

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

PASCAL TECHNOLOGIES,
Petitioner

v.

CAMBRIDGE ENTERPRISE LIMITED, UNIVERSITAT DE BARCELONA,
AND UNIVERSITAT POLITÈCNICA DE CATALUNYA,
Patent Owner

Case No. IPR2024-01235
U.S. Patent No. 11,230,656

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 11,230,656**

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<i>Reflex Packaging, Inc. v. Lenovo (U.S.) Inc.</i> , No. 5:10-CV-01002-EJD, 2012 WL 1622694 (N.D. Cal. May 8, 2012)	38, 40
<i>Texas Instrs., Inc. v. United States Int’l Trade Comm’n</i> , 805 F.2d 1558 (Fed. Cir. 1986)	39

EXHIBIT LIST

Exhibit No. ¹	Description
1001	U.S. Patent No. 11,230,656 (“the ’656 Patent”)
1002	Prosecution File History of the ’656 Patent
1003	Excerpt of comparison of GB1617508.5 specification to ’656 Patent specification.
1004	Expert Declaration of Mircea Dincă, Ph.D.
1005	CV of Mircea Dincă, Ph.D.
1006	Zhongjian Xie and Yao Zhu, “Demonstration of liquid crystal for barocaloric cooling application,” arXiv 1609.07939v1 (submitted Sept. 26, 2016).
1007	Lluís Mañosa et al., “Advanced materials for solid-state refrigeration,” J. Mater. Chem. A, 1, 4925-4936 (2013), DOI: 10.1039/C3TA01289A (submitted 28 Nov. 2012; accepted 25 Jan. 2013; published 29 Jan. 2013).
1008	Lluís Mañosa et al., “Advanced Materials for Solid-State Refrigeration,” [cond-mat.mtrl-sci] (2013), DOI: 10.48550/arXiv.1303.3811 (submitted 15 Mar. 2013).
1009	Satyanarayan Patel et al., “Elastocaloric and barocaloric effects in polyvinylidene di-fluoride-based polymers,” Appl. Phys. Lett. 108, 072903 (2016), DOI: 10.1063/1.4942000 (received 16 Oct. 2015; accepted 30 Jan. 2016; published 16 Feb. 2016).
1010	E. Stern-Taulats et al., “Inverse barocaloric effects in ferroelectric BaTiO ₃ ceramics,” APL Materials 4, 091102 (2016), DOI: 10.1063/1.4961598 (received 17 June 2016; accepted 11 Aug. 2016; published 19 Sept. 2016).
1011	Nuria Pol Català, “Efectes barocalòrics en cristalls plàstics,” Final Degree Project, Escola Tècnica Superior d’Enginyeria Industrial de Barcelona (23 June 2016).
1012	Certified Translation of Nuria Pol Català, “Efectes barocalòrics en cristalls plàstics,” Final Degree Project, Escola Tècnica Superior d’Enginyeria Industrial de Barcelona (23 June 2016).
1013	Lluís Mañosa et al., “Inverse barocaloric effect in the giant magnetocaloric La-Fe-Si-Co compound,” Nature Comms. 2:595

¹ Citations to patents are made by column and line cite; citations to patent publications are made by paragraph number; citations to other exhibits are made with reference to page number.

Exhibit No. ¹	Description
	(2011), DOI: 10.1038/ncomms1606 (received 20 July 2011; accepted 22 Nov. 2011; published 20 Dec. 2011).
1014	Lluís Mañosa et al., “Giant solid-state barocaloric effect in the Ni-Mn-In magnetic shape-memory alloy,” <i>Nature Mats.</i> 9, 478-481 (2010), DOI: 10.1038/nmat2731 (published 4 April 2010).
1015	P. Lloveras et al., “Giant barocaloric effects at low pressure in ferroelectric ammonium sulphate,” <i>Nature Comms.</i> 6, 8801 (2015), DOI: 10.1038/ncomms9801 (received 17 July 2015; accepted 5 Oct. 2015; published 26 Nov. 2015).
1016	Andrés Mencke et al., “A simple apparatus for time-resolved x-ray diffraction biostructure studies using static and oscillating pressures and pressure jumps,” <i>Rev. Sci. Instrum.</i> 64, 383-389 (1993), DOI: 10.1063/1.1144261 (received 2 Dec. 1991; accepted 6 Oct. 1992; published 1 Feb. 1993).
1017	E.L. Rodriquez & F.E. Filisko, “Thermoelastic temperature changes in poly(methyl methacrylate) at high hydrostatic pressure: Experimental,” <i>J. Appl. Phys.</i> 53, 6536–6540 (1982), DOI: 10.1063/1.330081 (published 1 Oct. 1982).
1018	Anchi Cheng et al., Kinetics and Mechanism of the Barotropic Lamellar Gel/Lamellar Liquid Crystal Phase Transition in Fully Hydrated Dihexadecylphosphatidylethanolamine: A Time-Resolved X-Ray Diffraction Study Using Pressure Jump, <i>J. Biophys.</i> , Vol. 67, Issue 1, 293-303 (July 1994), DOI: 10.1016/S0006-3495(94)80480-1 (received 8 Feb. 1994; final form 25 April 1994; published July 1994; available online 6 Jan. 2009).
1019	Richard J. Lewis, Sr., <i>Hawley’s Condensed Chemical Dictionary</i> (13th ed. 1997).
1020	X. Moya et al., Caloric materials near ferroic phase transitions, <i>Nature Mater.</i> 13, 439-450 (received 30 July 2013; accepted 19 March 2014; published 22 April 2014; issue date May 2014), DOI: 10.1038/nmat3951.
1021	J. Li. Tamarit et al., “Thermodynamic Study of Some Neopentane Derivated by Thermobarometric Analysis,” <i>Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals</i> , 250:1, 347-358 (received 01 Jun. 1993; accepted 09 Jul 1993; published online 24 Sept. 2006), DOI: 10.1080/10587259408028219.

Exhibit No.¹	Description
1022	J. Timmermans, “Plastic Crystals: A Historical Review,” Journal of Physics and Chemistry of Solids, Vol. 18, Issue 1, 1-8 (Jan. 1961).
1023	H. G. Kreul et al., “Differential Thermal Analysis and Dielectric Studies on Neopentanol under Pressure,” Z. Naturforsch. 47:11, 1127-1134 (received 27 July 1992; published 1992), DOI: 10.1515/zna-1992-1106.
1024	Declaration of Sylvia Hall-Ellis, Ph.D.

I. MANDATORY NOTICES UNDER 37 C.F.R. §42.8(a)(1)

A. Real Party-in-Interest under 37 C.F.R. §42.8(b)(1)

Pascal Technologies is the Petitioner and real party-in-interest. No other parties exercised or could have exercised control over this Petition and no other parties funded or directed this Petition.

U.S. Patent No. 11,230,656 (“the ’656 Patent”) has not been the subject of an IPR or other post-grant proceeding.

B. Lead and Back-Up Counsel under 37 C.F.R. §42.8(b)(3)

Petitioner provides the following designation of counsel.

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C. Service Information under 37 C.F.R. §42.8(b)(4)

A copy of this entire Petition, including all Exhibits and a Power of Attorney, is being served by FEDERAL EXPRESS, costs prepaid, to the address of the attorney or agent of record for Patent Owner at the USPTO for the '656 Patent:

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Petitioner consents to electronic service at DLPascalIPR@bakerbotts.com. A Power of Attorney is filed concurrently herewith under 37 C.F.R. §42.10(b).

II. CLAIM LISTING

Claim 1

1[pre]	A method comprising employing an organic material as a barocaloric cooling or heating agent, wherein the method comprises:
1[a]	(i) applying hydrostatic pressure to an organic material;
1[b]	(ii) permitting heat flow from or to the organic material;
1[c]	(iii) releasing hydrostatic pressure from an organic material that is under applied pressure; and
1[d]	(iv) permitting heat flow to or from the organic material.

Claim 2

2	The method according to claim 1, wherein the organic material is an organic compound or a salt thereof optionally wherein at least one of the following is present: - the organic material has a molecular weight of at most 2,000; - the organic material has a molecular weight of at least 50; - the organic material is an organic compound or a salt thereof, and the organic compound has two or more carbon-carbon bonds; - the organic material is an organic compound or a salt thereof, and the organic compound has two or more carbon-hydrogen bonds; - and - the organic material is a liquid crystal or a plastic crystal.
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Claim 3

3	The method according to claim 1, wherein the organic material is a plastic crystal optionally wherein: - the plastic crystal comprises a cycloalkyl group, and the cycloalkyl group is an adamantantyl group optionally substituted with one or more groups selected from the group consisting of alkyl, halo, hydroxyl and oxo; or - the plastic crystal comprises an alkyl group, and the alkyl group is a C₄₋₂₀ alkyl group, optionally substituted with one or more groups selected from the group consisting of hydroxyl, amino and nitro.
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Claim 6

6	The method according to claim 1, wherein the organic material has a phase transition at a temperature within the range 200 to 450 K, optionally wherein the phase transition of the organic material is a first-order phase transition.
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Claim 7

7	The method according to claim 1, wherein at least one of the following is present: the organic material has an entropy change at a phase transition, ΔS_0, of at least $10 \text{ J K}^{-1} \text{ kg}^{-1}$; a phase transition in the organic material displays a latent heat, Q_0, that is at least 1 kJ kg^{-1}; the organic material has a volume change at the phase transition of at least $1.0 \text{ mm}^3 \text{ g}^{-1}$; and the organic material is provided within a pressure-transmitting medium.
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Claim 8

8	The method according to claim 1, wherein hydrostatic pressure is applied to the organic material at a temperature that is within 50 K, of a phase transition temperature of the organic material, where the phase transition temperature is the temperature for the phase transition in the absence of the hydrostatic pressure optionally wherein: the applied hydrostatic pressure is at most 1.0 GPa; or the applied hydrostatic pressure is at least 0.1 MPa.
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Claim 9

9 <pre></pre>	A method of barocaloric cooling or heating, the method comprising the steps of:
9[a]	(i) applying hydrostatic pressure to an organic material;
9[b]	(ii) permitting heat flow from or to the organic material;
9[c]	(iii) releasing hydrostatic pressure from an organic material that is under applied pressure; and
9[d]	(iv) permitting heat flow to or from the organic material.

Claim 10

10	The method according to claim 9, wherein the organic material is an organic compound or a salt thereof optionally wherein at least one of the following is present: - the organic material has a molecular weight of at most 2,000; - the organic material has a molecular weight of at least 50; - the organic material is an organic compound or a salt thereof, and the organic compound has two or more carbon-carbon bonds; - the organic material is an organic compound or a salt thereof, and the organic compound has two or more carbon-hydrogen bonds; - and - the organic material is a liquid crystal or a plastic crystal.
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Claim 11

11	The method according to claim 9, wherein the organic material is a plastic crystal optionally wherein: - the plastic crystal comprises a cycloalkyl group, and the cycloalkyl group is an adamantantyl group optionally substituted with one or more groups selected from the group consisting of alkyl, halo, hydroxyl and oxo; or - the plastic crystal comprises an alkyl group, and the alkyl group is a C₄₋₂₀ alkyl group, optionally substituted with one or more groups selected from the group consisting of hydroxyl, amino and nitro.
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Claim 14

14	The method according to claim 9, wherein the organic material has a phase transition at a temperature within the range 200 to 450 K, optionally wherein the phase transition of the organic material is a first-order phase transition.
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Claim 15

15	The method according to claim 9, wherein at least one of the following is present: the organic material has an entropy change at a phase transition, ΔS_0, of at least $10 \text{ J K}^{-1} \text{ kg}^{-1}$; a phase transition in the organic material displays a latent heat, Q_0, that is at least 1 kJ kg^{-1}; and the organic material has a volume change at the phase transition of at least $1.0 \text{ mm}^3 \text{ g}^{-1}$; or the organic material is provided within a pressure-transmitting medium.²
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Claim 16

16	The method according to claim 9, wherein hydrostatic pressure is applied to the organic material at a temperature that is within 50 K of a phase transition temperature of the organic material, where the phase transition temperature is the temperature for the phase transition in the absence of the hydrostatic pressure optionally wherein: the applied hydrostatic pressure is at most 1.0 GPa; or the applied hydrostatic pressure is at least 0.1 MPa.
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² The inclusion of both “and” and “or” in this claim limitation appears to be a scrivener’s error, (*compare* Ex[1001],22:15-24(claim 15) *with* Ex[1001],21:18-27(claim 7)), as the other “or” terms were removed from this claim during prosecution. *See* Ex[1002],59-65 (July 14, 2021 Response after Ex Parte Quayle Action). Both the Examiner and Applicant understood the claim is satisfied if “at least one” condition is met. *See* Ex[1002],114,123,128-133 (January 28, 2021 Non-Final Rejection at 5-10 (interpreting “and/or” as “or”); May 26, 2021 Applicant’s Amendment and Response at 13 (“the claims have been amended to remove the term ‘and/or’.”); *see also* Ex[1001],18:9-13,claim 7 (containing the same limitations as claim 15 and using only “and”).

III. INTRODUCTION

Pascal Technologies (“Petitioner”) petitions for *inter partes* review of Claims 1-3, 6-11, and 14-16 (collectively, “Challenged Claims”) of US Patent No. 11,230,656 (“the ’656 Patent”), assigned to Cambridge Enterprise Limited, Universitat De Barcelona, and Universitat Politècnica De Catalunya (collectively, “Patent Owner” or “PO”). For the reasons discussed below, the Challenged Claims should be found unpatentable and canceled.

IV. REQUIREMENTS UNDER 37 C.F.R. §42.104

A. Grounds for Standing

Petitioner certifies the ’656 Patent is eligible for *inter partes* review and Petitioner is not barred or otherwise estopped.

B. Priority Date

The application issued as the ’656 Patent was filed April 12, 2019, and is a national stage entry of PCT/EP2017/076203 (the “PCT Application”). Ex[1002],169. The PCT Application has an international filing date of October 12, 2017, and claims priority to GB1617508.5 (the “Priority Application”), which was filed October 14, 2016. Ex[1002],365. The prior art relied upon here in predates this October 14, 2016 filing date.

C. Identification of Challenge and Statement of Precise Relief Requested

Petitioner requests *inter partes* review of Claims 1-3, 6-11, and 14-16 of the '656 Patent under the following grounds.

Ground	Claims	Summary Basis for Challenge
1	1-2, 6-10, and 14-16	Obvious over Xie (§103)
2	1-3, 6-7, 9-11, and 14-15	Obvious over the combination of Mañosa and Patel (§103)
3	1-3, 6-7, 9-11, and 14-15	Obvious over Mañosa and Tamarit (§103)
4	1-3, 6-7, 9-11, and 14-15	Obvious over the combination of Xie and Tamarit (§103)
5	1-3, 6-7, 9-11, and 14-15	Obvious over the combination of Mañosa, Patel, and Tamarit (§103)

Submitted with this Petition is the declaration of Mircea Dincă, Ph.D., a qualified technical expert. Ex[1004], ¶¶5-11.

V. OVERVIEW OF THE '656 PATENT

A. Background

1. Barocaloric Cooling/Heating Method

The '656 Patent is directed to using organic materials exhibiting barocaloric (BC) effects for cooling or heating. Ex[1001], Abstract, 1:21-22. "BC effects [(BCEs)] are reversible thermal changes driven by changes of hydrostatic pressure

and have long been exploited in fluids to achieve continuous cooling in the well known vapour-compression systems employed in refrigerators and air conditioners.”

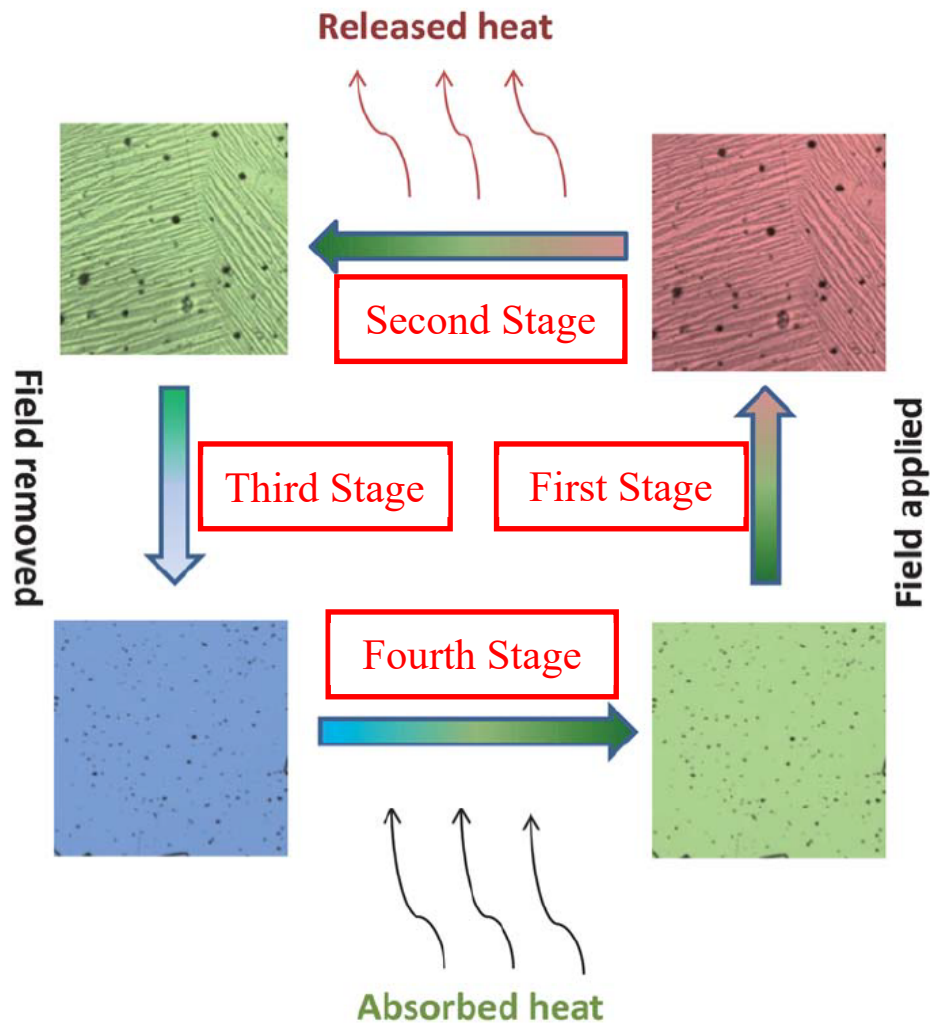
Ex[1010],1. The '656 Patent admits there has been “strong interest in developing cooling systems that avoid” “environmentally harmful fluids” used in vapor-compression refrigeration systems. Ex[1001],1:32-35; *see also, e.g.*, Ex[1010],1; Ex[1013],2; Ex[1015],2.

Solid materials exhibiting magnetocaloric, electrocaloric, elastocaloric, and barocaloric effects are potential alternatives to these harmful fluids. Ex[1001],1:35-61. Unlike other caloric effects, BCEs are “easy to generate” and can be “observed at relatively low applied stresses.” *Id.*; *see also, e.g.*, Ex[1009],091102-1; Ex[1014],478; Ex[1015],Abstract,2,5. Barocaloric materials also exhibit minimal energy losses and can avoid mechanical breakdown. *Id.* at 1:59-61.

Barocaloric materials come in two varieties: conventional and inverse. Under hydrostatic pressure, conventional barocaloric materials increase in temperature, while inverse barocaloric materials decrease in temperature. Ex[1001],13:9-24,15:4-23. The '656 Patent admits there is no novelty in using either conventional or inverse barocaloric materials. Ex[1001],14:19-21. A POSITA would understand the behavior of both conventional and inverse BCEs in cooling applications: “A reference to organic materials displaying conventional barocaloric effects is also a reference to organic materials displaying inverse barocaloric effects [because] ...

such materials are equally useful in the methods of this invention.” Ex[1001],9:10-26; Ex[1004],¶39.

The ’656 Patent admits organic barocaloric materials work “within conventional heating and cooling cycles in place of conventional materials, where the heating and cooling cycle is adapted to exploit the barocaloric effects of the organic materials,” for example, in well-known cycles. Ex[1001],14:60-15:3. Prior art reference Mañosa, discussed in greater detail below, illustrates an exemplary solid-state refrigeration cycle using a material exhibiting a “giant caloric effect attained by applying a general external field.” *See* §VIII.B(citing Ex[1007],4926).



