UNITED STATES PATENT AND TRADEMARK OFFICE

_____

BEFORE THE PATENT TRIAL AND APPEAL BOARD

_____

NESPRESSO USA, INC.,
Petitioner,

v.

K-FEE SYSTEM GMBH,
Patent Owner.

_____

Case No. IPR2023-00485
U.S. Patent No. 11,230,430

_____

DECLARATION OF LAURENS HOWLE, PH.D., P.E. IN SUPPORT OF PATENT OWNER'S RESPONSE

TABLE OF CONTENTS

I. Introduction and Qualifications 1

II. Materials Considered 6

III. Understanding of Governing Law 12

IV. The Level of Ordinary Skill in the Art and Perspective Applied in this Declaration 16

V. Overview of the '430 Patent 17

VI. Overview of the Prior Art 18

A. Yoakim (U.S. Patent Pub. No. 2010/0239734) 20

B. Jarisch (U.S. Patent Pub. No. 2013/0064937) 24

C. Rossi (WO 2010/099806) 25

D. Castellani (U.S. Patent Pub. No. 2008/0105131) 26

VII. Summary of Opinions 27

VIII. K-fee's Second German Priority Application Supports the '430 Patent's Claims 28

A. The Embodiment of Figures 16, 17, and 18 33

B. The Second German Application Covers "an upper end portion that has an annular convexity and a lower end portion that has an annular concavity relative to the central axis of the base element." 54

C. The Second German Application Covers a Barcode Located on the Bottom Side of the Flange 57

IX. The '430 Patent Is Not Unpatentable As Obvious 66

A. Yoakim Fails to Disclose a Capsule Free of a Filter (Claims 1, 7) 66

B. Neither Yoakim Nor Rossi Disclose or Render Obvious a Pump Control Limitation (Claims 1, 7).....75

C. Yoakim Does Not Disclose or Render Obvious A Side Wall Having Indentations (Claims 5, 7) 84

D. A Person of Ordinary Skill in the Art Would Not Have Been Motivated To Combine the References.....88

1. A Person of Ordinary Skill in the Art Would Not Have Been Motivated to Combine Rossi with Yoakim and Jarisch.....88

2. A Person of Ordinary Skill in the Art Would Not Have Been Motivated to Combine Yoakim, Jarisch, Rossi, and Castellani.....99

DECLARATION OF LAURENS HOWLE

I, Laurens "Lars" Howle, Ph.D., P.E., hereby declare under penalty of perjury that the following statements are made based on my personal knowledge and are true and correct.

I. Introduction and Qualifications

1. I have been retained by McDermott Will & Emery on behalf of K-Fee System Gmbh ("K-fee") to provide an analysis of U.S. Patent No. 11,230,430 ('430 Patent), the applications to which it claims priority, and certain issues raised in IPR2023-00485. I understand that the Parties are in litigation in which K-fee accuses Petitioner's VertuoLine system of meeting the claim requirements.

2. I am being compensated at my standard hourly rate of $600 per hour for my time. My compensation is not in any way contingent on my performance, the result of this proceeding, or any of the issues involved therein. I am also being reimbursed for expenses incurred as a result of activities performed as an expert.

3. From 1983 – 1989, I was Plant Manager and Vice President of Manufacturing at Kaye Products, Inc. At Kaye Products, I was responsible for all phases of manufacturing of the physical therapy equipment produced by that company. These responsibilities included, *inter-alia*, production scheduling and line balancing, procurement and inventory maintenance of raw materials, warehousing of completed product, design, installation, and maintenance of various automated

and semi-automated manufacturing processes. At Kaye Products, I had up to 30 direct reports.

4. Also at Kaye Products, I programmed custom bar codes for use in inventory control of more than 250 different raw materials and components. These bar codes were integrated with the custom line-of-business software system I wrote for controlling and tracking product manufacturing.

5. I hold B.S.E., M.S., and Ph.D. degrees from Duke University in the field of Mechanical Engineering. In 1993, I joined the faculty in the Department of Mechanical Engineering and Materials Science as an Assistant Professor. In 2000, I was promoted to Associate Professor with tenure. Later, in 2020, I was promoted to my current rank of Full Professor with tenure.

6. At Duke University, I have taught widely across the undergraduate and graduate curricula. At the undergraduate level, I have taught Mechanical Design, Analysis for Mechanical Design, Modeling and Control of Dynamical Systems, Fluid Mechanics, Heat and Mass Transfer, Wind Turbine Design and Analysis, Advanced Computer Aided Design, Manufacturing Engineering, and Advanced Manufacturing Engineering. At the graduate level, I have taught courses in Wind Turbine Design and Analysis, Introduction to Scientific Computing, Probabilistic Pharmacokinetics and Pharmacodynamics, Computational Fluid Dynamics and Heat

Transfer, Advanced Computational Fluid Dynamics, and Topics in Nonlinear Dynamics.

7. Additionally, I was previously a Professor of Radiology at the Duke University Medical Center and have also previously been a Professor of Marine Science and Conservation at the Duke University Marine Laboratory.

8. From 2008 to the present, I have been owner and Manager-Member of BelleQuant Engineering, PLLC, a North Carolina based and licensed professional engineering consulting firm (license number P-0774).

9. Through my research at Duke University, my experience in industry, and my consulting activities for numerous Governmental Agencies, and Non-Governmental Organizations, I have considerable experience with a wide array of measurement techniques and automated data acquisition methods. Such techniques include optical measurement of flow patterns using shadowgraphy and Schlieren methods, particle image velocimetry, active feedback control of fluid motions, displacement/angular measurement using potential change, optical gradients, and optical grating methods. I have considerable experience designing and using strain gauges, thermocouples, thermistors, photo emitter/detector circuitry, ultrasonic and inductive proximity sensors, Hall effect transducers, piezoelectric elements, pressure transducers, ultrasonic and impellor flow meters, accelerometers, and interferometers.

10. Through my research activities at Duke University, I gained considerable expertise with and contributed to the understanding of fluid flow in porous media by publishing peer-reviewed papers in the Scientific Literature; including the journal *Nature*. These contributions included developing models for anisotropic dispersive thermal conductivity in fluid-saturated packed beds. Additional contributions include developing shadowgraphic methods for fluid flow pattern visualization and measurement in fluid-saturated porous layers. Building on this body of work, I developed methods for control of fluid motion in bulk fluid and fluid-saturated porous layers through active feedback control of thermal boundary conditions.

11. In 2020, I was named as a Fellow of the Undersea and Hyperbaric Medical Society. In 2012, I was named as a Fellow of the American Society of Mechanical Engineers. In 2011, a New Product Award was granted at the MCEE expo in Montreal for a product that I designed. In 2009, I was a finalist for a design award from "INDEX: Design to Improve Life," a Danish nonprofit organization.

