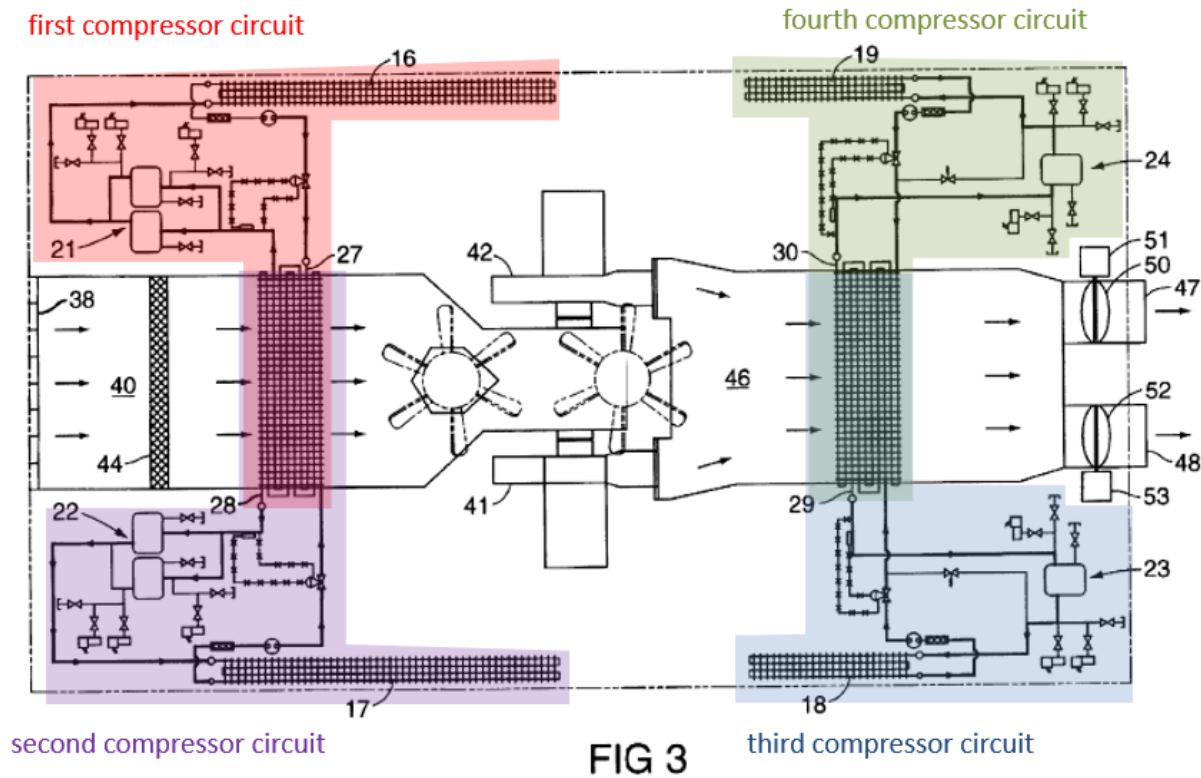
Taras, FIG. 3 (annotated).

B. Overview of Kreymer (Ex. 1005)

80. The reference I refer to as “Kreymer” is U.S. Patent 5,715,701, included as Exhibit 1005. It issued and published on February 10, 1998. Naum Kreymer is the inventor. On its face, it is assigned to FMC Corporation.

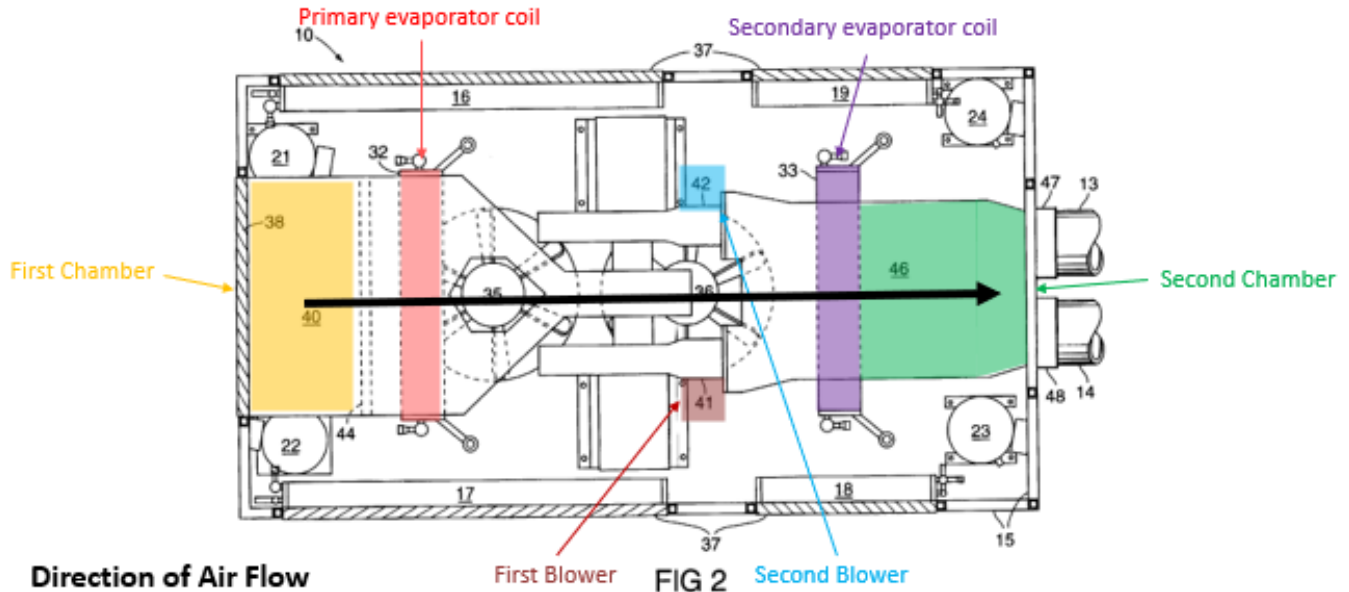
81. Kreymer is titled “Double Blower Air Conditioning Unit.” Kreymer Cover. Kreymer describes “[a] method and apparatus for providing conditioned air to an aircraft parked at an airport.” Kreymer at Abstract. As shown in Figure 3 below, Kreymer discloses an air-conditioning (AC) unit with well-known components of a refrigeration system—a compressor, a condenser coil, an evaporator coil, and an expansion valve. Kreymer at 1:44-2:10, 2:63-3:10, FIG. 3.

82. Kreymer discloses an AC system with four compressor circuits as shown below in Figure 3. Specifically, the “first compressor 21” is in the same refrigerant circuit as the “first evaporator coil 27” and the “first condenser coil 16.” Kreymer at 1:51-53, 1:61-63. The “second compressor 22” is in the same refrigerant circuit as the “second evaporator coil 28” and the “second condenser coil 27.” Kreymer at 1:53-55, 1:63-65. The “third compressor 23” is in the same refrigerant circuit as the “third evaporator coil 29” and the “third condenser coil 18.” Kreymer at 1:55-57, 1:65-2:1. The “fourth compressor 24” is in the same refrigerant circuit as the “fourth evaporator coil 30” and the “fourth condenser coil 19.” Kreymer at 1:57-59, 2:1-3.

**Kreymer, FIG. 3 (annotated)**

83. As shown in Kreymer's Figure 2 (annotated below), the "first evaporator coil 27" and the "second evaporator coil 28" form a "primary evaporator coil 32," which passes through a "first chamber 40" in "fluid connection" with "a first blower 41 and a second blower 42" so that the air passing through the first blower 41 and second blower 42 from an inlet "must pass through the primary evaporator coil 32." Kreymer at 2:3-5, 2:12-17. The "third evaporator coil 29" and the "fourth evaporator coil 30" form a "secondary evaporator 33," which passes through a "second chamber 46" in "fluid connection" with the "first blower 41 and second blower 42" so that the air passing through the outlets from the first and second blowers "must pass through the secondary evaporator coil 33."

Kreymer at 2:22-28. The primary and secondary evaporator coils and the direction of air flow are shown below in Figure 2.



Kreymer, FIG. 2 (annotated)

84. The AC system “is able to accommodate various aircraft sizes” by operating the first and second blower in conjunction with configurable dampers to adjust the airflow directed to the aircraft. Kreymer at Abstract, 3:14-27. If the PCA needs to produce more cooling capacity at a given time for a particular aircraft, Kreymer instructs that each compressor circuit can be selectively turned on to “obtain the desired cooling.” Kreymer at 2:66-3:13. Kreymer instructs that a “mode selector switch” in a remote control can be used to adjust the number of operating compressors and blowers, and the configuration of the dampers. Kreymer at 2:35-40. The mode selector switch can be set to an aircraft type. *See, e.g., id.* at 3:14-27 (automatic configuration for “narrow body aircraft”); *id.* at 3:28-

44 (automatic configuration for “wide body aircraft”); *id.* at 3:45-61 (automatic configuration for “jumbo body aircraft”). Kreymer’s system then operates “automatically,” including selecting which refrigeration circuits are operating based on cooling needs and the size of the aircraft. *Id.* at 2:53-52. The remote control can alternatively have three buttons for starting and selecting the aircraft type with one input. *Id.* at 4:11-15 (“[T]hree buttons may be used with a push button to start the air conditioning unit for a narrow body, and a push button to start the air conditioning unit for a wide body, and another push button to start the air conditioning unit for a jumbo body.”).

C. Overview of Taras (Ex. 1006)

85. The reference I refer to as “Taras” is International Patent Publication No. 2007/046794 (Taras), a PCT application filed on October 17, 2005, and published on April 26, 2007. Ex. 1006. Michael F. Taras is the first named inventor. On its face, Carrier Corporation filed Taras.

86. Taras relates to systems with “machinery driven by variable speed drives and, more particularly, to systems for heating, ventilation, air-conditioning and refrigeration application with variable speed components.” Taras at ¶1. In particular, Taras discloses a HVAC system having VFDs driving a compressor, a condenser fan, and an evaporator fan. An example of this system is illustrated in FIG. 3, annotated below:

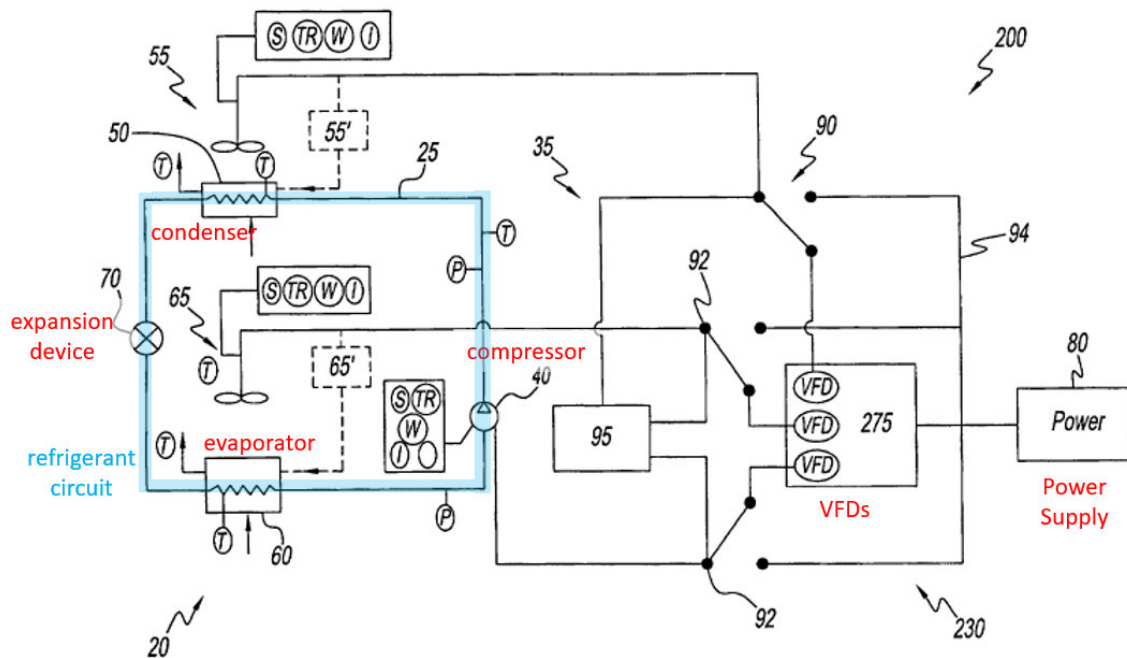


Fig. 3

Taras, FIG. 3 (annotated)

87. The system is a well-known air refrigeration system that employs a vapor compression cycle. “The vapor compression system 20 includes a compressor 40, a condenser 50, and an evaporator 60 interconnected in the circuit 25 with various valves and interconnected pipes . . . [A]n expansion device 70 is positioned between the condenser and evaporator within the circuit 25.” *Id.* at ¶17. The system further includes condenser and evaporator fans. “[F]ans 55 and 65 [] in fluid communication with the condenser 50 and the evaporator 60, respectively.” *Id.*

88. The VFDs in Taras are used to drive the compressor 40, the condenser fan 55, and the evaporator fan 65. The “[p]ower/control system 230 has a plurality

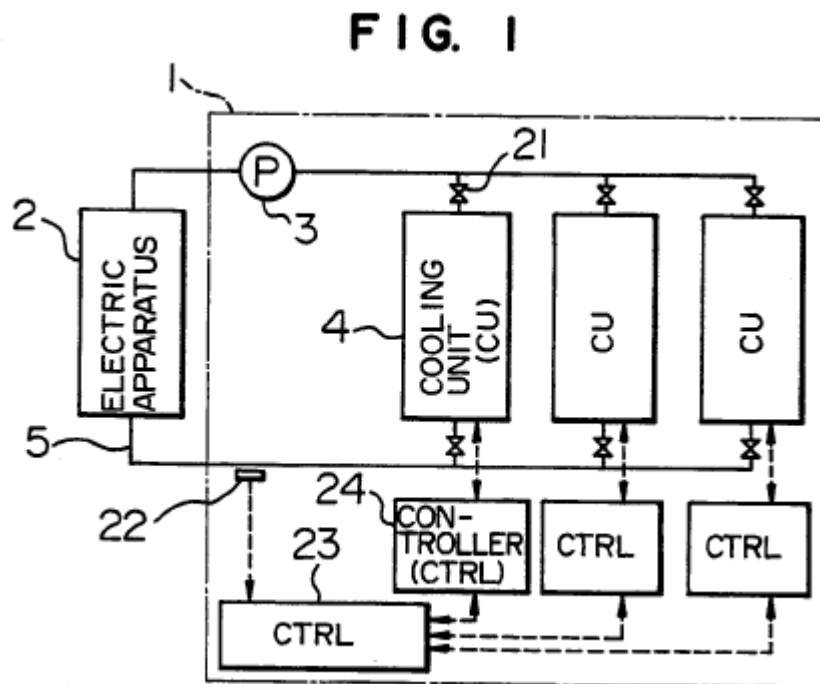
of variable frequency drives 275 that are operated by the system controller. Each of the VFDs are connected to the various components of the refrigerant system 20, such as, for example, the motor of compressor 40 and the motors of each of the fans 55 and 65.” *Id.* at ¶31. The “VFD adjusts the speed of the motor of compressor 40 by varying the frequency and/or voltage of the power provided to the motor” by converting the frequency and/or voltage supplied by the main supply. *Id.* at ¶19. As a result, the “motor of compressor 40 [can] run at lower or higher than normal operating speed” as compared to the single operating speed that it could operate at if connected directly to the main electrical supply. *Id.* In the context of a refrigeration system, evaporator fan is the same as a blower.

89. Taras discusses why VFDs would be used in a HVAC system. One strategy to alter the cooling capacity of a system is to shutdown and restart the refrigeration circuit by turning it on or off. *See, e.g.* Kreymer at 2:53-52; *see also* Carrier at 4 (discussing control of capacity in constant speed pumps or fans). However, this binary control system presents disadvantages. Taras states, for example, that adjusting the speed of the compressor through a VFD “improve[s] system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system change or a user alters the conditioned space setpoint,” such as in the context of a PCA supplying cooled air to varying aircraft types. *See* Taras at 19.

D. Overview of Takahashi (Ex. 1007)

90. The reference that I refer to as “Takahashi” is U.S. Patent No. 5,351,498. It was issued and published on October 4, 1994. Tatsuya Takahashi is the first-named inventor. It is assigned to Hitachi, Ltd. and Hitachi Microcomputer System Ltd.

91. Takahashi, entitled “Cooling system for electronic apparatus and control method therefore,” discloses “a cooling system having two or more cooling units in which an operation frequency of each cooling unit can be reduced.” Takahashi at 1:7-12. An embodiment is illustrated in FIG. 1, reproduced below.



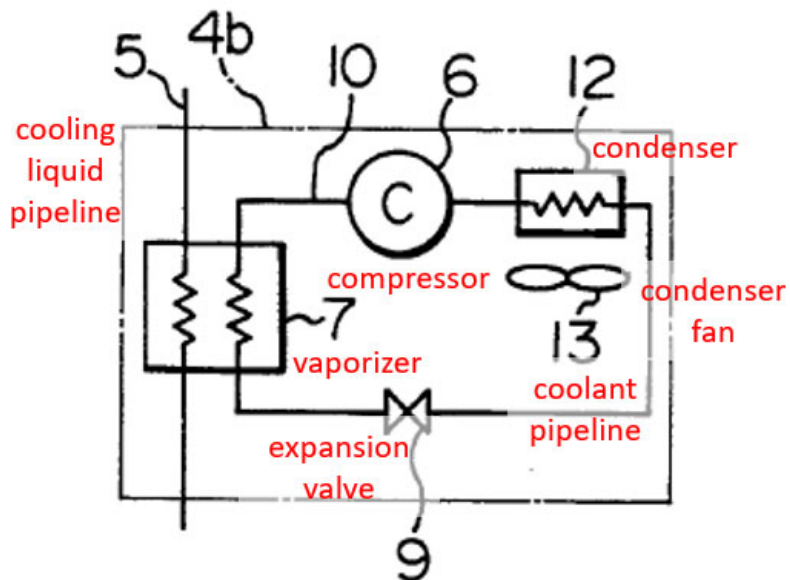
Takahashi, FIG. 1

92. The cooling system in Takahashi includes multiple “cooling units 4.” *Id.* at 3:41-4:2. The cooling units are controlled by a “controller 23 for controlling

the operation of each cooling unit 4 . . . ; and a plurality of unit controllers 24 each for performing a variable control of the individual cooling unit 4 based on a command from the controller 23.” *Id.* at 3:41-4:2.

93. Takahashi’s cooling unit is a refrigeration system constructed according to the well-known thermodynamic cycle, system, and components discussed in Section VIII.A.1. As shown below in FIG. 3, the cooling unit can be a “air-cooling condenser-type cooling unit.” *Id.* at 4:3-8. The “air-cooling condenser-type cooling unit 4b comprises, as shown in FIG.3, an air condenser . . . [a] compressor 6,” an “expansion valve 6,” and a “vaporizer 7.” *See id.* at 4:9-28. The word “vaporizer” here is another way to refer to an “evaporator.”

FIG. 3



Takahashi, FIG. 3 (annotated)

94. In Takahashi, a VFD is used to drive the “compressor[s] 6 comprising a motor 31.” *Id.* at 4:29-47. “The motor 31 is connected to an AC power supply through an inverter 35 capable of varying the frequency of outputted AC power and switching circuit 36 for turning on and off the power supply.” *Id.* at 4:43-47.

95. The system of Takahashi can detect abnormalities in cooling units. *Id.* at 7:17-27. A POSITA would have understood that an “abnormality” means that a cooling unit is operating sub optimally, i.e., has failed or is about to fail. Specifically, when a cooling unit presents an abnormality, its unit controller transmits a signal to a central controller: “[T]he controller 23 receives the information from the unit controller 24 that one of the three cooling units 4 in operation has been stopped due to the abnormality.” *Id.* at 7:46-48. In response, the controller controls the remaining cooling units to operate at a higher capacity to compensate for the cooling capacity loss caused by the abnormality: “[T]he controller 23 controls the unit controllers 24 to perform a degenerated operation by use of the two cooling units which [are] still operating. . . . [T]he controller 23 commands the unit controllers 24 connected to the two operating cooling units 4 to change the operation frequency to [1.5x higher frequency].” *Id.* at 7:46-52, 58-61.

96. A POSITA interested in designing or solving problems in HVAC&R, including the control systems for HVAC&R systems, of which a PCA used for a

grounded aircraft is one example, would look to Takahashi to improve such systems because Takahashi contains the same type of refrigeration system, cycle, and components and teaches the use of control systems for systems with a refrigeration circuit. *See also* Taras at ¶ 19.

E. Overview of Lechmotoren (Ex. 1008)

97. The reference that I refer as “Lechmotoren” is a certified English translation of the German Utility Model DE 296 22 089. Lechmotoren was issued on April 9, 1998, and published May 20, 1998. It was assigned to Lechmotoren GmbH.

98. Lechmotoren was originally published in German. Ex. 1021 (“Lechmotoren German”).]

99. The Lechmotoren reference describes a PCA. For example, this publication explains that the application is for an air conditioning unit for aircraft on the ground. Lechmotoren at 1:10-14.

100. Lechmotoren explains that these types of air conditioning units for grounded aircraft were well known in the art. *Id.* at 1:15-26. Lechmotoren further cites other references describing PCAs, such as British patent, GB 2 005 819, German patent DE 33 14 762, and U.S. Patent 2,929,223. *See id.* at 1:28-2:8

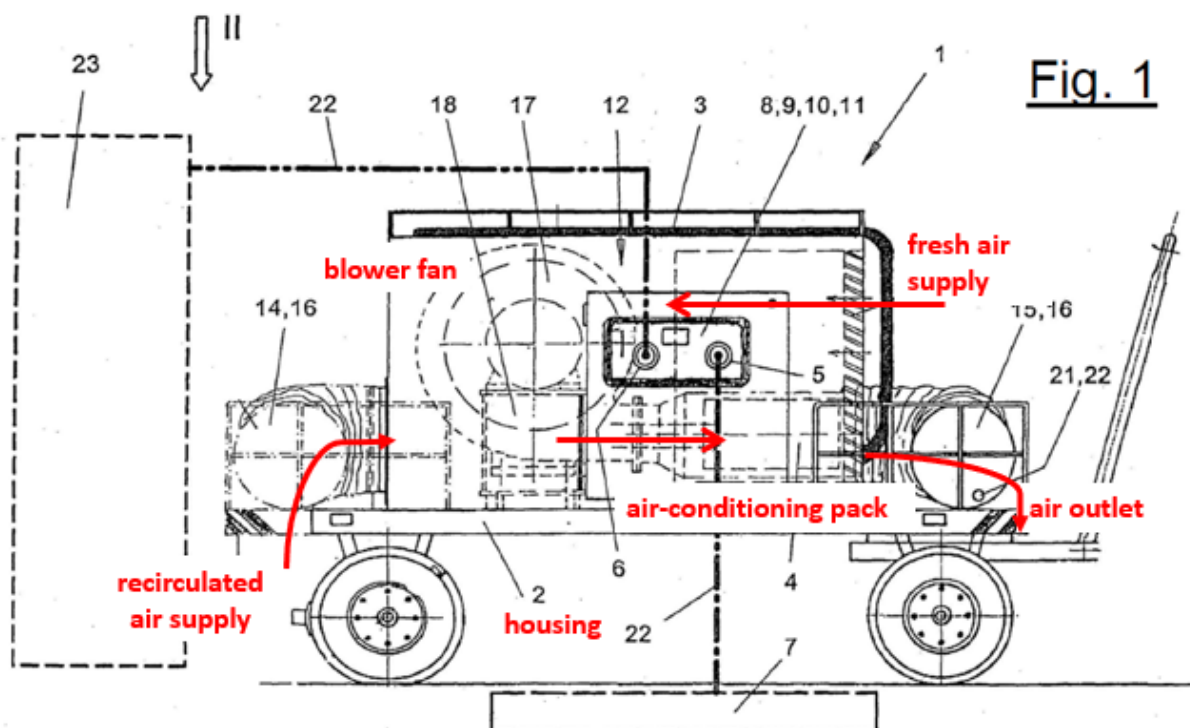
101. Lechmotoren states that its PCA is designed to adapt to variable operating conditions. *Id.* at 3:37-4:7. To that end, Lechmotoren employs controllable air-conditioning packs. *Id.*

102. The PCA unit described in Lechmotoren can have multiple air-conditioning packs. *Id.* at 4:9-11. The air-conditioning packs can be configured to operate as a heating device and/or a cooling device. *Id.* at 4:11-15. The air-conditioning packs can work with thermodynamic cycles to provide both heating and cooling. *Id.* at 4:9-16.