Ex[1004],¶63 (citing Ex[1007],FIG.1(annotated)).

The '656 Patent admits the first and second steps to using a conventional barocaloric material involve applying hydrostatic pressure to the material before permitting heat flow from or to the material (for conventional and inverse barocaloric, respectively). Ex[1001],15:4-7;³ Ex[1007],4926,FIG.1 (First Stage:

³ Mañosa's diagram illustrates use of a material exhibiting a "conventional" BCE, where hydrostatic pressure applied to a barocaloric material increases the

“Field applied” and Second Stage: “Released heat”). In the third and fourth steps in the cycle, hydrostatic pressure is removed from the barocaloric material before heat flows to or from the (conventional or inverse) material. Ex[1001],15:13-22; Ex[1007],4926,FIG.1 (Third Stage: “Field removed” and Fourth Stage: “Absorbed heat”).

The '656 Patent admits some large BCEs are driven by hydrostatic pressure near phase transitions. Specifically, applying hydrostatic pressure produces first-order phase transitions in barocaloric materials that can reversibly “release or absorb latent heat.” Ex[1001],2:1-8. The '656 Patent also admits there was a known “desire to identify materials exhibiting large barocaloric effects ... at relatively low pressure,” exhibiting “large diabatic temperature changes in response to an applied isotropic stress.” Ex[1001],2:36-44.

2. *Inorganic vs Organic Barocaloric Materials*

The '656 Patent alleges materials exhibiting significant BCEs identified prior to the date of invention were “generally” limited to *inorganic* materials. Ex[1001],2:56-58. The '656 Patent admits inorganic materials, “such as Mn_3GaN

temperature of the material and heat flows from the material. Ex[1001],15:8-12; Ex[1007],4926. However, the '656 Patent admits that the cycle can also be used with inverse barocaloric materials, where the application of hydrostatic pressure decreases its temperature and heat flows to the organic material, and that a “skilled person” would understand how to use both kinds of materials. Ex[1001],9:14-26,15:4-23; *see also, e.g.*, Ex[1007],4926.

and ammonium sulfate” were “known to provide significant barocaloric effects.” *Id.* Thus, the alleged novelty is in employing an *organic* material as a barocaloric agent. Ex[1001],2:58-61. However, caloric effects in organic materials were identified and published *more than two centuries ago*. Ex[1020],439. And the ’656 Patent admits BCEs have been observed in both inorganic and organic materials and “*organic materials may be used as alternatives to the inorganic materials* that have previously been described for use in barocaloric cooling.” Ex[1001],5:29-32,5:26-46,15:4-27,18:21-25; *see also generally* Exs[1006]-[1007]; Exs[1009]-[1015]; Ex[1020]. Thus, the ’656 Patent undercuts any alleged novelty of the claimed invention as well as its attempts to distinguish prior art disclosing both inorganic and organic barocaloric materials. *See, e.g.*, Ex[1001],2:56-65,5:22-6:3.

Mañosa, like the ’656 Patent, discusses the concept of large isothermal entropy and adiabatic temperature-changes close to phase transitions, caloric effects in both inorganic and organic materials, and their potential use in solid-state cooling cycles. *See* §VIII.B; *see also, e.g.*, Ex[1001],1:43-2:44,5:33-64,Ex[1007],Abstract,4925-4926,4933-4934,Figure1. Moya’s 2014 article references organic barocaloric materials, such as poly(methyl methacrylate) (PMMA) and inorganic barocaloric materials, such as polycrystalline nickelate. Ex[1020],444. Moya’s Figure 2 also plots “caloric effects at phase transitions” of both inorganic and organic materials.

It is also well-known that plastic crystals can be organic materials, as claimed in claims 3 and 11, or inorganic. For example, Timmermans “Plastic Crystals: A Historical Review” from 1961 is cited in the ’656 Patent and discloses both inorganic and organic materials. Ex[1001],7:66-8:4 (citing Ex[1022]).

In fact, the ’656 Patent admits there are numerous advantages to using organic barocaloric materials over inorganic barocaloric materials. *First*, the “barocaloric effects for the organic materials are comparable to or exceed those previously observed for inorganic materials.” Ex[1001],2:66-3:4. *Second*, the latent heat values and adiabatic temperature changes of “organic materials, such as plastic crystals, may be comparable to or exceed those reported for Mn_3GaN or ammonium sulfate.” Ex[1001],3:2-11. *Third*, phase transition temperatures of organic materials may lie closer to ambient temperatures than phase transition temperatures of inorganic materials. Ex[1001],3:11-13. *Fourth*, organic materials may respond to smaller pressure inputs than inorganic materials and have latent heat values comparable to currently used refrigeration materials. Ex[1001],3:14-19. *Fifth*, organic materials have other advantages over inorganic materials including large scale and wide availability, low costs, low toxicity, and ease of use and disposal. Ex[1001],3:20-25;

see also, e.g., Ex[1009],072903-1⁴ (explaining advantages of barocaloric polymers include “ease of fabrication (shape), low cost, and lost processing temperatures).

It is, therefore, unsurprising the ’656 Patent admits multiple prior art references propose using organic barocaloric materials in cooling applications and thereby admits what was in the knowledge of the art at the time of the invention. The ’656 Patent specification was, in fact, amended to identify one such prior art reference by Zhongjian Xie and Yao Zhu. (Ex[1006],“Xie”); *see also* VIII.A. Xie discloses the use of dihexadecylphosphatidylethanolamine (DHPE), *an organic material, as a barocaloric agent “for cooling applications.”* Ex[1006],1,5. The ’656 Patent uses sleight of hand to focus away from Xie to Mencke—referenced in Xie—before asserting there “is no suggestion *in this paper* that organic materials would be generally useful in providing barocaloric cooling within a cooling apparatus.” Ex[1001],5:67-6:3 (discussing Ex[1016],“Mencke”). The ’656 Patent fails to address or properly distinguish Xie. And there has been no substantive examination of either Xie’s proposal to use organic barocaloric materials in cooling applications, nor Xie’s disclosure of other limitations of the Challenged Claims.

The ’656 Patent admits another prior art publication discloses BCEs of an organic material. Satyanarayan Patel’s article (Ex[1009],“Patel”) discloses BCEs of

⁴ The page numbering in Patel includes a prefix, “072903-”. Subsequent references to Patel, Ex[1009], omit this prefix.

polyvinylidene difluoride-trifluoroethylene-chlorotrifluoroethylene (PVDF-TrFE-CTFE), *an organic polymer*. Ex[1001],5:38-46 (citing Ex[1009,Patel]). The '656 Patent never addresses Patel's explanations that PVDF, and its co-polymers, "promises high potential for eC [elastocaloric] and BC refrigeration applications" or that it may support "solid-state refrigeration" by operating analogously to a typical vapor compression cycle, "where heating and cooling effects are obtained using fluid compression and expansion." Ex[1009],1,4. Additionally, Patel discloses other benefits of PVDF-TrFE-CTFE, including "ease of fabrication (shape), low cost, and low processing temperatures." Ex[1009],1. But the '656 Patent fails to address or distinguish Patel.

The '656 Patent also admits the "analysis of the organic materials" by Lloveras and Stern-Taulats predates the '656 Patent.⁵ Ex[1001],18:21-25 (citing (Ex[1015],"Lloveras") and (Ex[1010],"Stern-Taulats"). Lloveras and Stern-Taulats both explain caloric materials may provide environmentally friendly alternatives to materials typically used in vapor-compression refrigeration systems. Ex[1015],2; Ex[1010],1. Stern-Taulats identifies both *inorganic* and *organic* materials as "good candidates for solid-state barocaloric (BC) cooling." Ex[1010],1 (referencing

⁵ The '656 Patent attempts to incorporate these prior art disclosures, "by reference in their entirety," (Ex[1001],18:21-25), when the disclosures in both Lloveras and Stern—of the benefits of organic barocaloric polymers in cooling applications—are further evidence that the Challenged Claims are invalid. Ex[1010],1.

“ceramic thin films” and “thicker films of polymers”). Similarly, Lloveras explains “[l]arge BC [barocaloric] effects have also been observed in poly(methyl methacrylate)” (PMMA), *an organic polymer*. Ex[1015],1. Despite these disclosures—of specific organic barocaloric materials and their benefits in solid-state refrigeration—the ’656 Patent fails to address or distinguish Lloveras and Stern-Taulats.⁶

Additionally, the ’656 Patent admits the identification of organic barocaloric materials is not a recent discovery. Rodriquez et al. published an article in 1982 “describ[ing] the barocaloric temperature changes of poly(methyl methacrylate)” — *the same organic material identified by Lloveras*—when PMMA is subjected to hydrostatic pressure.⁷ Ex[1001],5:33-38 (citing Ex[1017,“Rodriquez”]). Rodriquez also explains the temperature changes in PMMA are perfectly reversible and graphs BCEs in PMMA as they would appear in the cycles described in Mañosa and the ’656 Patent—(1) applying hydrostatic pressure (P_{on}); (2) increasing temperature before heat flows from PMMA (ΔT_{on}); (3) removing hydrostatic pressure (P_{off}); (4) decreasing temperature before heat flows into PMMA (ΔT_{off}):

⁶ The only substantive challenge to the ’656 Patent during prosecution involved Lloveras’s disclosure regarding BCEs of PMMA, which is discussed below in §V.C.

⁷ The ’656 Patent admits that what Rodriquez refers to as a “thermoelastic” effect is a BCE. *Compare* Ex[1001],5:33-38,8:52-56 *with* Ex[1017],6537-6538,FIG.3.

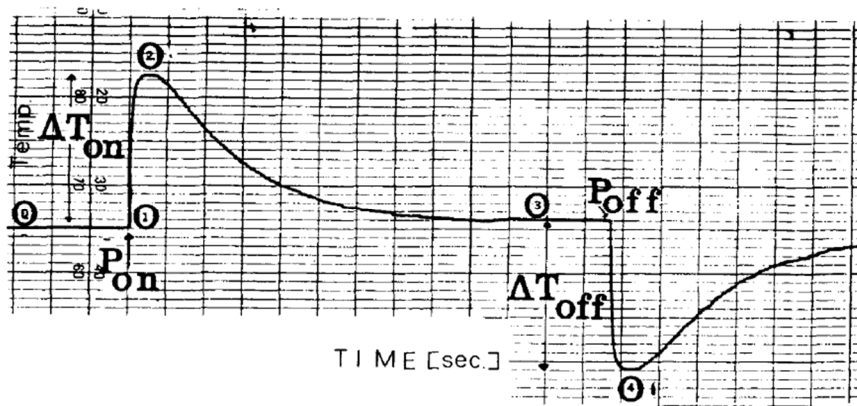


FIG. 3. Typical recording of thermoelectric effect corresponding to a delayed release of pressure.

Ex[1017],Abstract,6537-39,FIG.3; see also, e.g., Ex[1001],15:4-27; Ex[1007],4926,FIG.1; Ex[1020],444 (inventor Moya's article citing Ex[1017]).

The inventors referenced Rodriguez's research on the barocaloric effects of PMMA twice before filing the '656 Patent. See Ex[1020],444 (citing Ex[1017] as ref.89); Ex[1015],2 (citing Ex[1017] as ref.9). The inventors attempted to distinguish PMMA's BCEs as "away from any transition," (Ex[1015],2), but Rodriguez actually states these BCEs are *associated with* phase transitions in PMMA. Ex[1004],¶47 (explaining Ex[1017],6539). In both instances, the inventors discussed use of barocaloric materials in cooling applications. Ex[1020],Abstract; Ex[1015],Abstract,2. In sum, the inventors were aware of, and published about, the use of organic barocaloric materials as heating or cooling agents before applying for the '656 Patent.

B. Description of the '656 Patent

Independent claims 1 and 9 of the '656 Patent are directed to using an organic material exhibiting BCEs as part of a standard refrigeration cycle, as disclosed in the '656 Patent and prior art. *See* §V.A.1.

The dependent Challenged Claims add few additional limitations to these broad independent claims. For example, dependent claims 2 and 10 merely require the “organic *material* is an organic *compound* or a salt thereof.” Further, as explained below, the Challenged Claims recite numerous optional limitations that do little to narrow the scope of the Challenged Claims. *See* §IX.D (addressing “optionally” terminology in claims 2, 3, 6, 8, 10, 11, and 16).

C. Prosecution History

The application of the '656 Patent was filed April 12, 2019 on behalf of Javier Eduardo Moya Raposo, Alexander Avramenko, Lluís Mañosa Carrera, Josep Lluís Tamarit Mur, and Pol Marcel Lloveras Muntané (collectively, the “Inventors” or “Applicant”), and is a national stage entry of PCT/EP2017/076203 (the “PCT Application”). Ex[1002],169. The PCT Application has an international filing date of October 12, 2017, and claims priority to GB1617508.5 (the “Priority Application”), which was filed October 14, 2016. Ex[1002],365. After filing the Priority Application and prior to filing the PCT Application, Applicant amended the specification to reference prior art reference Xie. Ex[1002],219,293; Ex[1003],7

(showing the discussion of Xie added in the PCT Application, as compared with the Priority Application).⁸ However, Applicant's amendment failed to address or distinguish Xie's disclosure of an organic material for barocaloric cooling applications, and instead distinguished an earlier reference, Mencke et al. *See* Ex[1003]; Ex[1001],5:52-6:3.

After a preliminary amendment, the application included 23 claims. Ex[1002],323-29. Then-pending independent claims 31, 39, and 47 correspond to '656 Patent issued claims 1, 9, and 17.

The only substantive examination of the claims occurred via the January 28, 2021 Non-Final Office Action. Ex[1002],123-37. In rejecting then-pending claim 39, the examiner indicated the specification lacks enablement for "means that would facilitate the application of the hydrostatic pressure and means permitting heat flow from or to the organic material." Ex[1002],127. Analogous subject matter is included in claims 1 and 9 of the '656 Patent Ex[1001],20:41-48,21:37-43. In response to the rejection, Applicant asserted, *inter alia*, that the specification's reference to the 2010 prior art reference, Mañosa, provided a basis for enablement. Ex[1002],111-13 (citing Ex[1014],"Mañosa2010"). Specifically, Applicant submitted that Mañosa2010 was disclosed in "the Examples section of the application" and

⁸ As discussed below, Xie renders obvious all limitations of the Challenged Claims.

describes methods for applying pressure and measuring heat transfer. Ex[1002],112. The rejection was subsequently withdrawn. *See* Ex[1002],71.

The examiner also rejected then-pending claims 31 and 39 as anticipated by Lloveras. Ex[1002],133-35 (citing Ex[1015]). *First*, Applicant distinguished the barocaloric material discussed in Lloveras, ammonium sulfate, which “lacks a carbon” and therefore “cannot be reasonably interpreted as an organic material,” because “a barocaloric organic material is a compound, or a salt of that compound, having a carbon atom, and optionally having one or more carbon-carbon bonds and/or one or more carbon-hydrogen bonds.” Ex[1002],115. *Second*, while Applicant acknowledged “Lloveras discusses poly(methyl methacrylate)” (PMMA), it cannot and did not assert PMMA—a material with chemical formula $(C_5O_2H_8)_n$, comprising carbon-carbon and carbon-hydrogen bonds—is not an organic material. Ex[1002],115; Ex[1004],¶46 (citing Ex[1019],742 (“methyl methacrylate”)). Instead, Applicant argued Lloveras “merely describes measuring ... the barocaloric effect of poly(methyl methacrylate),” but “does not describe the actual step of employing the compound as a barocaloric cooling or heating agent.” Ex[1002],115-16.

The examiner then issued the June 9, 2021 Ex Parte Quayle Action, closing prosecution on the merits by indicating then-pending claim 39 was allowable without articulating a basis for the allowability and without reference to

Mañosa2010, Lloveras, Patel, Xie, or any other prior art reference, but rejecting it as “incomplete for omitting essential steps” and “indefinite for failing to particularly point out and distinctly claim the subject matter which ... the applicant regards as the invention.” Ex[1002],71-74. Then-pending claim 31 recited only “A method comprising employing an organic material as a barocaloric cooling or heating agent.” Ex[1002],102-03.

Applicant substantively amended then-pending claim 31 to incorporate the “essential steps” allowed in then-pending claim 39 and now appearing in both independent claims 1 and 9. Ex[1002],59-60. The examiner then allowed all pending claims, including claim 31, without further examination on the merits. Ex[1002],22-24. A Notice of Allowance was mailed September 9, 2021. Ex[1002],18,70-74.

VI. DISCRETIONARY DENIAL IS NOT APPROPRIATE

A. Discretion Under 35 U.S.C. §314(a)

The factors identified in *General Plastic Industrial Co., Ltd. v. Canon Kabushiki Kaisha*, IPR2016-01357, Paper 19 (PTAB, Sept. 6, 2017), do not provide a basis for denying institution. To Petitioner’s knowledge, there is no prior petition challenging the validity of the ’656 Patent, no litigation involving that patent, and no reason why the PTAB could not complete this review within a year of institution.

B. Discretion Under 35 U.S.C. §325(d)

Petitioner respectfully submits the Board should not exercise its discretion under 35 U.S.C. §325(d). None of the prior art references relied upon herein were substantively raised during prosecution. Xie and Patel are each briefly addressed in the specification of the '656 Patent, but neither reference was substantively examined during prosecution, either alone or in combination with other references relied upon herein. Ex[1002],123-37. The USPTO erred in overlooking the teachings in these references and the Board has declined to exercise its discretion under §325(d) based on a reference being cited in an IDS when, as here, “there is no evidence that the Examiner considered the particular disclosures cited” in the reference. *See, e.g., Microsoft Corp. v. Parallel Networks*, IPR2015-00486, Paper 10 at 15 (PTAB, 2015); *HTC Corp. v. Motiva Patents, LLC*, IPR2019-01666, Paper 9 at 6-10 (PTAB, 2020).

While two Mañosa references, from 2010 and 2011, and Català were disclosed in an Information Disclosure Statement on April 12, 2019, only the 2010 Mañosa reference is addressed in the specification of the '656 Patent. Ex[1001],19:11-13,20:25. Like Xie and Patel, the 2010 Mañosa reference was never substantively examined. Moreover, the Mañosa reference relied upon herein, “Advanced Materials for Solid State Refrigeration,” is dated 2013, was not disclosed to the USPTO.

Tamarit was also not disclosed to the USPTO. None of Català, Tamarit, or the 2010 and 2011 Mañosa articles were substantively considered during prosecution.

Accordingly, the Board should not decline institution under 35 U.S.C. §325(d).

VII. LEVEL OF ORDINARY SKILL IN THE ART

A POSITA pertaining to the '656 Patent at the relevant time would be a person with a B.S. in engineering or an equivalent field, with two to four years of academic or industry experience in caloric materials or comparable industry experience who would, where necessary or desired, work or consult with others. A person with less education but more relevant practical experience, or more relevant education but less practical experience, may also meet this standard. Ex[1004],¶33.