12. I am the lead inventor on United States Patent No. 9,884,166, titled "Jetless Intravenous Catheters and Mechanical Assist Devices for Hand Injection of Contrast Media During Dynamic Computer Tomography and Methods of Using Same".

13. I have served as an expert witness on more than 25 cases, have testified at trial on six occasions, and have been deposed eight times. Directly related to single-serve beverage brewing systems, I served as an expert and/or testified at trial in the cases 337-TA-929 "Certain beverage brewing capsules, components thereof, and products containing the same", 337-TA-929 (Enforcement and Rescission Proceeding), C15-0522RSL "Eko Brands, LLC v. Adrian Rivera Maynez Enterprises, Inc., et al.", 4:16-cv-2702 "Solofill, LLC v. Adrian Rivera, Adrian Rivera Maynez Enterprises, Inc.", LA CV16-04676 JAK (SSx) Lead Case; LA CV16-04753 JAK (SSx); LA CV16-04706 JAK (SSx); LA CV16-047702 JAK (SSx), "Rivera v. Remington Designs, LLC; Rivera v. Eko Brands, LLC and Espresso Supply, Inc; Rivera v. Solofill, LLC; Rivera v. Creative Concepts", and 4:20-cv-03732 "Eko Brands, LLC v. Solofill, LLC and Robert Vu". I have accumulated more than 1,300 hours designing, analyzing, and evaluating single-serve beverage brewing systems.

14. My knowledge, experience, and training meet or exceed the level of a person of ordinary skill in the art (POSITA) for the technical subjects at issue in this litigation (including but not limited to mechanical engineering, fluid delivery devices, thermal and fluids engineering, and product design).

15. Additional information regarding my education and technical experience is included in my Curriculum Vitae, which is attached to this Report as Appendix A.

II. Materials Considered

16. All of the opinions contained in this Declaration are based on the documents I reviewed and my knowledge and professional judgment. In forming the opinions expressed in this Declaration, while drawing on my experience, I reviewed the following documents:

Exhibit	Description
Ex. 2001	Declaration of Laurens "Lars" Howle ("Howle Decl.")
Ex. 2002	Examiner-Initiated Interview Summary for Appl. No. 17/324,182
Ex. 2003	Examiner-Initiated Interview Summary for Appl. No. 17/108,175
Ex. 2004	*K-fee System GmbH v. Nespresso USA, Inc*., Case No. 2:21-cv-3402 GW(AGRx), Dkt. No. 126-1 (Apr. 1, 2022)
Ex. 2005	*K-fee System GmbH v. Nespresso USA, Inc*., Case No. 2:21-cv-3402 GW(AGRx), Dkt. No. 211 (June 17, 2022)
Ex. 2006	U.S. Patent No. 11,254,491
Ex. 2007	U.S. Patent No. 10,858,177
Ex. 2008	Excerpts of file history for U.S. Patent No. 10,858,176
Ex. 2009	Excerpts of file history for U.S. Patent No. 10,870,531
Ex. 2010	Excerpts of file history for Appl. No. 17/547,363

Exhibit	Description
Ex. 2011	Applicant-Initiated Interview Summary for Appl. No. 17/963,392
Ex. 2012	File history for U.S. Patent 11,254,491
Ex. 2013	Notice of Allowance for Appl. No. 17/330,572
Ex. 2014	Excerpts from Appl. No. 17/670,629
Ex. 2015	Excerpts from Appl. No. 17/670,765
Ex. 2016	Suggestion for Declaration of Interference, Appl. No. 13/697,297
Ex. 2017	Declaration of Laurens "Lars" Howle in Support of Patent Owner's Response ("Howle Decl.")
Ex. 2018	Transcript of deposition of Michael Jobin taken June 22, 2023
Ex. 2019	Transcript of deposition of Michael Jobin taken November 28, 2023
Ex. 2020	NOT USED
Ex. 2021	NOT USED
Ex. 2022	U.S. Patent Appl. Pub. No. 2009/0007792
Ex. 2023	U.S. Patent Appl. Pub. No. 2008/0302252
Ex. 2024	WO Pub. No. WO2008100597A1
Ex. 2025	Bialetti Moka Express (https://www.bialetti.com/it_en/moka-express.html)
Ex. 1001	U.S. Patent No. 11,230,430 ('430 Patent)

Exhibit	Description
Ex. 1002	Prosecution History of U.S. Patent No. 11,230,430 (’430 Patent File History)
Ex. 1003	Declaration of Michael Jobin (Jobin Decl.)
Ex. 1004	U.S. Patent Pub. US2010/0239734A1 (“Yoakim”)
Ex. 1005	U.S. Patent Pub. US2013/0064937A1 (“Jarisch”)
Ex. 1006	U.S. Patent Pub. US2013/0064929A1 (“Jarisch 929”)
Ex. 1007	PCT Pub. WO2010/026053A1 (“Denisart”)
Ex. 1008	U.S. Patent Pub. US2012/0269933A1 (“Rapparini”)
Ex. 1009	U.S. Patent Pub. 2008/0105131 (“Castellani”)
Ex. 1010	PCT Pub. WO2005/079638A1 (“Panesar”)
Ex. 1011	U.S. Patent Pub. 2006/0233921 (“Mock”)
Ex. 1012	National Coffee Association (“NCA”)
Ex. 1013	U.S. Patent Pub. 2002/0078831 (“Cai”)
Ex. 1014	U.S. Patent No. 726,793 (“Bezzera”)
Ex. 1015	U.S. Patent Pub. 2009/0007793 (“Glucksman”)
Ex. 1016	U.S. Patent No. 3,387,553 (“Tavera”)
Ex. 1017	U.S. Patent No. 3,631,793 (“Bednartz”)
Ex. 1018	U.S. Patent No. 4,136,202 (“Favre”)
Ex. 1019	U.S. Patent No. 6,142,063 (“Beaulieu”)
Ex. 1020	U.S. Patent No. 4,389,925 (“Piana”)