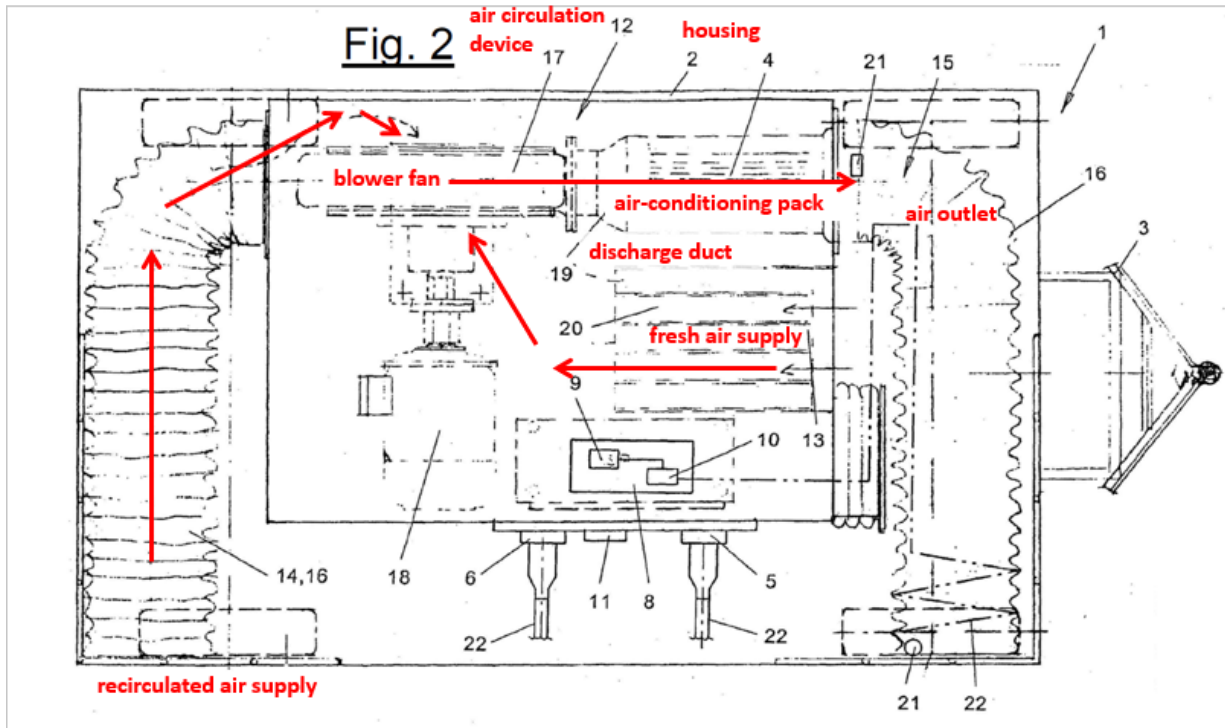
103. Lechmotoren allows different configurations of the air-conditioning packs within its PCA unit. *Id.* 4:9-11. For example, a PCA could have one air-conditioning pack configured for cooling and another configured for heating. As another example, a PCA could have 2 air-conditioning packs that are capable of providing cooling and heating. *See id.* 4:9-17.

104. Lechmotoren also describes a control system on the PCA. *Id.* 4:22-28. That control system can receive connections from sensors or switches that measure climate conditions (e.g., temperature or humidity) around or inside the aircraft. *Id.* The control system may employ thresholds to perform its control. *Id.*

105. Figures 1 and 2 of Lechmotoren, reproduced below, show a side and a top view of an example of a PCA. *Id.* 6:16-18. The reproduced figures include annotations showing the airflow within Lechmotoren's example of a PCA.



Lechmotoren, FIG. 1



Lechmotoren, FIG. 2.

106. The illustrated air conditioning unit operates by moving air through an “air circulation device (12),” inside the housing. Lechmotoren’s unit receives a fresh air or recirculated air intake, conditions the air inside by moving the air through one or more air-conditioning packs and blows the conditioned air into the aircraft cabin via a hose. *See id.* 10:18-35.

107. To acquire fresh air, the air circulation device includes a fresh air supply (13) which may include filters, dehumidifiers, or humidifiers. *Id.* at 10:18-21, 10:37-11:2. Alternatively, the air circulation device may receive recirculated air supply (14) from the aircraft, through a hose connecting the aircraft to the PCA unit. *Id.* at 10:21-25. The recirculated air supply may include filters, dehumidifiers, or humidifiers. *Id.* at 10:37-11:2.

108. Lechmotoren discloses a blower, in the form of fan (17). As explained, Lechmotoren's air circulation device (12) has one or more fans, annotated as fans (17). The fans draw in the fresh or recirculated air and push it through the air circulation device (12) into the discharge duct (19). *Id.* at 11:4-13. As such, the fan (17) is a blower that generates an air flow from the air inlet to the air outlet.

109. The frequency of the blower can be regulated. The blower, i.e., fan (17), is driven by an electric motor (18). Lechmotoren 11:15-17. The frequency of the motor can be adjusted from, for example, a 5000 rpm frequency at full load, to a 2500 rpm frequency at reduced load. *Id.* 11:21-29.

110. The blower further pushes the conditioned air through the air outlet 15, that is connected to air that is conditioned through air hoses (16) to the aircraft (23). *Id.* at 10:27-35.

111. The air flow generated in the air circulation device interacts with the air-conditioning packs. As explained, fan (17) pushes the air through air-conditioning packs (4) where the air is conditioned. *See id.* at 11:4-9. In certain configurations, at least one of the air-conditioning packs works with a thermodynamic cycle with a compressor and condenser to provide cooling output. *See id.* at 10:7-11. A POSITA would understand such an air-conditioning pack, operating with a "thermodynamic cycle with compressor and condenser,"

(Lechmotoren at 10:9), to also include an evaporator, which is responsible for removing heat from the air being conditioned. *See, e.g.*, Taras at ¶ 17. A POSITA would understand that in such configuration, air flow would interact with the evaporator of the air-conditioning pack to cool the air. *See, e.g., id.*

112. The PCA disclosed in Lechmotoren is capable of sharing a power supply with the aircraft. The application describes multiple configurations for power sharing. Figure 3 illustrates two of these configurations, a series and a parallel one. *See* Lechmotoren at 3:1-6, 6:33-7:8. Two of these configurations are illustrated in its Figure 3, reproduced below with annotations.

Fig. 3

Lechmotoren, Figure 3 (annotated). Green highlights (straight lines) indicate electrical connections and blue highlights (dashed lines) indicate air hose connections.

114. To operate in the series configuration, the PCA includes “one input-side electrical connection (5) with a socket or the like, which can be connected to

the external supplier (7) by cable (22).” Lechmotoren at 7:10-14 (External supplier is the power supply. *See, e.g., id.* at 7:23-25, 15:11). The PCA also includes “one electrical connection (6) on the output side with a socket or the like, which leads to at least one aircraft (23) via a cable (22).” *Id.* at 7:14-17. The connections on the input side and output side are illustrated in excerpted Figure 2, reproduced below.

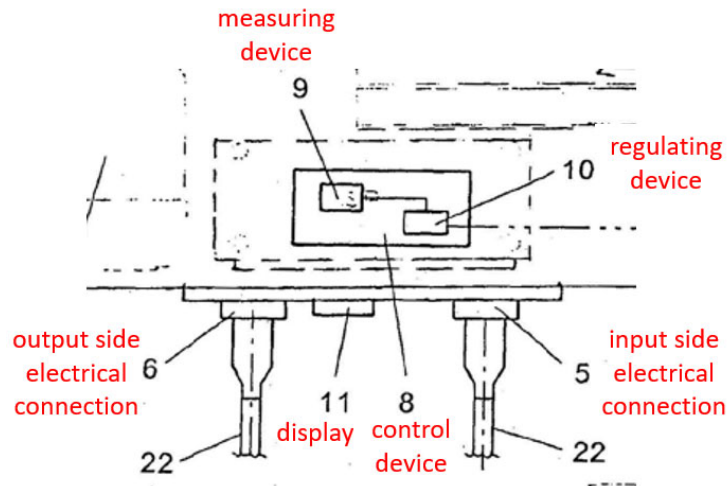


Figure 2, excerpted.

115. In the series configuration, the PCA can adjust its cooling output and, consequently, power consumption based on the needs of the aircraft. *See* Lechmotoren at 3:1-16 (“The air-conditioning system can utilize the residual output not required for the aircraft”); *id.* at 8:10-17 (“The air conditioning unit (1) only draws as much output from the power supply unit (7) as is not needed by the aircraft (23).”) The adjustment of its cooling output is obtained by having the air-

conditioning packs configured to have variable and controllable output. *Id.* at 8:3-4.

116. The adjustment of the power control output is performed by a control system (8). *Id.* at 8:4-8 (“The air conditioning unit (1) has a suitable control system (8), which is preferably designed as a programmable logic control system.”); *id.* at 8:15-17 (“The control system (8) is preferably designed to use as much of the remaining energy as possible to operate the air conditioning unit.”); *id.* at 11:15-29 (describing adjustment of the fan speed by the control system (8) in response to the available electrical energy).

117. To perform this adjustment, the system may employ a “measuring device (9) for measuring the aircraft’s (23) power or output demands. The measuring device (9) can be integrated into the control system (8) or arranged externally.” *Id.* at 8:23-27. In addition, the control system also has “a suitable regulating device (10) that adjusts the output of the air-conditioning pack (4) to the available residual energy and controls it in a suitable manner.” *Id.* at 8:27-31.

118. Lechmotoren also includes protective features in response to certain types of failures or malfunctions. For example, the air conditioning unit includes safety circuits, sensors, and switches that can measure and monitor the operating conditions of the PCA and can be switched off to prevent damage from, for example, overheating. *See id.* at 12:12-23.

F. Overview of Carrier (Ex. 1040)

119. Carrier is a public white paper published by the Carrier Corporation in October 2005. Carrier Corporation is an industry leader in HVAC&R systems, engineering, and design.

120. I understand Carrier was available on Carrier Corporation's website on a page titled "White Papers" at least by December 1, 2007, and publicly available elsewhere by at least January 10, 2006. Declaration of Ingrid Hsieh-Yee (Ex. 1022) at ¶¶ 29, 31, 37, 49-50. On at least December 1, 2007, Carrier was listed on the landing page of Carrier Corporation's White Papers page and was titled "Variable Frequency Drive, Operation and Application of Variable Frequency Drive (VFD) Technology." *Id.* A POSITA interested in designing or solving problems in HVAC&R, including the control systems for HVAC&R systems, of which a PCA used for a grounded aircraft is one example, would look to Carrier Corporation's White Papers page to improve such systems including because of Carrier's well-known status as an industry leader in HVAC&R systems, engineering, and design.

121. I also understand Carrier was posted to a forum discussion on "Refrigeration-Engineer.com" in the topics of "TECHNICAL REFRIDGERATION" and "Electrical" in a thread regarding "Starting & protecting AC motors." *Id.* at ¶¶ 38, 40. I understand this forum had over 14,000

members as of October 12, 2007. *Id.* at ¶ 40. This forum is a technical forum a POSITA would have referred to in improving HVAC&R systems, including a PCA. A POSITA interested controlling motor control of compressors in refrigeration systems, such as a PCA, would have been familiar with and consulted this forum.

122. Carrier teaches how to use variable frequency drives (VFDs) in HVAC applications. It is “intended to provide a basic understanding of. . . VFD operation and benefits.” Carrier at 2. The paper, from 2005, states that “[VFD] usage has increased dramatically in HVAC applications. The VFDs are now commonly applied to air handlers, pumps, chillers, and tower fans.” *Id.*

123. Carrier also lists advantages of VFDs. “Variable frequency drives provide the following advantages: energy savings, low motor starting current, reduction of thermal and mechanical stresses. . . simple installation, high power factor, lower KVA.” *Id.* at 4. These benefits can be seen by implementing VFDs in HVAC compressors as well as other air flow handlers such as blowers, and condenser fans. *Id.* (discussing advantages of variable speed capacity control for “centrifugal pumps, fans and compressors”).

IX. A POSITA would have found claims 2-9 and 11-12 obvious in view of the combination of Kreymer and Taras

A. A POSITA would have combined Kreymer and Taras

124. Kreymer and Taras are, both, in the same field of endeavor as the '169 patent, as they are all directed to air refrigeration systems that employ well-known HVAC&R techniques. For example, the '169 patent is directed to a PCA system that preconditions air using "self-contained cooling modules 36 operates in accordance with well-known refrigerator principles." '169 patent at 6:23-33. Kreymer discloses an air refrigeration system producing preconditioned air to a parked aircraft that includes compressors, condenser, evaporators, and expansion devices that are connected in a refrigerant circuit and, like the '169 patent, contains separate compressor circuits that are operated in a coordinated and configurable manner to adjust the overall cooling or heating capacity of the air refrigeration system. Kreymer at 2:63-3:13. Likewise, Taras discloses the same type of air refrigeration system that includes a compressor, expansion valve, evaporator, compressor, and fans. *See, e.g.*, Taras at ¶¶ 1, 11, 16-17, FIG. 3. In addition, Kreymer is analogous art to the '169 patent as both patents are directed to PCA systems for parked aircraft that employ refrigeration operations employing the same well-known HVAC&R principles. *Compare* '169 patent at 1:13-15 with Kreymer at Abstract (discussing supply of conditioned air to parked aircraft); *compare* '169 patent at 6:23-33 with Kreymer at 1:46-2:10; 2:63-3:13 (describing

refrigeration systems having compressors, condensers, and evaporators in a refrigerant circuit). PCAs are an implementation of HVAC&R systems for cooling and/or heating a parked aircraft. Both Kreymer and Taras are in the area of knowledge of a POSITA.

125. A POSITA would have been motivated to combine Kreymer and Taras to obtain a PCA with multiple refrigeration units that employ VFDs to drive its compressors for several reasons. Kreymer describes a PCA system with an adjustable cooling capacity by “cycling an entire cooling system,” of which it has four, “on and off,” which is described as more efficient than “cycling” a single large unit “on and off.” *See* Kreymer at 2:63-3:13. In essence, a POSITA would have understood that Kreymer provides discrete step adjustments to the cooling capacity of its refrigeration system by running either 1, 2, 3, or 4 of its refrigeration circuits at any given time, i.e., four discrete capacity settings. *See id.* A POSITA would have understood the value of capacity adjustment, and that a capacity can be adjusted in a variety of steps between fully off and fully on. Kreymer teaches that providing cooling to an aircraft is a challenge because “narrow body aircraft,” “wide body aircraft,” and “jumbo body aircraft” all have different cooling capacity requirements. *Id.* at 1:9-14. A POSITA would have also recognized that Kreymer’s discrete adjustments are one embodiment of a continuum of adjustment, where the number of adjustment levels are a design choice ranging on a spectrum

between on/off control of a single unit and continuous adjustment; all of these choices on the spectrum (Kreymer's embodiment is a particular choice with four levels) yield predictable results for efficiency and flexibility, and POSITA would choose appropriately from the spectrum of levels for any given application with a full expectation of success in optimizing cooling level and efficiency versus design complexity and cost. Kreymer also teaches that having multiple independent refrigeration components provides redundancies in case one fails. *See id.* at 3:67-4:2.

126. Kreymer was filed in 1996. A POSITA, thus, would have recognized that other approaches for adjustability of the cooling capacity in Kreymer's refrigeration circuits and system as a whole could provide similar results and opportunities for optimization to adequately provide the necessary cooling capacity to a wide variety of aircraft. By 2009, VFDs were a well-known mechanism for controlling motor speed in a compressor and the cooling capacity of a refrigeration system. A POSITA would have recognized Taras's teaching, which was filed in 2007, that VFD-driven compressors provide fine adjustment and a multiplicity or spectrum of levels to refrigeration capacity, offering an obvious approach for implementing Kreymer's spectrum of cooling performance in a multi-compressor system that would implement the essential idea of capacity adjustment in the Kreymer PCA system. *See Taras* at ¶ 19; *see also* Ex. 1019

(“Rafuse”) at 3:57-65 (“If the VFD-controlled AC motor drives a compressor, the speed, and thus the refrigeration capacity, of the compressor can be controlled by varying the input signal to the VFD.”). A POSITA interested in designing a PCA that can adjust its cooling output to the cooling requirements in variety of aircraft would look to Taras’s teaching that using a VFD to drive a compressor in a refrigeration circuit provides “adjustment[s] that improve system performance *under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system change or a user alters the conditioned space setpoint.*” Taras at ¶19 (emphasis added). A POSITA reading Taras would have understood Taras was assigned to Carrier Corporation and would have looked to Carrier Corporation’s white paper website for more information on capacity control in HVAC systems. A POSITA would have been further motivated to add the VFD control of each of the compressors in Kreymer’s PCA system based on Carrier’s teaching, published in 2005 and publicly available at least by December 1, 2007, that VFDs provide the following technical advantages: “energy savings,” “low motor starting current,” “reduction of thermal and mechanical stresses on motors and belts during starts,” simple installation,” “high power factor,” and “lower KVA [i.e., power used by the system].” Carrier at 4; *see id.* at 5-6 (describing in detail the ways VFDs provide these benefits). Carrier states “VFDs provide the most energy efficient means of capacity control,” which as

discussed, is an important design constraint for a PCA used to cool a variety of aircraft. *Id.* at 10. As a result, a POSITA would have been motivated to add a VFD to each refrigeration circuit to maximize energy gains and efficiency of each refrigeration circuit and the system as a whole. *See, e.g.*, Ex. 1020 (“Schnetzka”) at FIG. 1B (illustrating variable-speed drive applied to multiple motors). A POSITA would have also been motivated to add a VFD from Taras to each of Kreymer’s refrigeration circuits because multiple refrigeration circuits provides well-understood failure and cooling capacity redundancies. Kreymer at 3:67-4:2. A POSITA would have been motivated to fine tune the capacity of each refrigeration circuit, as taught by Taras, based on Kreymer’s teachings that having multiple refrigeration levels is beneficial in having a PCA for cooling multiple aircraft types with varying cooling capacity needs. Kreymer at 2:52-53, 2:66-3:13; Taras at ¶19. A POSITA would also have been motivated to include a central controller in the combined system to control the output of the VFDs and refrigeration system to realize the energy gains and efficiency of operating VFDs in a refrigeration system, to optimize the system redundancies and multiple refrigeration circuits, and to match the desired cooling capacity requirements described by Taras and Kreymer. Carrier at 4; *see id.* at 5-6; Taras at ¶19; Kreymer at 1:9-14, 3:67-4:2; *see also* Rafuse at 3:57-65. It was well within the knowledge of a POSITA by 2009 that power-electronic VFD-driven refrigeration circuits

would be controlled by a central controller that provided setpoints or operating settings to optimize performance and efficiency. *See* Ex. 1011 at 11 (“The advantage of this reset control is that the capacity of the heating system increases as the load increases, greatly improving controllability. This use of one control loop to provide input to a second control loop is generally called cascading...”)
(Referring to an HVAC system in which one control, e.g., a central controller, provides setpoints to govern the operation of a second controller like a VFD)); *see also id.* at 57 (FIG. 2-27 showing “Speed Signal from Control System” (a central controller) providing a command or reference signal to a “VFD”); *id.* at 56 (“One of the most important developments in recent years has been the advancement of variable frequency drive (VFD) technology. These drives use solid-state electronic circuitry to adjust the frequency and voltage of the power to the motor, which in turn varies the speed,” and “the inverter consists of high speed bipolar transistors that control both voltage and frequency sent to the motor.”). In summary, it was well known in the prior art that a VFD controller would receive a command input from another cascaded or central controller to optimize overall system performance. *Id.* at 7 (“Another capability that is expected of modern control systems is energy management. This means that while control systems are providing the essential HVAC functions, they should do so in the most energy efficient manner possible.”).

127. As discussed in Taras, a POSITA would have understood that the variable capacity provided by VFDs comes with a trade-off when operating at the main supply frequency, as power loss through the VFD would be suboptimal when operating the compressor motor of a refrigeration system at the frequency of the main supply. *See* Taras at ¶2. This well-known trade-off would not discourage a POSITA from employing VFDs to obtain variable capacity control in a PCA for several reasons. First, Taras itself implements VFDs despite the tradeoff. *See* Taras at cl. 6 (“The system (10, 100, 200) of claim 5, wherein said variable speed device (75, 175, 275) is a variable frequency drive (75, 275), and wherein said compressor motor is an AC motor.”). Kreymer also cited Sasaki, which discusses a method of using variable speed, as opposed to a binary on/off selection, of fan motors to alter the rate of supplying air in a system. *See* Kreymer at References Cited; *see also* Sasaki at 12:12-16 (“Instead, two inverters may be used for driving the motors 18aM and 18bM, respectively, and the output frequencies of these inverters may be controlled to continuously change the air-supplying rates F and F of the fans 18a and 18b, continuously, not stepwise as in the embodiments described above.”). A POSITA would have understood the value of implementing a VFD to drive a compressor in a refrigeration based on Kreymer’s disclosure. Second, a POSITA reading Taras and Kreymer would have understood that providing varying cooling capacity for variety of aircraft would benefit greatly in

efficiency and performance overall from the ability to operate the compressor at frequencies, and thus speeds, that vary from the main supply frequency. *See* Taras at ¶ 19 (“([VFD] adjustment allows the motor of compressor 40 to run at lower or higher than normal speed. . . . [S]uch speed adjustment will improve system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system changes or a user alters the conditioned space setpoint.”); *see* Kreymer at 1:8-14. Third, a POSITA, seeking more information about the use of VFDs in air refrigeration systems, such as Kreymer, would have found the plethora of benefits discussed in Carrier to outweigh the tradeoff of power loss as compared to powering the compressor motor with the mains supply at the supply frequency. *See* Carrier at 4-6. Fourth, to the extent that a POSITA would have been concerned with the power loss, Taras itself provides a solution to this problem, through the use of bypass circuitry when the compressor operates at the same frequency as the mains supply, but not at other speeds. Taras at ¶ 19 (“However, when compressor 40 is required to operate at its normal speed to meet sensible and latent capacity demands, then the use of VFD 75 incurs efficiency losses and additional power draw.”).

128. Use of Taras’s technique is well within the skill of a POSITA and was predictable and well-known prior to 2009. *See* Carrier at 4, Taras at ¶¶ 19, 31. The

use of VFDs provide additional benefits well-known to a POSITA. See Section III.B (evidence of advantages of VFD in the prior art).