VIII. SUMMARY OF THE PRIOR ART

A. Xie (Ex[1006])

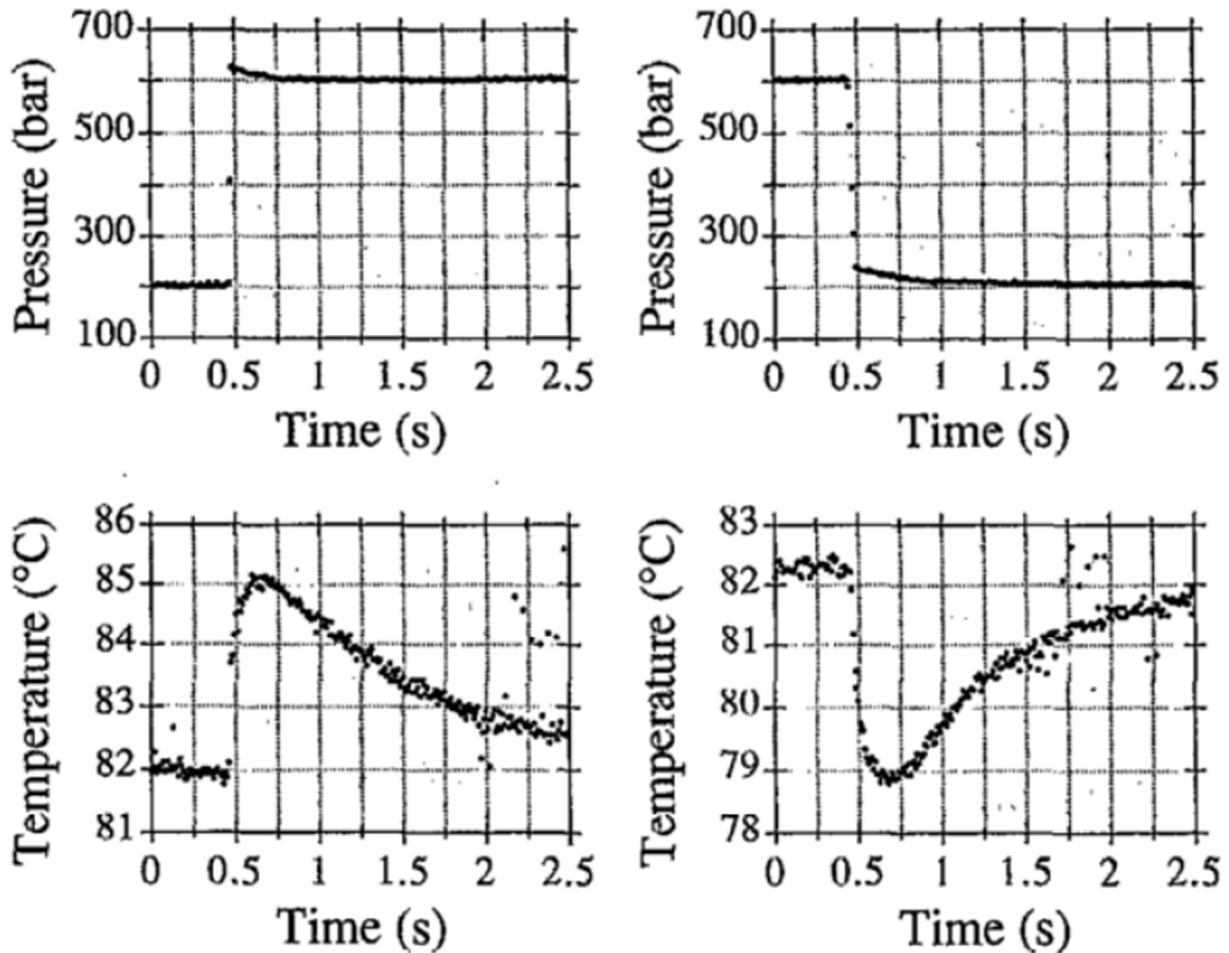
The article by Zhongjian Xie and Yao Zhu, “Demonstration of liquid crystal for barocaloric cooling application,” (Ex[1006]), was submitted and publicly available on September 26, 2016. Xie is briefly referenced in the specification of the '656 Patent admitting DHPE exhibits BCEs. Ex[1001],5:52-54.⁹ Xie was also

⁹ The '656 Patent mischaracterizes the temperature change discussed in Xie and Mencke as not attributable to DHPE, and instead arising due “pressure-driven temperature changes in water.” Ex[1001],5:58-64. This statement is both misleading and unsupported. Ex[1004],¶61. Mencke only discusses the effect of water on the response time and not the barocaloric effect. Ex[1004],¶61 (citing Ex[1016],FIG.3).

identified in an Information Disclosure Statement, (Ex[1002],249), and in the International Search Report (“ISR”) as a reference of “particular relevance” indicating the ’656 Patent’s claimed invention is not novel or directed to an inventive step; Ex[1002],321. Yet Xie was never substantively examined during prosecution. *See* §§V.A,V.C.

Xie proposes using liquid crystals (DHPE) in excess water as barocaloric materials for cooling applications. Like the ’656 Patent, Xie explains vapor-compression technology typically relies on hazardous gases, and alternative refrigeration technologies have focused on solid caloric materials. Ex[1006],Abstract,1. DHPE is a lipid and an organic compound based on its inclusion of at least a “hexadecyl” ((CH₂)₁₅CH₃) structure comprising carbon atoms and repeating carbon-hydrogen bonds. Ex[1004],¶57; *see also* §IX.A-B.

DHPE undergoes a phase transition between liquid crystal and gel phases when subjected to hydrostatic pressure. This phase transition occurs near room temperature in response to a relatively small pressure change and is accompanied by a large entropy change. Ex[1006],Abstract,2. Xie illustrates a temperature change of ~3K at ~82°C (~352K) in response to a pressure change of 400bar/40MPa.



Ex[1006],2,FIG.1(a).

Xie's Figure 1(a) shows increasing the pressure on DHPE from ~200bar to ~600bar produces a temperature increase of ~3°C (from ~82°C to ~85°C). Ex[1006],2,FIG.1(a). After the DHPE has returned to ~82°C, the hydrostatic pressure is removed and the temperature of the DHPE falls from ~82°C to ~79°C. *Id.* Thus, DHPE exhibits “a conventional [barocaloric] effect” where pressure changes prompt a phase transition in DHPE and produce temperature changes.

Ex[1006],2; *see also, e.g.*, Ex[1001],5:52-58. Moreover, DHPE exhibits a BCE “much larger than current BC materials.” Ex[1006],2.

In addition to the BCEs of DHPE, Xie states liquid crystals offer a number of advantages over solid barocaloric materials. Ex[1006],1-2. *First*, uniaxial pressure applied to a liquid provides hydrostatic pressure to the entirety of the liquid material. Ex[1006],1. *Second*, liquids do not have the same breakage problem exhibited by solid materials. Ex[1006],1,5. *Third*, “the gas coolants in vapor compressor [systems] may be directly replaced by the liquid BC material.” Ex[1006],1. *Fourth*, DHPE responds to “low pressure (tens of MPa)”. Ex[1006],5. *Finally*, DHPE is non-toxic and sustainable. Ex[1006],Abstract,5.

B. Mañosa (Ex[1007])

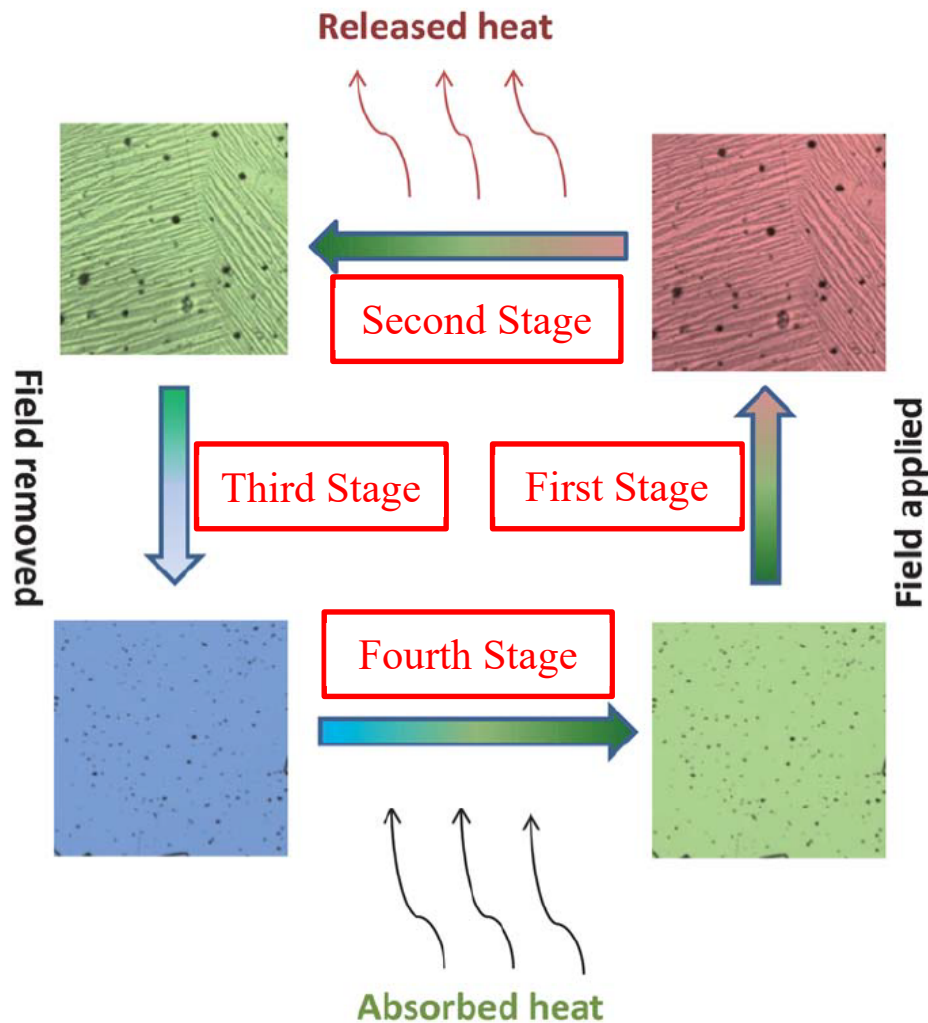
The article by Lluís Mañosa (a named inventor on the '656 Patent) and others, “Advanced Materials for Solid-State Refrigeration,” (Ex[1007],“Mañosa”) was submitted to the Journal of Materials Chemistry A on November 28, 2012; accepted on January 25, 2013; and published on January 29, 2013. *Id.* Mañosa was also submitted to ArXiv and available online as of March 15, 2013. Ex[1008]. Mañosa is a named inventor on the '656 Patent. Two earlier articles by Mañosa were disclosed as non-patent literature references 14 and 15 in the April 12, 2019 Information Disclosure Statement. Ex[1002],248 (citing Ex[1013], Ex[1014]). However, the 2013 Mañosa reference (Ex[1007]) relied upon herein was not disclosed to the

USPTO nor addressed during prosecution of the '656 Patent.¹⁰ *See generally* Ex[1002]; §V.C.

Mañosa discusses research into solid-state materials exhibiting caloric effects, including BCEs, and experimentally determining those caloric effects. Ex[1007],4925-26. Mañosa explains high isothermal entropy—i.e., heat—is “found when the material is in the vicinity of a phase transition.” Ex[1007],Abstract. Mañosa also explains materials may exhibit conventional or inverse caloric effects in the presence of an external field, and both conventional and inverse materials may be used “in efficient and environmental[ly] friendly refrigeration.” Ex[1007],Abstract,4925-26,4929,4933-34.

Mañosa illustrates an exemplary solid-state refrigeration cycle involving a material exhibiting a “giant caloric effect attained by applying a general external field”:

¹⁰ The '656 Patent briefly references the 2010 article by inventors Lluís Mañosa and Josep-Lluís Tamarit, among others, “Giant solid-state barocaloric effect in the Ni-Mn-In magnetic shape-memory alloy.” Ex[1001],20:21-38 (citing Ex[1014]). The '656 Patent states that a “[d]ifferential thermal analysis under hydrostatic pressure was performed as described by Mañosa et al.” Ex[1001],19:11-12. Mañosa2010 explains that the barocaloric effect is “used in most present cooling technologies that are based on the compression and expansion cycles of gases,” and discloses measurements of “the barocaloric effect resulting from the application of a hydrostatic pressure” in materials that also exhibit magnetocaloric effects and could be used to produce “more efficient and accurate cooling devices.” Ex[1014],478-80. But this disclosure was addressed only with respect to enablement. Ex[1002],111-13.



Ex[1004],¶63 (annotating and discussing Ex[1007],FIG.1). As Mañosa explains, in the first stage, a field—hydrostatic pressure for barocaloric materials—is adiabatically applied to a conventional caloric material, resulting in a temperature increase in that material. Ex[1007],Abstract,4926(FIG.1 description). In the second stage, the material is cooled as heat is transferred to a heat sink. *Id.* In the third stage, the field is adiabatically removed and the material cools below its initial temperature.

Id. In the fourth stage, the material returns to its original state by absorbing heat from a cold reservoir, which cools the reservoir. *Id.*

Mañosa address several caloric effects, including barocaloric, magnetocaloric, elastocaloric, and electrocaloric effects. Ex[1007],4927-34. When addressing BCEs, Mañosa provides experimental evidence of the inverse BCE exhibited by La-Fe-Si and Gd-Si-Ge compounds, (Ex[1007],4927-29,FIGS.3,5-6), and the conventional BCE of Ni-Mn-In compounds, (Ex[1007],4931-32,FIG.12). The La-Fe-Si compound is identified as “an attractive material with a temperature change of ~2K at ~240K with 2kbar of hydrostatic pressure, but Mañosa also notes its below-room-temperature transition temperature is a potential drawback. Ex[1007],4928-29,FIG.5.

C. Patel (Ex[1009])

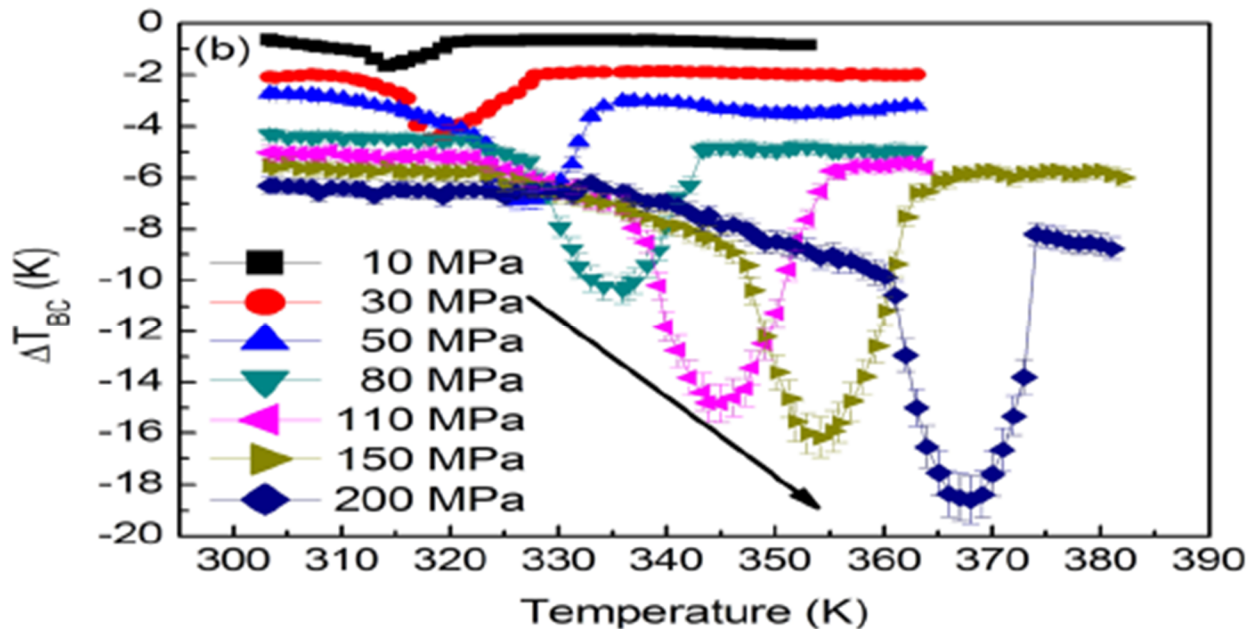
The article by Satyanarayan Patel et al., “Elastocaloric and barocaloric effects in polyvinylidene di-fluoride-based polymers,” (Ex[1009],“Patel”) was received by Applied Physics Letters on October 16, 2015; accepted January 30, 2016; and public online on February 16, 2016. Despite a brief reference to Patel in the specification of the '656 Patent and its inclusion in the April 12, 2019 Information Disclosure Statement, (Ex[1002],249), Patel was never substantively examined during prosecution.

Patel discusses experimental measurement of the multicaloric effect of polyvinylidene di-fluoride-based (PVDF) polymers. Ex[1009],Abstract,1-5. Patel explains “there is a dire need to develop suitable alternatives for integrated cooling” and “materials which can demonstrate more than one caloric effect”—such as electrocaloric, magnetocaloric, elastocaloric, and barocaloric effects—are potential candidates. Ex[1009],1. PVDF and its co-polymers are also identified as potentially exhibiting strong elastocaloric and BCEs. Ex[1009],1.

PVDF is an organic compound based at least on the construction provided in the '656 Patent. For example, a POSITA would understand polyvinylidene fluoride portion ($\text{—H}_2\text{C=CF}_2\text{—}$) of PVDF has alternating CH_2 and CF_2 groups with multiple carbon-carbon bonds and multiple carbon-hydrogen bonds. Ex[1004],¶69 (citing Ex[1019],909(“polyvinylidene fluoride”)).

As noted above, Patel explains PVDF-TrFE-CTFE shows high potential for elastocaloric and barocaloric refrigeration applications. Ex[1009],1. In fact, Patel experimentally determined the reaction of PVDF-TrFE-CTFE to hydrostatic pressure can be a “staggeringly high temperature drop of $\sim 19\text{K}$ ”—“an order of magnitude improvement over the other results reported for bulk ferroelectric

samples till date.” Ex[1009],4,Table I.¹¹ Near room temperature ($\sim 300\text{K}$ or 26.85°C) and under only 200MPa of hydrostatic pressure, PVDF-TrFE-CTFE exhibits a substantial temperature drop of 6K .

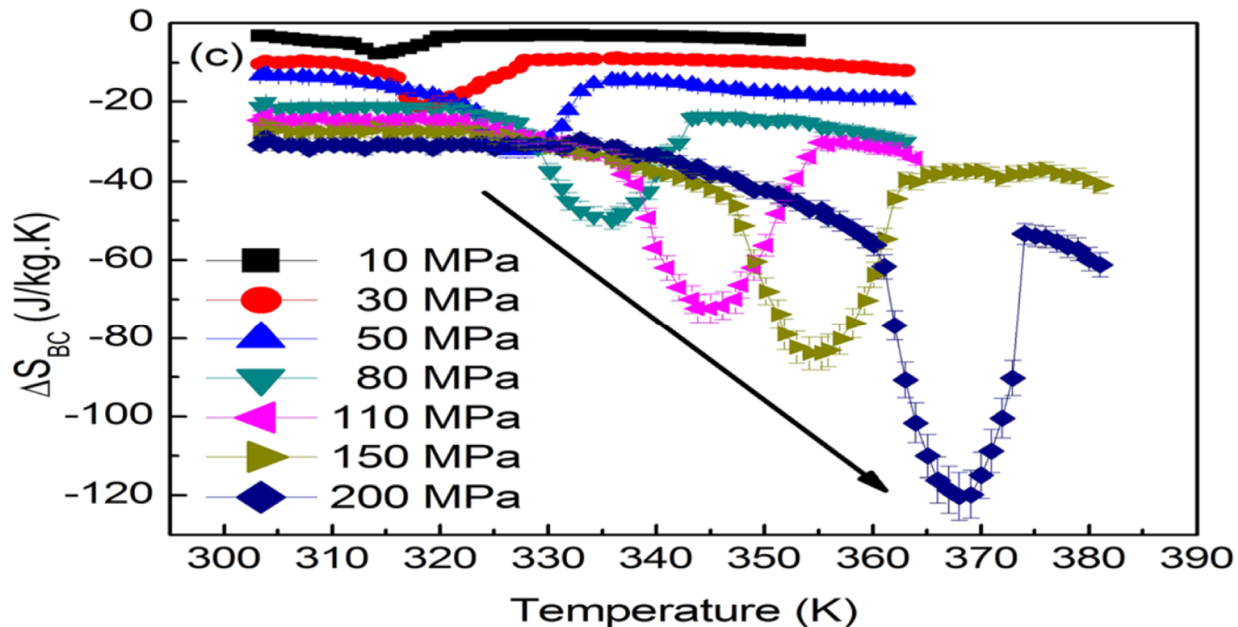


Ex[1009],4,FIG.3(b).

Patel also discloses the entropy change of PVDF-TrFE-CTFE at various temperatures and hydrostatic pressures. For example, when applying a hydrostatic pressure of at least 30MPa , PVDF-TrFE-CTFE exhibits an entropy change ΔS_0 at the

¹¹ Patel issued an erratum in 2018 explaining that their original calculations included a sign error and that the values used in Figures 3 and Table I are indicative of the absolute values of ΔT_{BC} and ΔS_{BC} . Ex[1009],8. Because the magnitude of the barocaloric effects of PVDF-TrFE-CTFE in Patel are accurate, a POSITA would have understood the benefits of and how to use PVDF-TrFE-CTFE, regardless of whether it is a conventional or inverse barocaloric material. Ex[1004],¶108.

phase transition, where the absolute value of the change exceeds at least $10 \text{ J K}^{-1} \text{ kg}^{-1}$.