Exhibit	Description
Ex. 1021	U.S. Patent No. 6,655,260 (“Lazaris”)
Ex. 1022	U.S. Patent Pub. 2006/0230941 (“Ryser”)
Ex. 1023	U.S. Patent Pub. 2009/0249961 (“Cheng”)
Ex. 1024	U.S. Patent Pub. 2004/0089158 (“Mahlich”)
Ex. 1025	PCT Pub. WO 2010/034663 (“Ozanne”)
Ex. 1026	ASM Handbook, Volume 14B: Metalworking: Sheet Forming, S.L. Semiatin, editor. (“ASM Handbook”)
Ex. 1027	https://www.italcoat.com/wp-content/uploads/2022/08/ITC-Coffee-Capusles.pdf (“Italcoat”)
Ex. 1028	EU Patent App. EP2145759A1 (“Geerts”)
Ex. 1029	Penix J.A. (1991) Thermoforming of Plastic Film and Sheet. In: Berins M.L. (eds) SPI Plastics Engineering Handbook of the Society of the Plastics Industry, Inc. (“Penix”)
Ex. 1030	U.S. Patent No. 3,437,253 (“Davis”)
Ex. 1031	U.S. Patent No. 5,261,558 (“Claydon”)
Ex. 1032	U.S. Patent No. 5,243,164 (“Erickson”)
Ex. 1033	U.S. Patent No. 6,645,537 (“Sweeney”)
Ex. 1034	EU Patent App. EP1849718A1 (“Rubino”)
Ex. 1035	PCT Pub. WO2010/041179A2 (“Mariller”)
Ex. 1036	EU Patent App. EP0455337B1 (“Bentley”)
Ex. 1037	U.S. Patent Pub. 2002/0048621A1 (“Boyd”)
Ex. 1038	U.S. Patent Pub. 2007/0203587A1 (“Erlandsson”)

Exhibit	Description
Ex. 1039	U.S. Patent Pub. 2005/0150391A1 (“Schifferle”)
Ex. 1040	PCT Pub. WO2005/044067A1 (“Ruchonnet”)
Ex. 1041	PCT Pub. WO2010/099806A1 (“Rossi”)
Ex. 1042	US Patent Pub. 2009/0205747 (“Lillard”)
Ex. 1043	U.S. Patent Pub. 2010/0078480A1 (“Aker”)
Ex. 1044	U.S. Patent Pub. 2013/0099597 (“Perentes”)
Ex. 1045	Official English translation of German application No. 102011010534.4 (“February 2011 Application”)
Ex. 1046	Official English translation German application No. 102010031988.0 (“July 2010 Application”)
Ex. 1047	Official English translation German application No. 102010044251.8 (“September 2010 Application”)
Ex. 1048	K-Fee System GmbH v. Nespresso USA, Inc. et al., Case No. 2:22-cv-00525 (“Complaint”)
Ex. 1049	K-Fee System GmbH v. Nespresso USA, Inc. et al., Case No. 2:22-cv-00525 – Supplemental Disclosure of Infringement Contentions (July 11, 2022) (“Infringement Contentions”)
Ex. 1050	Excerpt from Prosecution History of U.S. Appl. No. 13/744,623 (“’623 Appl.”)
Ex. 1051	https://nestle-nespresso.com/our_products/product (“Nespresso Vertuo System”)
Ex. 1052	K-Fee System GmbH v. Nespresso USA, Inc. et al., Case No. 2:21-cv-3402; Dkt. 111 (“Claim Construction Order”)

Exhibit	Description
Ex. 1053	Excerpt from Prosecution History of U.S. Appl. No. 16/438,818 ("'818 Appl.")
Ex. 1054	K-Fee System GmbH v. Nespresso USA, Inc. et al., Case No. 2:21-cv-3402; Dkt. 211 ("Summary Judgment Order")
Ex. 1055	Food Packaging and Shelf Life: A Practical Guide (2009), Chapter 11 – "Packaging and the Shelf Life of Coffee" ("Food Packaging")
Ex. 1056	Illy, Andrea, and Rinantonio Viani, eds. Espresso coffee: the science of quality. Academic Press, 2005. ("Espresso Coffee")
Ex. 1057	Excerpt from Appl. No. 16/538,752: Nov. 8, 2019 Office Action Rejection ("752 Appl. First Rejection")
Ex. 1058	Excerpt from Appl. No. 16/538,752: Jan. 23, 2020 Response to Office Action ("752 Appl. First Response")
Ex. 1059	Excerpt from Appl. No. 16/538,752: Apr. 28, 2020 Office Action Rejection ("752 Appl. Second Rejection")
Ex. 1060	Excerpt from Appl. No. 16/538,752: Jul. 27, 2020 Response to Office Action ("752 Appl. Second Response")
Ex. 1061	Excerpt from Appl. No. 16/538,752: Nov. 3, 2020 Notice of Allowance ("752 Appl. Notice of Allowance")
Ex. 1062	Excerpt from Appl. No. 16/860,441: Jul. 13, 2020 Office Action Rejection ("441 Appl. First Rejection")
Ex. 1063	Excerpt from Appl. No. 16/860,441: Oct. 13, 2020 Response to Office Action ("441 Appl. Response")
Ex. 1064	Excerpt from Appl. No. 16/860,441: Nov. 12, 2020 Notice of Allowance ("441 Appl. Notice of Allowance")
Paper 9	Decision Granting Institution of *Inter Partes* Review

17. I also referenced other publications in order to confirm my understanding of the state of the art.

18. My opinions are additionally guided by my appreciation of how a POSITA would have understood the claims of the ’430 Patent and its earlier-filed applications at the time of the invention, which I have been asked to assume is September 2, 2010.

III. Understanding of Governing Law

19. I am not an attorney and do not have formal legal training. Consequently, I offer no opinion on the law itself. The following understanding of law has been provided to me by counsel. I have applied this understanding in my analysis.

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

21. I have been informed and understand that a patent is entitled to the filing date of its earlier-filed applications so long as the earlier-filed applications provide written description support by disclosing the claimed invention to a POSITA, with all of the POSITA’s knowledge and creativity.

A. Priority

22. I have been informed and understand that a patent is entitled to the filing date of its earlier-filed applications so long as the earlier-filed applications provide written description support by disclosing the claimed invention to a POSITA, with all of the POSITA's knowledge and creativity. I further understand that support for the claimed embodiments as a whole may be shown through description of a combination of elements that are linked to create the claimed embodiments in an earlier-filed application.

B. Anticipation

23. I have been informed that a patent claim is invalid as anticipated under 35 U.S.C. § 102 if each and every element of a claim, as properly construed, is found either explicitly or inherently in a single prior art reference. Under the principles of inherency, if the prior art necessarily functions in accordance with, or includes the claimed elements, it anticipates.

24. I have been informed that a claim is invalid under 35 U.S.C. § 102(a) if the claimed invention was known or used by others in the U.S., or was patented or published anywhere, before the Applicant's invention.

25. I further have been informed that a claim is invalid under 35 U.S.C. § 102(b) if the invention was patented or published anywhere, or was in public use, on

sale, or offered for sale in this country, more than one year prior to the filing date of the patent application (critical date).

26. And a claim is invalid, as I have been informed, under 35 U.S.C. § 102(e), if an invention described by that claim was described in a U.S. patent granted on an application for a patent by another that was filed in the U.S. before the date of invention for such a claim.