129. Finally, a POSITA had a reasonable expectation of success in combining Kreymer with Taras to obtain adjustable outputs in a multi-compressor PCA using VFDs. In fact, VFDs had already been successfully applied to HVAC&R systems. *See, e.g.,* Schnetzka, Taras, Carrier, Rafuse, Sasaki, Takahashi; *see also* Section B. Thus, any modification of Kreymer to accommodate VFDs as detailed in Taras would be implemented using well known methods that yield predictable results— “VFD installation is as simple as connecting the power supply to the VFD.” Carrier at 10; *see also id.* at 5 (noting the “Easy Installation” of VFDs in refrigeration systems).

B. Claim 2

1. **2[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising**

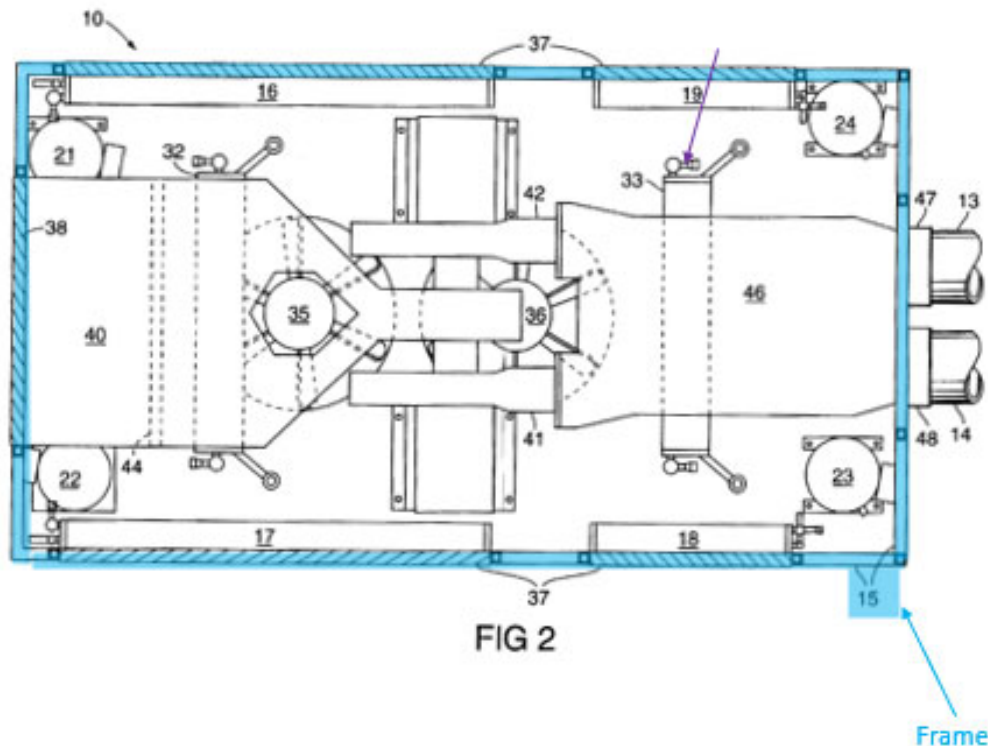
130. For the purposes of my analysis, I have assumed that the preamble of claim 2 is limiting on the claim.

131. Kreymer discloses and renders obvious “[a] method and apparatus for providing conditioned air to an aircraft parked at an airport.” Kreymer at Abstract; *see also id.* at 2:41-51. Kreymer describes its system is an “air conditioning unit

10.” *Id.* at 1:47. A POSITA would have understood that Kreymer’s system is a PCA.

2. **2[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet**

132. The combination of Kreymer and Taras discloses and renders obvious this limitation. For example, Kreymer discloses an “air conditioning unit 10 [that] has a frame 15.” Kreymer at 1:47-48, FIG. 3 (annotated below).



Kreymer, FIG. 2 (annotated).

133. The air conditioning unit is described as having a flow duct formed by connected chambers that include blowers inducing an air flow from an air inlet to an air outlet. “A first chamber 40 is in fluid connection between [] the inlet grill

38 and a first blower 41 and a second blower 42.” *Id.* at 2:11-15. “A second chamber 46 is in fluid connection between the first blower and the second blower and a first outlet 47 and a second outlet 48.” *Id.* at 2:22-24. The blowers generate flow from the air inlet to the air outlet. *See, e.g., id.* at 3:18-26 (“The first blower 41 draws air in through the inlet grill to the first chamber 40. . . . The air passes through the first blower 41 to the second chamber 46. . . . The air then passes through [] the first outlet 41.”); *see also id.* 3:28-62. Kreymer’s duct, the chambers in fluid connection, its blower, and the flow of air from an inlet to an outlet to a parked aircraft is shown below in Figure 3:

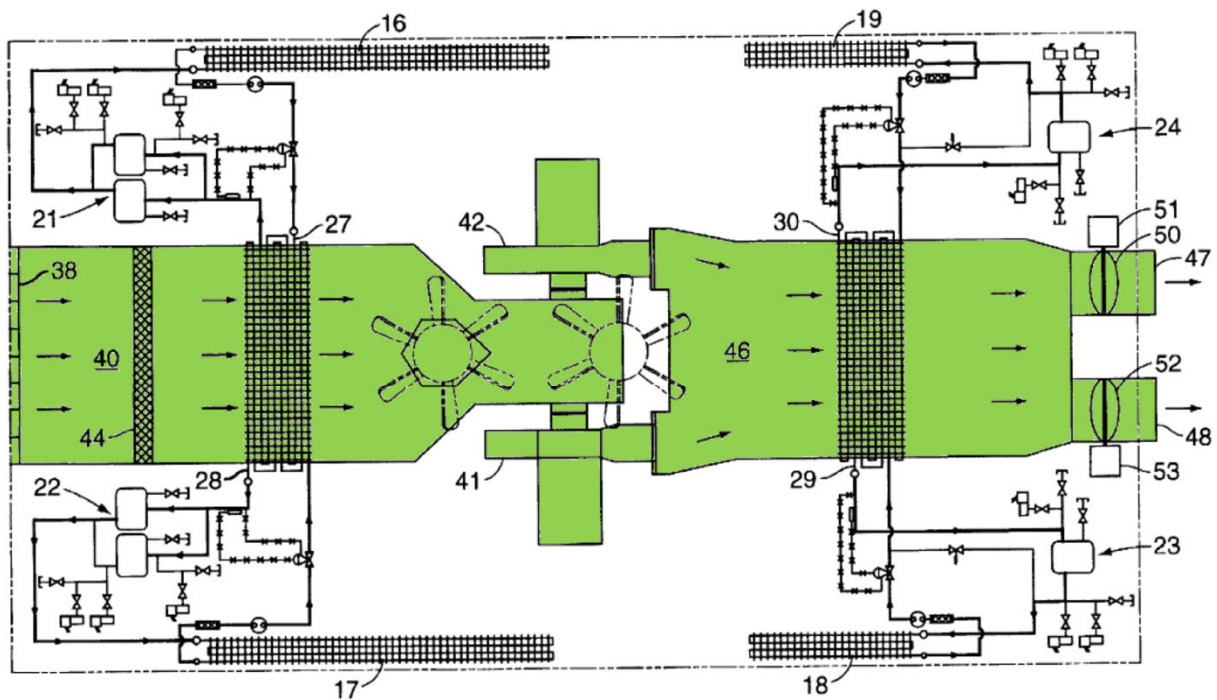


FIG 3
Kreymer, FIG. 3 (annotated).

134. The outlet can be connected to an aircraft through hoses. “A first hose 13 is connected to the first outlet 47. A second hose is connected to the second outlet 48.” *Id.* at 2:31-33. “The first hose 13 is connected to. . . a first coupling of the aircraft 9. If necessary, the second hose 14 is connected to. . . a second coupling of the aircraft.” *Id.* at 2:43-47.

3. **2[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and**

135. Kreymer discloses and renders obvious this limitation. For example, Kreymer discloses an embodiment having four refrigeration systems, each with a refrigerant circuit. The refrigerant circuits are annotated in the reproduction of FIG. 3, below.

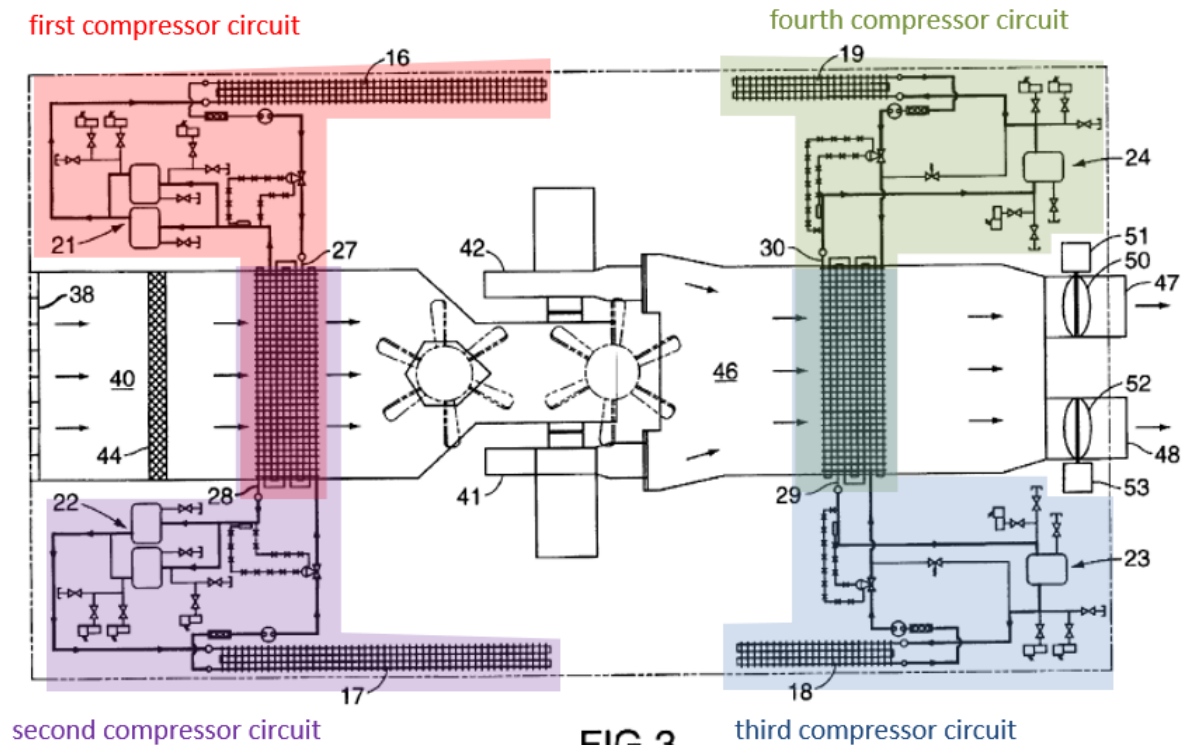
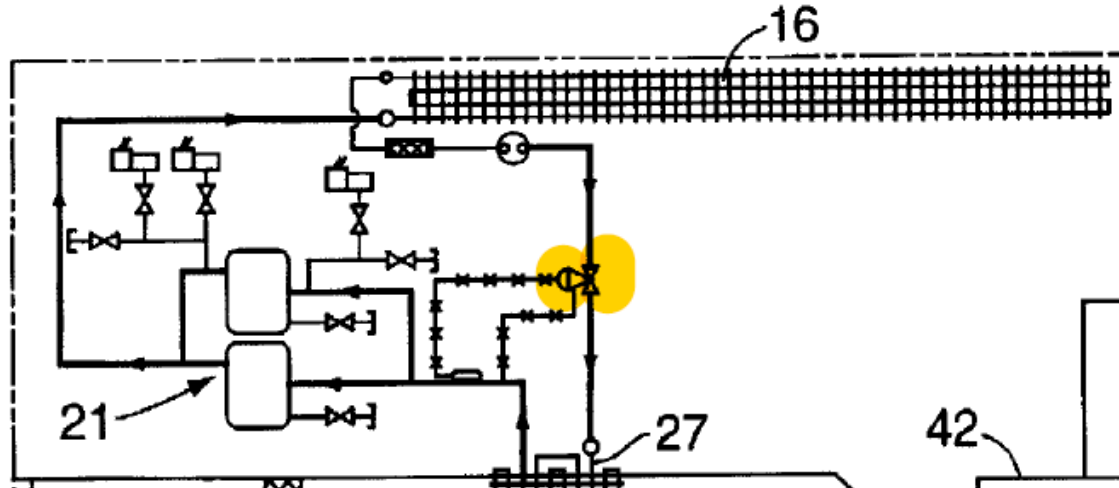


FIG 3

Kreymer, FIG. 3 (annotated).

136. Each refrigerant circuit includes a compressor, a condenser, an expansion valve, and an evaporator. See Kreymer at 2:63-3:10. Kreymer also discloses the evaporator interacting with the air flow in the flow duct: “The primary evaporator coil 32 extends across . . . so that air . . . must pass through the primary evaporator coil 32.” *Id.* at 2:14-21. Similarly, as discussed above, Kreymer discloses a secondary evaporator interacting with the air flow in the flow duct: The secondary evaporator coil 33 extends across . . . so that air . . . must pass through the secondary evaporator coil 33.” *Id.* at 2:23-28.

137. FIG. 3 discloses an expansion valve:



Kreymer, FIG. 3 (excerpted and annotated).

A POSITA examining Kreymer would have understood the highlighted component in the schematic above is the standard schematic symbol for an expansion valve. Each refrigeration circuit in the schematic has the expansion valve. *See id.* at FIG. 3. A POSITA would also have the systems of Kreymer to employ an expansion valve because it is an ordinary part of a refrigeration circuit, as admitted by the applicant of the '169 patent. '169 patent at 6:31-33; *see also* Taras at ¶17.

4. 2[c]: at least one variable frequency driver for power supply of the at least one compressor

138. The combination of Kreymer and Taras discloses and renders obvious this limitation. Taras discloses a “variable frequency drive 75 (‘VFD’) that is connected to the AC motor of compressor 40 and which is also connected to a power source 80.” Taras ¶18. “VFD 75 adjusts the speed of the motor of

compressor 40 by varying the frequency and/or voltage of the power provided to the motor.” Taras at ¶19.

139. As discussed above, it would be obvious for a POSITA to modify each of the compressor motors of the compressors in the refrigeration circuits of Kreymer with the compressor motors driven by VFDs because a POSITA would have understood the benefits of VFD-driven compressors and Taras’s teaching that VFDs provides benefits to an air refrigeration circuit that has varying capacity demands based on the requirements of the conditioned space, such as varying aircraft types. *See* Taras at ¶ 19.

140. Further, also as discussed above, a POSITA would have had a reasonable expectation of success in modifying Kreymer’s compressor motors with Taras’s VFD-driven compressors because using VFDs to control motor speed was a well-known method that yields predictable results.

5. 2[d]: and a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems,

141. The combination of Kreymer and Taras discloses and renders obvious this limitation in many exemplary ways. For example, Kreymer discloses “a remote control . . . electrically connected to the air conditioning unit 10. The remote control switches comprise a start switch 60, a stop switch 61, and a mode selector switch 62” based on the type of aircraft. Kreymer at 2:34-40. Based on

the user's selection of a setting in the "mode selector switch 62" that alters the number of compressors and blowers operating and the configuration of the dampers, a POSITA would have understood that Kreymer's remote control is a central controller or communicates with a central controller for controlling the operation of the PCA and the VFDs in the plurality of refrigeration systems in the combination of Kreymer and Taras. *See* Kreymer at 2:35-40, 2:53-52, 2:66-3:17, 3:45-61, 4:11-15.

142. To the extent Kreymer's remote controller is not a central controller, a POSITA would have found it obvious for Kreymer's system to have a central controller to carry out the instructions received from the remote controller. Specifically, the PCA "is operated automatically after being turned on by the remote control 57." Kreymer at 2:52-53; *see id.* at 2:25-3:10. POSITA would have understood this to indicate the presence of a central controller or "dispatcher" for the four refrigeration circuits in Kreymer's embodiment. Kreymer also discloses that its multiple refrigeration circuits are turned on "if additional cooling is desired" and that its system turns on the additional refrigeration circuits as opposed to turning on and off the entire system while the remote controller indicates the aircraft type. *Id.* at 2:65-3:13.

143. A POSITA implementing Taras's VFDs to drive Kreymer's compressors would have understood VFDs "use[] power electronics to vary the

frequency of the input power to the motor, thereby controlling motor speed.” Carrier at 1. A POSITA would have understood that an overall controller or central controller, which could include a microprocessor and the like, would dispatch the individual stages of Kreymer with commands for speed to each VFD. Thus, a POSITA would have found it obvious to implement a controller to control the operation of the VFDs driving each compressor in each of the plurality of the refrigeration systems in the combination of Kreymer and Taras. *See* Section IX.A (citing, e.g., Ex. 1011 at 7, 11, 57).

144. In another example, the combination of Kreymer and Taras discloses a “system controller” that controls the operation of the VFDs driving the compressors, which a POSITA would have understood to be a central controller. For example, Taras discloses a “[p]ower/control system 230” that controls multiple components in the refrigeration system. Taras at ¶30. “Power/control system 230 has a plurality of variable frequency drives 275 that are operated by the system controller.” *Id.* at ¶31. Thus, Taras’s system controller controls the VFDs in each refrigeration system and also the operation of the VFD by controlling the system’s cooling output.

6. **2[e]: wherein the central controller automatically adjusts the cooling performed by the preconditioned air unit according to at least one of: the selected type of aircraft, the ambient temperature, the humidity, the cabin temperature, or the outgoing airflow from the preconditioned air unit.**

145. The combination of Kreymer and Taras discloses and renders obvious this limitation. For example, Kreymer discloses a “mode selector switch 62 [] turned to a position designating the type of aircraft. . . such as narrow body, wide body or jumbo body.” *Id.* at 2:51-56. Once the operator selects the type of aircraft, the unit automatically configures itself to provide the amount of cooling and the direct the airflow by adjusting the refrigeration systems, blowers and dampers. *See id.* at 2:59-3:62; *see also id.* 2:52-53(“The air conditioning unit 10 is operated automatically after being turned on.”). The selected position of selector switch 62 is used to adjust the amount of cooling and the operation of blowers and dampers. *See id.* at 2:52-3:62. Specifically, as discussed above, based on the user’s selection of a setting in the “mode selector switch 62,” the central controller alters the number of compressors and blowers operating and the configuration of the dampers, i.e., “the outgoing airflow from the preconditioned air unit.” *See* Kreymer at 2:35-40, 2:53-52, 2:66-3:17, 3:45-61, 4:11-15. And as a result, the central controller “automatically” adjusts the cooling performed by the PCA as a result of the type of aircraft the PCA cools. This disclosure matches the ’169 patent’s disclosure of the central controller “automatically adjust[ing] the cooling

performed by the [PCA] to the *selected type* of aircraft,” including “wide body” aircraft. ’169 patent at 10:18-22, FIG. 2.

146. To the extent Kreymer does not disclose a central controller to automatically adjust the cooling performed by its PCA in response to the claimed variables, a POSITA would have found it obvious to add a central controller to the combination of Kreymer and Taras that performs such functions. Indeed, a POSITA implementing Taras’s VFDs to drive Kreymer’s compressors would have understood VFDs “use [] power electronics to vary the frequency of the input power to the motor, thereby controlling motor speed.” Carrier at 1. Kreymer plainly operates with a central controller informed or provided by the remote control in order to dispatch the operation of Kreymer’s four refrigeration sections as needed. Adding the VFDs of Taras simply provides or illustrates the obvious possibility of more choices on the spectrum of operating level or effort, again, to be dispatched or selected by a central controller. Thus, a POSITA would have understood and found it obvious to automatically adjust speed of the VFDs and thus the cooling performed by the PCA based on the type of aircraft on Kreymer’s mode selector switch or as informing a central controller.

147. Further, the combination of Taras and Kreymer discloses that Taras’s “[p]ower/control system 230 provides electric power for driving the components, e.g., compressor 40 and fans 55 and 65, as well as control over one or more of the

components of the vapor compression system 20.” Taras at ¶30. Taras describes its “vapor compression system 20,” which is driven by the central controller “[p]ower/control system 230,” being operated “at speeds different from a normal operating speed to satisfy the conditioned space thermal load, adjusting a speed of said electric motor to satisfy the conditioned space thermal load, wherein said speed is adjusted by a variable speed device (75, 175, 275).” *Id.* at ¶¶ 30-31; *see id.* at cl. 13. A POSITA would have understood “thermal load,” to be the required interior space cooling requirements, including the ambient temperature, the humidity, the cabin temperature, and the type of aircraft (i.e., the amount of space required to be cooled).

C. Claim 3: A preconditioned air unit according to claim 2, wherein the housing further accommodates at least one condenser fan positioned for generation of an airflow interacting with at least one of the condensers of the plurality of refrigeration systems.