Ex[1009],4,FIG.3(c).

Finally, like other organic BC materials, PVDF has “other advantages such as ease of fabrication (shape), low cost, and low processing temperatures.” Ex[1009],1. Moreover, the BCE of PVDF is analogous to the traditional “vapor compression cycle, where heating and cooling effects are obtained using fluid compression and expansion.” *Id.*

D. Català (Exs[1011],[1012])

Nuria Pol Català is a final degree project, “Barocaloric effects in plastic crystals,” (Exs[1011],[1012],“Català”)¹² dated June 2016 for a bachelor’s degree from the Escola Tècnica Superior d’Enginyeria Industrial de Barcelona (“ETSEIB”) at the Universitat Politècnica de Catalunya. Ex[1024].

Català was identified in the ISR and in the Written Opinion of the International Searching Authority (“Written Opinion”) and was publicly available before the October 14, 2016 priority date. Ex[1002],320,374; Ex[1024]. The Written Opinion identifies Català as of “particular relevance,” indicating the claimed invention is not novel or directed to an inventive step. Ex[1002],320. Additionally, the two directors supporting Català’s project are inventors José Luis Tamarit Mur and Pol Marcel Lloveras Muntane. Ex[1012],Cover,63; Ex[1001],Cover. Yet the ’656 Patent makes no mention of Català and Català was never substantively examined during prosecution.

Català discusses problems with existing refrigeration systems, including environmental risks, and therefore seeks “an alternative to current refrigerants” such as solid state materials that are “easier to contain and avoid contamination.” Ex[1012],1,7,11. Català investigated “the barocaloric effects in materials called

¹² Ex[1012] is a certified translation of Ex[1011] from Catalan to English; therefore, subsequent references to Català identify the English translation, Ex[1012].

plastic crystals” due to their potential use as “suitable candidates to replace current refrigerants.” The plastic crystals identified by Català, Tris(hydroxymethyl)aminomethane (TRIS) ($\text{NH}_2\text{C}(\text{CH}_2\text{OH})_3$) and 2,2-Dimethyl-1-propanol-99% (NPA) ($(\text{CH}_3)_3\text{CCH}_2\text{OH}$), are organic and contain multiple carbon-carbon bonds and carbon-hydrogen bonds. Ex[1012],1,32,Table4.1.

Català explains “the application of an external field causes isothermal entropy changes or adiabatic temperature changes” in caloric materials. Ex[1012],12. For barocaloric materials, application of hydrostatic pressure can produce a change of volume and entropy. Ex[1012],12-13,16,19,29-32,45,50-51.

Català describes how to use solid-state refrigerants in a real-world refrigerant cycle derived from an ideal inverted Carnot cycle. “The cycle begins at point 1, which is at low pressure (p_1) and in the high temperature phase.” Ex[1012],16-17. The barocaloric material transitions from State 1 to State 2 when it is adiabatically compressed, “causing an increase in temperature.” *Id.* The barocaloric material is then brought into contact with a thermal bath, releasing heat into the bath and bringing the temperature of the material down, as the material transitions from State 2 to State 3. *Id.* Adiabatic expansion causes the material to cool (transition from State 3 to State 4). *Id.* And finally, the material absorbs heat “from the system to be cooled” as the material returns to its initial state. *Id.*

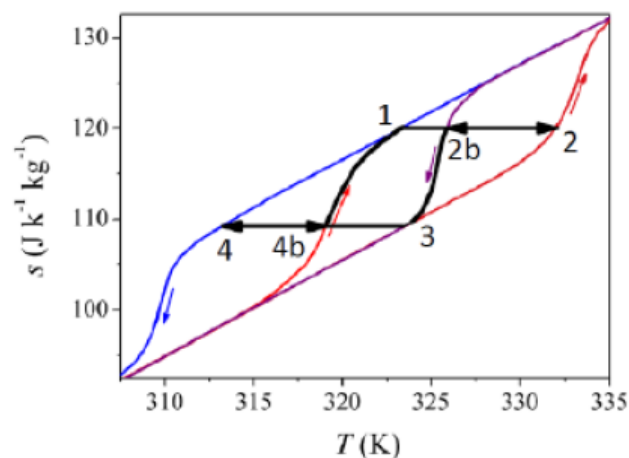
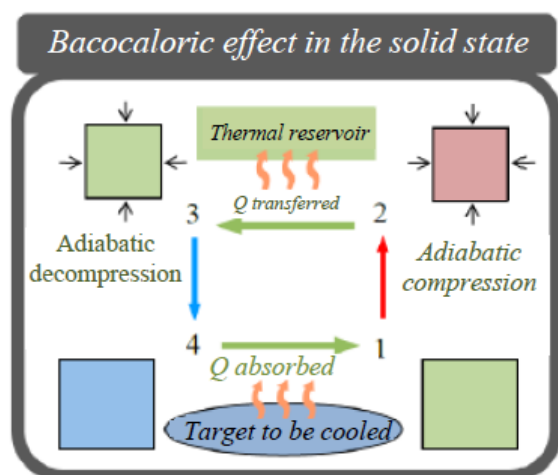


Figure 2.7. Refrigeration cycle of a machine, hysteresis present [2].

Ex[1012],17. Català notes NPA supports “cyclic compression refrigeration machines for working pressures higher than 0.5 kbar” and “exceeds the best BCE results in solids to date” by a factor of 3 and has a refrigerant capacity 33 times better than the best results in other barocaloric solids. Ex[1012],61. Moreover, NPA operates between 240 and 330K (at room temperature), depending on the applied pressure. *Id.*

E. Tamarit (Ex[1021])

The article by J. Li. Tamarit, “Thermodynamic Study of Some Neopentane Derivated by Thermobarometric Analysis,” (Ex[1021]), was published online on September 24, 2006. Tamarit is both an inventor of the ’656 Patent and the supervisor to Català on the final degree project. Ex[1001],Cover; Ex[1012],Cover.

The prior art repeatedly links barocaloric effects—a change in temperature when pressure is applied—as occurring due to changes in volume and entropy at

phase transitions. Ex[1004], ¶¶145-46 (citing Ex[1007], 4928; Ex[1013], 4; Ex[1009], 3-4; Ex[1010], Abstract; Ex[1012], 12, 31; Ex[1021], 349-54). And Tamarit discloses volume changes, high entropy variations, and pressure-temperature diagrams at first order phase transitions for six organic plastic crystals, including TRIS and NPA. Ex[1021], Table I; Ex[1004], ¶81. A POSITA would thus have understood Tamarit identifies organic plastic crystals that were likely to exhibit barocaloric effects. Ex[1004], ¶¶81, 144-45.

IX. CLAIM CONSTRUCTION

Claim terms are construed according to their ordinary and customary meaning as understood by a POSA and the prosecution history. 37 C.F.R. §42.100(b). For terms not explicitly construed below, and in the absence of a clear statement that shows “unmistakable [and] unambiguous evidence of disclaimer,” (*Omega Eng’g, Inc. v. Raytek Corp.*, 334 F.3d 1314, 1332 (Fed. Cir. 2003)), Petitioner interprets them for purposes of this review in accordance with their plain and ordinary meaning, (*Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005)(en banc)).

Although several terms related to “organic” are addressed below, Petitioner asserts they are entitled to the full scope of their plain and ordinary meaning and no construction is necessary. However, Applicant also defined “organic” in the ’656 Patent specification, as discussed below in greater detail. The organic materials

identified herein satisfy the definition of “organic,” under either a plain and ordinary meaning or as defined in the ’656 Patent specification.

A. “organic”

The ’656 Patent defines “organic” broadly as a material having “one or more carbon atoms, and most typically two or more carbon atoms”. Ex[1001],Abstract,3:47-48,6:19-21. *See, e.g.,* Ex[1019],823-824(“organic chemistry” “embraces all compounds of carbon”). In contrast, an inorganic material “does not contain a carbon atom.” Ex[1001],6:23-25; *see also* Ex[1002],115 (arguing ammonium sulfate is not organic because it “lacks a carbon atom”). An organic material may include a metal ion and “nevertheless be referred to as an organic material.” Ex[1001],7:1-7. A POSITA would also understand “organic” to refer to materials containing carbon. Ex[1004],¶52.

The ’656 Patent also states an organic material “usually possess[es] one or more carbon-carbon bonds, such as two or more carbon-carbon bonds,” (Ex[1001],Abstract,3:47-50,6:19-23), and “will typically also contain hydrogen, and the material will usually have one or more carbon-hydrogen bonds, such as two or more carbon-hydrogen bonds.” Ex[1001],3:47-50,6:26-29. However, neither the carbon-carbon bonds nor the hydrogen and carbon-hydrogen bonds are required, as indicated by the use of “usually” and “typically.” *See, e.g., Reflex Packaging, Inc. v. Lenovo (U.S.) Inc.*, No. 5:10-CV-01002-EJD, 2012 WL 1622694, at *4 (N.D. Cal.

May 8, 2012) (explaining terms like “usually” and “typically” make it clear none of the language ... is inherently limiting”). Accordingly, as defined in the ’656 Patent, a material is organic if it contains “one or more carbon atoms.”

B. “organic material”

The specification of the ’656 Patent does not limit the scope of the claimed “organic material” of independent claims 1 and 9. While the ’656 Patent describes what the “organic material” “may” or “may not” be or what properties it “may” exhibit, for example, under the headings “Organic Material” and “Organic Material Properties,” (Ex[1001],3:47-62,6:10-14:4), these descriptions are not limiting. *Cadence Pharm. Inc. v. Exela PharmSci Inc.*, 780 F.3d 1364, 1369 (Fed. Cir. 2015). “The claims, not specification embodiments, define the scope of patent protection. The patentee is entitled to the full scope of his claims,” and it is improper to “limit him to his preferred embodiment or import a limitation from the specification into the claims.” *Kara Tech. Inc. v. Stamps.com Inc.*, 582 F.3d 1341, 1348 (Fed. Cir. 2009); *see also Comark Comms., Inc. v. Harris Corp.*, 156 F.3d 1182, 1186 (Fed. Cir. 1998) (quoting *Texas Instrs., Inc. v. United States Int’l Trade Comm’n*, 805 F.2d 1558, 1563 (Fed. Cir. 1986)) (“This court has cautioned against limiting the claimed invention to preferred embodiments or specific examples in the specification.”). Moreover, the specification is not limiting because it caveats many of these statements with terms such as “generally,” “typically,” “usually,” and “here,” along

with explicit statements that these descriptions at most correspond to “one embodiment” or “other embodiments,” (*see, e.g.,* Ex[1001],6:14-15,6:19-23,6:67,7:18-25). *See, e.g., Reflex*, 2012 WL 1622694, at *4.

For example, the specification states: “The barocaloric organic material may have a molecular weight of 2,000 or less, such as 1,000 or less. Here, the organic material is not a polymer.” This is not an “unmistakable [and] unambiguous evidence of disclaimer” as to the scope of the claimed “organic material”—it merely states an exemplary organic material with a low molecular weight is not a polymer. Therefore, it would be improper to import this limitation into the meaning of “organic material.” *Kara*, 582 F.3d at 1348.

In fact, to import these limitations from the specification by, for example, excluding organic polymeric materials, would be to conflate the scope of the independent and dependent claims. “The concept of claim differentiation ... states that claims should be presumed to cover different inventions. This means that an interpretation of a claim should be avoided if it would make the claim read like another one.” *Laitram Corp. v. Rexnord, Inc.*, 939 F.2d 1533, 1538 (Fed. Cir. 1991); *see also* 37 CFR §1.75 (“One or more claims may be presented in dependent form, referring back to and further limiting another claim or claims in the same application”). Claims 1 and 9 do not provide any limitations on the “organic material” except that it is “employ[ed] ... as a barocaloric cooling or heating agent.”

Ex[1001],20:41-42. Therefore, if the “organic material may have a molecular weight that is at most 500, at most 700, at most 1,000, at most 2,000, at most 5,000, or at most 10,000,” this description addresses similar language in claim 2 and does not limit claim 1. *Compare* Ex[1001],20:49-54 *with* Ex[1001],8:42-44. If the specification limited claim 1, it would eliminate the differences between claims 1 and 2. While claim differentiation is a guide, rather than a rigid rule, (*Laitram*, 939 F.2d at 1538), there is no description in the ’656 Patent limiting the claims to a single embodiment or to otherwise overcome this presumption. A POSITA would understand that some materials with molecular weights of 2,000 or less may not be polymers, but there is no basis for excluding polymers from the ’656 Patent’s claim term “organic material.” Ex[1004],¶53. For example, while “high polymers” may have higher molecular weights, “low polymers” can have a molecular weight below 2000, and under some definitions can have a molecular weight as low as 300. *See, e.g.,* Ex[1004],¶53 (citing Ex[1019],902 (“low polymer”)). Ultimately, the ’656 Patent claims neither claim nor exclude polymers.

Even where the specification uses more explicit language to describe the claimed “organic material,” such language is not limiting. For example, the ’656 Patent also states a “barocaloric organic material is a compound, or a salt of that compound.” Ex[1001],3:47-48. But claim 2 recites the “method according to claim 1, wherein the organic material is an organic compound or a salt thereof....”

Ex[1001],20:49-51. Despite the specification's description of what the "organic material" is, the doctrine of claim differentiation limits an attempt to conflate the "organic material" of claim 1 with the "organic compound" of claim 2.

Similarly, Applicant has not disclaimed the scope of any claims by, for example, importing limitations from the specification into the Challenged Claims. During prosecution, independent claims 1 and 9 were rejected under 35 U.S.C. § 102 over Lloveras. Ex[1002],133-136 (May 26, 2021 Amendment/Request for Reconsideration) (citing Ex[1015]). Lloveras discloses PMMA, an organic material exhibiting BCEs. *Id.* Applicant distinguished the disclosures in Lloveras for four reasons. Ex[1002],114-115 (May 26, 2021 Amendment/Request for Reconsideration) (citing Ex[1015]). *First*, Applicant argued the ammonium sulphate disclosed by Lloveras is not organic because it "lacks a carbon atom." *Second*, Applicant asserted Lloveras "does not describe the actual step of employing the compound as a barocaloric cooling or heating agent." *Id.* (emphasis in original). *Third*, Applicant argued Lloveras does not disclose "the particular steps recited in Claim 39," i.e., steps (i)-(iv) in current claim 9. *Id.* (emphasis in original). *Fourth*, Applicant argued Lloveras fails to "describe a means for transferring heat as recited in the claims that can transfer heat for a barocaloric transition with latent heat, $|Q_0|$, that is at least 25 kJ kg¹." *Id.* Applicant did not distinguish Lloveras by importing limitations from the specification, for example, by arguing the claimed "organic

material” excludes organic polymers, including the PMMA disclosed in Lloveras. *See, e.g.*, Ex[1001],3:56-58. To exclude only certain specific organic materials identified in the specification and known in the prior art while allowing the patentee to claim all other organic materials would be legally improper.

C. “organic compound”

Claims 2 and 10 recite the “organic material” of claims 1 and 9 is also an “organic compound.” The ’656 Patent does not provide a definition for “compound.” Accordingly, the plain and ordinary definition of “compound” is sufficient. For example, a typical dictionary definition for compound is a “substance composed of atoms or ions of two or more elements in chemical combination.” Ex[1004],¶54 (citing Ex[1019],291(“compound”)). Because all of the prior art cited discloses compounds under any definition, no construction is necessary.

D. “agent”

The specification of the ’656 Patent and claim 1 reference “use of the organic material as a cooling agent” or as a “heating agent.” Ex[1001],Abstract,1:25-26,2:48-55,4:13-15,3:27-28,14:6-11,15:45-50,17:45-48,20:41-43(Claim 1). The ’656 Patent does not define “agent.” *Id.* However, a POSITA would understand the ’656 Patent uses “agent” to refer to the material changing temperature within a refrigeration cycle “for example within a cooling apparatus,” and that thereby enables the cooling or heating process. *See, e.g.*, Ex[1001],14:5-9; Ex[1004],¶55.

E. “optionally”

The term “optionally” is used in claims 2, 6, 8, 10, 14, and 16 of the ’656 Patent and denotes the non-required recitations following the term “optionally.” *Boehringer Ingelheim Pharm., Inc. v. Hec Pharm Co., Ltd.*, No. 15-CV-5982(PGS)(TJB), 2017 WL 11633325, at *6 (D.N.J. Jan. 5, 2017) (citing MPEP §2173.05(h) and *Ex Parte Cordova*, 10 U.S.P.Q.2d 1949 (Bd. Pat. App. & Interf. 1987)). Accordingly, the “optionally” included recitations in claims 2, 6, 8, 10, 14, and 16 have no patentable weight and no bearing on the obviousness analysis herein. *In re Johnston*, 435 F.3d 1381, 1384 (Fed. Cir. 2006) (“optional elements do not narrow the claim because they can always be omitted.”)

X. ASSERTED GROUNDS OF INVALIDITY

A. Ground 1: Claims 1-2, 6-10, and 14-16 Are Rendered Obvious by Xie in View of the Knowledge of a POSITA

1. Claim 1

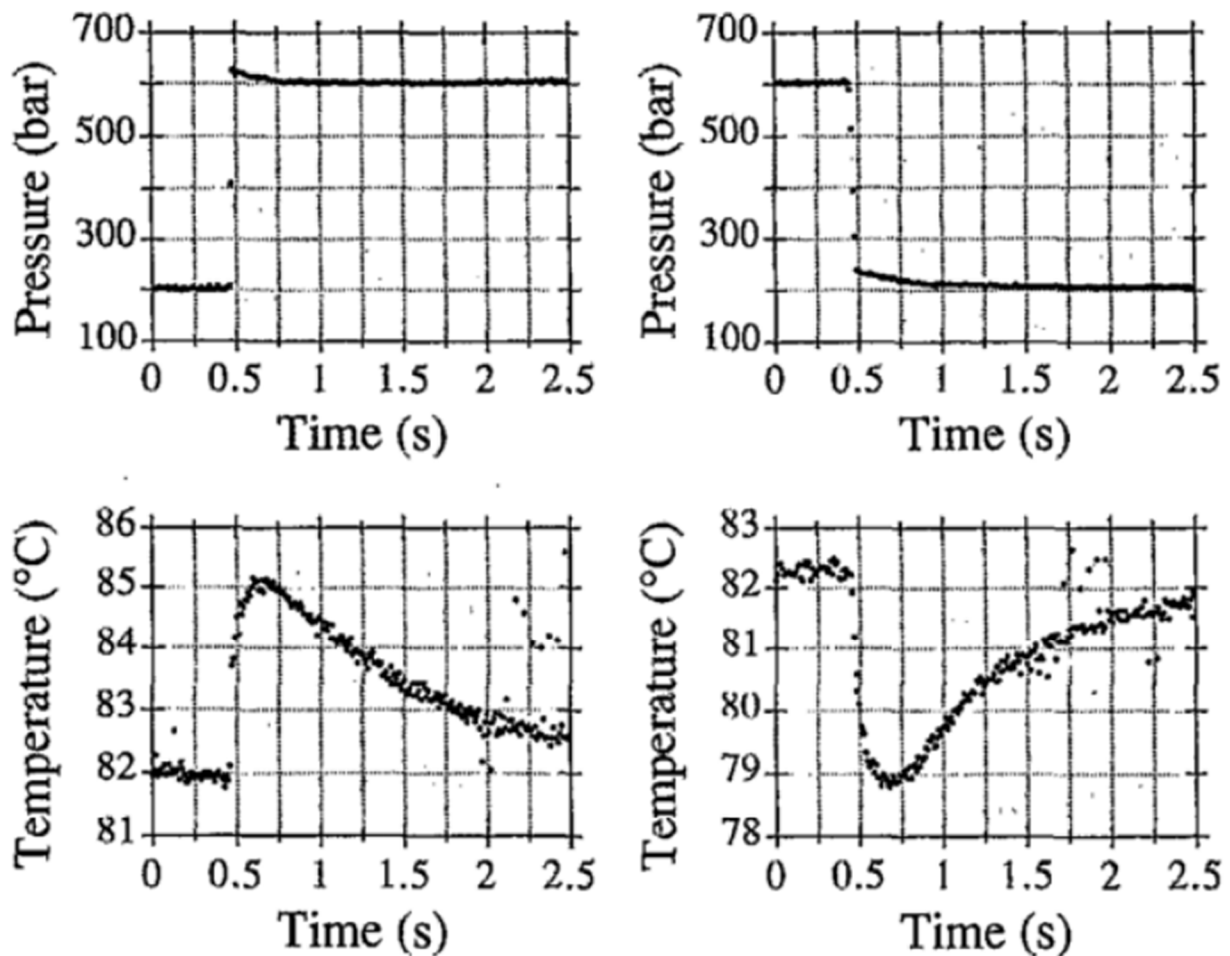
Xie in view of the knowledge of a POSITA discloses, and renders obvious, all elements of claim 1 of the ’656 Patent. Ex[1004], ¶¶82-90.