C. Obviousness

27. I have been informed that a patent claim is invalid as "obvious" under 35 U.S.C. § 103 in light of one or more prior art references if it would have been obvious to a person of ordinary skill in the art at the time of the alleged invention ("POSITA"), taking into account (1) the scope and content of the prior art, (2) the differences between the prior art and the claims, (3) the level of ordinary skill in the art, and (4) any so called "secondary considerations" of non-obviousness, which include "long felt need" for the claimed invention, commercial success attributable to the claimed invention, unexpected results of the claimed invention, skepticism of others, failure by others to achieve the claimed invention, and "copying" of the claimed invention by others.

28. I have been informed that a claim can be obvious in light of a single prior art reference or multiple prior art references. To be obvious in light of a single prior art reference or multiple prior art references, there must be a reason that would have

prompted a POSITA to modify the single prior art reference, or combine two or more references, in a manner that provides the elements of the claimed invention. This reason may come from a teaching, suggestion, or motivation to combine, the reference(s) themselves, the knowledge or "common sense" of a POSITA, or from the nature of the problem to be solved. The reason that would have prompted a POSITA to modify the single prior art reference or combine two or more references may be explicit or implicit from the prior art as a whole. I have been informed that, under the law, the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results. I also understand it is improper to rely on hindsight in making the obviousness determination.

D. Claim Construction

29. I understand that claim construction is a matter that will be decided by the Board presiding over this IPR. I understand that the relevant inquiry in claim construction is the question of how a person of ordinary skill in the art would have understood the claim terms at the time of the earliest priority date, in light of the patent specification, the prosecution history, and any other relevant intrinsic and extrinsic evidence.

30. For the purposes of this Declaration, I understand that Petitioner has not proposed formally construing any term of the '430 Patent, and therefore, the claim

terms should be given their plain and ordinary meaning as would be understood by a person of ordinary skill in the art.

IV. The Level of Ordinary Skill in the Art and Perspective Applied in this Declaration

31. I have reviewed the qualifications that Petitioner contends that a person having ordinary skill in the art ("POSITA") in the related U.S. Patent No. 11,254,491 (the "'491 Patent") would have. I note that the Board, in its Decision Granting Institution of Inter Partes Review of the '491 Patent, adopted Patent Owner's definition of the level of ordinary skill, which requires a POSITA to have a bachelor's degree in engineering plus five years of experience in design of mechanical beverage systems, or similar products, as well as experience with sensors for recognizing an identifier. IPR2022-01574, Paper 12 at 14-15. Additional education might substitute for some of the experience, and substantial experience might substitute for some of the educational background. For purposes of this Declaration, I adopt this definition with respect to the '430 Patent.

32. I would have qualified as a person of at least ordinary skill in the art as of September 2, 2010, and I have a sufficient level of knowledge, experience, and education to provide an expert opinion in the field of the challenged claims of the '430 Patent.

V. Overview of the ’430 Patent

33. The ’430 Patent is titled “Portion Capsule Having An Identifier” and was published on January 25, 2022. Ex. 1001 at (45), (54). The foreign application priority data of the ’430 Patent lists priority to three German patent applications: DE 10 2010 031 988.0 filed on July 22, 2010 (Ex. 1046 or “the first German application”); DE 10 2010 044 251.8 filed on September 2, 2010 (Ex. 1047 or “the second German application”); and DE 10 2011 010 534.4 filed on February 7, 2011 (Ex. 1045 or “the third German application”) (collectively, “the German applications”). Ex. 1001 at (30). The ’430 Patent has two independent claims (Claims 1 and 7) and eight dependent claims (Claims 2-6, 8-10). *See generally id*.

34. The claims of the ’430 Patent are generally directed to a beverage system that includes a single-serve capsule containing a beverage raw material and a beverage machine (such as a coffee machine). Ex. 1001 at Abstract. The capsule has a flange and a barcode on a bottom side of the flange. *Id*. The beverage machine includes: a sensor / detector to read the barcode; a brewing chamber to receive the capsule; and a pump controlled to supply water into the capsule. *Id*. The machine includes: a mandrel to pierce the cover in a region that is offset from the central axis; a seal that seals against the cover in a region between a peripheral edge of the flange and the region of the cover that is pierced by the mandrel; a pair of holding arms for engaging the capsule; and a dropping box for the capsule to fall into. *Id*. The pump

is controlled to push the water into the capsule only upon a determination that the read barcode agrees with a stored reference. *Id*.

VI. Overview of the Prior Art

35. In my review of the prosecution history files of the ’430 Patent, I noted that USPTO Examiner Jennison considered all four references that Petitioner relies on for its arguments – (1) Yoakim (U.S. Patent Pub. No. 2010/0239734); (2) Jarisch (U.S. Patent Pub. No. 2013/0064937); (3) Rossi (WO 2010/099806); and (4) Castellani (U.S. Patent Pub. No. 2008/0105131). Patent Owner submitted for consideration the ultimately unsuccessful Petitions for inter partes review against three other patents in this patent family. *See* Ex. 1002, Part 1 at 301. Even after the Examiner mailed a Notice of Allowability, I understand that Patent Owner complied with its duty of candor to the USPTO by submitting all of the information concerning validity that Petitioner asserted against patents related to the ’430 Patent in a co-pending district court litigation. *See* Ex. 1002, Part 1 at 232, 304, 321-24 (showing submission of Petitioner’s Preliminary Invalidity Contentions and Claim Charts from Civ. No. 2:21-cv-3402 GW(ARGx) dated Sept. 22, 2021). Examiner Jennison considered all of these submissions. *See* Ex. 1002, Part 1 at 301; Ex. 1002, Part 4 at 422.

36. As evidenced by his communications with the Patent Owner, Examiner Jennison was well aware of the prior art landscape, including the now-cited art, in

this and related applications. In his November 2, 2021 Notice of Allowance, Examiner Jennison pointed out the numerous limitations not disclosed by the cited art. Ex. 1002, Part 1 at 233. Additionally, approximately one month after issuing the Notice of Allowance for the '430 Patent, Examiner Jennison issued a Notice of Allowance for contemporaneously-prosecuted U.S. Patent Appl. No. 17/383,951 (the "'951 Application") in this patent family, concluding that "allowance of claims 21, 24-35 is indicated as none of the cited prior art discloses or suggests a pump controlled to supply water into the single-serve capsule only upon detection of the identifier by the sensor/detector and a determination by the beverage machine that the single-serve capsule is suitable for use with the beverage machine." Ex. 1002 at 334-339, 406-407. Moreover, in an *Examiner-Initiated Interview Summary* for two applications related to the '430 patent, Examiner Jennison verified the priority dates in light of the co-pending applications and recent IPRs; acknowledged that the number of references filed in the IDS documents is not excessive; and confirmed the identification of the references that had been repeatedly relied upon in the applications he had Examined – these lists of references confirmed by the Examiner include each of the referenced relied on in the current Petition (shown below). Ex. 2003 at 2, 4; Ex. 2002 at 2, 4.