148. The combination of Kreymer and Taras renders claim 3 obvious. Kreymer discloses “[a] first condenser fan 35 and a second condenser fan 36 [] placed adjacent to condenser fan outlets in the air conditioning unit.” Kreymer at 2:6-10. The first condenser fan 35 and the second condenser fan 36 are within, i.e., “accommodate[d]” by the frame, i.e., housing. Figures 2 and 3, annotated below, illustrate these condenser fans:

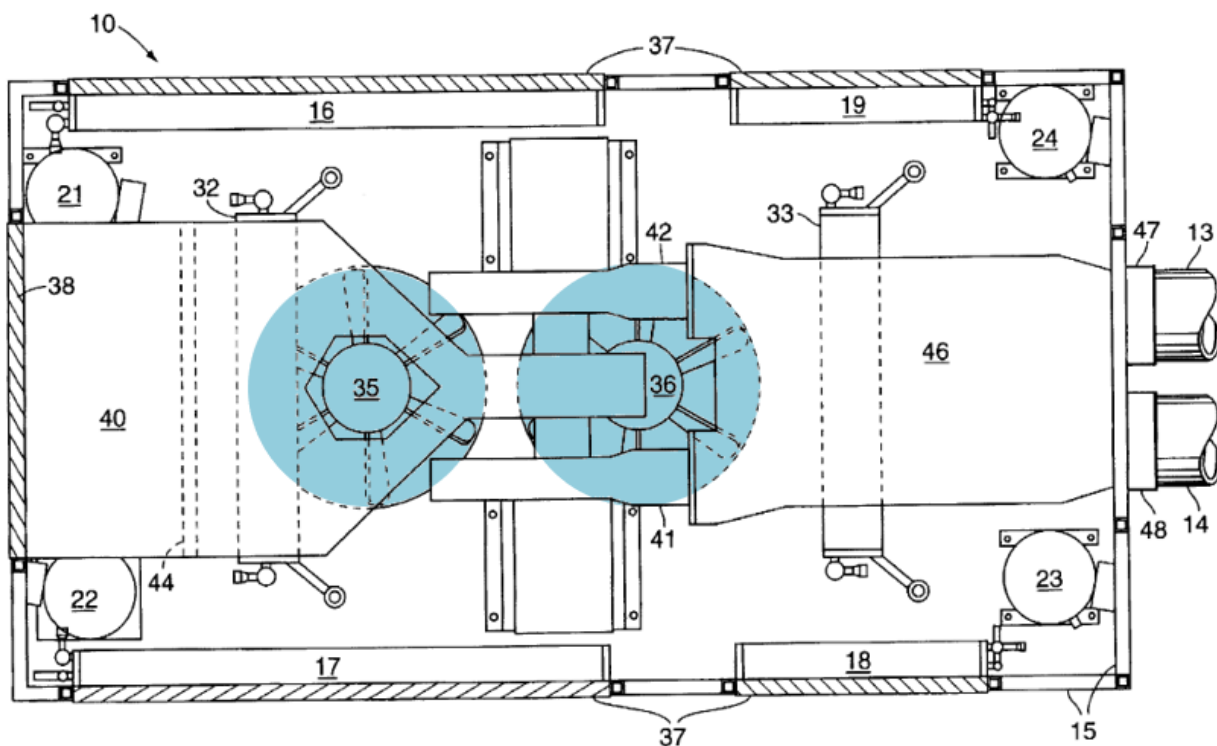


FIG 2

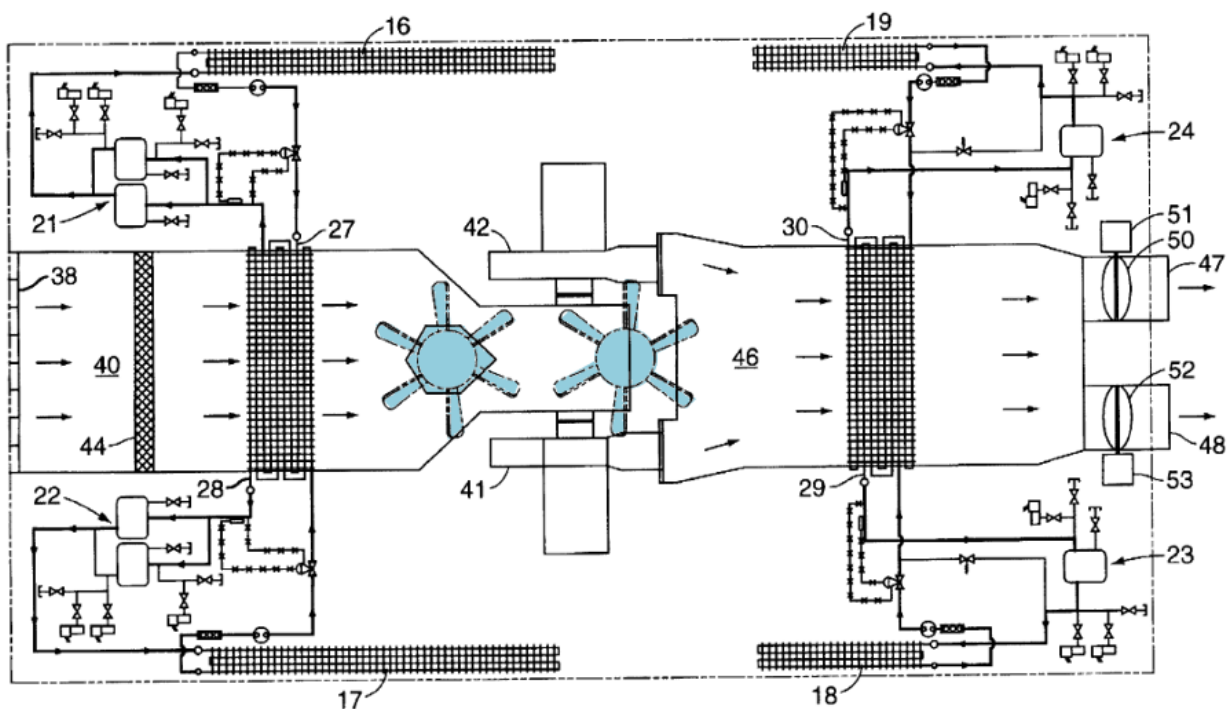


FIG 3

149. The condenser fans generate an airflow which interacts with all of, and therefore “at least one,” of the condensers 16-19. As annotated below, the condenser fans blow air out of an outlet on the bottom of the unit (red arrows in Figure 1), which draws air through the condenser intakes 37 on the side of the unit to interact with condensers 16-19 (blue arrows in Figure 2). See Kreymer at 2:8-10 (“Condenser air intakes 37 are placed adjacent to the first, second, third, and fourth condenser coils 16, 17, 18, 19.”).

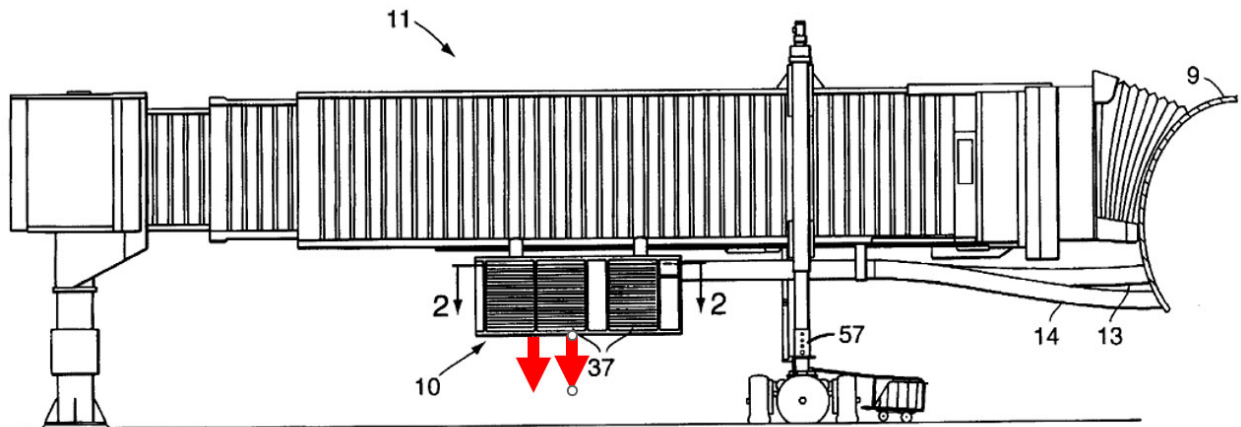


FIG 1

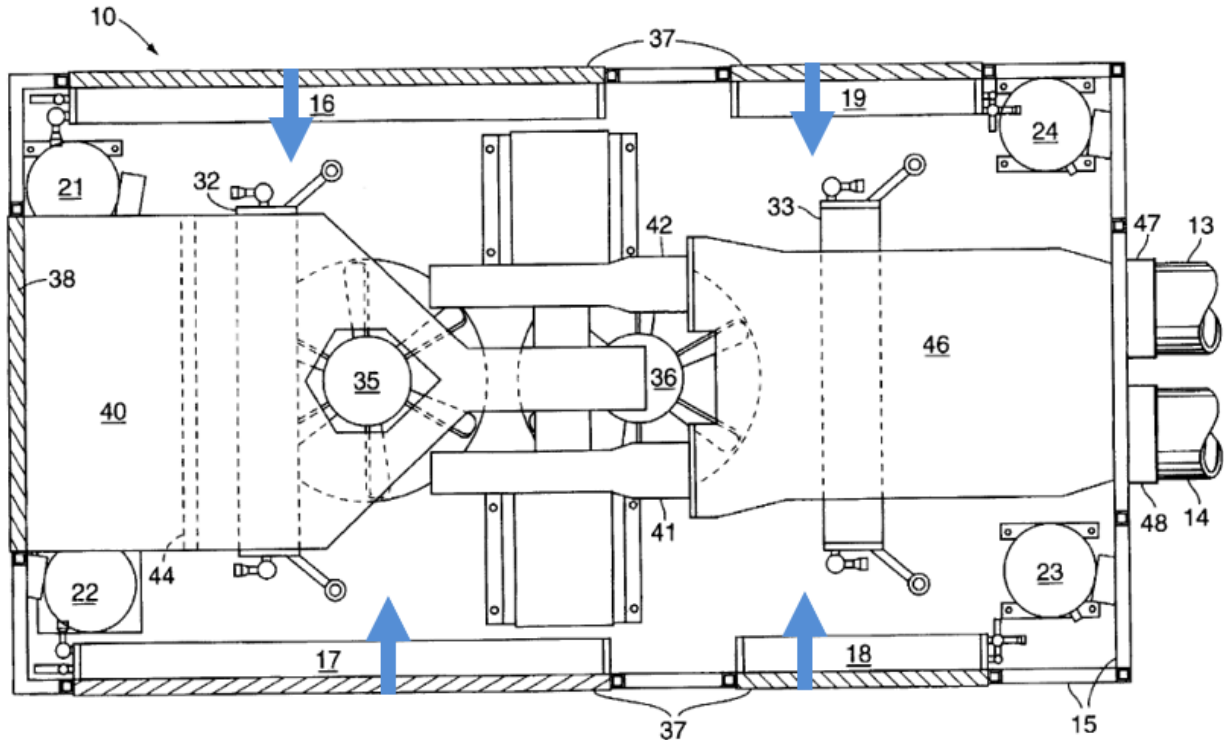


FIG 2

150. A POSITA also would have understood by 2009 that condenser fans were conventional, well-known components of air refrigeration systems to generate airflow that interacts with condensers to remove heat from the refrigeration system through the condensers. For example, Taras discloses a condenser fan that generates airflow that interacts with the condenser. Taras ¶17 (“fan[] 55... in fluid communication with the condenser 50”), cl. 9 (“condenser fan 55”). In other words, a POSITA would have understood that condenser fans are useful for helping air interact with the condenser to remove heat from a refrigeration system. *See* Kreymer at 2:57-62 (“The first condenser fan 35 blows air out of the adjacent outlet, causing air to enter through the condenser air intakes

37. If additional cooling is desired, the second condenser fan 36 blows air out of the adjacent outlet, causing more air to enter through the condenser air intakes 37.”).

D. Claim 4: A preconditioned air unit according to claim 2, wherein the housing further accommodates at least one variable frequency driver connected for power supply of at least one condenser fan for generation of an airflow interacting with at least one of the condensers of the plurality of refrigeration systems.

151. The combination of Kreymer and Taras renders claim 4 obvious. As discussed with respect to claim 3, the combined system includes condenser fans that generate airflow interacting with a condenser. Kreymer at 2:6-10; Taras at ¶17. Moreover, Taras discloses a VFD connected to and supplying power to a condenser fan. Taras at ¶31 (“Each of the VFDs are connected to various components of the refrigerant system 20, such as, for example . . . the [condenser] fan[] 55”).

152. A POSITA would have been motivated to incorporate Taras’s VFD to drive the condenser fan of the combined system to obtain an adjustable amount of air flow across the condensers. Indeed, it would have been known to a POSITA by 2009 that VFDs were widely used in driving fans in “HVAC applications” and the benefits associated with such usage, such as many benefits including being more energy efficient than an on/off approach and reducing thermal and mechanical stresses on motors and belts during starts. *See* Carrier at 4 (describing

the benefits of VFD); Taras at ¶22 (“This allows for selective variable speed control of the fan motors”); *see also id.* at ¶19 (“speed adjustment will improve system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system change or a user alters the conditioned space setpoint”); Section IX.A.

E. Claim 5: A preconditioned air unit according to claim 2, wherein the housing further accommodates a variable frequency driver connected for electrical power supply of the blower.

153. The combination of Kreymer and Taras render obvious claim 5. For example, Kreymer discloses a system having two blowers 41, 42 that may be enabled or disabled in accordance with the amount of airflow desired by an application. Kreymer at 3:63-4:3. This on/off adjustment of airflow provided by the dual blower system, however, is binary and not well-suited for an application, such as a PCA, where there are a variety of cooling capacity requirements based on different aircraft sizes. Taras further discloses the use of VFDs for a blower fan.

154. For example, Taras discloses an evaporator 60, and an evaporator fan 65 that is a blower generating air flow through that evaporator. Taras at ¶17. A POSITA would have understood the blower fan of Kreymer, which generates air flow through the evaporator to be comparable to the evaporator fan of Taras, which performs the same function. Kreymer at 2:11-21; Taras at ¶¶17, 31. A POSITA

would have found it obvious to incorporate Taras's VFD to drive the blowers of Kreymer to obtain finer adjustments of the air flow in Kreymer. *See* Taras at ¶22 ("This allows for selective variable speed control of the fan motors"); *see also id.* at ¶19 ("speed adjustment will improve system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system change or a user alters the conditioned space setpoint"); ¶31 ("Each of the VFD's are connected to the various components of refrigerant system 20, such as, for example, the motor of compressor 40 and the motors of each of the fans 55 and 65 [evaporator fan]."). As discussed regarding claim 4, by 2009 a POSITA would have understood that a variable-frequency approach offers many benefits including being more energy efficient than an on/off approach, and reducing thermal and mechanical stresses on motors and belts during starts. Carrier at 4 (describing the benefits of VFD driving fans in HVAC application), as well as potentially reducing external noise from the PCA..

F. Claim 6: A preconditioned air unit according to claim 2, wherein at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver.

155. The combination of Kreymer and Taras renders obvious claim 6 in light of the additional teachings of Taras's variable frequency drivers. Taras discloses that "the plurality of variable frequency drives 275 [] are operated by the system controller." Taras at ¶31. The VFDs that drive compressor motors

“adjust[]the speed of the motor of the compressor by varying the frequency . . . of the power provided.” *Id.* at ¶19. A POSITA would have understood that a VFD’s output frequency is altered by using a controller in order to alter the speed setting of the motor and thus the cooling capacity of a system. Indeed, it was well-known by 2009 that VFDs “use[] power electronics to vary the frequency of the input power to the motor, thereby controlling motor speed.” *Carrier* at 1; *see also Sasaki* at 4:28-42. A POSITA would have understood “power electronics” to include a controller configured for varying the output frequency of a VFD in a PCA system. *Ex. 1011* at 57 (describing a microprocessor controller “in most” VSDs, i.e., VFDs).

G. Claims 7 and 8: A preconditioned air unit according to claim 6, wherein the controller is configured for variation of the output frequency of the at least one variable frequency driver above the frequency of the mains supply of the preconditioned air unit.

156. The combination of *Taras* and *Kreymer* renders claims 7 and 8 obvious in view of *Taras*’s VFD teachings. *Taras* discloses that the system controller can provide an output frequency of the combination’s VFD higher than the frequency of the power supply. For example, *Taras*’s Figure 3, annotated below, illustrates a system in which the compressor may be powered either by the VFD 275 or directly by the mains supply, i.e., power source 80, depending on the state of the bypass switch 92. *Taras* at ¶31.

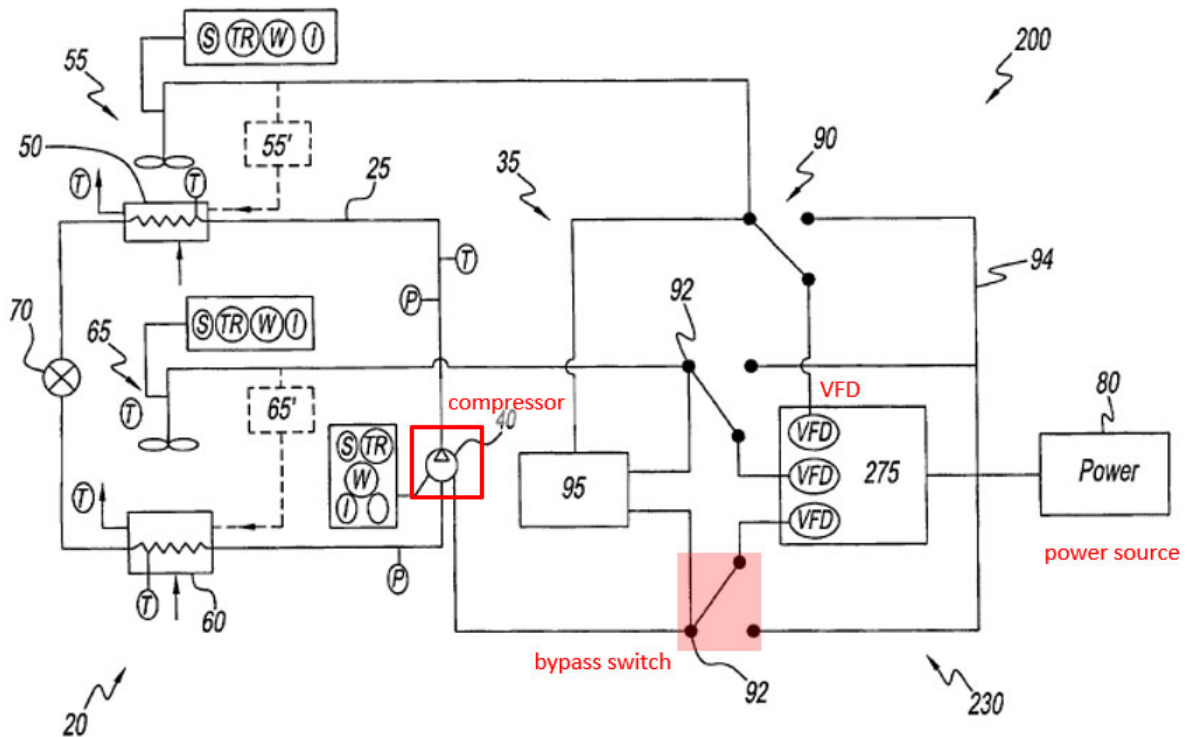


Fig. 3

Taras, FIG. 3 (annotated)

157. When the bypass switch is configured such that the compressor is powered directly by the mains supply, the compressor operates at “the normal operating speed.” Taras at ¶19. It is well within the knowledge of a POSITA that the compressor motor speed—which, in the Kreymer-Taras combination is driven by the VFD—operates proportional to the frequency of electrical supply of the motor. *See* Carrier at 3 (“Speed (rpm) = frequency (hertz) x 120 / no. of poles”). Thus, as an example, in the Kreymer-Taras combination, the compressor motor operates at the frequency of the main supply at one point. *See* Taras at ¶19. In

contrast, at another point in time, the VFD can vary the frequency provided such that “the motor of compressor 40 [runs] at lower or *higher than normal operating speed*.” *Id.* (emphasis added). A POSITA would have understood that the speed of a motor is directly proportional to the frequency of the electricity supplied to it so that operating the “motor of compressor 40” “higher than normal operating speed” requires increasing the output frequency of the VFD supplying power above the frequency of the power supply—thus, in the combined system, the controller is configured to vary the output frequency of at least one VFD driving a compressor motor to provide an output frequency higher than the frequency of the mains supply.

H. Claim 9: A preconditioned air unit according to claim 2, wherein the housing further accommodates a rectifier connected to a mains supply input of the air unit for generation of a power DC voltage supply.

158. The combination renders obvious claim 9 in light of Taras’s teachings and the knowledge of a POSITA. A POSITA designing a PCA for parked aircraft would have understood using an airport’s AC supply main was a preferred power source and thus would motivate a POSITA to convert AC power to a DC voltage supply for the components in a PCA. *See* Lechmotoren at 1a:10-15, 1a:23-2:6, 2:22-27. For example, Taras discloses that “[t]he power electronics used to adjust or control the frequency and voltage via VFD 75 are known in the art, such as for example, rectifiers and inverter bridges.” Taras at ¶19. A POSITA would have

known that Taras's rectifier in a VFD is one of the "three basic sections" of a VFD. *See, e.g.,* Carrier at 3 ("[T]he three basic sections of the VFD: the rectifier, dc bus, and inverter."); Schnetzka at ¶3 ("A variable speed drive (VSD) for heating, ventilation, air-conditioning and refrigeration (*HVAC&R*) applications typically includes a rectifier or converter, a DC link, and an inverter.") (emphasis added); *see* Carrier at 1 (stating "VSD" is a "more generic term" for VFD).

159. The POSITA would also have known that Taras's rectifiers convert AC power from a mains supply (e.g., power supply 80) to DC voltage. As a result, it would have been obvious to a POSITA for the rectifier to be connected to the mains power supply of the PCA to generate a power DC voltage supply because rectification of the AC power supply into DC voltage is the first step of the well-known power electronics circuitry used to provide a variable-frequency power supply.

- A. Claim 11: A preconditioned air unit according to claim 2, further comprising at least one of: a user interface panel with input keys and a display, a remote control, a computer interface, a network interface, or a loudspeaker.**

160. The combination renders claim 11 obvious in light of Kreymer's disclosures. For example, Kreymer discloses "a remote control 57 . . . with [] remote control switches electrically connected to the air conditioning unit 10." Kreymer at 2:35-40; *see id.* at 4:9-15 ("In another embodiment, for the control switches, a set of push buttons may be used to replace the start button and the mode

selector switch. Instead, three buttons may be used with a push button to start the air conditioning unit for a narrow body, and a push button to start the air conditioning unit for a wide body, and another push button to start the air conditioning unit for a jumbo body.”); *id.* at cl. 7 (“designating *on a control panel* whether the aircraft has a first designation a second designation, or a third designation”) (emphasis added).

A. Claim 12: A preconditioned air unit according to claim 2, further comprising a heater in the flow duct.

161. The combination renders claim 12 obvious in light of Kreymer’s disclosures. For example, Kreymer discloses a “resistance heating or other types of heating across the first chamber or second chamber,” which as discussed in claim 2[a], forms a flow duct for ambient air and an air outlet for connection with the parked aircraft. Kreymer at 4:4-8; Section IX.B.2.

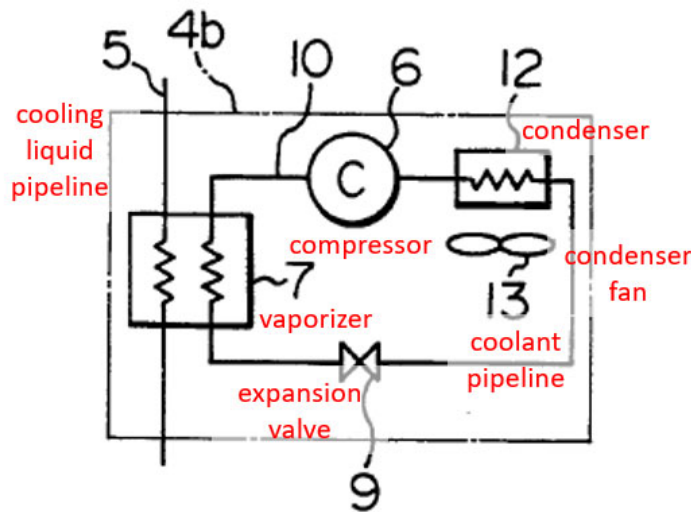
X. A POSITA would have found claims 14-22 obvious in view of the combination of Kreymer, Taras, and Takahashi

A. A POSITA would have combined Kreymer, Taras, and Takahashi.

162. Takahashi is in the same field of endeavor of Kreymer, Taras, and the ’169 patent, which includes refrigeration systems that employ well-known thermodynamic principles. *See, e.g.*, Takahashi at 4:9-28 (describing a cooling unit having a compressor, condenser, evaporator, and expansion device); *see also* Takahashi at FIG. 3 (reproduced below). Indeed, a POSITA interested in exploring

the known design choices for control of a refrigeration system with VFDs would look to other refrigeration systems comprising a compressor, condenser, evaporator, and expansion device also controlled by motors regulated by VFDs to evaluate the known options for the control of such systems. Accordingly, Takahashi, Kreymer, and Taras are analogous to each other and the '169 patent.

FIG. 3



Takahashi, FIG. 3 (annotated).

163. A POSITA would have been motivated to combine Takahashi with Kreymer and Taras to obtain a fault tolerant PCA system. For example, Kreymer discloses a multi-unit refrigeration system with multiple refrigerant circuits that can be enabled to provide additional cooling when needed depending on the aircraft type inputted into the “mode selector switch.” Kreymer at 2:34-40.