- (a) 1[pre]: A method comprising employing an organic material as a barocaloric cooling or heating agent, wherein the method comprises:**

To the extent the preamble is limiting, Xie renders it obvious. Ex[1004], ¶83.

Xie teaches using an organic material, dihexadecylphosphatidylethanolamine (DHPE) exhibiting BCEs. Ex[1006],2.¹³ Xie states DHPE is a lipid—“a solid crystal”—that becomes a “liquid crystal ... in excess water” and “exhibits a conventional barocaloric effect.” “When pressure [400bar/40MPa] is applied and removed, the temperature increases [~ 3 K] and decreases, respectively.” *Id.*

¹³ Even if the specific material disclosed in Xie, DHPE, were improperly excluded from the “organic material” employed “as a barocaloric cooling or heating agent,” it would have been obvious to a POSITA to use an organic material as a barocaloric cooling or heating agent based on Xie’s disclosure of DHPE, a liquid crystal. *See, e.g.,* Ex[1004],¶¶40-44; §§X.B.1,X.C.1. Likewise, the organic materials that exhibit barocaloric effects disclosed in Patel and Tamarit in Grounds 2-5 also render obvious the use of organic materials that exhibit barocaloric effects.



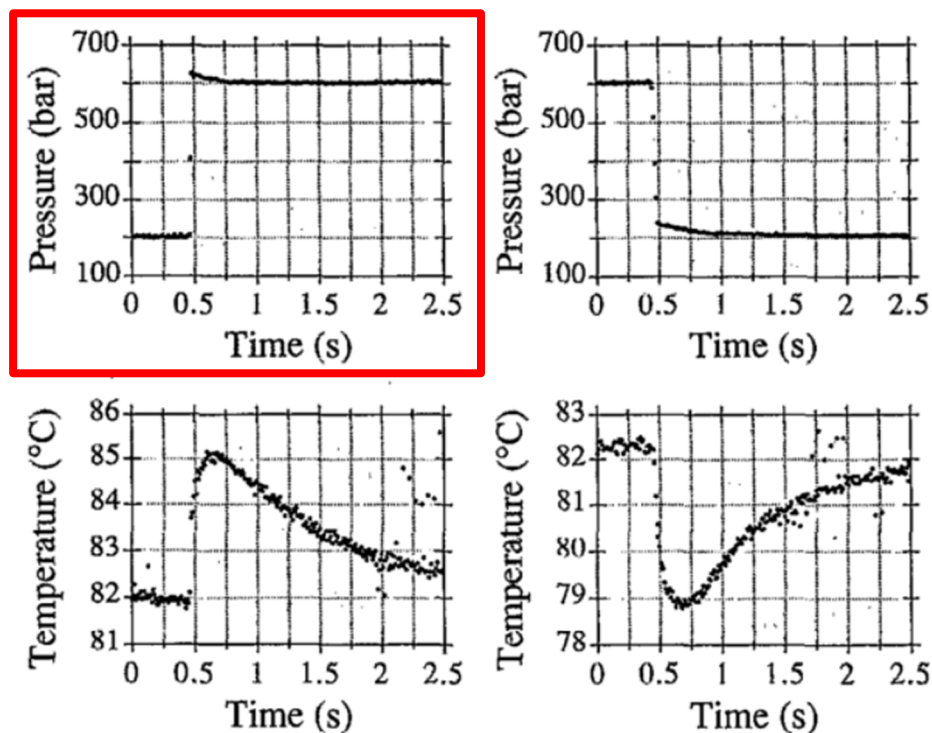
Ex[1006],FIG.1.

Further, a POSITA would have understood and considered it obvious the graphs in Xie's Figure 1 represent the four method steps recited in claim 1. Ex[1004],¶¶85-86. Thus, Xie expressly discloses employing DHPE, a liquid crystal and therefore an organic material, as a barocaloric cooling or heating agent to carry out the recited method steps. *See, e.g.*, Ex[1019],676("liquid crystal" is "An organic compound"). In light of the knowledge of a POSITA regarding use of organic materials exhibiting BCEs (*see, e.g.*, §§V.A-X.B, herein), a POSITA would have

understood Xie renders obvious employing both (1) the express organic material (DHPE) in the recited steps and, (2) an organic material in general. EX[1004],¶¶83-86. Although Petitioner refers to the specific disclosure of DHPE in Xie (or other organic materials in Patel and Tamarit), all grounds render obvious both the express materials disclosed and the more general concept of employing an organic material as recited in the claims.

(b) 1[a]: (i) applying hydrostatic pressure to an organic material;

Xie renders obvious this limitation. Ex[1004],¶87; Ex[1006]. Xie discloses application of 400Bar/40MPa of hydrostatic pressure to DHPE in water. Ex[1006],1-2,FIG.1.

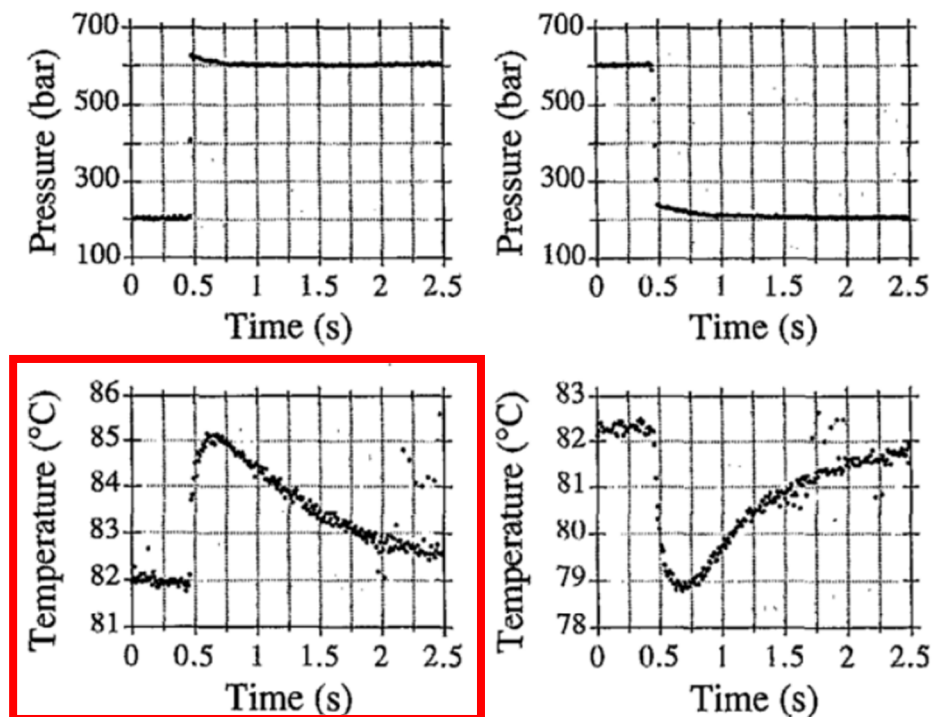


Ex[1006],FIG.1

- (c) 1[b]: (ii) permitting heat flow from or to the organic material;

Xie renders obvious this limitation. Ex[1004],¶88; Ex[1006]. Xie explains the application of 400bar of hydrostatic pressure (limitation 1[a]) produces a temperature change of ~3K, with heat flowing from the DHPE as it returns to ~82°C.

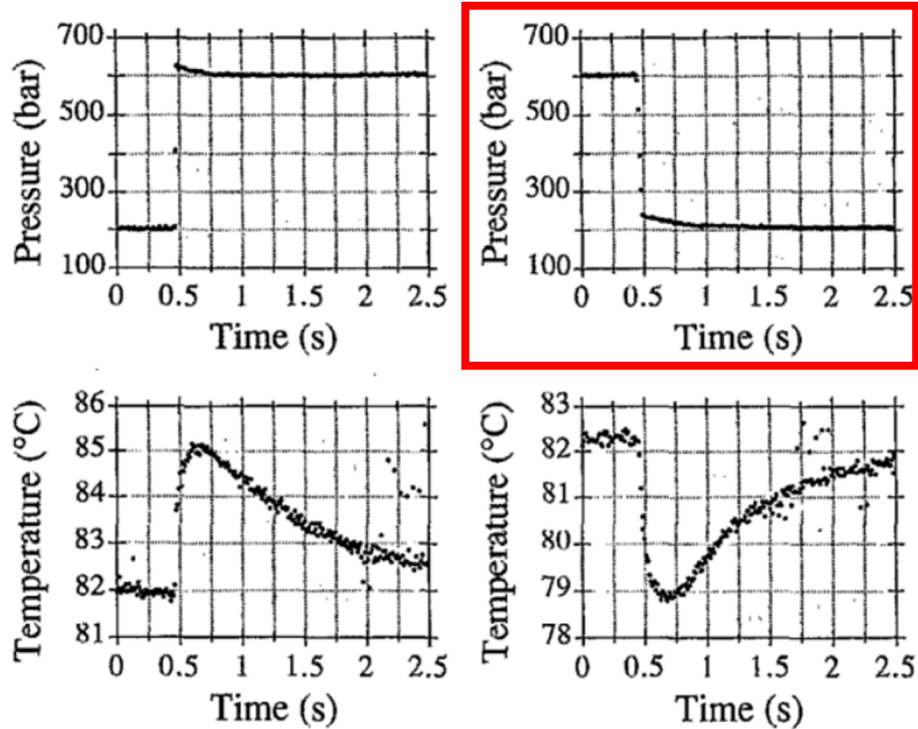
Ex[1006],1,FIG.1.



Ex[1006],FIG.1.

- (d) 1[c]: (iii) releasing hydrostatic pressure from an organic material that is under applied pressure; and

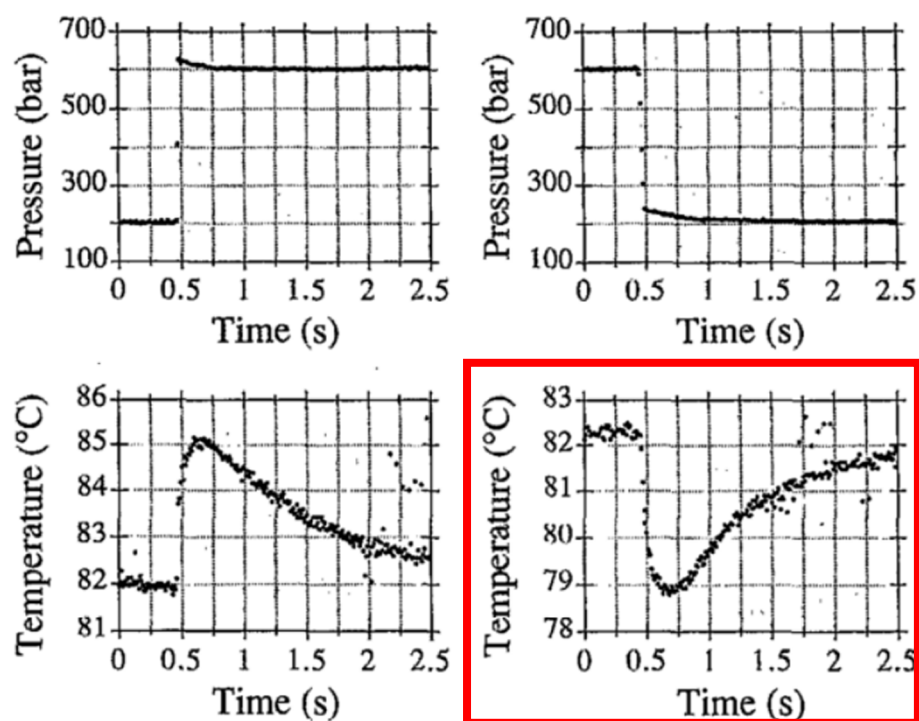
Xie renders obvious this limitation. Ex[1004],¶89; Ex[1006]. Xie explains the hydrostatic pressure on the DHPE in water is released. Ex[1006],1-2,FIG.1.



Ex[1006],FIG.1.

- (e) 1[d]: (iv) permitting heat flow to or from the organic material.

Xie renders obvious this limitation. Ex[1004],¶90; Ex[1006]. Xie explains removing the hydrostatic pressure from the DHPE in water (limitation 1[c]) produces a temperature decrease of ~3K before heat flows to the organic material returns to ~82°C. Ex[1006],1,FIG.1



Ex[1006],FIG.1.

2. *Claim 2*

- (a) **2:** The method according to claim 1, wherein the organic material is an organic compound or a salt thereof optionally wherein at least one of the following is present:

the organic material has a molecular weight of at most 2,000;

the organic material has a molecular weight of at least 50;

the organic material is an organic compound or a salt thereof, and the organic compound has two or more carbon-carbon bonds;

the organic material is an organic compound or a salt thereof, and the organic compound has two or more carbon-hydrogen bonds; and

the organic material is a liquid crystal or a plastic crystal.

Xie renders obvious this claim. Ex[1004],¶¶91-92. As discussed above for claim 1, the organic material disclosed by Xie, DHPE, is “an organic compound.” For example, it is an organic “substance composed of identical molecules consisting of atoms of two or more chemical elements.” Ex[1004],¶91; §IX.C (citing Ex[1019],291(“compound”)).

As noted above, inclusion of the term “optionally” does not require the subsequent claim language to be disclosed by the prior art. Even so, Xie discloses at least two of these limitations. First, the “organic material” disclosed in Xie, DHPE is a “*liquid crystal* ... in excess water.” Ex[1006],2. Second, DHPE is an organic compound containing “two or more carbon-hydrogen bonds.” Ex[1004],¶91. For example, the “hexadecyl” ((CH₂)₁₅CH₃) functionality *alone* contains 16 carbon atoms and 33 hydrogen atoms and includes repeating –(CH₂)– entities, where each

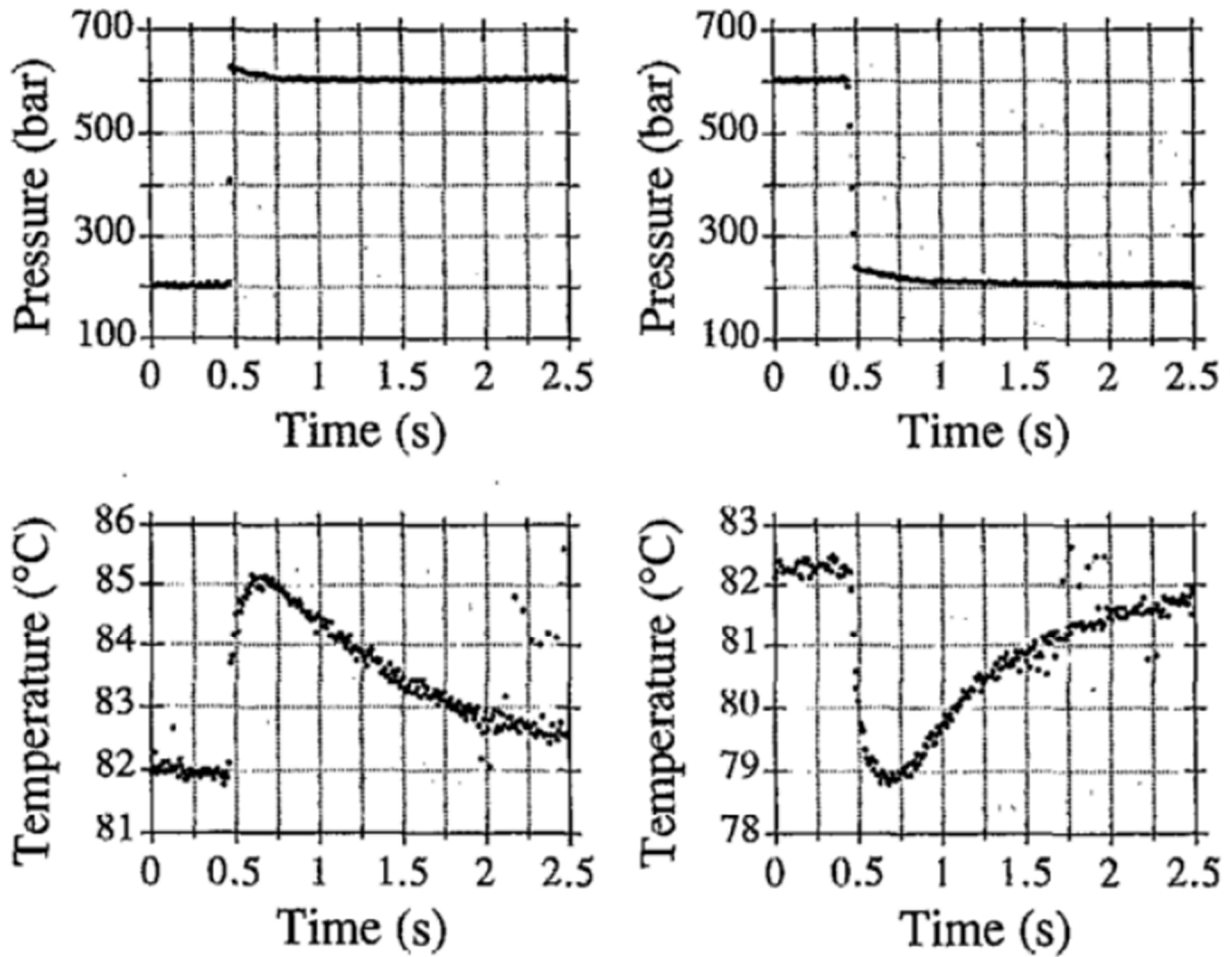
carbon atom has two carbon-hydrogen bonds. Ex[1004],¶91 (citing Ex[1019],571(“*n*-hexadecane”)).

3. Claim 6

- (a) **6: The method according to claim 1, wherein the organic material has a phase transition at a temperature within the range 200 to 450 K, optionally wherein the phase transition of the organic material is a first-order phase transition.¹⁴**

Xie renders obvious this claim. Ex[1004],¶93; Ex[1006]. Xie discloses a phase transition in DHPE “between the lamellar liquid crystal, L_α , and the lamellar gel, L_β , phase” at $\sim 82^\circ\text{C}$. Ex[1006]; *see also id.*, FIG.1(caption). A POSITA would understand $\sim 82^\circ\text{C}$ is $\sim 355.15\text{K}$ —“a temperature within the range 200 to 450K.” Ex[1004],¶93.

¹⁴ Based on the claim construction of the term “optionally,” the phrase “optionally wherein the phase transition of the organic material is a first-order phase transition” should be interpreted as “the phase transition of the organic material may be a first-order phase transition” and no disclosure of a “first-order phase transition” in the prior art is necessary for this claim to be found invalid.



Ex[1006],FIG.1.

4. *Claim 7*

- (a) 7: The method according to claim 1, wherein at least one of the following is present:

the organic material has an entropy change at a phase transition, $|\Delta S_0|$, of at least $10 \text{ J K}^{-1} \text{ kg}^{-1}$;

a phase transition in the organic material displays a latent heat, $|Q_0|$, that is at least 1 kJ kg^{-1} ;

the organic material has a volume change at the phase transition of at least $1.0 \text{ mm}^3 \text{ g}^{-1}$; and

the organic material is provided within a pressure-transmitting medium.

Xie renders obvious this claim. Ex[1004], ¶¶94-96. Xie discloses providing DHPE “in excess water.” Ex[1006], 2. The ’656 Patent specification mentions that “[t]ypically, the pressure-transmitting medium is not water,” (Ex[1001], 16:66-67), which may be the case for inorganic barocaloric materials. Ex[1004], ¶94. However, the specification admits “[p]ressure-transmitting media are well known in the art and include liquid and solid materials.” Ex[1001], 16:64-66. *See, e.g.*, Ex[1001], 5:6-9, 10:3-4. The ’656 Patent therefore admits liquids, like water, may be “a pressure-transmitting medium,” as disclosed in Xie, even if water is not *typically* used. Ex[1004], ¶95. Moreover, a POSITA would understand water is a well-known pressure-transmitting medium. Ex[1004], ¶¶94-95.