Summary List of Potentially Relevant References Most Heavily Relied Upon By Petitioner

Petitioner alleges in its numerous IPR petitions that "K-fee never provided guidance on the relevance of its voluminous IDS references" (See page 2 of the '923 and the '430 Petitions).

Based upon the observed pattern and history of Petitioner and/or its affiliates world-wide filings against Applicant and its related patents, below is a summary of references that have been repeatedly relied upon by Petitioner and/or its affiliates in attacking the patentability of Applicant's claims.

- US2008/0105131A1 (Castellani)
- US2010/0239734A1 (Yoakim)
- WO2005/044067A1 (Ruchonnet)
- WO2005/079638A1 (Panesar)
- WO2010/026053A1 (Denisart)
- WO2010/099806A1 (Rossi)
- US2002/0048621A1 (Boyd)
- WO2002/028241A1 (Boyd)
- US20060233921A1 (Mock)
- US2010/0078480A1 (Aker)
- US2012/0269933A1 (Rapparini)
- US2013/0064929A1 (Jarisch 2)
- US2013/0064937A1 (Jarisch 1)
- WO2011/141532A1 (Jarisch)
- EP0512468A1 (Fond)

A. Yoakim (U.S. Patent Pub. No. 2010/0239734)

37. Yoakim is titled "Method for Preparing a Beverage or Food Liquid and System Using Brewing Centrifugal Force" and was published on September 23, 2010, from an application filed May 7, 2010. Ex. 1004 at (54), (43), (22).

38. Yoakim generally relates to a capsule-based system and method for preparing a liquid food or beverage through centrifugation. Ex. 1004 at Abstract. Specifically, Yoakim describes a method of brewing or extraction that uses centrifugal forces to rotate a capsule so that "the centrifugal rotation of the capsule urges the liquid to flow through the ingredient(s) in a radial or centrifugal flow path to prepare the liquid food." *Id*. at [0020].

39. The device described in Yoakim can introduce water into the capsule after the capsule is pierced "at substantially no pressure" such as by "a hot water feed mechanism using a principle of aspiration or vaporization;" a "low-pressure pump such as a peristaltic pump or a diaphragm pump and the like;" or some other "water feed means for introducing water in the capsule." Ex. 1004 at [0132], [0133], [0149]; *see also id*. at [0180] ("A fluid transport means such as a low pressure pump 6 can be provided in the water circuit to transport water from the reservoir to the module . . . Water can be fed into the module 4 at low or substantially no pressure."); [0428] ("Water can be fed in the beverage preparation module 124 at low pressure or even at gravity pressure."). The device described in Yoakim also contains a "control unit" that can be programmed to vary the centrifugal rotation speeds used to drive the capsule in rotation. *Id*. at [0153].

40. Yoakim teaches a filter inside the capsule made of "a series of slits" where "the brewed liquid can pass through the slits whereas the solid particles are retained in the capsule." Ex. 1004 at [0171]; *see also id.* at [0271] ("Preferably, the capsule comprises an internal filter portion placed at the periphery of the enclosure. The internal filter portion can be an internal perforated lid and/or a portion of porous material."), [0375] ("Preferably, the outlet openings of the enclosure of the capsule have an average diameter or width which is smaller than the average size of the particles forming the food substance."), [0376] ("Therefore, the openings can have

a filtering function per se."); *see also* Figs. 28, 29, 39. Yoakim teaches sizing these slits "to also filter the brewed liquid and maintain solid particles of the substance in the capsule." Ex. 1004 at [0131]. Yoakim further teaches that "[a]n additional filtering layer can be used to filter liquid depending on the size of the outlets" and "depending on the size of the outlets," it may be necessary to provide additional filtering to ensure the solid particles are retained in the capsule. *Id*. at [0171]. The figures in Yoakim further teach a filter inside the capsule – for example, Figures 41 and 42 include a porous wall 180, which is a filter and depicted within the cavity of the capsule. Ex. 1004 at [0451] ("According to FIGS. 41 and 42, the capsule in the system of the invention may also comprise an enclosure which is formed of a dished body 102 and a porous wall 180. The dished body comprises a main cavity 182 for storing the food substance and a peripheral recess 181 for receiving the liquid extract that traverses the porous wall 180 during the centrifugation process."), [0452] ("The porous wall 180 can have openings (i.e., pores) along its whole surface…").

41. Yoakim describes that compared to "known methods using brewing water pressurized by a pump," "surprising improved brewing results are obtained" because "water flow is more uniformly distributed by centrifuge effect and it creates less or no preferential flow paths in the coffee bed as compared to traditional methods using a positive pressure obtained by a pressure pump." Ex. 1004 at [0124]; *see also id*. at [0443] ("Consequently, the water distribution is also more uniform

compared to known methods using a pressure pump to provide a water piston through the coffee in the capsule."); *see also id.* at [0132], [0180] (stating that without the use or activation of a pump, "hot water is introduced into the capsule at substantially no pressure. Water can be brought by a hot water feed mechanism using a principle of aspiration or vaporization"). Moreover, Yoakim describes that "flow rates [] are influenced by two key parameters: the rotational speed of the capsule in the device and the back-pressure exerted on the centrifuged liquid." Ex. 1004 at [0521]. "The back-pressure can be varied by varying the closing force of a flow restriction valve placed downstream of the enclosure of the capsule and/or by varying the cross-section of the restriction outlets." *Id*.; *see also id*. at [0523] [0136]; [0429]; [0501].

42. Yoakim teaches indentations on the "outer surface" of the capsule—specifically, Yoakim teaches the enclosure has "a widening side wall located between top and bottom walls, and an outer surface or structure for engaging external rotational driving means of a centrifugal device with the outer surface or structure configured to offer resistance…." Ex. 1004 at [0016].

43. Yoakim further describes an identification means and control means for operating the device according to predetermined brewing parameters. Ex. 1004 at [0485]-[0488]. The identification means comprises "capsule recognition means" which can be recognized by sensing means connected to the control means. *Id*. at

[0025] ("identification means comprising capsule recognition means which are recognized by sensing means connected to the control means of the device to control the preparation parameters accordingly."), [0487], [0495]. As an example, the recognition means can be differentiable by an "identifiable shape," or a visual code. *Id*. at [0496]; [0525] ("The recognition means can be any mechanical, topical, magnetic or radio-frequency recognition means capable of delivering information to the brewing device, via a sensing device 231, as to which type of capsule is inserted in the device. For example, the recognition means is a barcode, a colour code, a RFID tag, a magnetically sensitive element, or a mechanical key or shape."); [0192] ("A recognition system uses a code on the capsule and recognized by the device, such as . . . shapes and combinations thereof.").