Kreymer discloses a desire for redundancy in the case of failure, such as in the case of a blower. Kreymer at 3:67-4:2. When combined with Taras, the system uses VFDs to control the compressors and adjust the cooling capacity of the system. Taras describes that using a VFD to enable a compressor to “run at lower or higher than normal operating speed,” i.e., “speed adjustment” will “improve system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system change or a user alters the conditioned space setpoint.” Taras at ¶ 19. With the application of VFDs, which can vary speed of the refrigeration components, a POSITA would have been motivated to look for prior art solutions for redundancy that employ VFDs rather than a purely on/off approach. Taras’s refined speed adjustment approach is tailored to the specific capacity needs of the application; in the PCA application for parked aircraft, capacity needs are varied, as discussed in Kreymer. A POSITA would be motivated to implement methods to detect suboptimal performance and system failure, and to use excess capacity in the PCA while cooling a particular aircraft to ameliorate loss of capacity due to a failure or pathology in part of the PCA system. *Id.*; Kreymer at 2:25-3:13.

164. Takahashi discloses a multi-cooler refrigeration system employing VFDs and controllers that detect operational abnormalities, disable the relevant module in response to those detected abnormalities, and adjust the cooling

performance of other modules in response to the failure. *See id.* 7:17-66; *see also* Takahashi 3:41-4:2.

165. A POSITA would have recognized the fault-tolerant feature as an obvious feature of a PCA system having multiple refrigerant circuits, such as Kreymer's, for the reasons discussed above: Kreymer and Taras supply motivation for a POSITA to build redundancies into a multi-refrigeration unit PCA system that is adjusted to operate for varying cooling capacity applications in variety of aircraft. And Takahashi's provides an additional solution—specifically, it provides a fault-tolerant architecture allowing a refrigeration system with multiple refrigerant circuits and VFDs, such as the Kreymer PCA combined with Taras's VFDs, to preserve its required cooling output upon failure of one of the refrigerant circuits, by increasing the operation of the remaining refrigeration circuits to compensate the loss resulting from the failure of a specific circuit. *See* Takahashi at 7:17-66. A POSITA would have understood the benefits and mechanisms for monitoring critical components in a PCA and returning a “fault” in case a refrigeration system is operating suboptimally and has failed or is about to fail. *See* Ex. 1011 at 231 (listing system faults and alarms).

166. A POSITA would have been motivated to modify the controller architecture of Kreymer and Taras, discussed above, with insight from the controller architecture of Takahashi, to implement its fault-tolerant controller

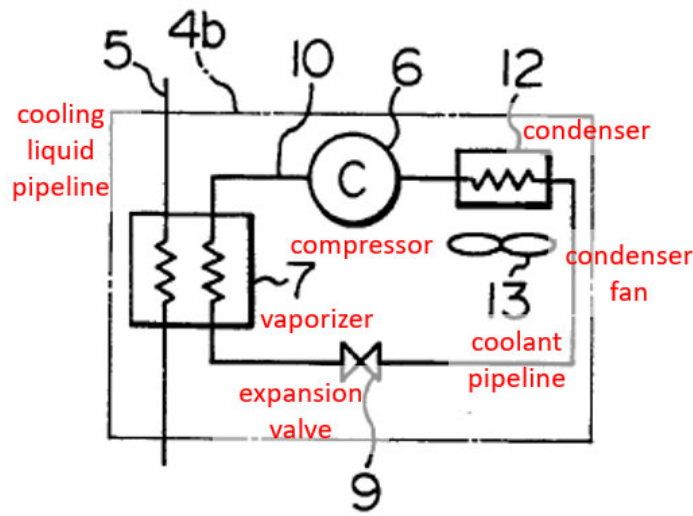
architecture and implement a well-known design choice to realize the benefits of a redundant, multi-refrigerant circuit system of the Kreymer-Taras PCA system capable of adjusting refrigeration levels for providing conditioned air to different types of aircraft. Specifically, a POSITA would have modified Kreymer-Taras Takahashi's use of individual unit controllers to control respective refrigerant circuits and communicate with the combination's central controller, as discussed above in Ground 1. *See e.g.*, Takahashi at FIG. 1 (reproduced above). For example, the unit controllers provide monitoring of sensors relating to their respective refrigerant circuits and can report failures to the central controller. *Id.* at 7:17-21. When the unit controllers detect an abnormality, the unit controller may stop operation of the refrigerant circuit and send a signal that an abnormality was detected to the central controller. *Id.* at 7:40-45. Finally, the central controller may increase its overall output capacity by engaging the remaining refrigerant circuits' output to compensate for cooling capacity loss from a limited or failed circuit. *Id.* at 7:45-66. Thus, as discussed above, a POSITA seeking redundancy and the ability to monitor multiple fine-tuned refrigeration systems in a PCA system for varying capacity requirements would have been motivated to modify the VFD-drive PCA system of the Taras-Kreymer combination to include the failure monitoring and response control system of Takahashi. Kreymer invites POSITA to do this with the discussion of redundancy. Kreymer at 4:1.

167. A POSITA would have had a reasonable expectation of success in implementing the modification of the VFD-drive PCA of the Taras and Kreymer combination with the fault-tolerant system of Takahashi. The controller architecture of Takahashi employs well-known elements, *e.g.*, controllers, sensors, and communication lines, to perform well-known functions, *e.g.*, monitor, control, measure, exchange information related to the system cooling performance. *See* Takahashi at 7:17-25 (“The unit controllers 24 always monitor the cooling units 4 to detect abnormalities by a variety of sensors arranged in the cooling units 4 in addition to the variable control of the cooling units 4 in accordance with a command from the controller 23 as described above. The variety of sensors may include a pressure sensor for detecting the pressure of the coolant discharged from the compressor, a temperature sensor for detecting the temperature of the same, and so on.”). These elements are similar to those discussed in Taras for controlling its VFDs based on system operating parameters and cooling performance. *See* Taras at ¶21 (“Sensors are disposed in various positions throughout the vapor compression system 20 to monitor operational parameters of the system. . . . The sensors include, but are not limited to, temperature sensors T (*e.g.*, temperature transducers), pressure sensors P (*e.g.*, pressure transducers), electric current sensors I, power sensors W, torque sensors TR, slip sensors S, transducers for each of these operational parameters, and the like.”) A POSITA thus would have

expected Takahashi's control system to succeed in combination with Taras and Kreymer.

168. Takahashi describes a conventional refrigerant circuit: one that includes a compressor, expansion valve, evaporator, and a compressor operating ON a compressible gas refrigerant, as shown below in annotated FIG. 3:

FIG. 3



Takahashi discloses that its teachings—which apply to standard HVAC&R systems described in Section VIII.A.1.—apply to transferring heat to both liquid and gas loads in contact with the vaporizer. See Takahashi at 4:2-8, FIGS. 2 and 3. A POSITA would have similarly understood the evaporator (vaporizer in Takahashi) could be used to cool either a liquid or gas in contact with the

evaporator and would have reasonably expected to succeed in combining Takahashi with Kreymer and Taras. In other words, the difference between cooling a non-compressible liquid or cooling a compressible gas is immaterial to a POSITA in the context of applying VFD control from Takahashi to the Kreymer-Taras-Takahashi combination. *See, e.g.*, Takahashi at 3:64-4:2. Taras explains this principle, which was within the knowledge of a POSITA by 2009: technological solutions and benefits for controlling and implementing VFDs in refrigeration systems that refrigerate non-compressible liquids (e.g., water) would also work with refrigeration systems that refrigerate compressible gases (e.g., ambient air pumped into an aircraft). Taras at ¶16 (“[T]he particular components of the system can be changed to accomplish the specific space conditioning objective. Such refrigerant system components are known by a person of ordinary skill in the art. For instance, fans moving air across the condenser and evaporator could be replaced by pumps circulating liquid, such as, for example, water or brine, for heat transfer purposes.”); *see also id.* at ¶32 (stating “control methodology” applicable to air flow refrigeration can be applied to liquid pumps); *see* Carrier at 4 (providing benefits from use of VFD in refrigeration systems).

B. Claim 16

- 1. 16[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising**

169. As discussed above for claim 2[pre], Kreymer discloses and renders obvious this limitation. Section IX.B.1. Specifically, limitation 2[pre] is identical to limitation 16[pre]. *Compare* '169 patent cl. 2 with cl. 16.

170. The addition of Takahashi to the Kreymer-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed above, the Kreymer-Taras-Takahashi combination discloses and renders this limitation obvious.

- 2. 16[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet**

171. As discussed above for claim 2[a], the combination of Kreymer and Taras discloses and renders obvious this limitation. Section IX.B.2. Specifically, limitation 2[a] is identical to limitation 16[a]. *Compare* '169 patent cl. 2 with cl. 16.

172. The addition of Takahashi to the Kreymer-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed above, the Kreymer-Taras-Takahashi combination discloses and renders this limitation obvious.

3. **16[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and**

173. As discussed above for claim 2[b], Kreymer discloses and renders obvious this limitation. Section IX.B.3. Specifically, limitation 2[b] is identical to limitation 16[b]. *Compare* '169 patent cl. 2 *with* cl. 16.

174. The addition of Takahashi to the Kreymer-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed above, the Kreymer-Taras-Takahashi combination discloses and renders this limitation obvious.

4. **16[c]: at least one variable frequency driver for power supply of the at least one compressor, and**

175. As discussed above for claim 2[c], the combination of Kreymer and Taras discloses and renders obvious this limitation. Section IX.B.4. Specifically, limitation 2[c] is identical to limitation 16[c]. *Compare* '169 patent cl. 2 *with* cl. 16.

176. The addition of Takahashi to the Kreymer-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed above, the Kreymer-Taras-Takahashi combination discloses and renders this limitation obvious.

5. **16[d]: a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems,**

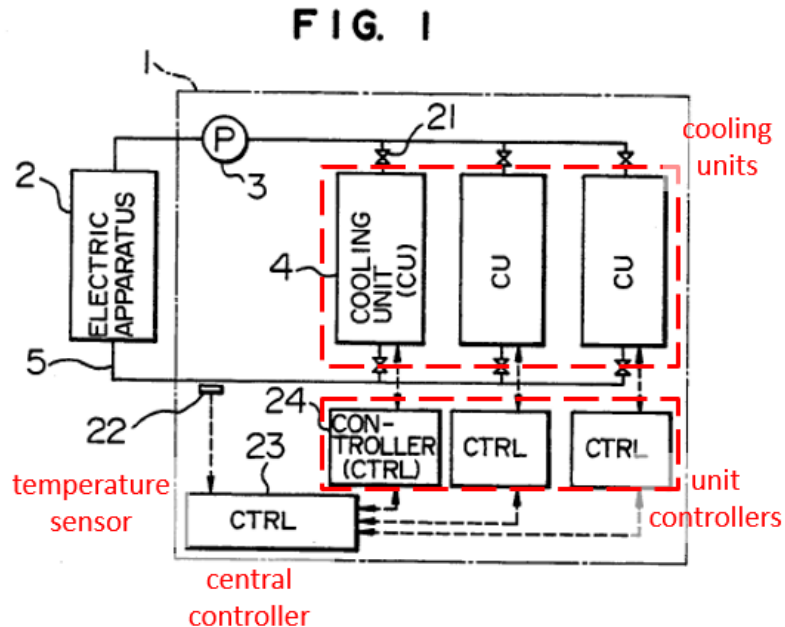
177. As discussed above for claim 2[d], the combination of Kreymer and Taras discloses and renders obvious this limitation. Section IX.B.5. Specifically, limitation 2[d] is identical to limitation 16[d]. *Compare* '169 patent cl. 2 *with* cl. 16.

178. The addition of Takahashi to the Kreymer-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed above, the Kreymer-Taras-Takahashi combination discloses and renders this limitation obvious.

6. **16[e]: wherein each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller.**

179. Takahashi discloses and renders obvious “each refrigeration system of the plurality of refrigeration systems is configured for failure detection.” Takashi discloses an architecture where unit controllers 24 monitors cooling units to detect abnormalities. *See* Takahashi, Figure 3 (reproduced below). “The unit controllers 24 always monitor the cooling units 4 to detect abnormalities by a variety of sensors arranged in the cooling units 4 in addition to the variable control of the cooling units 4 in accordance with a command from the controller 23 as

described above. The variety of sensors may include a pressure sensor for detecting the pressure of the coolant discharged from the compressor, a temperature sensor for detecting the temperature of the same, and so on.” Takahashi at 7:17-45.

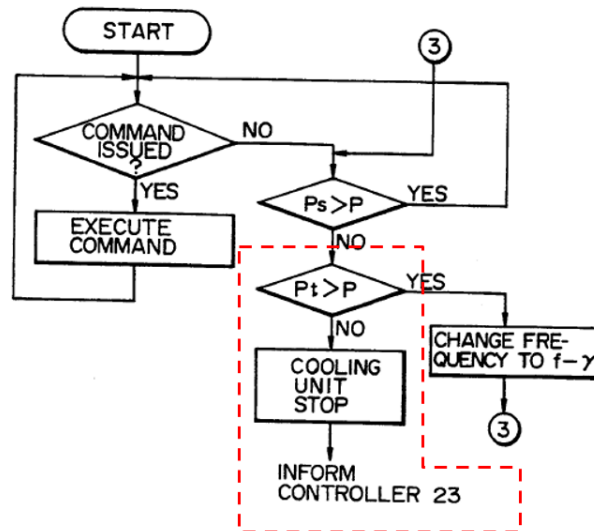


Takahashi, FIG. 1 (annotated)

180. Takahashi further discloses that “in the event that one refrigeration system fails, the failing refrigeration system transmits a failure signal to the central controller.” The unit controller “fetches a pressure value P detected by a pressure sensor 14 arranged in each cooling unit 4.” Takahashi 7:28-31. If the measured pressure value is above “an operation stop level P_t ,” the cooling unit 4 is deemed failed and disabled. Takahashi 7:34-45 (“[T]he unit controller 24 turns the switching circuit 36 off to stop the operation of the cooling unit 4.”) “Then, the unit controller 24 informs the controller 23 of the stopped operation.” *Id.*; *see also*

FIG. 8 (reproduced below) and 3:36-38 (“FIG. 8 is a flow chart showing the operation of a unit controller . . . for detecting an abnormality.”)

FIG. 8



Takahashi, FIG. 8 (annotated)

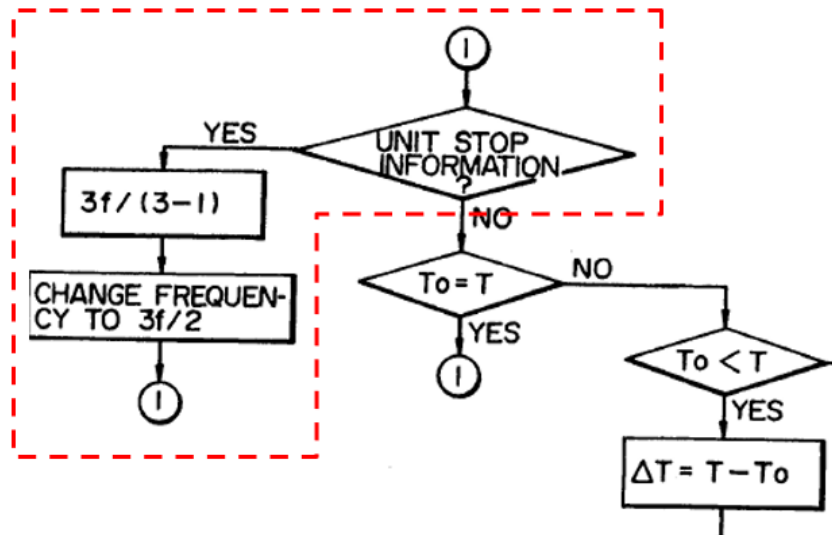
181. As discussed above, a POSITA would have been motivated to apply Takahashi’s controller architecture and transmission of failure signals to the PCA with multiple VFD-driven compressors that result from the Kreymer-Taras combination. Section X.A. The POSITA would also have had reasonable expectation of success in implementing the Kreymer-Taras-Takahashi combination. *Id.*

- C. Claims 17 and 22: A preconditioned air unit according to claim 16, wherein the central controller is further configured to automatically adjust the required amount of cooling among the**

remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal.

182. The Kreymer-Taras-Takahashi combination discloses and renders obvious claims 17 and 22 in view of Takahashi's disclosures. As an initial matter, the Kreymer-Taras-Takahashi combination discloses and renders obvious claims 16.

183. Takahashi discloses that "the central controller [] further configured to automatically adjust the required amount of cooling among the remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal." Specifically, Takahashi describes that the central controller, controller 23, can implement a compensation strategy after failure of a cooling unit by increasing operation in the remaining operating cooling units. "[T]he controller 23 controls the unit controllers 24 to perform a degenerated operation by use of the two cooling units which [are] still operating. . . . [T]he controllers 23 commands the unit controllers 24 connected to the two operating cooling units 4 to change the operation frequency to [1.5x higher frequency] . . . [E]ach unit controller 24 controls the inverter 35 to change the operation frequency in accordance with the command." Takahashi at 7:46-66; *see also id.* at FIG. 7 (reproduced below).



Takahashi, FIG. 7 (excerpted)

184. As discussed above, a POSITA would have been motivated to apply Takahashi's fault-tolerant architecture to preserve cooling output and provide further redundancy to the multi-cooling unit system in Kreymer upon failure of a cooling unit to the PCA with multiple VFD-driven compressors. Section X.A. The POSITA would also have had reasonable expectation of success in implementing the Kreymer-Taras-Takahashi combination. *Id.*

D. Claim 18: A preconditioned air unit according to claim 16, wherein at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver.

185. The Kreymer-Taras-Takahashi combination renders claim 18 obvious in view of Taras's disclosures, as discussed above for claim 6, because the additional limitation of claim 18 is identical to the additional limitation of claim 6. See Section IX.F. The Kreymer-Taras-Takahashi combination also renders claim

18 obvious in view of the additional teachings of Takahashi, which describes “a plurality of unit controllers 24 each for performing a variable control of the individual cooling unit 4 based on a command from the controller 23.” Takahashi at 3:57-64. Takahashi also discloses “the respective unit controllers 24 [] change the operation frequency” of the variable frequency drivers. *Id.* at 6:38-41. A POSITA would find it obvious to implement the control strategy and architecture of Takahashi to control the frequency of the VFDs in the Kreymer-Taras combination to vary the cooling output of the refrigeration circuit. *See id.* at 5:1-4 (“Therefore, if the inverter 35 is controlled to change the operation frequency, the rotational speed of the motor 31 is changed, so that the cooling power of the cooling unit 4 can be adjusted.”). Accordingly, a POSITA would find it obvious to implement the unit controller for variation of the output frequency of the VFDs.

E. Claim 19: A preconditioned air unit according to claim 18, wherein the controller of the variable frequency driver is further configured for adjustment of the output frequency in response to a sensor output connected to the controller.

186. The Kreymer-Taras-Takahashi combination renders claim 19 obvious in view of Takahashi’s additional disclosures. That combination includes a controller (e.g., Takahashi’s controller 23) that sends commands to a unit controller (e.g., Takahashi’s unit controller 24), which adjusts individual VFD’s output frequencies based on the commands. Takahashi also teaches that the controller 23 receives output from a connected temperature sensor 22 and controls the operation

of each cooling unit “based on the difference between a temperature detected by the temperature sensor 22 and a predetermined set temperature.” Takahashi at 3:42-64. The unit controller 24 also monitors its respective cooling unit using a “variety of sensors” such as a pressure or temperature sensor. Takahashi at 7:17-25. Takahashi’s unit controllers 24 adjust output frequency of the respective VFDs in response to sensor output. *See id.* at 7:28-40 (describing lowering output frequency in response to pressure sensor output).

187. A POSITA would have understood the benefits of adjusting the output frequency of the combination’s VFD-driven compressors in response to a sensor output connected to the controller. *See* Section IX.A. Specifically, as described regarding Ground 1, claims 6-8, it was well-known that adjusting the output frequency of the VFD adjusts the speed of the motor driving the compressor and that doing so “improve[s] system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system change or a user alters the conditioned space setpoint,” such as a PCA or parked aircraft. Taras at ¶ 19. Based on these teachings and the knowledge of a POSITA, it would have been obvious to a POSITA to incorporate the connected temperature sensor of Takahashi to adjust the speed of the refrigeration system compressors by varying the output frequency of the combination’s VFDs in response to the sensed pressure/temperature. *See also id.*

F. Claim 20: A preconditioned air unit according to claim 18, wherein the central controller is connected to at least one controller of at least one voltage frequency driver.

188. The Kreymer-Taras-Takahashi combination renders claim 20 obvious. As discussed in connection with claims 18, a combination of Kreymer, Taras, and Takahashi provides a system with a central controller (e.g., Takahashi's controller 23) that is connected to a unit controller (e.g., Takahashi's unit controller 24) that controls a VFD in the combination. *See also* Takahashi at FIG. 1.

G. Claim 21: A preconditioned air unit according to claim 16, wherein at least one variable frequency driver keeps the ratio between the output voltage and the frequency substantially constant to maintain a high motor torque throughout the entire output frequency range.

189. The Kreymer-Taras-Takahashi combination discloses and renders obvious claim 21. It was well-known that, in its rated range, the torque of an AC motor driven by an AC signal is proportional to the ratio between the voltage and the frequency of the signal. Ex. 1034 ("Fitzgerald") at 580-81 (describing the "constant volts-per-hertz" operation). Thus, keeping a constant ratio between the VFD output's voltage and frequency is a well-known strategy that has been utilized by POSITAs decades before the '169 patent's alleged invention to keep the torque in an AC motor constant, as demonstrated by decades-old literature. *See, e.g.*, Ex. 1016 ("Stich") at 1:20-27; Fitzgerald at 580-81. Moreover, this control strategy is particularly relevant here and provides a motivation to implement in the

combination because it can be used to “provide substantially constant torque over a wide speed range,” such as the combination here for a PCA application for cooling aircraft as taught by Taras. Stich at 3:14-21; Taras at ¶ 19 (stating that “speed adjustment” will “improve system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system change or a user alters the conditioned space setpoint.”). This strategy applies whether the motor torque is “high” or not. *See* Stich at FIG. 2a.

190. A POSITA would have been further motivated to operate the combination’s VFD using the volts-per-Hz strategy while keeping the ratio constant because, at least, it was a well-known safeguard against damaging an AC motor operated over a range of frequencies and associated speeds.. Fitzgerald at 580-81 (stating that a reducing the frequency without reducing the voltage in a typical AC motor operating at the rated voltage and frequency “will increase the flux density to the point of potential machine damage” and that “it is typical to operate a machine at constant flux density” using the constant volts-per-hertz operation). A POSITA would have had a reasonable expectation of success because it could implement this well-known strategy in Taras’s VFD that is capable of “adjust[ing] the speed of the motor compressor 40 by varying the frequency and/or voltage of the power provided to the motor.” Taras at ¶19.

H. Claim 14: A preconditioned air unit according to claim 2, wherein each refrigeration system of the plurality of refrigeration systems

is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller.

191. As discussed above, the combination of Kreymer and Taras discloses and renders obvious claim 2. *See* Section IX.B. The Kreymer-Taras-Takahashi combination further discloses and renders obvious this limitation, which is identical to claim 16[e]. *See* Section X.B.6 (claim 16[e]).

I. Claim 15

- 1. 15[a]: A preconditioned air unit according to claim 2, wherein: at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver;**

192. As discussed above, Kreymer and Taras disclose and render obvious claim 2. Taras and Takahashi further disclose and render obvious this limitation, which is identical to the limitations of claims 6 and 18. *See* Sections IX.F, X.D (cls. 6, 18).

- 2. 15[b]: the controller is configured for variation of the output frequency of the at least one variable frequency driver above the frequency of the mains supply of the preconditioned air unit;**

193. Taras discloses and renders obvious this limitation, which is identical to the limitation in claim 7. *See* Section IX.G (cl. 7).