5. Claim 8

- (a) **8: The method according to claim 1, wherein hydrostatic pressure is applied to the organic material at a temperature that is within 50 K, of a phase transition temperature of the organic material, where the phase transition temperature is the temperature for the phase transition in the absence of the hydrostatic pressure optionally wherein:**

**the applied hydrostatic pressure is at most 1.0 GPa; or
the applied hydrostatic pressure is at least 0.1 MPa.**

Xie renders obvious this claim. Ex[1004], ¶¶97-98.

As explained above, the wherein clause following “optionally” is not a required limitation, has no patentable weight and no bearing on the analysis herein. *See* §IX.E. Further, the “optional” clauses are meaningless. They recite *every* hydrostatic pressure value could be applied to the organic material in independent claims 1 and 9, because the first “option” recites all hydrostatic pressures from 0 GPa up to “at most 1.0 GPa” and the second “option” recites all hydrostatic pressures from “at least 0.1 MPa” to an infinitely large hydrostatic pressure. Ex[1004], ¶98. Accordingly, the “optional” clauses claim application of any hydrostatic pressure values between zero and infinity, and thus fail to narrow the scope of the claim.

With respect to the first wherein clause of claim 8, the article by Anchi Cheng, Andres Méncke, and others, “Kinetics and Mechanism of the Barotropic Lamellar Gel/Lamellar Liquid Crystal Phase Transition in Fully Hydrated Dihexadecylphosphatidylethanolamine: A Time-Resolved X-Ray Diffraction Study Using Pressure Jump,” (Ex[1018]), explains the phase transition temperature of DHPE is 68.5°C at atmospheric pressure. Ex[1018],295; Ex[1004], ¶97. Xie discloses hydrostatic pressure is applied to DHPE at a phase transition of ~82°C. Ex[1006],2; Ex[1004], ¶97. Accordingly, a POSITA would understand Xie discloses

hydrostatic pressure applied to DHPE at a temperature (82°C) within 50 K of the phase transition temperature of DHPE absent hydrostatic pressure (68.5°C).
Ex[1004],¶97.

6. Claim 9

- (b) 9: A method of barocaloric cooling or heating, the method comprising the steps of:**
- (i) applying hydrostatic pressure to an organic material;**
 - (ii) permitting heat flow from or to the organic material;**
 - (iii) releasing hydrostatic pressure from an organic material that is under applied pressure; and**
 - (iv) permitting heat flow to or from the organic material.**

Xie renders obvious this claim for the same reasons provided for claim 1. *See* §X.A.1; Ex[1004],¶99. Claim 1 and 9 recite the same four method steps and differ only in the preamble. *See* §X.A.1. Claim 9 more broadly recites a “method of barocaloric cooling or heating” and does not require the “organic material as a barocaloric cooling or heating agent” as recited by claim 1. Because Xie discloses the use of DHPE, an organic compound, as a barocaloric cooling or heating agent, as well as the same four method steps recited in claim 1, Xie also renders obvious claim 9. Ex[1004],¶¶82-90,99.

7. Claim 10

- (a) **10: The method according to claim 9, wherein the organic material is an organic compound or a salt thereof optionally wherein at least one of the following is present:**

the organic material has a molecular weight of at most 2,000;

the organic material has a molecular weight of at least 50;

the organic material is an organic compound or a salt thereof, and the organic compound has two or more carbon-carbon bonds;

the organic material is an organic compound or a salt thereof, and the organic compound has two or more carbon-hydrogen bonds; and

the organic material is a liquid crystal or a plastic crystal.

Xie renders obvious this claim for the same reasons provided for claims 2 and

9. See §§X.A.2, X.A.6; Ex[1004], ¶¶91-92, 100.

8. Claim 14

- (a) **14: The method according to claim 9, wherein the organic material has a phase transition at a temperature within the range 200 to 450 K, optionally wherein the phase transition of the organic material is a first-order phase transition.**

Xie renders obvious Claim 14 for the same reasons provided for claims 6 and

9. See §§X.A.3, X.A.6; Ex[1004], ¶¶93, 101.

9. Claim 15

- (a) **15: The method according to claim 9, wherein at least one of the following is present:**

the organic material has an entropy change at a phase transition, $|\Delta S_0|$, of at least 10 J K⁻¹ kg⁻¹;

a phase transition in the organic material displays a latent heat, $|Q_0|$, that is at least 1 kJ kg⁻¹; and

the organic material has a volume change at the phase transition of at least 1.0 mm³ g⁻¹;

or the organic material is provided within a pressure-transmitting medium.

Xie renders obvious this claim for the same reasons provided for claims 7 and

9. *See* §§X.A.4, X.A.6; Ex[1004], ¶¶94-96, 102.

10. Claim 16

- (a) **16: The method according to claim 9, wherein hydrostatic pressure is applied to the organic material at a temperature that is within 50 K of a phase transition temperature of the organic material, where the phase transition temperature is the temperature for the phase transition in the absence of the hydrostatic pressure optionally wherein:**

the applied hydrostatic pressure is at most 1.0 GPa; or

the applied hydrostatic pressure is at least 0.1 MPa.

Xie renders obvious this claim for the same reasons provided for claims 8 and

9. *See* §§X.A.5-6; Ex[1004], ¶¶97-98, 103.

B. Ground 2: Claims 1-3, 6-7, 9-11, and 14-15 are Rendered Obvious Over Mañosa in Combination with Patel and in view of the Knowledge of a POSITA

1. Reasons for Combination

It would have been obvious to combine Mañosa with Patel and a POSITA would have been motivated to and had reasonable expectations of success in doing so. Ex[1004], ¶¶104-115. *First*, both Mañosa and Patel address problems associated

with conventional refrigeration devices. Ex[1007],4925-26,4933-34; Ex[1009],1; Ex[1004],¶105. *Second*, Mañosa and Patel both identify solid-state refrigeration as a potential solution to these conventional refrigeration problems. Ex[1007],4925-26,4933-34; Ex[1009],1; Ex[1004],¶106. *Third*, the solid-state refrigeration solutions discussed in both Mañosa and Patel involve the use of materials exhibiting BCEs and rely on experimentally determined caloric effects. Ex[1007],4926-27; Ex[1009],4; Ex[1004],¶107.

Fourth, Mañosa and Patel both identify materials exhibiting inverse BCEs. Mañosa addresses inverse BCEs of a family of inorganic compounds (La-Fe-Si), (Ex[1007],4928-32), while Patel addresses inverse BCEs of an organic material, PVDF-TrFE-CTFE, (Ex[1009],1,4-5). Ex[1004],¶108. But because both barocaloric materials in Patel and Mañosa exhibit inverse BCEs, the substitution of Patel's organic barocaloric material for Mañosa's barocaloric material is obvious.¹⁵ And the '656 Patent admits "*organic materials* [such as Patel's organic barocaloric, PVDF-TrFE-CTFE,] *may be used as alternatives to the inorganic materials* that have previously been described for use in barocaloric cooling," like the inorganic compounds (La-Fe-Si) discussed in Mañosa. *See* Ex[1001],5:29-32; Ex[1004],¶109.

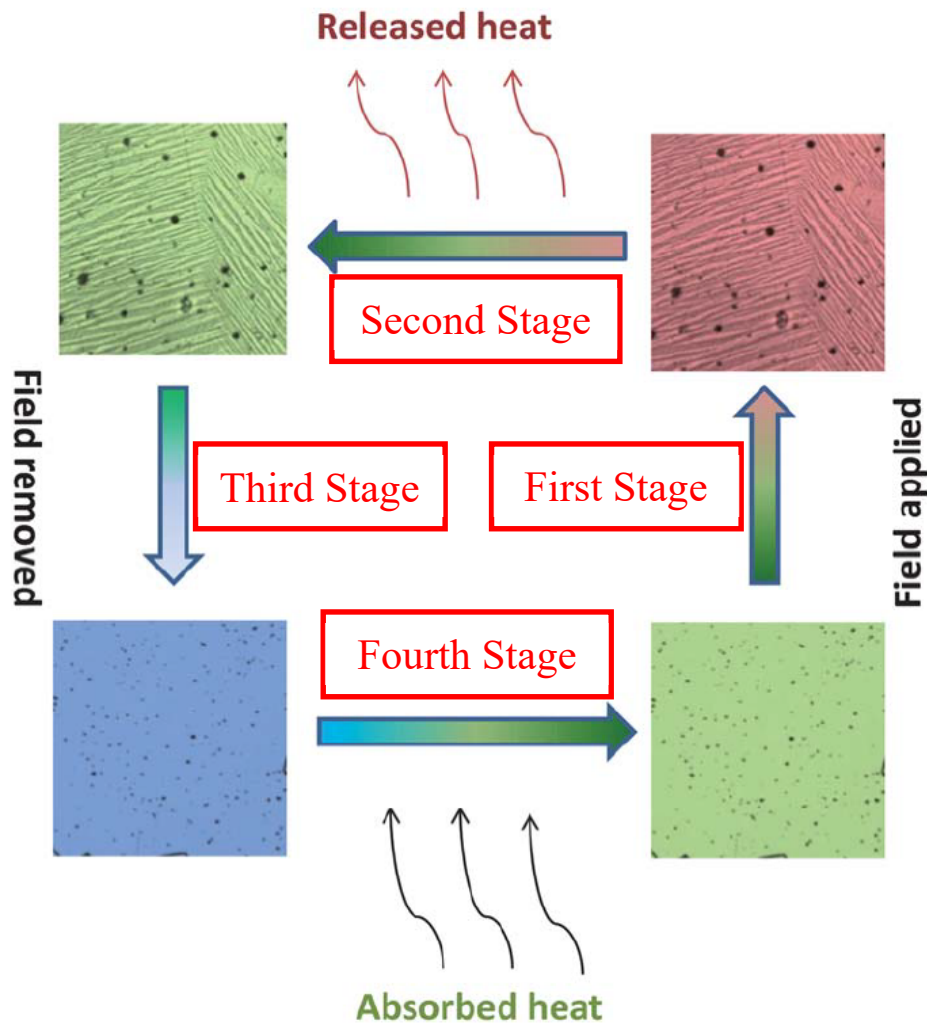
¹⁵ Even if one reference disclosed a conventional barocaloric material and the other an inverse barocaloric material, the result would still be obvious, because "such materials are equally useful in the methods of this invention." Ex[1004],¶108 (citing Ex[1001],9:9-26,13:9-24,14:19-21).

Fifth, the only drawback identified in Mañosa's barocaloric material is its phase temperature is below room temperature. Ex[1007],4928; Ex[1004],¶110. As Mañosa explains, most caloric materials exhibit small temperature changes at room temperature, which has limited their use in refrigeration applications. Ex[1007],4925. But Patel resolves this problem, because PVDF-TrFE-CTFE boasts "a substantial temperature drop of 6K near 300K (room temperature)." A POSITA would understand a room temperature barocaloric would be highly beneficial in the cooling applications discussed in Mañosa. Ex[1004],¶110.

Finally, the '656 Patent also admits there are numerous advantages to using organic barocaloric materials over inorganic barocaloric materials. §V.A.2. For example, in comparison to inorganic barocaloric materials, organic materials exhibit (1) higher BCEs; (2) higher latent heat values and adiabatic temperature changes, including in plastic crystals; (3) phase transition temperatures closer to ambient temperatures; (4) smaller pressure input requirements; (5) numerous other advantages including availability and scale of materials available; low costs, low toxicity; and ease of use and disposal. A POSITA would therefore have been motivated to substitute the inorganic barocaloric material in Mañosa for an organic barocaloric material, such as PVDF-TrFE-CTFE as identified in Patel. Ex[1004],¶112.

Therefore, a POSITA would be motivated to substitute one inverse barocaloric material (from Patel) for another inverse barocaloric material (from Mañosa) because Patel's organic barocaloric material displays strong temperature changes at room temperature, which is the drawback identified in Mañosa. Ex[1004],¶114.

Mañosa also addresses the benefits of caloric materials when “designing solid-state refrigeration devices as alternatives to the presently existing technologies.” Ex[1007],4933. Mañosa discloses an exemplary refrigeration cycle based on solid-state refrigeration.



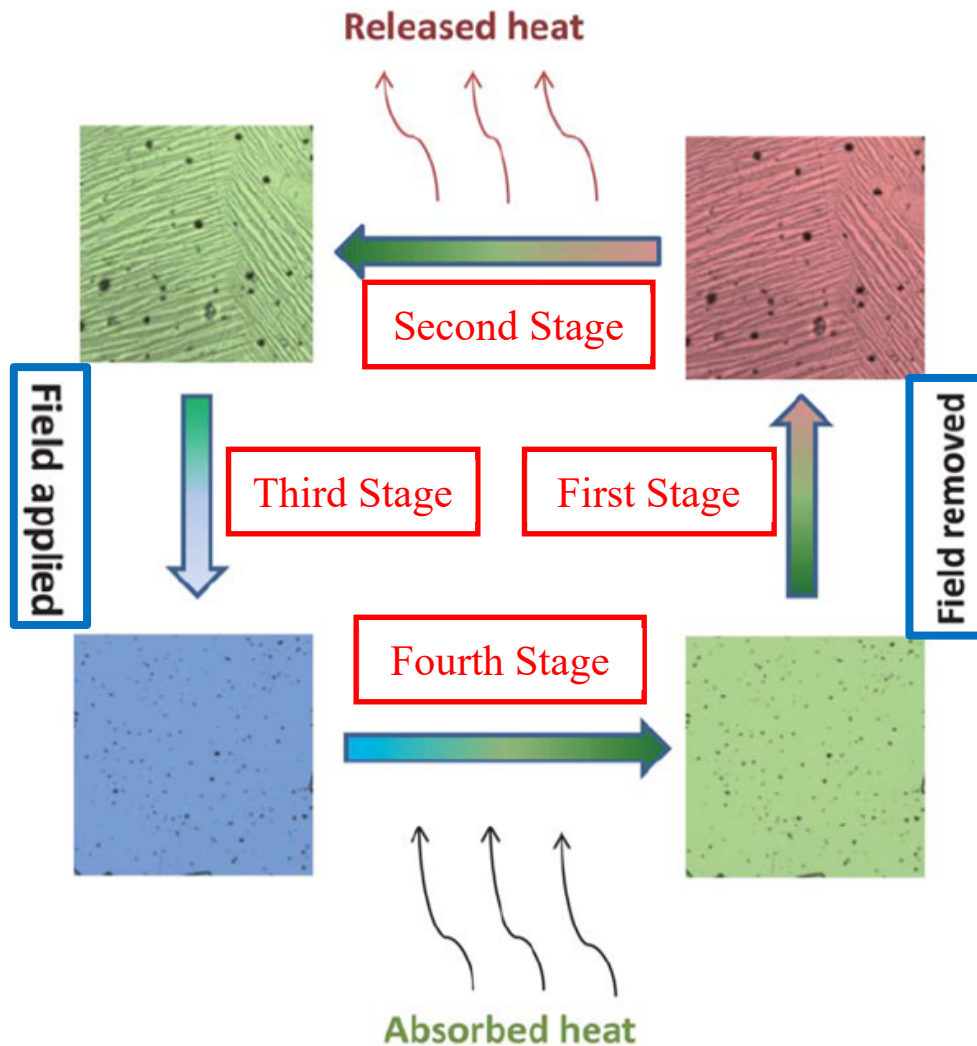
Ex[1004],¶111 (citing Ex[1007],4926,FIG.1 (“Schematic diagram for a solid-state based refrigerating cycle based on a conventional giant caloric effect.”)). Mañosa explains that “[c]omputational discovery of new caloric and multicaloric materials” and “recent progress in the development and understanding of multicaloric materials have resulted in significant advances that suggest solid-state refrigeration can become a reality in a near future.” Ex[1007],4934.

While Mañosa admits research into “barocaloric and elastocaloric effects” was in early stages in 2013, (Ex[1007],4934), Patel’s 2016 article explains “materials which can demonstrate more than one caloric effect[—multicaloric materials—]are expected to perform with higher [coefficient of performance] when individual caloric effects can be coupled or made to operate in a crossover.” Ex[1009],1. In sum, Patel’s research continues the work of Mañosa into the benefits of multicaloric materials for solid-state refrigeration. And while not relied upon for this Ground, both Xie and Moya suggest that a person of ordinary skill in the art would have been aware of the benefits of multicaloric materials. For example, Xie states multicaloric materials “may be used to improve the caloric performance (multicaloric effect) of liquid crystal[s].” Ex[1006],5. Moya suggests there “are likely to be many multicaloric materials given that the structural degree of freedom [] underpins mC [mechanocaloric] effects,” referring to barocaloric and elastocaloric effects, and these effects have been published since 1805. Ex[1020],439-440.

Further, by 2016 and before the filing of the Priority Application, Patel explains multicalorics may include materials exhibiting both elastocaloric and BCEs and focuses on one such multicaloric material: PVDF. Ex[1009],1. As Patel explains, PVDF is a “cross-linked polymer (with high crystallinity) [that] promises high potential for eC and BC effects.” Ex[1009],2. Patel also explains PVDF has “other advantages such as ease of fabrication (shape), low cost, and low processing

temperatures” and works similarly to refrigeration techniques using existing vapor compression cycle using “heating and cooling effects [] obtained using fluid compression and expansion.” Ex[1009],1. Accordingly, Patel’s organic barocaloric offers benefits over the materials identified in Mañosa.

As noted above, the materials identified in both Mañosa and Patel exhibit inverse BCEs. As the ’656 Patent admits, a “skilled person” would understand how to use inverse barocalorics. Ex[1001],9:10-26. For example, a POSITA could simply modify Mañosa’s schematic diagram to use inverse BCEs by switching the “Field applied” and “Field removed” labels, as shown by the blue outlines below.



Ex[1004],¶113 (amending Ex[1007],4926,FIG.1). In fact, the '656 Patent admits heat flows from a conventional barocaloric material subjected to hydrostatic pressure, but heat flows to an inverse barocaloric material under hydrostatic pressure. Ex[1001],15:4-23. Accordingly, the '656 Patent admits the above substitution would have been obvious to a POSITA. Ex[1004],¶113 (citing Ex[1001],9:10-26).

In sum, the combination of Mañosa with Patel would have been well within the skill of a POSITA, because it is nothing more than using an organic inverse barocaloric material (PVDF-TrFE-CTFE) in place of the inorganic inverse barocaloric identified in Mañosa. Ex[1004],¶114. Moreover, because PVDF-TrFE-CTFE works similarly to existing vapor compression cycle technology, (Ex[1009],1), and the '656 Patent admits organic barocaloric material, like PVDF-TrFE-CTFE, may be used “within conventional heating and cooling cycles in place of conventional materials, where the heating and cooling cycle is adapted to exploit the barocaloric effects of the organic materials,” (Ex[1001],14:60-65), a POSITA would have had a reasonable expectation of success in implementing this combination. Ex[1004],¶114.