B. Jarisch (U.S. Patent Pub. No. 2013/0064937)

44. Jarisch is titled "Capsule, System and Method for Preparing a Beverage by Centrifugation" and published March 14, 2013 from an application filed May 12, 2011. Ex. 1005 at (22), (43), (54).

45. Jarisch is directed to a capsule for the preparation of a beverage comprising a container and beverage ingredient therein, wherein the container comprises a code adapted for being identified or read by external readings means. Ex. 1005 at Abstract. The code is arranged on the container to be read while the

capsule is rotated around an axis. *Id.* Jarisch particularly focuses on the detection of the capsule. *Id*. at [0001].

C. Rossi (WO 2010/099806)

46. Rossi is titled "System of Edible-Product Making Machine and Load Element and Process for Control of Machine" and was published on September 10, 2010. Ex. 1041 at (54), (43).

47. Rossi relates generally to a process and system for controlling the operation of an edible-product making machine that uses single-use capsules. *E.g*., Ex. 1041 at cl. 1. The process described in Rossi consists of a first step of recognizing an identifying element and validation element on the capsule; a second step of validating the validation element; and a third step of activating a cycle of production only after recognizing the identifying element and the now-validated validation element. *Id*. at 6. The use of a validation element is described to "help to prevent the use of an already-used single load element," and the identification element "preferably contains information about the contents of the load element." *Id*. at 7-8.

48. Specifically, the first step may consist of "unlocking the machine when both the identification element and the unvalidated validation element are recognized." Ex. 1041 at 9. The second step of validation of the validation element may consist of "mechanical destruction of the validation element," which ensures that the validation element cannot be re-recognized. In the third activation step, the

machine "activates a cycle of edible-product production" after it recognizes on the capsule the same identifying element and the validated validation element. *Id*. at 8-10. "The use of an activation step of automatically activating the cycle of edible-product production only when the same identifying element is recognized in combination with the validated validation element ensures that the operating condition actually used are the correct conditions as selected by the machine in the first recognition step" so as to "help to prevent the user from making the mistake of inserting into the machine a different load element to the one that was first recognized, for which the operating conditions are set." *Id*. at 8.

D. <u>Castellani (U.S. Patent Pub. No. 2008/0105131)</u>

49. Castellani is titled "Delivery Head for Espresso Coffee Machines" and published May 8, 2008. Ex. 1009 at (54), (43).

50. Castellani generally describes a "delivery head" for an espresso machine that allows for the easy loading and ejecting of single-use capsules. Ex. 1009 at [0010]. A capsule can be placed in the delivery head, and the delivery head can be closed by pressing a lever downward. Ex. 1009 at [0045]-[0046]. The top of the capsule is then perforated and "pressurized water is delivered which, through the delivery duct 20 and the hole formed by the top perforating element 18 can enter the coffee capsule and diffuse there-through owing to the provision of suitable channels formed inside said capsule 10." *Id*. at [0049].

VII. Summary of Opinions

51. In my opinion, Petitioner's arguments fail because: (1) Petitioner cannot demonstrate that Yoakim teaches the "single-serve capsule is free of a filter that is located inside of the cavity" limitations of independent claims 1 and 7; (2) Petitioner cannot demonstrate that Yoakim alone and/or in combination with Rossi teaches or renders obvious the "pump" limitations of independent claims 1 and 7; (3) Petitioner cannot demonstrate that Yoakim alone and/or in combination with Rossi teaches or renders obvious the "configured to determine if the single-serve capsule belongs to a group of single serve capsules operable for use with the beverage machine" limitation of independent claim 7; (4) Petitioner cannot demonstrate that Yoakim teaches or renders obvious the "side wall [having/includes] indentations" limitations of independent claim 7 and dependent claim 5; (5) Petitioner cannot demonstrate a person of ordinary skill in the art ("POSITA") would have been motivated to combine the teachings of Yoakim, Jarisch, Rossi, and Castellani to arrive at the novel beverage systems of independent claims 1 and 7; and (6) The Jarisch reference is not prior art because the '430 Patent is entitled to the priority date of the second German application.

52. Moreover, in my opinion, Petitioner's asserted combination fails to render obvious claims 1–10. First, Jarisch is not prior art because the '430 Patent is entitled to a priority date at least to the second German application. Second, the

Petition fails to show that Yoakim teaches a capsule free of a filter, as required by independent claims 1 and 7. Third, neither Yoakim nor Rossi teaches pump control, as required by independent claims 1 and 7. Fourth, the Petition fails to show that Yoakim teaches a capsule having a side wall with indentations, as required by dependent claim 5 and independent claim 7. Fifth, neither Yoakim nor Rossi teaches a determination that the single-serve capsule belongs to a group of single serve capsules operable for use with the beverage machine as required by independent claim 7.

VIII. K-fee's Second German Priority Application Supports the '430 Patent's Claims

53. The disclosures in the first and second German application are similar in many respects, with the second German application adding features to the common inventive aspect disclosed in both applications. Both applications teach a "portion capsule" containing a beverage raw material, such as ground coffee, wherein the portion capsule has an "identifier" to indicate that the portion capsule is "suitable just for a quite specific coffee machine." Ex. 1046 at 22; Ex. 1047 at 30. The disclosed invention can thus prevent potential serious safety problems and/or damage to the coffee machine that may arise from the use of a capsule that is "not suitable" for a particular coffee machine. Ex. 1046 at 22; Ex. 1047 at 30. The applications specify that the identifier may take a variety of forms and is "preferably a machine-readable print…preferably a barcode, a logo or a repeat pattern." Ex. 1046

at 24; Ex. 1047 at 33. Importantly, the applications state that the disclosures with respect to the identifiers are broadly applicable to all of the disclosed embodiments or examples, specifically stating that "[w]hat has been said in relation to the identifier applies to all other examples." Ex. 1046 at 28; Ex. 1047 at 38. Immediately after that statement, the applications describe Figure 2, stating that "it is possible, as symbolized by the arrow 15, for the barcode to be provided on that side of the peripheral region of the basic element which is directed away from the membrane." Ex. 1046 at 28; Ex. 1047 at 38. The membrane 4 is sealed or bonded to the upper most area of the capsule so as to close the cavity. Ex. 1046 at 27; Ex. 1047 at 37, Fig. 2. Alternatively, the "capsule has a barcode in the region of the upper side of the membrane." Ex. 1046 at 28; Ex. 1047 at 38. Lastly, the identifier can be used to control the operation of the coffee machine. Ex. 1046, at 28; Ex. 1047 at 37-38.