3. **15[c]: at least one variable frequency driver is configured to keep the ratio between the output voltage and the frequency substantially constant;**

194. The knowledge of POSITA in view of Kreymer, Taras, and Takahashi discloses and renders obvious this limitation, which is broader than the limitation of claim 21. *See* Section X.G (cl. 21).

4. **15[d]: each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller; and**

195. Takahashi discloses and renders obvious this limitation, which is identical to the limitation of claims 14 and 16[e]. *See* Sections X.B.6 (cl. 16[e]).

5. **15[e]: the central controller is further configured to automatically adjust the required amount of cooling among the remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal.**

196. Takahashi discloses and renders obvious this limitation, which is identical to the limitation of claim 17. *See* Section X.C (cl. 14).

XI. A POSITA would have found claims 9-10 obvious in view of the combination of Kreymer, Taras, and Carrier

A. A POSITA would have combined Kreymer, Taras, and Carrier

197. Carrier is in the same field of endeavor as both Kreymer, Taras, and the '169 patent, as it is directed to air refrigeration systems implementing well-known HVAC&R techniques, including VFDs and control systems of refrigeration

systems incorporating VFDs. *See also* Section IX.A. Specifically, Carrier explains how to use VFDs to drive compressors, fans, and other components in HVAC&R systems and why a POSITA would want to use VFDs for such applications. *See* Carrier at 2, 10 (listing benefit of VFDs in HVAC&R systems).

198. A POSITA would have been motivated to combine Carrier with Kreymer and Taras to obtain details in the implementation of VFDs as applied to HVAC&R systems. Carrier provides solutions to certain known challenges in the use of VFDs. For example, Carrier explains the role of a rectifier in a VFD: “The rectifier in a VFD is used to convert incoming ac power into direct current (dc) power.” *Id.* at 3. In other words, the VFD is a conduit for power from the main electrical supply to the AC motor, whether that is a compressor, a fan, or another component of a refrigeration system powered by an AC motor. “A VFD may have multiple rectifier sections, with 6 rectifiers per section, enabling a VFD to be ‘12 pulse,’ ‘18 pulse,’ or ‘24 pulse.’” *Id.*; *see also id.* at 9 (“There are a minimum of six rectifiers for a three- phase AC VFD. There can be more, however. Manufacturers offer 12, 18, 24, and 30 pulse drives.”). Moreover, a POSITA would have understood that Taras was assigned to Carrier Corporation and that a POSITA would similarly look toward Carrier to implement VFDs in HVAC&R systems, including the systems in Taras and Kreymer.

199. One problem with VFDs is that they create harmonics, which is a “current form at an integral multiple of the fundamental frequency,” which in the United States is 3-phase, 60 Hz. *Id.* at 6-7. A POSITA would have understood that a VFD that is connected to a three-phase, 60hz AC voltage supply—the standard in the US—would have created harmonics, that harmonics can damage equipment in a system, and that electrical standards encourage reducing harmonics. *See id.* at 7-8. Thus, a POSITA would have been motivated to reduce harmonics caused by VFDs in a system. A POSITA would have implemented the teachings of Carrier to mitigate this problem. For example, Carrier states multi-pulse VFDs can mitigate potential harms from harmonics generated by VFDs. *See id.* at 10 (“The two wave forms [from multi-phase rectifiers] effectively cancel each other out.”); *id.* at 9; *see also id.* at 6 (“When evaluating VFDs, it is important to understand how harmonics are provided and the circumstances under which harmonics are harmful.”). A POSITA implementing a 3-phase VFD would have understood there are a “minimum of six rectifiers” so that the harmonics created by the VFD for each phase would cancel out, reducing the harmonics. *See id.* at 9 (“There are a minimum of six rectifiers for a three- phase AC VFD. . . . If the power connected to each set of rectifiers is phase shifted, then some of the harmonics produced by one set of rectifiers will be opposite in polarity from the harmonics produced by the other set of rectifiers. The two wave forms effectively cancel each

other out.”). A POSITA would have known of the problem of harmonics generated by VFDs and recognized that the multi-pulse technique to mitigate harmonics described in Carrier would improve the VFDs disclosed in Taras. Use of Carrier’s technique is, moreover, well within the skill of a POSITA. *Id.*; *see also* Carrier at 4. Indeed, Carrier states “VFD installation is as simple as connecting the power supply to the VFD.” *Id.* at 10.

200. A POSITA had a reasonable expectation of success when combining Kreymer with Carrier and Taras. In fact, Carrier is, itself, an instructional white paper directed to the goal of instructing a POSITA on how to use VFDs in HVAC&R systems. Carrier at 2 (“This paper is intended to provide a basic understanding of common VFD terms, VFD operation, and VFD benefits.”). Carrier explains VFDs are a plug-and-play solution. *Id.* at 10 (“VFD installation is as simple as connecting the power supply to the VFD.”). Accordingly, a POSITA implementing a rectifier to obtain a multi-pulse VFD as instructed by Carrier would predictably obtain mitigation of the presence and effects of harmonics. Carrier at 9.

B. Claim 9: A preconditioned air unit according to claim 2, wherein the housing further accommodates a rectifier connected to a mains supply input of the air unit for generation of a power DC voltage supply.

201. As discussed above in Section IX.B, Kreymer and Taras disclose and render obvious claim 2. Carrier further discloses and renders obvious the

additional limitation of claim 9. Carrier explains that a VFD generally includes a rectifier. “[T]he three basic sections of the VFD: the rectifier, dc bus, and inverter.” Carrier at 3. The rectifier is connected to a mains supply. “The rectifier in a VFD is used to convert incoming ac power into direct current (dc) power.” *Id.* The rectifier is used to generate a DC voltage supply in a dc bus: “After the power flows through the rectifier it is stored on a dc bus.” *Id.*

C. Claim 10: A preconditioned air unit according to claim 9, wherein the rectifier is selected from the group consisting of a 12-pulse rectifier, an 18-pulse rectifier, and a 24-pulse rectifier.

202. As discussed above, Kreymer and Taras disclose and render obvious claim 9. Carrier further discloses and renders obvious the additional limitation of claim 10. Indeed, as discussed above, a POSITA would be motivated to include a multi-phase VFD to reduce harmonic distortion, which in the US, would mean using at least a six-pulse rectifier. *Id.* Carrier provides multiple examples of rectifiers that might be implemented in a VFD to reduce harmonics, including that the “VFD may have multiple rectifier sections, with 6 rectifiers per section, enabling a VFD to be ‘12 pulse,’ ‘18 pulse,’ or ‘24 pulse.’” *Id.* at 3; *see also id.* at 9 (“There are a minimum of six rectifiers for a three- phase AC VFD. There can be more, however. Manufacturers offer **12, 18, 24**, and 30 pulse drives.”) (emphasis added).

XII. A POSITA would have found claims 1, 2, and 13 obvious in view of Lechmotoren and Taras

A. A POSITA would have combined Lechmotoren and Taras

203. Lechmotoren and Taras are analogous to each other, as they both relate to air refrigeration systems. Lechmotoren discloses an “air conditioning unit for air conditioning . . . of aircraft[] on the ground.” Lechmotoren at 1:10-13. The air conditioning unit can use “one or more air-conditioning packs” that can “provide both cooling output and heating output.” Lechmotoren at 4:9-17. The packs “can also work with a thermodynamic cycle with compressor and condenser and can therefore provide heating and/or cooling output as required.” Lechmotoren at 10:7-11. Taras discloses improvements to these types of air refrigeration systems. For example, Taras discloses a refrigerant system that includes “typical components for achieving desired characteristics [i.e., cooling and heating] in the conditioned space.” Taras at ¶17 (describing system having compressors, condensers, evaporators, expansion devices in a refrigerant circuit).

204. Lechmotoren is analogous to the '169 patent, as they both relate to PCAs. Lechmotoren discloses “an air conditioning unit for air conditioning . . . aircraft[] on the ground,” Lechmotoren at 1:10-13, and performs that operation by preconditioning air in a housing external to the aircraft and blowing the conditioned air to the cabin. *See id.* at 10:27-35. The '169 patent is directed to “a

preconditioned air unit supplying preconditioned air . . . to an aircraft parked on the ground.” ’169 patent at 1:13-15.

205. Taras is analogous to the ’169 patent, as they both relate to air refrigeration systems that employ conventional air refrigeration technology. Specifically, the ’169 patent is directed to a PCA system that preconditions air using “self-contained cooling modules 36 [that] operate[] in accordance with well-known refrigerator principles.” ’169 patent at 6:23-33. These described self-contained cooling modules operating in accordance with well-known refrigerator principles are air refrigeration systems. Taras discloses improvements to these types of air refrigeration systems. For example, Taras discloses a refrigerant system that includes “typical components for achieving desired characteristics [i.e., cooling and heating] in the conditioned space.” Taras ¶17 (describing system having compressors, condensers, evaporators, expansion devices in a refrigerant circuit).

206. A POSITA would have been motivated to combine Lechmotoren and Taras to obtain a PCA with multiple refrigeration units that employs VFDs to drive its various motors, including its compressors, as detailed below.

207. Lechmotoren discloses a PCA unit having “one or more air-conditioning packs” that can “provide both cooling output and heating output.” Lechmotoren 4:9-17. In some embodiments, these packs are conventional air

refrigeration systems. *See* Lechmotoren 10:7-11. Each “air-conditioning pack (4) has a variable and controllable output.” *Id.* 8:3-4. The variable and controllable output in Lechmotoren is desirable so that the air conditioning unit can adapt its output to different ambient conditions, such as temperature, humidity, and aircraft size. *Id.* 8:4-10. The variable and controllable output in Lechmotoren is also desirable to adapt to the aircraft’s power demand when the aircraft and the PCA share a power supply. *Id.* 8:10-17. In addition to varying the output of the air-conditioning packs, Lechmotoren also discloses variation in the frequency of its blower fan, to achieve the same type of adjustments. *See id.* 11:19-29 (discussing variations to fan (17)).

208. Lechmotoren does not describe, in detail, the well-known and conventional details of its refrigeration systems or the manner by which the refrigeration systems’ motors are driven to obtain the variable cooling output. A POSITA seeking such details in the prior art would have found Taras.

209. For example, Taras discloses as “typical components for achieving desired characteristics in the conditioned space [] a refrigerant circuit 25 . . . compressor 40, a condenser 50, and an evaporator 60” in addition to “an expansion device 70.” Taras ¶17. A POSITA would have known these disclosures to be additional detail to Lechmotoren’s air-conditioning packs of having “compressor

and condenser” to also include the refrigerant circuit, the evaporator, and the expansion device.

210. Taras explains that its VFD can be used to implement the variable and controllable output to adapt to different conditions discussed in Lechmotoren, including driving the compressor motors for each of its air-conditioning packs: “VFD 75 adjusts the speed of the motor of compressor 40. . . . This adjustment allows the motor of compressor 40 to run at lower or higher than normal speed. . . [S]uch speed adjustment will improve system performance under circumstances when thermal load in the conditioned space or environmental conditions for the refrigerant system changes or a user alters the conditioned space setpoint.” Taras ¶ 19. For reasons similar to those discussed above regarding Kreymer and Taras, a POSITA would have been motivated to use VFDs to drive compressor motors in Lechmotoren’s air conditioning packs to achieve the well-known energy and operational benefits of implementing VFDs to refrigeration circuits. *See* Section IX.A.; *see also* Carrier at 4-6. A POSITA would also have been motivated to include a central controller in the combined system to control the output of the VFDs and refrigeration system to realize the energy gains and efficiency of operating VFDs in a refrigeration system, to optimize the cooling adjustments described in Lechmotoren, and to match the desired cooling capacity requirements described in Taras. Carrier at 4; *see id.* at 5-6; Taras at ¶19; Lechmotoren at 8:10-

17, 11:19-29; *see also* Rafuse at 3:57-65. As discussed in paragraph 126, it was well within the knowledge of a POSITA by 2009 that power-electronic VFD-driven refrigeration circuits would be controlled by a central controller that provided setpoints or operating settings to optimize performance and efficiency.

211. A POSITA would have reasonable expectation of success in combining Lechmotoren with Taras to obtain a more adjustable output for different loads and higher efficiency using VFDs. *See* Carrier at 4. Thus, any modification of Lechmotoren to accommodate VFDs as detailed in Taras would be implemented using well known *methods* that yield predictable results. *See also id.* at 5 (noting the “Easy Installation” of VFDs in refrigeration systems).

B. Claim 1

- 1. 1[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising**

212. For the purposes of my analysis, I have assumed that the preamble of claim 1 is limiting on the claim.

213. Lechmotoren discloses and renders obvious this limitation.

214. The device disclosed in Lechmotoren is a preconditioned air unit because it preconditions the air before supplying it to the aircraft. Lechmotoren discloses “an air conditioning unit for air conditioning. . . aircraft[] on the ground.” Lechmotoren 1:10-13. The unit operates by blowing into the aircraft fresh or

recirculated air treated by multiple air-conditioning packs. *See, e.g.*, Lechmotoren 10:3-11, 10:27-33; 11:4-13.

2. 1[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet

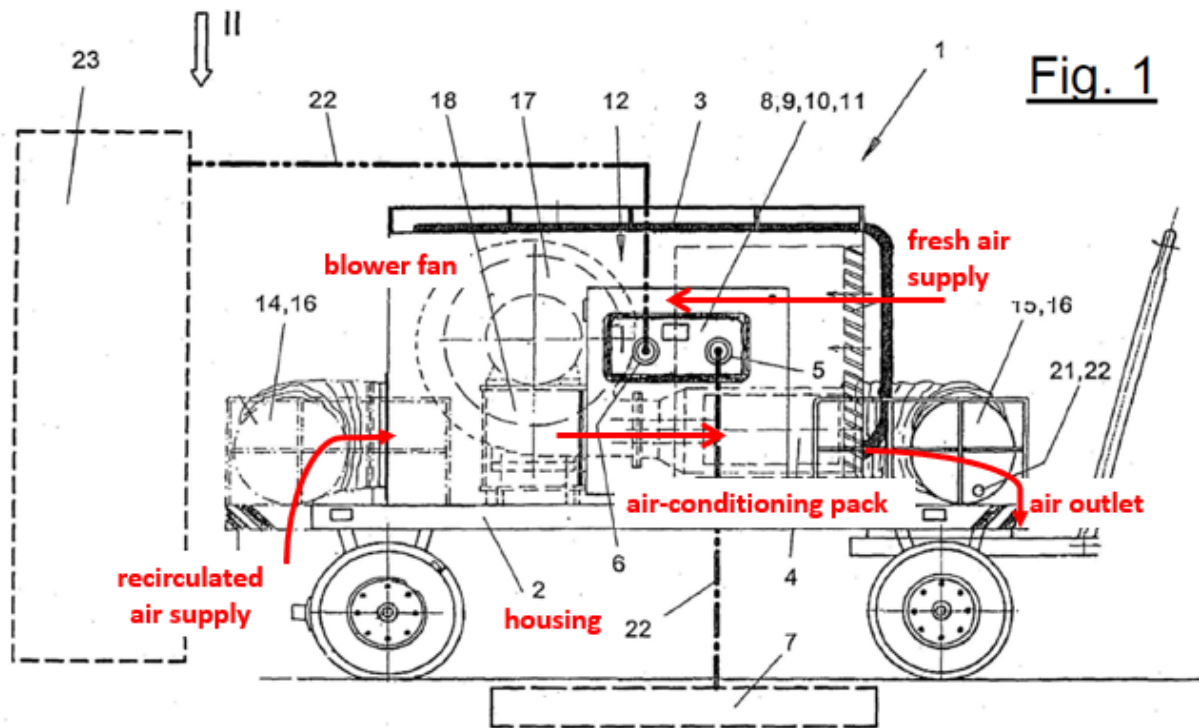
215. Lechmotoren discloses this limitation. FIGS. 1 and 2, reproduced below, illustrate embodiments of Lechmotoren disclosing this limitation.

216. Lechmotoren discloses a housing. Specifically, Lechmotoren discloses that “[t]he air conditioning unit (1) has. . . an air circulation device (12) . . . in a housing or frame (2).” Lechmotoren 7:32-35.

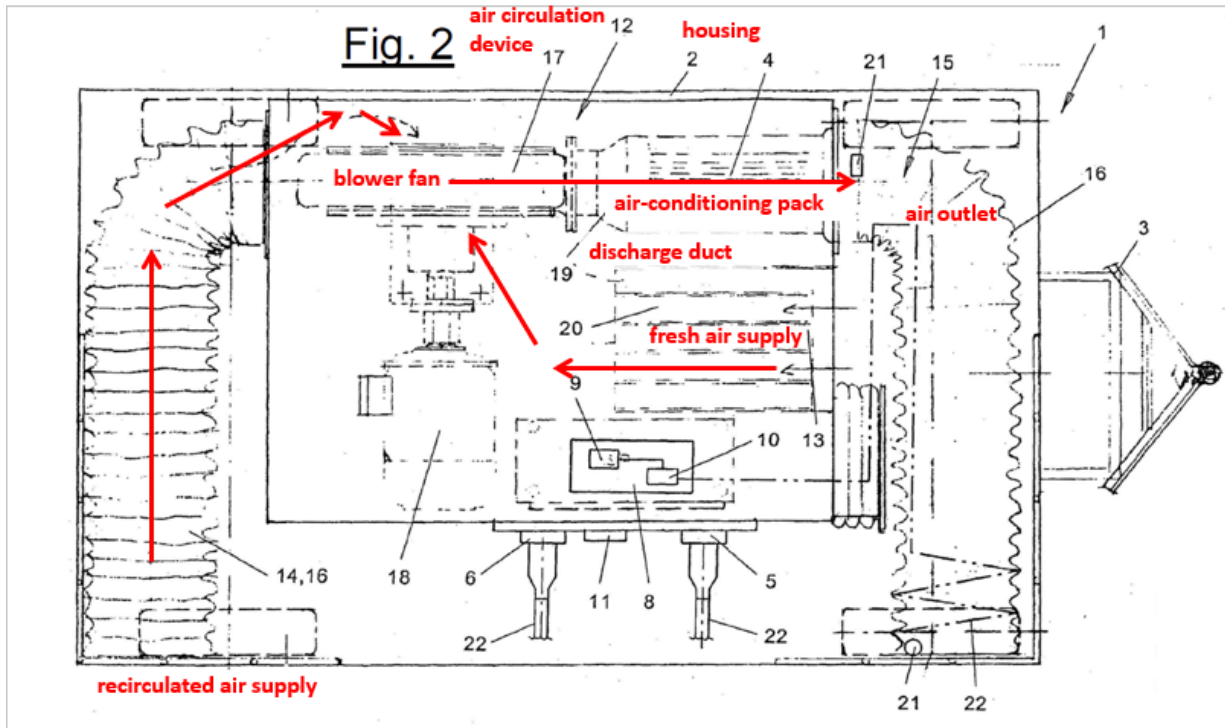
217. Lechmotoren discloses that the housing accommodates “a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft.” Specifically, Lechmotoren discloses “an air circulation device (12)” that includes a flow duct. “The air circulation device consists of at least one air supply (13), which . . . draws in outside air from the housing (2).”*Id.* at 10:18-21. The air supply (13), which is an air inlet for ambient air, is a part of the flow duct.” “The air circulation device (12) also has one or more air outlets (15) on the housing (2) with connected supply air hoses (16) . . . which lead to the aircraft (23).”*Id.* at 10:27-32.

218. Lechmotoren discloses “a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet.” The flow duct,

in the air circulation device (12) is connected to “one or more fans (17).” These fans generate an air flow from the air inlet toward the air outlet. “The one or more fans (17) or similar devices that draw in fresh air or recirculated air. . . and blow it into the aircraft (23) through the air outlet (15).” *Id.* at 11:4-9. The one or more fans (17) are, thus, a blower.



Lechmotoren, FIG. 1



Lechmotoren, FIG. 2

3. 1[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and

219. The combination of Lechmotoren and Taras discloses and renders obvious this limitation.

220. Lechmotoren discloses “a plurality of refrigeration systems.” Specifically, Lechmotoren discloses air-conditioning pack (4) [that] can also work with a thermodynamic cycle with compressor and condenser and can therefore provide heating and/or cooling output.” Lechmotoren at 10:7-11. Each air-conditioning pack is, thus, a refrigeration system. the “air-conditioning pack[s]”

that “can be present . . . in multiples.” Lechmotoren 10:1-7. Lechmotoren further discloses that an air flow generated by a fan that sends air through the flow duct and through the air-conditioning pack for refrigeration. *Id.* at 11:4-9.

221. The combination of Lechmotoren and Taras renders obvious having each refrigeration system including “at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant.” As an initial note, Lechmotoren does not explicitly disclose an expansion valve, an evaporator, or a refrigerant circuit. However, a POSITA would know that a well-known implementation for an air-conditioning pack (4) that works with “a thermodynamic cycle with compressor and condenser” is a refrigeration system having a compressor, a condenser, evaporator, and expansion valve connected in a refrigerant circuit. *See* Lechmotoren at 10:7-11

222. Moreover, Taras renders an air-conditioning pack that includes an expansion valve and an evaporator connected through a refrigerant circuit, in addition to a compressor and condenser. Specifically, Taras discloses a refrigerant system with “a refrigerant circuit 25,” “a compressor 40, a condenser 40, and an evaporator 60 interconnected in the circuit 25,” and “an expansion device 70 [] positioned between the condenser and evaporator within the circuit 25.” Taras at

¶17; *see also id.* at ¶16 (“Such refrigerant system components are known by a person of ordinary skill in the art.”).

223. A POSITA would have been motivated to apply the details of the well-known refrigerant system components described in Taras to each of Lechmotoren’s air-conditioning packs that work with a thermodynamic cycle and includes a compressor and condenser. Specifically, a POSITA would have found Taras to provide the well-known and conventional details of a refrigeration system that are not explicitly disclosed by Lechmotoren.

224. In addition, the combination of Taras and Lechmotoren discloses the evaporator interacting with the air flow in the flow duct. As discussed above, Lechmotoren discloses that an air flow generated by a fan (17) that sends air through the flow duct and through the air-conditioning pack for refrigeration. Lechmotoren at 11:4-9.

225. A POSITA would have understood that the Lechmotoren’s disclosure of the air flow through the air-conditioning pack for refrigeration would include an air flow through an evaporator of the air-conditioning pack. It is well-known to a POSITA that in a typical refrigerant system, refrigeration of air is performed through an interaction between the air and the evaporator of the refrigeration system. *See, e.g.*, Ex. 1010 at 49.1 (describing the heat exchange between air and refrigerant through the evaporator in a “typical room air conditioner”); Kreymer at

2:13-33, 2:63-3:13 (describing cooling of air through interaction between the air and the evaporator).

226. In addition, Taras explicitly discloses a fan 65 that generates an air flow through evaporator 60. Taras at ¶17. A POSITA would understand the fan (17) of Lechmotoren to correspond to the evaporator fan 65 and, accordingly, understand that that Lechmotoren's fan (17) generates an air flow in the duct to interact with an evaporator, for cooling. *See, e.g.*, Kreymer at 2:14-33; Ex. 1010 at 49.1.

4. 1[c]: at least one variable frequency driver for power supply of the at least one compressor, and

227. Taras discloses and renders obvious the use of a variable frequency driver for power supply of at least one compressor of each refrigeration system in the system formed by the combination of Lechmotoren and Taras.

228. Taras discloses a variable frequency driver for power supply of the at least one compressor. “The power/control system 30 provides electrical power for driving the components, e.g., compressor 40 . . . Power/control system 30 has a variable frequency drive 75 (“VFD”) that is connected to the AC motor of compressor 40 and which is also connected to a power source 80.” Taras ¶ 18.