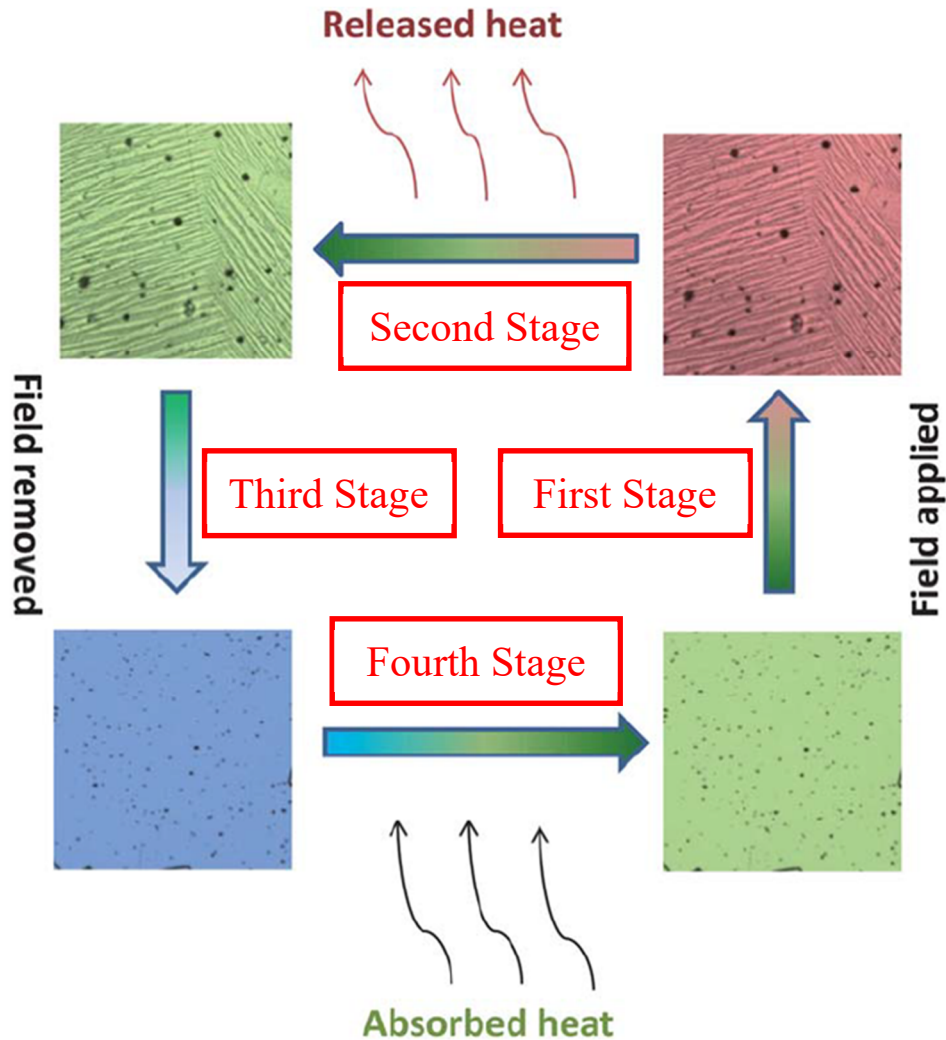
Further motivations are discussed below.

2. Claim 1

As shown below, claim 1 is disclosed, or rendered obvious, by Mañosa in view of Patel, which disclose all elements of claim 1 of the '656 Patent.

To the extent the preamble of claim 1 (1[pre]) is limiting, Mañosa in view of Patel renders obvious this limitation. Ex[1004],¶¶83,117. Mañosa discloses a “[s]chematic diagram for a solid-state based refrigerating cycle based on a conventional giant caloric effect” involving first applying a field to a material to increase the material’s temperature and then removing the field to decrease the

material's temperature. Ex[1004],¶118. As Mañosa explains, that field can be hydrostatic pressure.



Ex[1004],¶118 (citing Ex[1007],4926,FIG.1). The patentee admitted the '656 Patent specification's reference to Mañosa2010's "[d]ifferential thermal analysis under hydrostatic pressure" enabled the four method steps recited in claims 1 and 9. Ex[1002],112 (citing Ex[1001],19:11-12 and Ex[1014]). To the extent the reference to Mañosa2010 is enabling of the four method steps in claims 1 and 9, Mañosa also

discloses “differential scanning calorimetry under applied hydrostatic pressure” and therefore also discloses the method steps of claims 1 and 9. Ex[1007],4927-29; Ex[1004],¶118.

Patel discloses an organic barocaloric material: PVDF-TrFE-CTFE. Patel explains the application of hydrostatic pressure to PVDF-TrFE-CTFE results in a temperature drop and removal of the hydrostatic pressure increases the temperature of PVDF-TrFE-CTFE.¹⁶ Ex[1004],¶119. Patel also explains PVDF-TrFE-CTFE is a “cross-linked polymer.” Based on its chemical composition, $(C_2H_2F_2)_n$, a POSITA would know PVDF is both an organic material and an organic compound, as those terms are construed in the ’656 Patent. Ex[1004],¶119.

PVDF-TrFE-CTFE is therefore an organic polymer exhibiting inverse BCEs producing between 1.8K and a “staggeringly high temperature drop of ~19K” at 368K when under pressure, as well as 6K at 300K (room temperature), in excess of many materials listed in Patel’s Table I. Ex[1009],4-5,FIG.3(b),Table I. Accordingly, and for the reasons identified above, a POSITA would have been motivated to use Patel’s PVDF-TrFE-CTFE as a barocaloric material in Mañosa’s

¹⁶ While the caloric effect exhibited by PVDF is an inverse barocaloric effect, the ’656 Patent treats conventional and inverse barocaloric effects as interchangeable. Ex[1001],20:41-48,21:37-43; *see also, e.g., id.*, 9:10-26 (“inverse barocaloric effects ... are equally useful in the methods of the invention.”).

refrigeration cycle, and would have a reasonable expectation of success in doing so. Ex[1004],¶120.

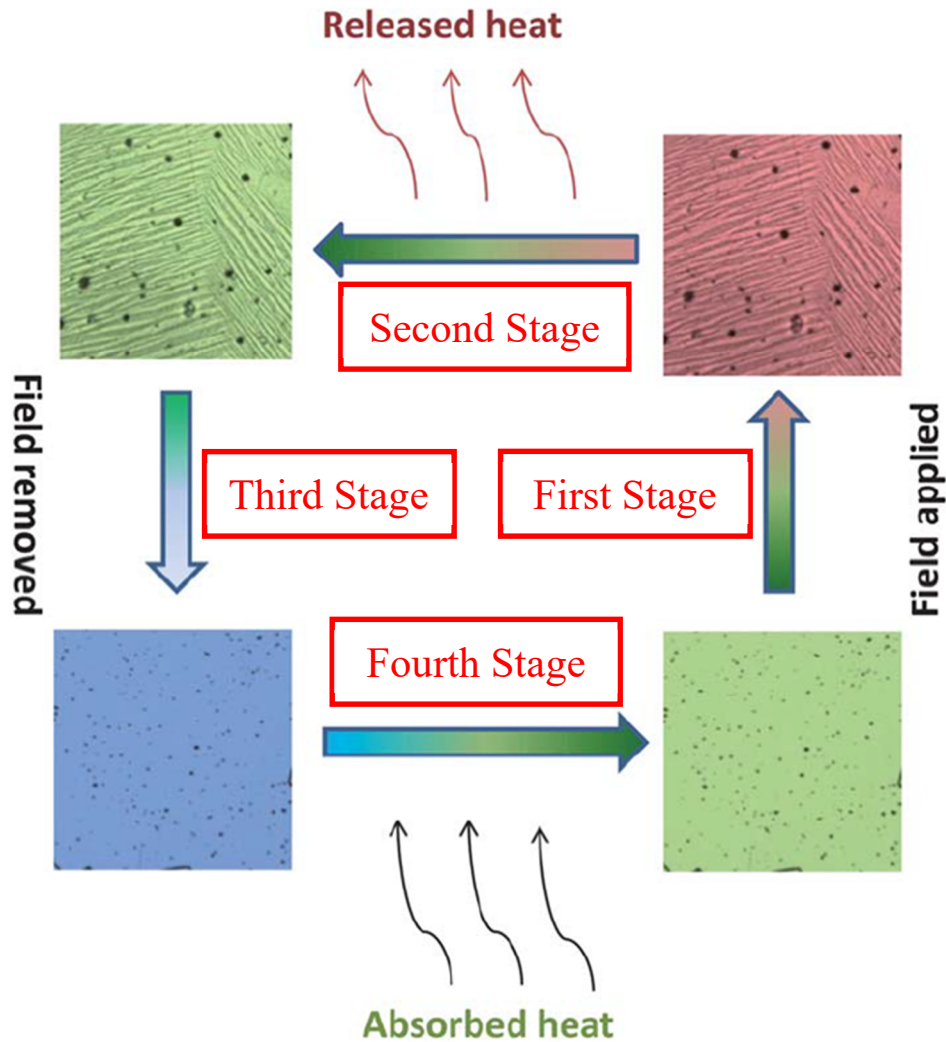
Accordingly, a POSITA would understand PVDF-TrFE-CTFE is an organic material as well as how to use PVDF-TrFE-CTFE as “a barocaloric cooling or heating agent,” for example, in Mañosa’s refrigeration cycle. Ex[1004],¶¶116-27.

Mañosa in view of Patel renders obvious limitation (i) of claim 1 (1[a]). Ex[1004],¶¶122-24.

Mañosa teaches adiabatically applying hydrostatic pressure to an inverse caloric material decreases its temperature and removing the field increases the caloric material’s temperature, (Ex[1007],4925), and “both conventional and inverse effects can enhance the refrigerant efficiency of a given device,” (Ex[1007],4934). Patel’s organic inverse barocaloric behaves exactly as Mañosa describes.

A POSITA would understand hydrostatic pressure could be applied to a barocaloric material and either conventional and inverse barocaloric materials could be used in view of Mañosa’s schematic diagram of a refrigerating cycle: a conventional barocaloric material could be started between Stages 4 and 1 to remove heat from a cold reservoir, while an inverse barocaloric material could be started between Stages 2 and 3 to remove heat from a cold reservoir. Ex[1004],¶123; *see also, e.g.*, Ex[1001],15:4-23.

For example, a POSITA would understand a simple modification to Mañosa's schematic diagram—by switching the “Field applied” and “Field removed” labels—would enable use of Patel's inverse barocaloric. Ex[1004],¶¶113,124 (citing Ex[1007],FIG.1(annotated)).



Mañosa in view of Patel renders obvious limitation (ii) of claim 1 (1[b]). Ex[1004],¶125. A POSITA using Patel's PVDF-TrFE-CTFE as the barocaloric material in Mañosa's refrigeration cycle would understand PVDF-TrFE-CTFE

returns to its original temperature in the fourth stage by absorbing heat, i.e., “permitting heat flow [] to the organic material.” Ex[1004],¶125; *see also* Ex[1001],15:4-12.

Mañosa in view of Patel renders obvious limitation (iii) of claim 1 (1[c]). Ex[1004],¶126. Because Patel teaches adiabatically releasing hydrostatic pressure increases PVDF’s temperature, a POSITA would understand Mañosa’s refrigeration cycle, at the first stage, teaches “releasing hydrostatic pressure from an organic material that is under applied pressure” to increase the temperature of Patel’s PVDF-TRFE-CTFE. Ex[1004],¶126; *see also* Ex[1001],15:13-23.

Mañosa in view of Patel renders obvious limitation (iv) of claim 1 (1[d]). Ex[1004],¶127. A POSITA using Patel’s PVDF-TRFE-CTFE as the barocaloric material in Mañosa’s refrigeration cycle would understand PVDF-TRFE-CTFE returns to its original temperature in the second stage by releasing heat, i.e., “permitting heat flow [] from the organic material.” Ex[1004],¶127; *see also* Ex[1001],15:13-23.

3. Claim 2

Mañosa in view of Patel renders obvious this claim. Ex[1004],¶¶128-31. As discussed above, Mañosa in view of Patel discloses the method of claim 1. §X.B.2.

Patel’s organic material, PVDF-TRFE-CTFE, is more specifically “an organic compound.” PVDF ($\text{—H}_2\text{C=CF}_2\text{—}$) contains two or more CH_2 and two or more CF_2

groups, with multiple carbon-carbon bonds and multiple carbon-hydrogen bonds and is therefore an organic “substance composed of identical molecules consisting of atoms of two or more chemical elements.” Ex[1004],¶130. PVDF also satisfies two optional limitations (having “two or more carbon-hydrogen bonds” and having “two or more carbon-carbon bonds”). Ex[1004],¶130.

Applicant also previously admitted PMMA is a compound exhibiting BCEs. During prosecution, Applicant admitted Lloveras describes “the barocaloric effect of poly(methyl methacrylate)” (PMMA) but argued it “does not describe the actual step of employing *the compound* as a barocaloric cooling or heating agent ... such as the applications recited in the present application.” Ex[1002],115-16. However, claim 2 is also rendered obvious by Lloveras in view of the knowledge of a POSITA.

4. *Claim 3*

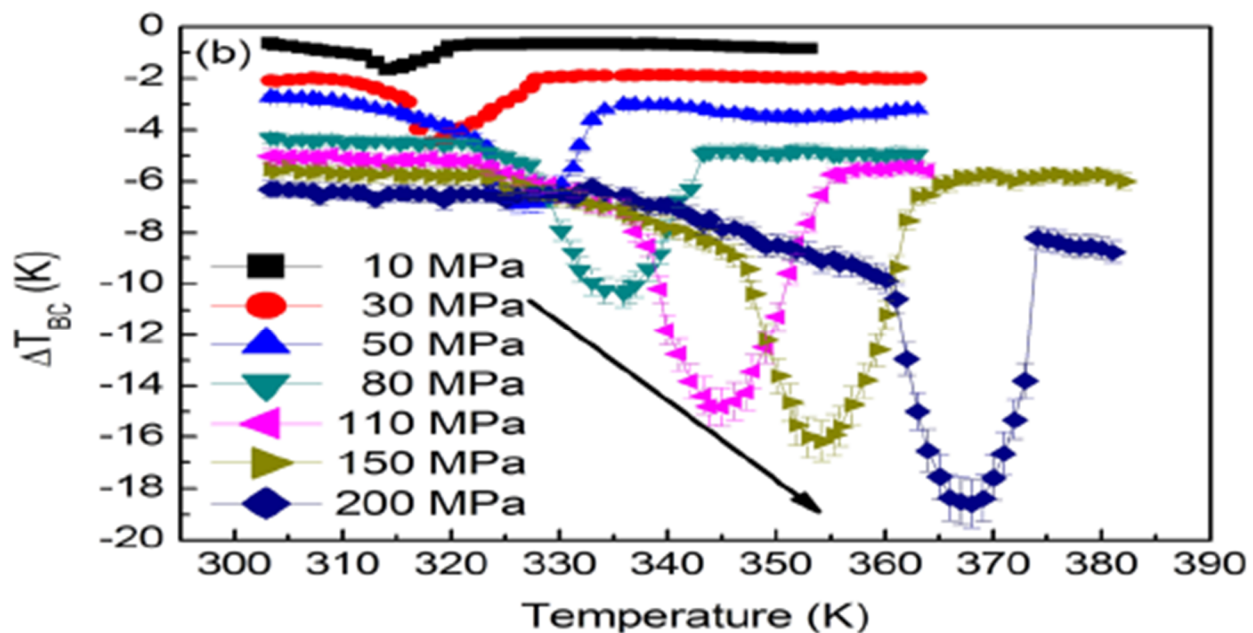
Mañosa in view of Patel in view of the knowledge of a POSITA renders obvious this claim. Ex[1004],¶¶132-34; *see also* Ex[1012],Abstract,1,7. As discussed above, Patel discloses BCEs of an organic polymer, PVDF-TRFE-CTFE. §X.B.1-2. The '656 Patent admits BCEs of “organic materials, such as plastic crystals” are comparable to or exceed BCEs of inorganic materials. Ex[1001],2:66-3:13. A POSITA would therefore have been motivated to identify organic barocaloric materials, and specifically plastic crystals, and substitute these for the inorganic barocaloric material discussed in Mañosa. Ex[1004],¶133. In fact, Català’s

identification of and research regarding two plastic crystals exhibiting BCEs, TRIS and NPA, are evidence a POSITA would also have a reasonable expectation of success with, would have been motivated to, and actually did, identify and use plastic crystals as a barocaloric heating or cooling agent within the claimed method. Ex[1004],¶133; Ex[1012],Abstract,1; *see also* §X.C.

5. *Claim 6*

Mañosa in view of Patel renders obvious this claim. Ex[1004],¶¶135-36. As discussed above, Mañosa in view of Patel discloses the method of claim 1. §X.B.2.

Patel's Figure B shows "a large temperature change is observed near the phase transitions for the respective applied pressures" of PVDF-TRFE-CTFE, where the phase transitions all occur between 300K and 390K, (Ex[1009],4,FIG.B), and are therefore "within the range 200 to 450 K."

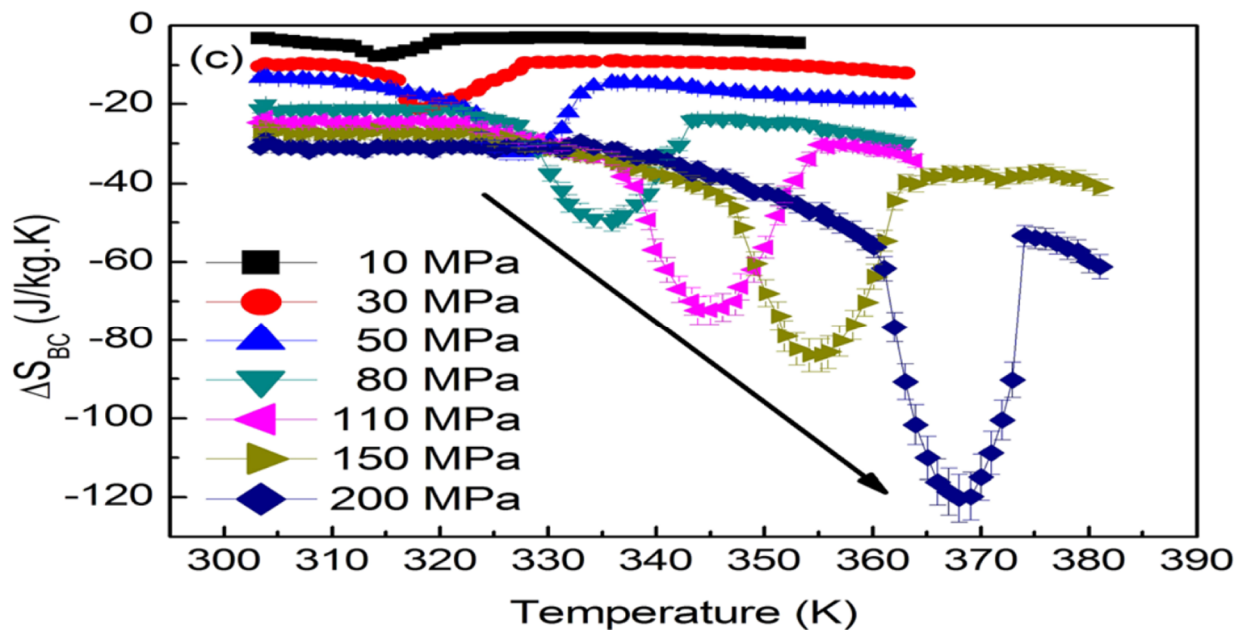


Ex[1009],4,FIG.3(b); Ex[1004],¶135. Claim 6 only “optionally” recites a first order phase transition.

6. Claim 7

Mañosa in view of Patel renders obvious this claim. Ex[1004],¶¶137-38. As discussed above, Mañosa in view of Patel discloses the method of claim 1. §X.B.2.

Patel discloses the entropy change of PVDF-TRFE-CTFE at various temperatures and hydrostatic pressures. Specifically, Patel discloses PVDF-TRFE-CTFE—when subjected to hydrostatic pressure between 30MPa and 200MPa—yields an entropy change ΔS_0 , at the phase transition, where the absolute value of the change exceeds at least $10 \text{ J K}^{-1} \text{ kg}^{-1}$, and reaches as high as nearly $120 \text{ J K}^{-1} \text{ kg}^{-1}$.



Ex[1009],4,FIG.3(c); Ex[1004],¶137.

7. Claim 9

Mañosa in view of Patel renders obvious this claim for the same reasons provided for claim 1. *See* §X.B.2; Ex[1004], ¶¶116-127,139. Claim 1 and 9 recite the same four method steps and differ only in the preamble. *See* §X.B.2. Claim 9 more broadly recites a “method of barocaloric cooling or heating” and does not require the “organic material as a barocaloric cooling or heating agent” recited by claim 1. Because Mañosa in view of Patel discloses the use of PVDF-TRFE-CTFE, an organic compound, as a barocaloric cooling or heating agent, as well as the same four method steps recited in claim 1, and a POSITA would have been motivated to combine Mañosa with Patel with a reasonable chance of success in doing so, Mañosa in view of Patel renders obvious claim 9. Ex[1004], ¶139.

8. Claim 10

Mañosa in view of Patel renders obvious this claim for the same reasons provided for claims 2 and 9. *See* §§X.B.3,X.B.7; Ex[1004], ¶¶128-31,140.