54. I have been informed that in order for the '430 Patent to be entitled to at least the September 2, 2010 filing date of German application DE 10 2010 044 251.8 (the "second German application"), the claims must find support in that application. In other words, the description in the second German application must indicate to a POSITA that the inventor was in possession of the claimed invention at the time the application was filed. As an initial matter, it is my belief that the USPTO has correctly identified the priority date of the '430 Patent each time it has addressed the priority of the applications in this patent family. In my review of the

’430 patent family prosecution file histories, I noted that in an *Examiner-Initiated Interview Summary* for two applications related to the ’430 patent, Examiner Jennison verified the priority dates in light of the co-pending applications and recent IPRs; acknowledged that the number of references filed in the IDS documents is not excessive; and confirmed the identification of the references that had been repeatedly relied upon in the applications he had Examined – these lists of references confirmed by the Examiner include each of the references relied on in the current Petition. Ex. 2003 at 2; *see also* Ex. 2002 at 2; Ex. 2003 at 4; Ex. 2002 at 4. Additionally, during the prosecution of the related ’491 Patent, when Examiner Jennison cited Jarisch in his Notice of References Cited, Patent Owner noted that “certain references cited by the Examiner in the ‘Notice of References Cited’ section of the Office Action are not prior art, in view of Applicant’s entitlement to at least the claimed September 02, 2010 priority application,” which predates Jarisch. Ex. 2012 at 1899. And finally, when discussing the status of the numerous IPR filings and co-pending applications in this patent family, Examiner Jennison concluded that “[t]he priority dates of the applications, and prior art cited, under Pre-AIA were verified.” Ex. 2003 at 2; *see also* Ex. 2002 at 2.

55. Moreover, the embodiments in the second German application are linked by the discussion of an identifier and the notion that the capsules are all intended for use in a coffee machine having a brewing chamber and a pump that

pumps water into the brewing chamber. The ordinarily skilled person would look to the drawings, including Figure 16's detailed discussion of the brewing chamber, and then look at page 36 of Ex. 1047 and learn that "Figure 16 shows a portion capsule with toothed ring in the brewing chamber." The skilled person would understand that the same brewing chamber is previously discussed in the general teachings of pages 1-6 of the application—the common brewing chamber described as operating with all of the capsules serves to link each example. *See, e.g.*, Ex. 1047 at 33:22-30 ("The portion capsule according to the invention makes it possible to prevent portion capsules which are not provided for a specific coffee machine to be introduced into the same. Furthermore, the identifier makes it possible for the coffee machine to detect which kind of capsule is located in ***its brewing chamber*** and to set the beverage-making or food-making process, i.e. for example the quantity of water, the pressure thereof and/or the temperature thereof, correspondingly."), 34:13-25 ("According to a further, or a preferred, subject matter of the present invention, the portion capsule has a peripheral region, which is preferably provided on the basic element. The periphery is preferably provided on that region of the basic element which is located opposite the base. For example, a membrane for closing the basic element may be arranged on this peripheral region once the raw material has been introduced into the portion capsule. The periphery, however, may also be used for guiding the capsule in an insertion shaft such that the capsule drops ***into a brewing***

chamber in a quite specific position. At the same time, the periphery can be used as a stop and/or sealing surface."). From these passages, a POSITA would readily conclude that the specifics of that brewing chamber are depicted by way of example in Figure 16.

56. Examiner Chou also "did not find any issue with patent owner's foreign priority date" when presented with the same list of references as Examiner Jennison. Ex. 2011 at 2, 4. Although Examiner Chou *initially* concluded that the German application did not provide support in an April 4, 2022 Office Action in related U.S. Application No. 17/547,363 (the "'363 Application," now U.S. Patent No. 11,542,094), Ex. 2010 at 3-4, in a subsequent interview on June 14, 2022 Examiner Chou "agreed that fig.16A is an example of the capsule that can be with a beverage machine. Thus, priority notification will be withdrawn." Ex. 2010 at 3-4, 11. Applicant's supporting evidence also included the statement in the second German application that the "identifier applies to all other examples" and the disclosure of the embodiment described in Figure 16. *Id*. at 11. Examiner Chou reached similar conclusions regarding a valid priority claim to the German applications for related U.S. Application Nos. 17/670,629 (the "'629 Application," now U.S. Patent No. 11,465,829) and 17/670,765 (the "'765 Application," now U.S. Patent No. 11,465,830), where entitlement to the German priority applications was also at issue and Patent Owner also overcame those priority rejections. It is my understanding

that in a recent Applicant-initiated interview with Examiner Chou, Patent Owner apprised him of the status of the various related IPR filings and brought to his attention the 15 references that Petitioner has consistently used in challenging the validity of Patent Owner's applications. *See id*. Examiner Chou concluded that he had "reviewed these references and did not find any issue with patent owner's foreign priority date." *Id*. at 2.

57. It is my opinion that the second German application provides priority support for at least the independent claim of the '430 Patent for two reasons: (1) a POSITA would have understood that the embodiment disclosed in Figures 16, 17, and 18 of the second German application recites each and every limitation in each of the claims of the '430 Patent; and (2) a POSITA would have understood that based on at least the disclosure of the second German application the inventor was in possession of the claimed invention.

A. The Embodiment of Figures 16, 17, and 18

58. A POSITA would have understood that the embodiment disclosed in Figures 16, 17, and 18 of the second German application alone satisfies the written description requirement, reciting every limitation in each of the claims of the '430 Patent. Moreover, a POSITA would have understood that additional relevant disclosures can be found, for example, in Figures 1 and 2 and the accompanying written description for each of Figures 1, 2, 16, 17, and 18. Moreover, a POSITA

would understand that the embodiments are linked by virtue of Fig. 16 and various passages in the general teachings of the application. As such, Petitioner's argument that the specification "lacks any disclosure linking together the remaining features across disparate embodiments," Pet. at 44, is incorrect because each limitation is disclosed with respect to the single embodiment that is described in Figures 16, 17 and 18.

59. It is my understanding that the written description requirement does not require the earlier filed application to describe the later filed claims verbatim; but rather, to clearly allow persons of ordinary skill in the art to recognize the claimed invention.

60. The second German application's written description and figures teach a "portion capsule" which contains a beverage raw material, such as ground coffee, wherein the portion capsule has an identifier, such as one in the form of a machine-readable barcode. As described with respect to the embodiment depicted in Figure 16, "[a]ccording to a further, or a preferred, subject matter of the present invention," the identifier can be "a…detection means to be sensed by a detector," which indicates "whether the respective portion capsule is suitable for the respective coffee machine." Ex. 1047 at 34:1-36:37, 41:13-35, Fig. 16; *see also id.* at 30:1-19. The disclosed invention thus uses an identifier to prevent "considerable safety-related

problems" and/or damage to the coffee machine that may arise from the use of a capsule that is "not suitable" for a particular coffee machine. *Id*. at 30:1-19.