229. Taras further explains that the variable frequency driver can adjust the frequency of the compressor 40. “VFD 75 adjusts the speed of the motor of

compressor 40 by varying the frequency and/or voltage of the power provided to the motor.” Taras¶19.

230. Taras further discloses that a system may have multiple VFDs to drive multiple compressor motors. For example, Taras at claim 16, which recites a method of operating a refrigerant system, discloses “a plurality of electric motors, and wherein each of said plurality of electric motors drives a refrigerant component,” such as a compressor.

231. A POSITA would have found it obvious to incorporate the VFDs of Taras to drive a compressor motor in each of Lechmotoren’s air-conditioning packs. As discussed above, a POSITA would have been motivated to combine Taras and Lechmotoren to obtain air-conditioning packs with variable and controllable output, as described in Lechmotoren. *See* Taras at ¶ 19; Lechmotoren at 11:8:3-17. In fact, Lechmotoren discloses the use of frequency regulation for its blower. *Id.* at 11:19-29.

5. 1[d]: a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems

232. The combination of Lechmotoren and Taras discloses and renders obvious “a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems.”

233. Lechmotoren discloses a central controller that is configured for controlling the operation of the preconditioned air unit. “The air conditioning unit (1) has a suitable control system (8), which is preferably designed as a programmable logic control system and allows the air conditioning output to be adapted to different ambient conditions.” Lechmotoren at 8:4-8; *see also id.* at 8:8-9:2. In fact, the controller is capable of controlling the output of each air-conditioning pack. *Id.* at 8:27-31 (“The control system (8) also has a suitable regulating device (10) that adjusts the output of the air-conditioning pack (4).”)

234. In addition, Taras provides details for a central controller that is configured to control the operation of the multiple variable frequency drivers. For example, Taras discloses a “[p]ower/control system 230” that controls multiple components in the refrigeration system. Taras ¶30. “Power/control system 230 has a plurality of variable frequency drives 275 that are operated by the system controller.” *Id.* at ¶31; *see also id.* at cl. 16.

235. As discussed above, a combination of Lechmotoren and Taras that provides variable and controllable output would employ the VFDs of Taras to drive at least one compressor in each air-conditioning pack of Lechmotoren. A POSITA incorporating Taras’ VFDs into Lechmotoren would have been further motivated to incorporate the system controller of Taras to operate the multiple VFDs, based

on the disclosures of the system controller of Taras to adjust the amount of cooling in accordance with the thermal load.

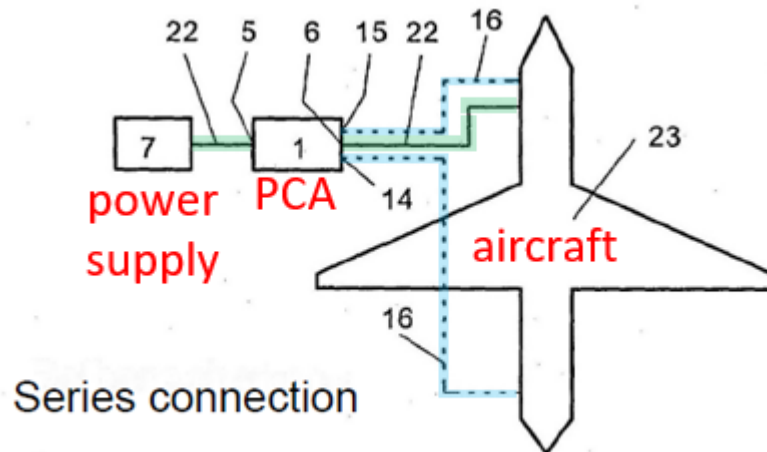
236. As a non-limiting example, a POSITA would have found commonality between Lechmotoren's control system (8) and Taras' "system controller." A POSITA would have also found commonality between Lechmotoren's regulating devices (10) in the control system (8) that adjust the output of air-conditioning packs (4) and the VFDs in Taras' system controller that adjusts the speed of the compressor to adjust to the thermal load. Accordingly, a POSITA would have incorporated the VFD controllers of Taras into control system (8) to operate as, or in coordination with, the regulating device (10) of Lechmotoren to adjust the cooling output.

237. As discussed above, a POSITA would understand that the inclusion of the VFD controllers of Taras in Lechmotoren would be a combination of prior art elements selected from well-understood design choices that would yield predictable results and known methods.

6. 1[e]: wherein the central controller has a power sharing control input for control of the preconditioned air unit power consumption

238. Lechmotoren discloses and renders obvious "a power sharing control input for control of the preconditioned air unit power consumption."

239. Lechmotoren discloses power sharing with the aircraft. Specifically, Lechmotoren discloses an arrangement where “[t]he air conditioning unit (1) is . . . connected electrically in series between the power supply unit (7) and the aircraft (23). Lechmotoren at 6:37-7:2; *see also id.* at FIG. 3, reproduced below. “The air conditioning unit (1) only draws as much output from the power supply unit (7) as is not needed by the aircraft (23). The control system (8) is preferably designed to use as much of the remaining energy as possible to operate the air conditioning unit (1).” *Id.* at 8:10-17.

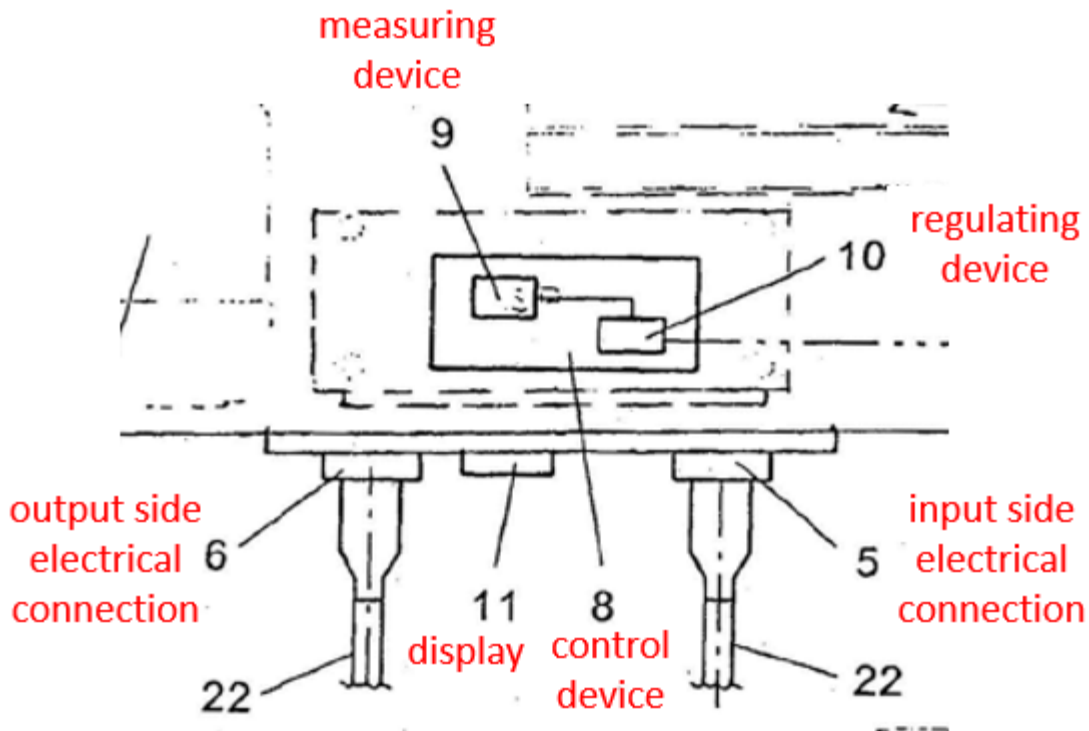


Lechmotoren, FIG. 3 (excerpted). Electrical connections are shown in green.

240. Lechmotoren discloses a power sharing control input. Lechmotoren’s control system includes a measuring device (9) for measuring the aircraft’s power demands. *Id.* at 8:23-27. “The measuring device can be . . . arranged externally to the control system.” *Id.* at 8:25-27. A measuring device that is external to the control system and provides data to the control system is necessarily connected to

the control via an input to the control system. *See* Lechmotoren 8:19-27 (describing “several [input/output] interfaces” of the control system).

241. Lechmotoren’s power sharing control input is used to control the preconditioned air unit power consumption. Figure 2, reproduced in part below, shows an example of a measuring device (9) providing an input to the regulating device (10) of the control system (8). The regulating device (10) “adjusts the output of the air-conditioning pack (4) to the available residual energy and controls it in a suitable manner.” *Id.* at 8:27-31. That is, the regulating device of the control system (8) adjusts the power consumption of the air-conditioning pack based on the power sharing input from the measurement device (9). *Id.* at 8:27-31. While Figure 2 illustrates a measuring device that is internal to the control system, a power sharing input from a measuring device (9) arranged externally to the control system would perform in the same manner.



Lechmotoren, FIG. 2 (excerpted)

C. Claim 2

1. 2[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising

242. As discussed above for claim 1, Lechmotoren discloses and renders obvious this limitation. Section XII.B.1. Specifically, limitation 2[pre] is identical to limitation 1[pre]. *Compare* '169 patent cl. 1 *with* cl. 2. For the reasons discussed above, the Lechmotoren-Taras combination discloses and renders this limitation obvious.

2. **2[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet,**

243. As discussed above for claim 1, the Lechmotoren discloses this limitation. Section XII.B.2. Specifically, limitation 2[a] is identical to limitation 1[a]. *Compare* '169 patent cl. 1 *with* cl. 2. For the reasons discussed above, the Lechmotoren-Taras combination discloses this limitation.

3. **2[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and**

244. As discussed above for claim 1, the combination of Lechmotoren and Taras discloses and renders obvious this limitation. Section XII.B.3. Specifically, limitation 2[b] is identical to limitation 1[b]. *Compare* '169 patent cl. 1 *with* cl. 2. For the reasons discussed above, the Lechmotoren-Taras combination discloses and renders this limitation obvious.

4. **2[c]: at least one variable frequency driver for power supply of the at least one compressor, and**

245. As discussed above for claim 1, Taras discloses and renders obvious this limitation. Section XII.B.4. Specifically, limitation 2[c] is identical to limitation 1[c]. *Compare* '169 patent cl. 1 *with* cl. 2. For the reasons discussed

above, the Lechmotoren-Taras combination discloses and renders this limitation obvious.

- 5. 2[d]: a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems,**

246. As discussed above for claim 1, the combination of Lechmotoren and Taras discloses and renders obvious this limitation. Section XII.B.5. Specifically, limitation 2[d] is identical to limitation 1[d]. *Compare* '169 patent cl. 1 with cl. 2. For the reasons discussed above, the Lechmotoren-Taras combination discloses and renders this limitation obvious.

- 6. 2[e]: wherein the central controller automatically adjusts the cooling performed by the preconditioned air unit according to at least one of: the selected type of aircraft, the ambient temperature, the humidity, the cabin temperature, or the outgoing airflow from the preconditioned air unit.**

247. Lechmotoren discloses this limitation. Specifically, Lechmotoren discloses “the central controller automatically adjust[ing] the cooling performed by the preconditioned air unit according to,” at least, “the ambient temperature,” “the humidity,” and “the cabin temperature.” For example, Lechmotoren discloses that its “suitable control system (8) . . . allows the air conditioning output to be adapted to different ambient conditions. These can be climatic or technical environmental conditions, e.g., temperature, humidity, aircraft size, etc.” Lechmotoren at 8:4-10.

248. To that end, Lechmotoren discloses sensors connected to the control system that can measure a range of temperatures and humidity values. *Id.* at 11:37-12:7 (“The air conditioning unit (1) may have one or more sensors and/or switches (21) that measure the climate values of the air blown into the aircraft (23). This applies in particular to a measurement of temperature and/or humidity.”). Lechmotoren further clarifies that sensors may be placed within the aircraft, which would measure the cabin’s temperature. *Id.* 12:34-8 (“One or more sensors or switches (21) can be placed in the aircraft (23) during air-conditioning and measure or switch by remote control on site.”)

D. Claim 13: A preconditioned air unit according to claim 2, wherein the central controller has a power sharing control input for control of the preconditioned air unit power consumption.

249. The combination of Lechmotoren and Taras discloses and renders obvious claim 2, as discussed above. Lechmotoren further discloses and renders obvious the limitation of claim 13.

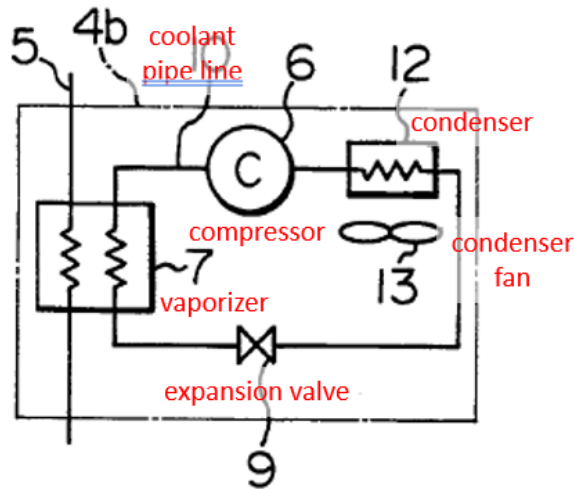
250. The limitation of claim 13 is identical to the limitation 1[e] in claim 1. Also as discussed above, Lechmotoren discloses and renders obvious the limitation 1[e]. *See* Section XIII.B.6 (cl. 1[e]). Nothing in the Lechmotoren-Taras combination that obviates claim 2 negates Lechmotoren’s teachings that disclose and renders obvious the limitation in claim 1[e].

XIII. A POSITA would have found claims 14-22 obvious in view of the combination of Lechmotoren, Taras, and Takahashi.

A. A POSITA would have combined Lechmotoren, Taras, and Takahashi

251. Takahashi is in the same field of endeavor of Lechmotoren and Taras, and the '169 patent. Specifically, Takahashi discloses refrigeration systems that employ well-known thermodynamic principles. *See, e.g.*, Takahashi at 4:9-28 (describing a cooling unit having a compressor, condenser, evaporator (labeled as “vaporizer” in Takahashi), and expansion device in a refrigerant circuit); FIG. 3 (reproduced below). The refrigerant systems disclosed in Takahashi is analogous to the refrigerant system disclosed in Taras (*see* Taras at ¶ 11, 17 and FIG. 3) and the '169 patent (*see, e.g.*, '169 patent at 1:55-59). Moreover, this refrigerant system “work[s] with a thermodynamic cycle with compressor and condenser,” in a manner analogous to the Lechmotoren’s air-conditioning pack. Lechmotoren 10:6-11.

FIG. 3

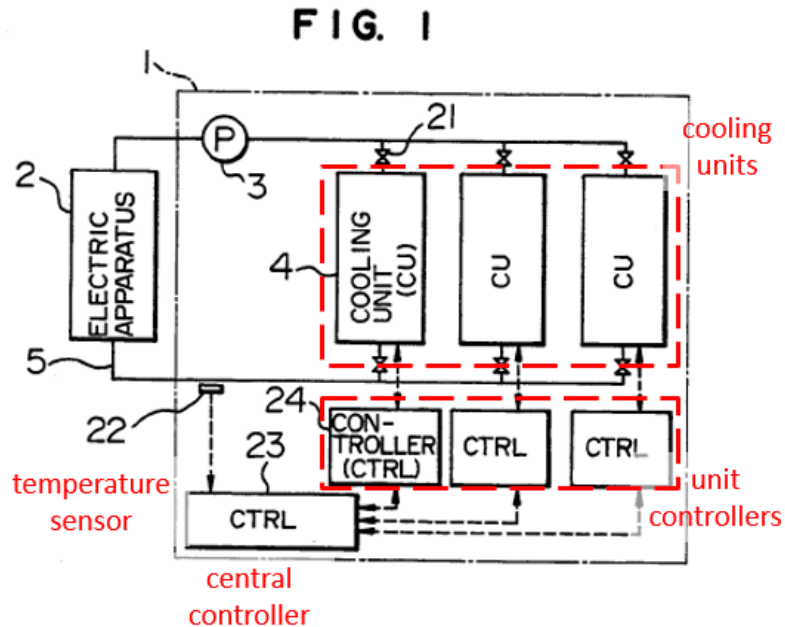


Takahashi, FIG. 3 (annotated).

252. Takahashi does not explicitly disclose an air refrigeration system. Instead, Takahashi discloses “cooling . . . a cooling liquid for a liquid-cooled electronic apparatus 2.” Takahashi at 3:42-64. The cooling liquid circulates in a “cooling liquid pipe line 5.” *Id.* This difference does not render Takahashi non-analogous to neither of the patents. For example, Taras states that, for “a person of ordinary skill in the art [] the particular type of the refrigerant system 10 can be varied . . . and the particular components of the system can be changed to accomplish the specific space conditioning objective.” Taras at ¶ 16. In fact, Taras is explicit that “fans moving air across the . . . evaporator could be replaced by pumps circulating liquid . . . for heat transfer purposes.” *Id.*

253. A POSITA would have been motivated to combine Takahashi with Lechmotoren and Taras to obtain a fault-tolerant PCA system. A POSITA would recognize this feature as an improvement to a PCA system having multiple cooling packs, such as Lechmotoren's. Specifically, Takahashi discloses a multi-cooler refrigeration system that can detect operational abnormalities and self correct. *See id.* at 7:17-66. This fault-tolerant architecture of Takahashi allows a refrigeration system with multiple refrigerant circuits, such as Lechmotoren's, to preserve its cooling output upon failure of one of the refrigerant circuits, by increasing the output of the remaining coolers to compensate the loss resulting from the failure. *See Takahashi* 7:17-66.

254. This feature is implemented by Takahashi through a control architecture with unit controllers 24 associated to each cooling unit 4, and a central controller 23 in communication with the unit controllers. *See Id.* at 3:41-4:2; and FIG. 2 (reproduced below). Takahashi also discloses sensors connected to the unit controllers 24 to monitor the cooling units 4. *Id.* at 7:17-25. When the unit controller 24 detects abnormal operation, it notifies the central controller 23. *Id.* at 7:41-45. The unit controller 24 then requests the remaining cooling units 4 to compensate for the abnormality, through their unit controllers 24. *Id.* at 7:45-66.



Takahashi, FIG. 1 (annotated)

255. A POSITA would have found obvious to modify the controller architecture of the Lechmotoren-Taras combination to implement the architecture disclosed in Takahashi, to implement this fault-tolerant feature, in view of the modification of Taras. *See, e.g.*, Section XII.B.5 (limitation [1d]). Specifically, the POSITA would modify the Lechmotoren-Taras controller by introducing individual unit controllers to control each respective refrigerant circuit, and that are themselves controlled by a central controller. *See e.g.*, Takahashi at FIG. 1 (reproduced above). The unit controllers provide monitoring of the respective refrigerant circuits and can report abnormalities or disruption to the central controller. Takahashi at 7:17-21. Moreover, when an abnormality is detected, the unit controller may stop operation of the refrigerant circuit under its control and inform the central controller. Takahashi 7:40-45. Finally, the central controller

may control working refrigerant circuits to increase its output capacity to compensate the loss from the failed circuit. Takahashi 7:45-66.

256. A POSITA would have had a reasonable expectation of success in implementing the modification of the PCA of Lechmotoren with the VFD systems of Takahashi. The controller architecture of Takahashi employs well-known elements. Specifically, Takahashi's control architectures employ well-known controllers, sensors, and communication lines. *See, e.g.*, Ex. 1011 at 4-5, 218. The controllers, sensors, and communication lines are performing their well-known ordinary functions, such as monitoring, measuring, controlling, and carrying/exchanging information. *Id.*

257. The fact that Takahashi focuses on cooling a "cooling liquid" instead of air does not diminish a POSITA's reasonable expectation of success. Takahashi's cooling units are identical to a PCA's refrigeration unit in that Takahashi's evaporator (called "vaporizer" in Takahashi) provides cooling. This cooling can be for any load, a liquid or a gas. *See, e.g.*, Takahashi at 3:64-2. As explained by Taras, a POSITA would have known that technological solutions for control of VFDs in refrigeration systems that refrigerate liquids would also work with refrigeration systems that refrigerate air flows. Taras at ¶16 ("[T]he particular components of the system can be changed to accomplish the specific space conditioning objective. Such refrigerant system components are known by a

person of ordinary skill in the art. For instance, fans moving air across the condenser and evaporator could be replaced by pumps circulating liquid, such as, for example, water or brine, for heat transfer purposes.”); *see also id.* at ¶32 (stating “control methodology” applicable to air flow refrigeration can be applied to liquid pumps). A POSITA would have understood this by comparing FIGs. 2 and 3 in Takahashi, which describes that substitution.

B. Claim 16

1. 16[pre]: A preconditioned air unit for supplying preconditioned air to an aircraft parked on the ground, the preconditioned air unit comprising

258. As discussed above for claim 1, Lechmotoren discloses and renders obvious this limitation. SectionXII.B.1. Specifically, limitation 1[pre] is identical to limitations 16[pre]. *Compare* ’169 patent cl. 1 *with* cl. 16.

259. The addition of Takahashi to the Lechmotoren-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed above, the Lechmotoren-Taras-Takahashi combination discloses and renders this limitation obvious.

2. **16[a]: a housing accommodating a flow duct with an air inlet for ambient air and an air outlet for connection to the parked aircraft, a blower connected with the flow duct for generation of an air flow from the air inlet toward the air outlet**

260. As discussed above for claim 1, Lechmotoren discloses this limitation. Section XII.B.2. Specifically, limitation 1[a] is identical to limitations 16[a]. *Compare* '169 patent cl. 1 *with* cl. 16.

261. The addition of Takahashi to the Lechmotoren-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed above, the Lechmotoren-Taras-Takahashi combination discloses and renders this limitation obvious.

3. **16[b]: a plurality of refrigeration systems, each of which includes at least one compressor, at least one condenser, at least one expansion valve, at least one evaporator connected in a flow circuit containing a refrigerant, and wherein the at least one evaporator interacts with the air flow in the flow duct, and**

262. As discussed above for claim 1, the combination of Lechmotoren and Taras discloses and renders obvious this limitation. Section XII.B.3. Specifically, limitation 1[b] is identical to limitations 16[b]. *Compare* '169 patent cl. 1 *with* cl. 16.

263. The addition of Takahashi to the Lechmotoren-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed

above, the Lechmotoren-Taras-Takahashi combination discloses and renders this limitation obvious.

4. 16[c]: at least one variable frequency driver for power supply of the at least one compressor, and

264. As discussed above for claim 1, Taras discloses and renders obvious this limitation. SectionXII.B.4. Specifically, limitation 1[c] is identical to limitations 16[c]. *Compare* '169 patent cl. 1 with cl. 16.

265. The addition of Takahashi to the Lechmotoren-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed above, the Lechmotoren-Taras-Takahashi combination discloses and renders this limitation obvious.