9. Claim 11

Mañosa in view of Patel renders obvious this claim for the same reasons provided for claims 3 and 9. *See* §§X.B.4,X.B.7; Ex[1004], ¶¶132-34,141.

10. Claim 14

Mañosa in view of Patel renders obvious Claim 14 for the same reasons provided for claims 6 and 9. *See* §§X.B.5,X.B.7; Ex[1004], ¶¶135-36,142.

11. *Claim 15*

Mañosa in view of Patel renders obvious this claim for the same reasons provided for claims 7 and 9. *See* §§X.B.6,X.B.7; Ex[1004],¶¶137-38,143.

C. Ground 3: Claims 1-3, 6-7, 9-11, and 14-15 are Rendered Obvious by Mañosa in Combination with Tamarit and in view of the Knowledge of a POSITA.

1. *Reasons for Combination*

It would have been obvious to combine Mañosa with Tamarit, and a POSITA would have been motivated to and had reasonable expectations of success in doing so. Specifically, a POSITA would have been motivated to substitute Tamarit's organic plastic crystals for the inorganic barocaloric material identified in Mañosa. Ex[1004],¶¶144-155; *see also supra* §V.A.

Caloric effects—temperature changes in a material “when subjected to a sudden change of an external field”—are “related to a change in the material's *entropy* when the external field is isothermally modified.” Ex[1007],4925; Ex[1004],¶145. “[T]he transition entropy-change (associated with the latent heat of a first-order phase transition) [] makes the major contribution to the field-induced entropy-change of the []caloric effect.” Ex[1007],4925-26, 4929 (explaining exemplary barocaloric effect is 75% of entropy-change). Ex[1004],¶¶145,148.

The '656 Patent's admitted prior-art lists “large barocaloric effect” in Mn_3GaN and ammonium sulfate due to “pressure-driven isothermal entropy change.”

Ex[1001],2:9-35. Mañosa lists the entropy-change value in La–Fe–Si. Tamarit, however, shows NPA and TRIS exhibit entropy-change values ΔS that are significantly higher:

Barocaloric Material	ΔS (J K ⁻¹ kg ⁻¹) ¹⁷
La–Fe–Si	8.6
Mn ₃ GaN	21
(NH ₄) ₂ SO ₄	60
NPA	191.7
TRIS	690.9

Ex[1004],¶¶146-47 (showing units conversions from the values in Tamarit); *see also* Ex[1001],Table2; Ex[1007],4929,FIG.5. The '656 Patent admits “it is desirable to identify materials displaying a large isothermal entropy change at relatively low pressure.” Ex[1001],2:36-39. A POSITA would therefore have been motivated to replace Mañosa’s inorganic material with the Tamarit’s high entropy-change plastic crystals. Ex[1004],¶148.

Giant barocaloric materials are also “sensitive to external hydrostatic pressure” due to *volume changes* at phase transitions. Ex[1004],¶¶149-50; Ex[1007],4928 (even 1% volume change may indicate BCE); *see also* Ex[1013],2,4 (discussing barocaloric effects in Ni-Mn-In and La-Fe-Si due to volume change). A POSITA would have understood volume changes at phase transitions as indicating

¹⁷ These calculations are consistent with the ΔS provided in the '656 Patent’s Table 2 for TRIS and NPA.

BCEs. Ex[1004], ¶¶149-50. For example, Patel used volumetric stress-strain data to estimate the temperature changes and “cooling capacity of PVDF-TrFE-CTFE.” Ex[1009], 3-4. Similarly, Stern-Taulats states “good candidates” for BCEs have “large volumetric thermal expansion” near phase transitions. Ex[1010], Abstract, 1. Tamarit identifies significant volume changes in multiple plastic crystals, including TRIS and NPA, at phase transitions. Ex[1021], 349-354.

The '656 Patent admits there are numerous advantages to using organic barocaloric materials over inorganic materials. §V.A.2; Ex[1004], ¶152. In comparison to inorganic barocaloric materials, organic materials exhibit (1) higher BCEs; (2) higher latent heat values and adiabatic temperature changes, including in plastic crystals; (3) phase transition temperatures closer to ambient temperatures; (4) smaller pressure input requirements; (5) numerous other advantages including availability and scale of materials available; low costs, low toxicity; and ease of use and disposal. Ex[1004], ¶152. A POSITA would therefore have been motivated to substitute Mañosa's inorganic material for Tamarit's organic plastic crystals. Ex[1004], ¶152.

In fact, Català actually combined the teachings of Tamarit with a refrigeration cycle like Mañosa's and did so prior to the '656 Patent's priority date. Ex[1012]. Català proposed and tested using the plastic crystals TRIS and NPA as barocaloric cooling agents in four-step method involving the steps claimed in Claims 1 and 9 of

the '656 Patent. Ex[1004],¶153 (citing Ex[1012],16-17,FIG.2.7). Català is dated June 2016 and the thesis defense and work completed by Català predates the October 14, 2016 priority date. *See* Ex[1024]. Thus, the combination of Mañosa with Tamarit was an obvious combination that a POSITA (Català) was motivated to make as well as a combination that was actually made. Ex[1004],¶154. Further, Català further demonstrates that the use of TRIS and NPA, organic plastic crystals, as barocaloric cooling or heating agents was in the knowledge of a POSITA before the '656 Patent priority date. *See* Ex[1004],¶154.

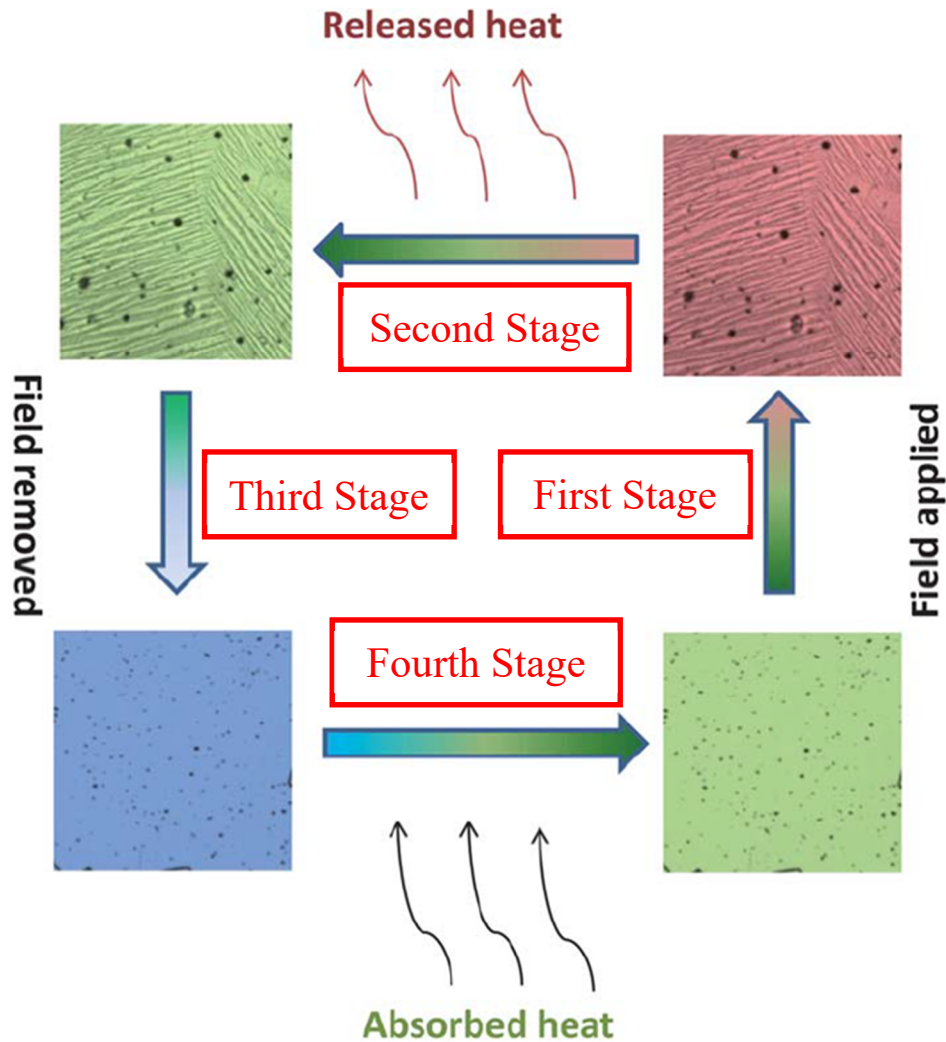
In sum, a POSITA would have been motivated and had reasonable expectations of success in substituting Tamarit's plastic crystals for Mañosa's inorganic barocaloric. Ex[1004],¶¶154-55.

Further motivations are discussed below.

2. Claim 1

As shown below, Mañosa in view of Tamarit discloses, and renders obvious, all elements of claim 1 of the '656 Patent.

To the extent the preamble of claim 1 (1[pre]) is limiting, Mañosa in view of Tamarit renders obvious this limitation for the same reasons articulated in Ground 2. Ex[1004],¶¶157-61; *see also* §§X.B.1-2 (discussing Mañosa's "[s]chematic diagram for a solid-state based refrigerating cycle based on a conventional giant caloric effect" by applying hydrostatic pressure to a barocaloric material).



Ex[1004],¶159 (citing Ex[1007],4926,FIG.1).

Tamarit discloses organic barocaloric materials, including NPA and TRIS. Ex[1004],¶¶81,160; Ex[1021],Abstract,349-54,Table1. The '656 Patent admits that the plastic crystals disclosed in Tamarit are organic materials. Ex[1001],Table2 (“Properties of Representative Plastic Crystal *Organic Materials*”). For the reasons provided above, a POSITA would have been motivated to substitute Mañosa’s inorganic barocaloric materials for the plastic crystals disclosed by Tamarit, because

the Tamarit's plastic crystals exhibit large entropy and volume changes at phase transitions and provide the benefits of organic barocaloric materials over inorganic barocaloric materials. Ex[1004],¶161.

Accordingly, a POSITA would understand NPA and TRIS are organic materials that could be used as “a barocaloric cooling or heating agent,” for example, in Mañosa's refrigeration cycle. Ex[1004],¶161.

Mañosa in view of Tamarit renders obvious limitation (i) of claim 1 (1[a]). Ex[1004],¶162. Mañosa teaches adiabatically applying hydrostatic pressure to an inverse caloric material decreases its temperature and removing the field increases the caloric material's temperature, (Ex[1007],4925), and “both conventional and inverse effects can enhance the refrigerant efficiency of a given device,” (Ex[1007],4934). Based on the suggestions in Mañosa and other prior art—that the entropy and volume changes in Tamarit's organic plastic crystals at phase transitions suggest their use as a barocaloric cooling or heating agent—a POSITA would understand hydrostatic pressure could be applied to Tamarit's organic plastic to prompt a change in temperature in the plastic crystal. Ex[1004],¶162.

Mañosa in view of Tamarit renders obvious limitation (ii) of claim 1(1[b]). Ex[1004],¶¶163-64. A POSITA using Tamarit's PVDF-TrFE-CTFE as the barocaloric material in Mañosa's refrigeration cycle would understand PVDF-TrFE-CTFE returns to its original temperature in the fourth stage by

absorbing heat, i.e., “permitting heat flow [] to the organic material.” Ex[1004],¶164;
see also Ex[1001],15:4-12.

Mañosa in view of Tamarit renders obvious limitation (iii) of claim 1(1[c]). Ex[1004],¶165. Because Tamarit teaches adiabatically releasing hydrostatic pressure increases PVDF’s temperature, a POSITA would understand Mañosa’s refrigeration cycle, at the first stage, teaches “releasing hydrostatic pressure from an organic material that is under applied pressure” to increase the temperature of Tamarit’s PVDF-TRFE-CTFE. Ex[1004],¶165; *see also* Ex[1001],15:13-23.

Mañosa in view of Tamarit renders obvious limitation (iv) of claim 1(1[d]). Ex[1004],¶166. A POSITA using Tamarit’s PVDF-TRFE-CTFE as the barocaloric material in Mañosa’s refrigeration cycle would understand PVDF-TRFE-CTFE returns to its original temperature in the second stage by releasing heat, i.e., “permitting heat flow [] from the organic material.” Ex[1004],¶166; *see also* Ex[1001],15:13-23.

3. Claim 2

Mañosa in view of Tamarit renders obvious this claim. Ex[1004],¶¶167-70. As discussed above, Mañosa in view of Tamarit discloses the method of claim 1. §X.B.2.

The ’656 Patent lists NPA and TRIS as “Representative Plastic Crystal Organic Materials” in Table 2. Ex[1001],Table2. Additionally TRIS

($\text{NH}_2\text{C}(\text{CH}_2\text{OH})_3$) and NPA ($(\text{CH}_3)_3\text{CCH}_2\text{OH}$) are explicitly identified as “globular compounds” or “plastic crystal compounds” in Tamarit. Ex[1021], Abstract, 349. They also contain “two or more elements in chemical combination;” two or more carbon atoms; “two or more carbon-hydrogen bonds;” and “two or more carbon-carbon bonds,” and therefore satisfy the required claim limitation, and two optional limitations. Ex[1004], ¶168.

4. *Claim 3*

Mañosa in view of Tamarit discloses and renders obvious this claim. Ex[1004], ¶¶171-73; Ex[1012].

Tamarit discloses the plastic crystals TRIS and NPA. Ex[1021], *passim*. Each of Tamarit’s plastic crystals comprises multiple alkyl groups in the form of methyl (CH_3). §X.D.3. Tamarit also states the entropy and volume variations “increase when the methyl ($-\text{CH}_3$) groups are substituted by the hydroxyl ($-\text{CH}_2\text{OH}$) group.” Ex[1004], ¶172; Ex[1021], 354. Because the barocaloric effects are linked to “entropy and volume variations,” a POSITA would have been motivated to, and expected to, increase the BCEs of Tamarit’s plastic crystals by substituting a hydroxyl group for a methyl group. Tamarit therefore discloses or renders obvious the required claim limitation, and one optional limitation. Ex[1004], ¶¶172-73.

5. Claim 6

Mañosa in view of Tamarit renders obvious this claim. Ex[1004],¶¶174-75.

Mañosa in view of Tamarit discloses the method of claim 1. §X.B.2.

Tamarit teaches NPA and TRIS have “first order phase transition” temperatures of 236.5K and 406.8K, respectively. Ex[1021],Abstract,Table1; Ex[1001],Table2.

6. Claim 7

Mañosa in view of Tamarit renders obvious this claim. Ex[1004],¶¶176-78.

As discussed above, Mañosa in view of Tamarit discloses the method of claim 1. §X.B.2.

Tamarit discloses volume changes at phase transitions in NPA and TRIS. Ex[1004],¶¶177-178. After converting Tamarit’s value using NPA’s and TRIS’s molecular masses (Ex.1021,Table1; Ex[1012],32,Table4.1), both volume changes exceed the volume change limitation of $1.0 \text{ mm}^3 \text{ g}^{-1}$:

Plastic Crystal	Molecular Mass g/mol	ΔV (from Tamarit) ($\text{cm}^3 \text{ mol}^{-1}$)	ΔV (as calculated) ($\text{mm}^3 \text{ g}^{-1}$)¹⁸
NPA	88.15	4.01	45.49
TRIS	121.14	5.07	41.85

Ex[1004],¶178.

¹⁸ These calculations are consistent with the ΔV provided in Table 2 for TRIS and NPA in the ’656 Patent.

Tamarit also discloses entropy change values at phase transitions of NPA and TRIS. Ex[1004], ¶¶147,176. After converting Tamarit's value using NPA's and TRIS's molecular masses, both entropy change values exceed the $|\Delta S_0|$, of at least $10 \text{ J K}^{-1} \text{ kg}^{-1}$:

Barocaloric Material	$\Delta S (\text{J K}^{-1} \text{ kg}^{-1})^{19}$
NPA	191.7
TRIS	690.9

Ex[1004], ¶¶147,176.

7. *Claim 9*

Mañosa in view of Tamarit renders obvious this claim for the same reasons provided for claim 1. *See* §X.D.2; Ex[1004], ¶¶156-66,180. Claim 1 and 9 recite the same four method steps and differ only in the preamble. *See* §X.D.2. Claim 9 does not require the “organic material as a barocaloric cooling or heating agent,” recited by claim 1. Because a POSITA would understand Tamarit's organic plastic crystals NPA and TRIS are barocaloric materials and can be barocaloric cooling or heating agents, as well as the same four method steps recited in claim 1, and a POSITA would have been motivated to combine Mañosa with Tamarit with a reasonable chance of success in doing so, Mañosa in view of Tamarit renders obvious claim 9. Ex[1004], ¶180.

¹⁹ These calculations are consistent with the ΔS provided in Table 2 for TRIS and NPA in the '656 Patent.

8. Claim 10

Mañosa in view of Tamarit renders obvious this claim for the same reasons provided for claims 2 and 9. *See* §§X.C.3,X.C.7; Ex[1004],¶¶167-70,181.

9. Claim 11

Mañosa in view of Tamarit renders obvious this claim for the same reasons provided for claims 3 and 9. *See* §§X.C.4,X.C.7; Ex[1004],¶¶171-173,182.

10. Claim 14

Mañosa in view of Tamarit renders obvious Claim 14 for the same reasons provided for claims 6 and 9. *See* §§X.C.5,X.C.7; Ex[1004],¶¶174-75,183.

11. Claim 15

Mañosa in view of Tamarit renders obvious this claim for the same reasons provided for claims 7 and 9. *See* §§X.C.6,X.C.7; Ex[1004],¶¶176-79,184.

D. Grounds 4 and 5: Claims 1-3, 6-7, 9-11, and 14-15 are Rendered Obvious Over Tamarit in Combination with Xie (Ground 4) or with Mañosa in Combination with Patel (Ground 5) and in View of the Knowledge of a POSITA

1. Reasons for Combination

It would have been obvious to combine Tamarit with Xie or Tamarit with Mañosa in combination with Patel, and a POSITA would have been motivated to and had reasonable expectations of success in doing so. Ex[1004],¶185. For example, a POSITA would have been motivated to substitute the organic plastic crystals of Tamarit for Xie's organic material. Ex[1004],¶185; *see also* §V.A.

Alternatively, a POSITA would have been motivated to substitute Tamarit's organic plastic crystals for Mañosa's inorganic material for the same reasons specified above. *See* §§V.A,X.B.1,X.C.1; Ex[1004],¶185.

Further, based on the analysis provided for Xie, (§X.A), for Mañosa in combination with Patel, (§X.B), and for Mañosa in combination with Tamarit (§X.C), a POSITA would have understood claims 1-3, 6-7, 9-11, and 14-15 to be obvious by the combination of Tamarit with Xie or Tamarit with Mañosa. Ex[1004],¶186.

XI. SECONDARY CONSIDERATIONS

Patent Owner has not identified evidence of secondary considerations of non-obviousness tied to the claimed invention of the '656 Patent. Accordingly, there is no objective evidence of non-obviousness that might warrant a finding that claims 1-3, 6-11, and 14-16 are patentable. Furthermore, even if Patent Owner were able to establish any secondary considerations and a proper nexus, any such secondary considerations would be insufficient to overcome the strong case of obviousness presented in Grounds 1-5. *Leapfrog Enters., Inc. v. Fisher-Price, Inc.*, 485 F.3d 1157, 1162 (Fed. Cir. 2007).

XII. CONCLUSION

Petitioner respectfully request institution of *inter partes* review and cancelation of Claims 1-3, 6-11, and 14-16 of the '656 Patent as unpatentable.

August 26, 2024

Respectfully submitted,

/Jeffrey Johnson/
Jeffrey Johnson (Reg. No. 53,078)

CERTIFICATE OF SERVICE

The undersigned hereby certifies on this August 26, 2024, that true and correct copies of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 11,230,656, Exhibits 1001-1024, and Power of Attorney were served in their entirety on the following parties via FedEx Express® or Express Mail:

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**CERTIFICATE OF COMPLIANCE WITH TYPE-VOLUME
LIMITATION, TYPEFACE REQUIREMENTS, AND TYPE STYLE
REQUIREMENTS**

1. This Petition complies with the type-volume limitation of 14,000 words, comprising 13,365 words, excluding the parts exempted by 37 C.F.R. §42.24(a).

2. This Petition complies with the general format requirements of 37 C.F.R. §42.6(a) and has been prepared using Microsoft® Word 2016 in 14-point Times New Roman.

Respectfully submitted,

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