5. 16[d]: a central controller that is configured for controlling the operation of the preconditioned air unit including variable frequency drivers of the plurality of refrigeration systems

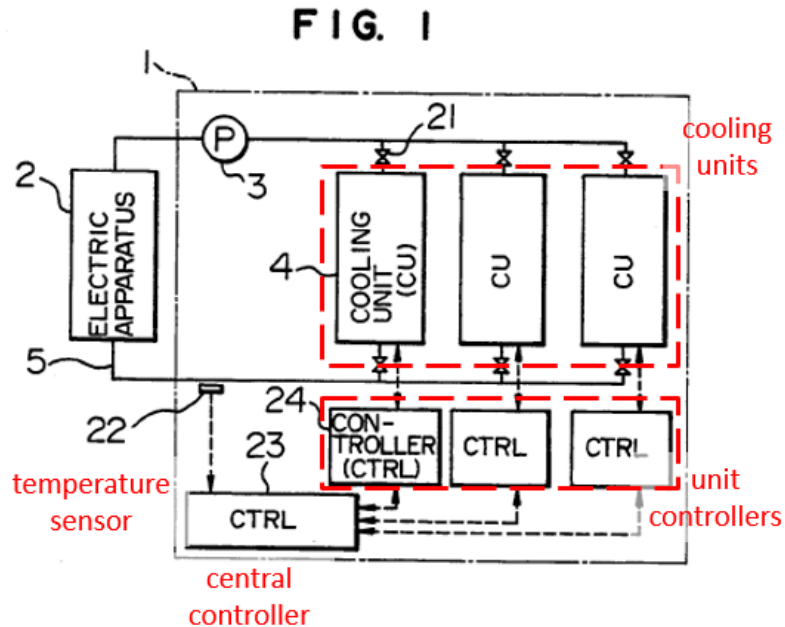
266. As discussed above for claim 1, the combination of Lechmotoren and Taras discloses and renders obvious this limitation. SectionXII.B.5. Specifically, limitation 1[d] is identical to limitations 16[d]. *Compare* '169 patent cl. 1 with cl. 16.

267. The addition of Takahashi to the Lechmotoren-Taras combination does not modify the elements in this limitation. Thus, for the reasons discussed

above, the Lechmotoren-Taras-Takahashi combination discloses and renders this limitation obvious.

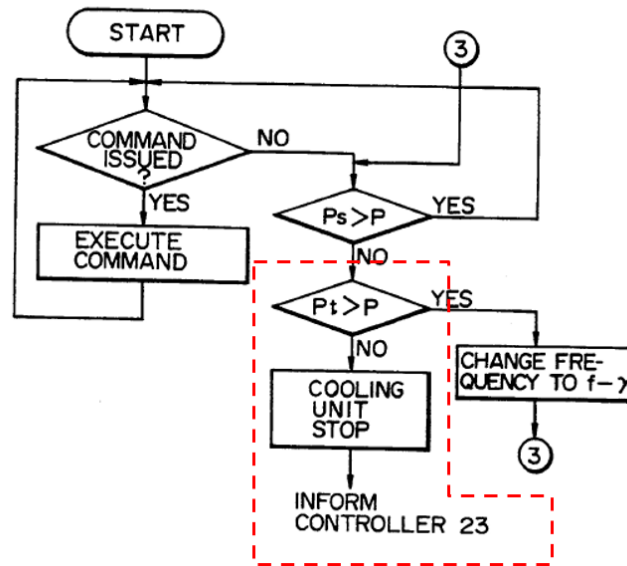
6. **16[e] wherein each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller.**

268. Takahashi discloses and renders obvious “each refrigeration system of the plurality of refrigeration systems is configured for failure detection.” Takashi discloses an architecture where unit controllers 24 monitors cooling units to detect abnormalities. *See* Takahashi at FIG. 3 (reproduced below). “The unit controllers 24 always monitor the cooling units 4 to detect abnormalities by a variety of sensors arranged in the cooling units 4 in addition to the variable control of the cooling units 4 in accordance with a command from the controller 23 as described above. The variety of sensors may include a pressure sensor for detecting the pressure of the coolant discharged from the compressor, a temperature sensor for detecting the temperature of the same, and so on.” Takahashi at 7:17-45.



Takahashi, FIG. 1 (annotated)

269. Takahashi further discloses that “in the event that one refrigeration system fails, the failing refrigeration system transmits a failure signal to the central controller.” The unit controller “fetches a pressure value P detected by a pressure sensor 14 arranged in each cooling unit 4.” Takahashi at 7:28-31. If the measured pressure value is above “an operation stop level P_t ,” the cooling unit 4 is deemed failed and disabled. Takahashi at 7:34-45 (“[T]he unit controller 24 turns the switching circuit 36 off to stop the operation of the cooling unit 4.”) “Then, the unit controller 24 informs the controller 23 of the stopped operation.” *Id.*; *see also id.* at FIG. 8 (reproduced below), 3:36-38 (“FIG. 8 is a flow chart showing the operation of a unit controller . . . for detecting an abnormality.”).

FIG. 8**Takahashi, FIG. 8 (annotated)**

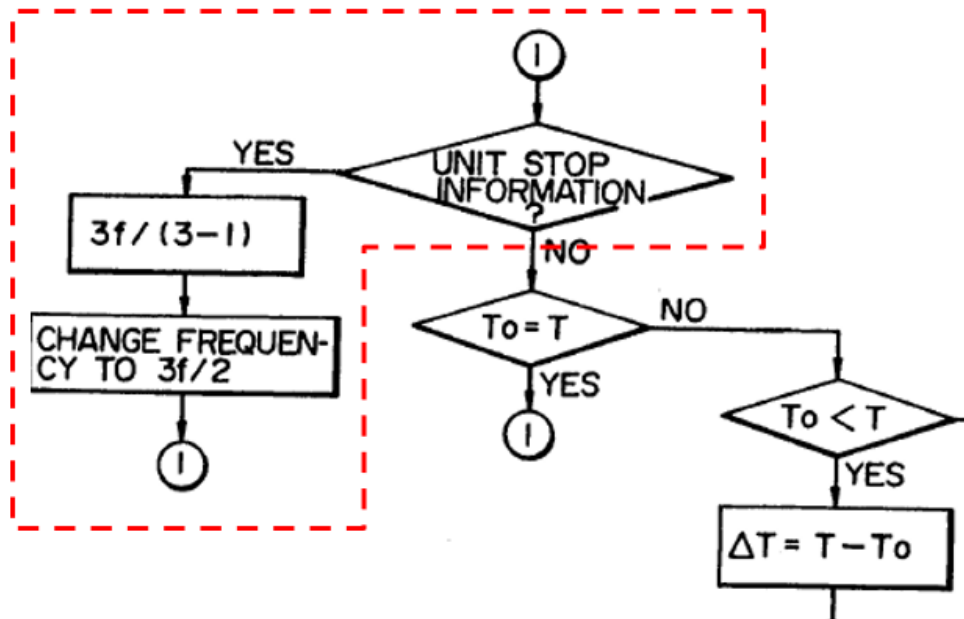
270. As discussed above, a POSITA would have been motivated to apply Takahashi's controller architecture and transmission of failure signals to the PCA with multiple VFD-driven compressors that result from the Lechmotoren-Taras combination. Section XIII.A. The POSITA would also have had reasonable expectation of success in implementing the Lechmotoren-Taras-Takahashi combination. *Id.*

- C. Claims 17 and 22: A preconditioned air unit according to claim 16, wherein the central controller is further configured to automatically adjust the required amount of cooling among the**

remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal.

271. The Lechmotoren-Taras-Takahashi combination discloses and renders obvious claims 17 and 22. As an initial matter, the Lechmotoren-Taras-Takahashi combination discloses and renders obvious claims 16.

272. Takahashi discloses that “the central controller [] further configured to automatically adjust the required amount of cooling among the remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal.” Specifically, Takahashi describes that the central controller, controller 23, can implement a compensation strategy after failure of a cooling unit by increasing operation in the remaining operating cooling units. “[T]he controller 23 controls the unit controllers 24 to perform a degenerated operation by use of the two cooling units which [are] still operating. . . . [T]he controllers 23 commands the unit controllers 24 connected to the two operating cooling units 4 to change the operation frequency to [1.5x higher frequency] . . . [E]ach unit controller 24 controls the invertor 35 to change the operation frequency in accordance with the command.” Takahashi at 7:46-66; *see also* FIG. 7 (reproduced below).



Takahashi, FIG. 7 (excerpted)

273. As discussed above, a POSITA would be motivated to apply Takahashi's fault-tolerant architecture to preserve cooling output upon failure of a cooling unit to the PCA with multiple VFD-driven compressors that result from the Lechmotoren-Taras combination by increasing the cooling output of remaining refrigeration circuits. Section XIII.A. The POSITA would also have had reasonable expectation of success in implementing the Lechmotoren-Taras-Takahashi combination. *Id.*

- D. Claim 18: A preconditioned air unit according to claim 16, wherein at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver.**

274. The Lechmotoren-Taras-Takahashi combination discloses and renders obvious claim 16. Taras further discloses and renders obvious this

limitation. Specifically, Taras discloses that “the plurality of variable frequency drives 275 [] are operated by the system controller.” Taras at ¶31. The VFDs that drive compressor motors “adjust[]the speed of the motor of the compressor by varying the frequency . . . of the power provided.” *Id.* at ¶19.

275. A POSITA would have understood that a VFD’s output frequency is altered by using a controller in order to alter the speed of the motor and thus the cooling capacity of a system. Indeed, it was well-known by 2009 that VFDs “use[] power electronics to vary the frequency of the input power to the motor, thereby controlling motor speed.” Carrier at 1. A POSITA would have understood “power electronics” include a controller configured for varying the output frequency of a VFD in a PCA system. *See* Section IX.A (citing, e.g., Ex. 1011 at 7, 11, 57).

276. Takahashi also discloses and renders obvious this limitation. Specifically, Takahashi discloses controllers configured to change the frequency of a compressor. Takahashi discloses “a plurality of unit controllers 24 each for performing a variable control of the individual cooling unit 4 based on a command from the controller 23.” Takahashi at 3:57-64. The “unit controllers 24 [] change the operation frequency” of the variable frequency drivers. Takahashi at 6:38-41. A POSITA would find it obvious to implement the control strategy and architecture of Takahashi to control the frequency of the VFDs to adjust the cooling output of the system in the Lechmotoren-Taras combination. *See* Takahashi at 5:1-4

(“Therefore, if the inverter 35 is controlled to change the operation frequency, the rotational speed of the motor 31 is changed, so that the cooling power of the cooling unit 4 can be adjusted.”). Accordingly, a POSITA would find it obvious to implement the unit controller for variation of the output frequency of the VFDs.

E. Claim 19: A preconditioned air unit according to claim 18, wherein the controller of the variable frequency driver is further configured for adjustment of the output frequency in response to a sensor output connected to the controller.

277. The Lechmotoren-Taras-Takahashi combination discloses and renders obvious claim 18. Takahashi further discloses “the controller of the variable frequency driver is further configured for adjustment of the output frequency in response to a sensor output connected to the controller.” Specifically, Takahashi discloses that a sensor output connected to the controller: “the controller 23 compares a temperature T detected by the temperature sensor 22 with a predetermined set temperature T_0 at constant time intervals.” Takahashi at 6:19-22.

278. Takahashi further discloses “the controller of the variable frequency driver is further configured for adjustment of the output frequency in response to a sensor output.” From the sensor output, a frequency difference is calculated. “If the determination result shows that T is higher than T_0 , the temperature difference . . . [is] converted to a frequency difference.” *Id.* at 6:31-35. This

frequency difference is used to adjust the output frequency. *Id.* at 6:35-45. These operations “are repeated until T becomes equal to To.” *Id.* at 6:45-46.

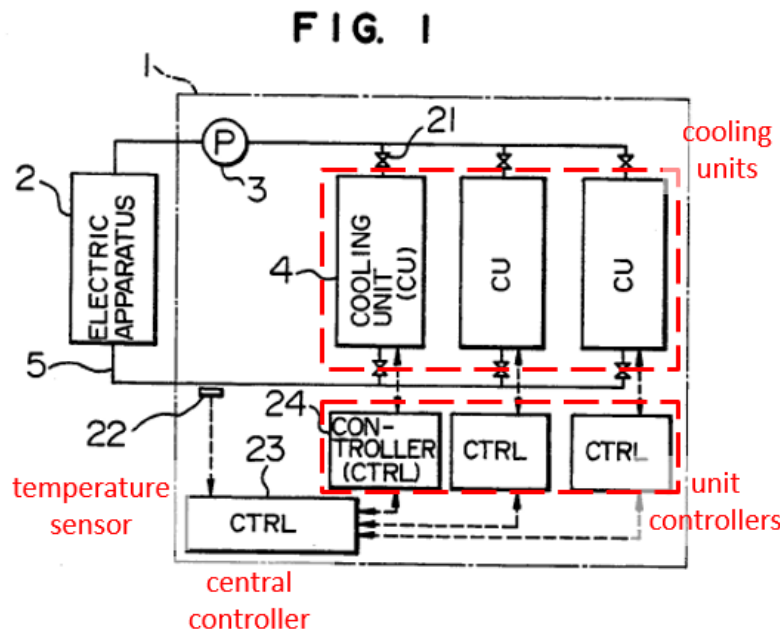
279. A POSITA would find obvious to incorporate the temperature sensor connected to the controller of Takahashi to adjust the speed of the refrigeration system compressors in response to the temperatures. The POSITA would be motivated to incorporate the temperature sensor of Takahashi to adjust the cooling output based on the temperature of the fluid to be cooled. This advantage is discussed, for example in Lechmotoren. Lechmotoren at 8:3-10 (discussing adjusting the air conditioning output to temperature). This advantage is also discussed in Taras. Taras at ¶19 (discussing adjustment of temperatures to adequate cooling to a thermal load).

280. A POSITA would recognize that this feature can be implemented by use of well-known temperature sensors, communication wires, and control performing their well-known functions of measuring temperature, transmitting data, and determining new commands based on that data.

F. Claim 20: A preconditioned air unit according to claim 18, wherein the central controller is connected to at least one controller of at least one voltage frequency driver.

281. As discussed above, the Lechmotoren-Taras-Takahashi combination discloses and renders obvious claims 16 and 18. Takahashi further discloses “the central controller [] connected to at least one controller of at least one voltage

frequency driver.” As discussed above, for claims 16 and 18, the combination of Lechmotoren, Taras, and Takahashi provides a system with a central controller (e.g., Takahashi’s controller 23) that is connected to a unit controller (e.g., Takahashi’s unit controller 24) that controls a VFD. Sections XIII.B, D.; *see also* Takahashi at FIG. 1 (reproduced below).



Takahashi, FIG. 1 (annotated)

- G. Claim 21: A preconditioned air unit according to claim 16, wherein at least one variable frequency driver keeps the ratio between the output voltage and the frequency substantially constant to maintain a high motor torque throughout the entire output frequency range.**

282. As discussed above, the Lechmotoren-Taras-Takahashi combination discloses and renders obvious claim 16.

283. The additional limitation disclosed in claim 21 is a strategy for motor control of VFDs that is well-known to a POSITA, and would have been obvious to

implement. Specifically, operating a variable frequency driver by keeping “the ratio between the output voltage and the frequency substantially constant” “throughout the entire output frequency range,” known as “constant volts-per-hertz” operation, is a well-known method to control VFDs. This strategy is also well known to maintain a “high motor torque.”

284. As discussed in Section X, it was well-known to a POSITA that, in its rated range, the torque of an AC motor driven by an AC signal is proportional to the ratio between the voltage and the frequency of the signal. Fitzgerald at 580-81 (describing the “constant volts-per-hertz” operation). It was also well known that keeping a constant ratio between the VFD output’s voltage and frequency would keep the torque in an AC motor constant.

285. This “constant volts-per-hertz” strategy has been utilized in the prior art for decades before the ’169 patent’s alleged invention to keep the torque in an AC motor constant, as demonstrated by decades-old literature. *See, e.g.,* Stich at 1:20-27; Fitzgerald at 580-81. This strategy applies whether the motor torque is “high” or not. *See* Stich at FIG. 2a.

286. The “constant volts-per-hertz” operation is particularly relevant to the Lechmotoren-Taras-Takahashi system, that employs variable frequency. In this system, changes in the frequency “improve system performance under circumstances when thermal load in the conditioned space or environmental

conditions for the refrigerant system change or a user alters the conditioned space setpoint.” Taras at ¶ 19; *see also* Lechmotoren at 8:3-12 (discussing adaptations in the cooling output to different ambient conditions). However, it was well-known to a POSITA that the benefits from using the VFD are diminished if the motor does not operate at constant torque. For example, a decrease in frequency without a corresponding decrease in the output voltage may lead to damage in the motor. Fitzgerald at 580-81. Conversely, an increase in frequency without a corresponding increase in the output voltage may lead to a decrease in torque that makes the compressor incapable of compressing the refrigerant fluid. *See, e.g.*, Ex. 1010 at 37.9 (discussing the torque requirements for a reciprocating compressor); *id.* at 37.13 (discussing torque requirements for a rotary compressor); *id.* at 37.35 (discussing torque requirements for a centrifugal compressor); *see also id.* at 37.6 (general discussion of torque requirements in motors).

287. Accordingly, a POSITA would be motivated to adopt the well-known “constant volts-per-hertz” operation to obtain a VFD-driven compressor that is capable of compressing the refrigerant fluid through the entire operating range and does not damage the motor at frequencies in the lower portion of the operating range. A POSITA would have found obvious to implement this strategy and would have a reasonable expectation of success in implementing this strategy, as this

strategy has been known for decades before the '169 patent as a strategy to control VFDs.

- H. Claim 14: A preconditioned air unit according to claim 2, wherein each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller.**

288. The combination of Lechmotoren, Taras, and Takahashi discloses and renders obvious this limitation. As an initial matter, Lechmotoren and Taras discloses and renders obvious claim 2. *See* Section XII.C. Therefore, the combination of Lechmotoren, Taras, and Takahashi also disclose and renders obvious claim 2, as nothing in Takahashi interferes with the above-discussed Lechmotoren-Taras combination.

289. Takahashi further discloses and renders obvious this limitation, which is identical to claim 16[e]. *See* Section XIII.B.6 (claim 16e).

290. As discussed above, a POSITA would have been motivated to implement the fault-tolerant system of Takahashi to the Lechmotoren-Taras system. Section XIII.A.

I. Claim 15

- 1. 15[a]: A preconditioned air unit according to claim 2, wherein: at least one variable frequency driver has a controller that is configured for variation of the output frequency of the at least one variable frequency driver;**

291. As discussed above, the Lechmotoren-Taras-Takahashi combination discloses and renders obvious claim 2. As discussed above, Takahashi and Taras further disclose and render obvious this limitation, which is identical to the limitation of claim 18. *See* Sections XIII.D (cl. 18).

- 2. 15[b]: the controller is configured for variation of the output frequency of the at least one variable frequency driver above the frequency of the mains supply of the preconditioned air unit;**

292. Taras further discloses its “controller [] configured for variation of the output frequency of the at least one variable frequency driver above the frequency of the mains supply of the preconditioned air unit. Specifically, Taras states that its VFD “allows the motor of compressor 40 to run at a . . . higher than normal operating speed.” Taras at ¶ 19. Taras also explains that the “use of compressor 40 at the normal operating speed” is obtained by powering the motor directly to the power source, i.e., the mains supply. *Id.* at ¶¶ 18-19 (explaining the use of the bypass device); *see also* FIG. 3 (reproduced below). As the “normal operating speed” is obtained with the frequency of the mains supply, adjustment of the VFD to operate at a “higher than normal operating speed” results from having Taras’ VFD providing a frequency higher than that of the mains supply.

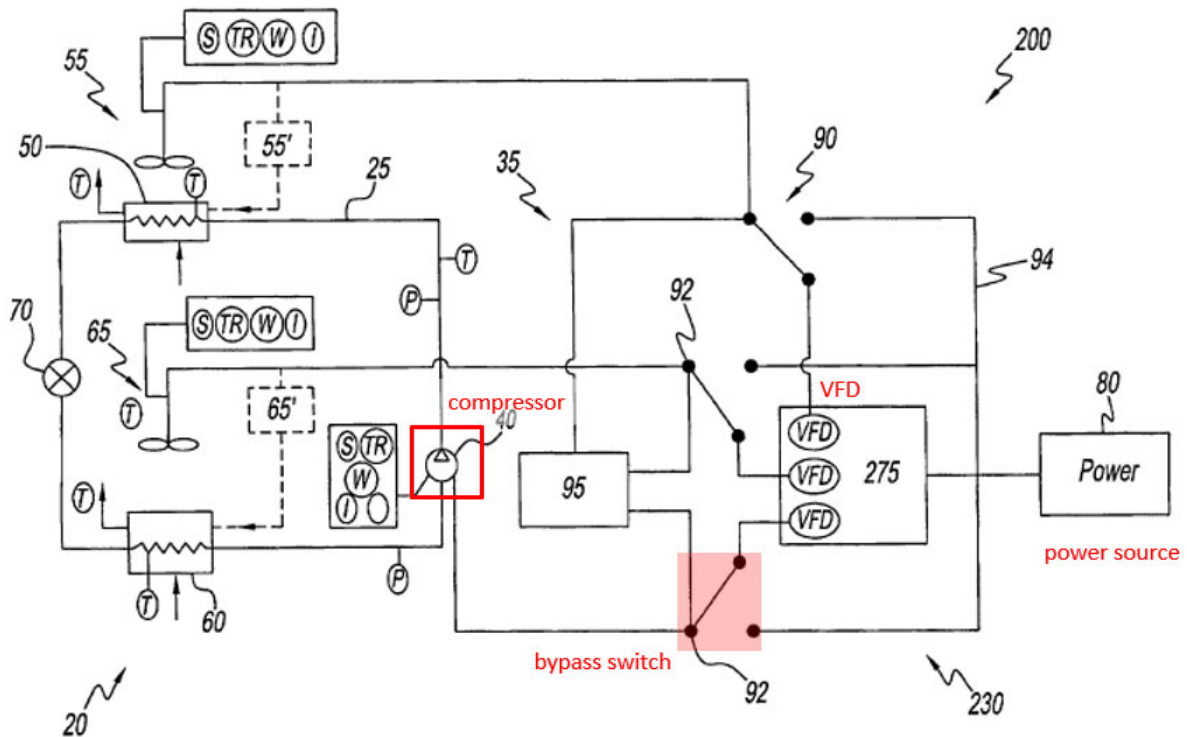


Fig. 3

Taras, FIG. 3 (annotated)

3. 15[c]: at least one variable frequency driver is configured to keep the ratio between the output voltage and the frequency substantially constant;

293. This limitation, which is broader than the limitation of claim 21, is well-known to a POSITA. Section XIII.G. This limitation is mere implementation of a “constant volts-per-Hertz” operation. *E.g.*, Stich at 1:20-27; Fitzgerald at 580-81.

294. As discussed above, a POSITA would have been motivated to implement the “constant volts-per-Hertz” operation in the combined system of

Lechmotoren, Taras, and Takahashi. Section XIII.B.G. Likewise, a POSITA would have found it obvious to, and would have a reasonable expectation of success in implementing the “constant volts-per-Hertz” operation in this system.

4. **15[d]: each refrigeration system of the plurality of refrigeration systems is configured for failure detection so that, in the event that one of the refrigeration systems fails, the failing refrigeration system transmits a failure signal to the central controller; and**

295. As discussed above, Takahashi discloses and renders obvious this limitation, which is identical to the limitation of claims 14 and 16[e]. *See* Sections XIII.H (cl. 14), XIII.B.6 (cl. 16[e]).

5. **15[e]: the central controller is further configured to automatically adjust the required amount of cooling among the remaining properly operating refrigeration systems of the plurality of refrigeration systems in response to the failure signal.**

296. As discussed above, Takahashi discloses and renders obvious this limitation, which is identical to the limitation of claims 17 and 22. *See* Section XIII.C (cls. 17, 22).

XIV. CONCLUSION

All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true. Further, I am aware that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001. I declare under penalty of perjury that the foregoing is true and correct.

Executed on Jan. 9, 2025 (date), in Belmont, MA (city, state).

A handwritten signature in black ink, appearing to read "Steven B. Leeb", written over a horizontal line.

Dr. Steven B. Leeb