61. A POSITA would have understood upon reading the second German application that the capsule features described are linked and would be intended to be combinable with each of the described embodiments. For example, the second German application describes that "*[t]he invention* will be explained hereinbelow with reference to figures 1-18. These explanations do not have a limiting effect on the general concept of the invention." Ex. 1047 at 35:1-37. Moreover, after the general description of the invention which included multiple examples identifier and the complete description of Figure 1, the second German application stated that "[w]hat has been said in relation to the identifier applies to all other examples." *Id.* at 38:8-9. The next example of identifier is found in the description of Figure 2, which provides an additional disclosure regarding the location of the identifier on the capsule. *Id.* at 38:11-27.

62. The second German application also makes clear that the brewing chamber for the embodiments is the same, which further demonstrates the linking of the embodiments. For example, the second German application provides that "the detection means is provided in the region of the brewing chamber." Ex. 1047 at 32:2. It continues that "the identifier makes it possible for the coffee machine to detect which kind of capsule is located in its brewing chamber." *Id.* at 33:25-27. The

capsule is guided such that "the capsule drops into a brewing chamber in a quite specific position." *Id.* at 34:23-24. The Figure 16 embodiment "shows a portion capsule with a toothed ring in *the brewing chamber*." *Id.* at 36:30-31. Thus, a POSITA would have understood there to be linking as all embodiments feature the same brewing chamber.

63. Moreover, the claims that are included at the end of the application further support the notion that the invention is a portion capsule, which can have any number of features that are introduced in connection with the different Figures and examples in the application. The combinable elements in the second German application are not only more limited in scope, but the specification provides guidance for how to combine them. *See* Ex. 1047 at 38 ("What has been said in relation to the identifier applies to all other examples"); *see also id.* at 31 ("According to the invention, then, it is provided that this portion capsule has an identifier"), 34 ("According to ***a further***, or a preferred, subject of the present invention, the portion capsule has a peripheral region"). Claim 1 is directed to the generic portion capsule of the invention. The multiple dependent claims then add additional features. Ex. 1047 at 46-48.

64. The multiple dependent claims demonstrate that the inventor contemplated that features from one embodiment were not confined solely to that individual embodiment. Indeed, the multiple dependent claims corroborate that the

inventor envisioned that, for this invention, features of one illustrative embodiment had applicability to other embodiments and such embodiments were linked and indeed combinable. For example, in withdrawing his drawing objections during the examination of the related '765 Application, Examiner Chou considered the multiple dependent claims of the second German application as sufficient for support for priority entitlement. Ex. 2015 at 2 ("[C]laim 7 can [] depend on claim 3 so that both identifier features can be added in independent claim."). As such, a POSITA would understand that the features from one embodiment were not confined solely to that individual embodiment.

65. Moreover, Petitioner has pointed to no evidence in the second German application that would militate any contrary outcome. Petitioner has pointed to nothing in the application that would prevent the linkage of the embodiments. In fact, it should be noted that when Petitioner attempted to demonstrate written description support in order to invoke an interference with Patent Owner, Petitioner was perfectly willing to link embodiments, cite to numerous different figures and rely on multiple dependent claims from the Jarisch EP application (EP 10169374.5). Ex. 2016 at 38-39 and *passim*.

66. As I previously stated, Figures 16, 17, and 18 of the second German application and their accompanying descriptions, which show "embodiments of the portion capsule according to figure 16," recite each and every limitation in each of

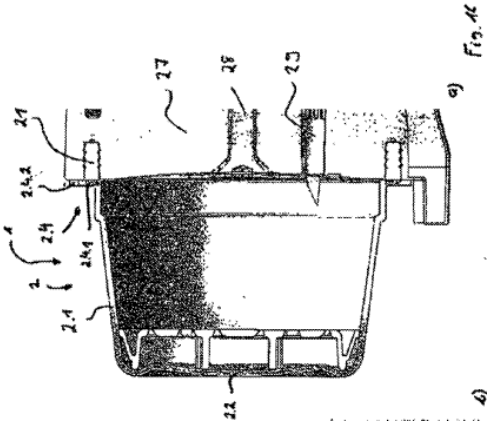
the claims of the ’430 Patent. For example, the preamble of claim 1 (“[a] beverage system for making a beverage”) finds support in the text accompanying Figures 17a-17c, which describes various aspects of the beverage system, including a “portion capsule,” “retaining arms,” “brewing chamber,” and “waste container.” *See* Ex. 1047 at 42:5-14. The second German application’s description of the inventor’s goals: further supports the preamble: “[t]he present invention relates to a portion capsule for making a beverage . . . .” *See, e.g.*, *id.* at 30:29-30; *see also id.* at 30:1-19 (the “object of the present invention [is] to provide a portion capsule which is suitable just for a quite specific coffee machine”). Additionally, the general description of the second German application states “[t]he object is achieved by a portion capsule for making a beverage . . . .” *Id*. at 30:21-22; *see also id*. at cl. 1 (“A portion capsule (1) for making a beverage . . . .”); *id*. at Abstract (“The present invention relates to a portion capsule for making a beverage . . . .”). Thus, a POSITA would have understood that the second German application supports the preamble of Claim 1 of the ’430 Patent.

67. Figure 16 of the second German application (duplicated below) provides support for claim limitation [1.a], “a single-serve capsule comprising: a base element with a cavity, in which a raw beverage material is provided,” when it discloses “a basic element 2, which in the present case is essentially conical and has a wall 2.1 and a base region 2.2. The raw material . . . [is] provided in this basic

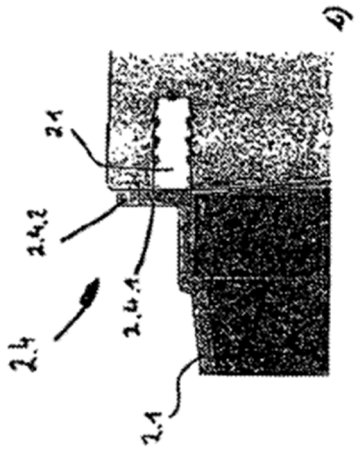
element." Ex. 1047 at 41:14-19. A POSITA would have easily understood that the conical basic element necessarily constitutes a cavity in which the raw beverage is located. Moreover, earlier in the description of the invention, the basic element is described as having "a cavity, in which a raw beverage material is provided." *Id.* at 30:1-7.

68. The general description and claims of the second German application further confirm this understanding. For example, the objective of the invention is described as "relat[ing] to a portion capsule for making a beverage, having a basic element with a cavity, in which a raw beverage material is provided . . . ." Ex. 1047 at 30:3-5; *see also id*. at 30:21-23 ("The object is achieved by a portion capsule for making a beverage, having a basic element with a cavity, in which a raw beverage material is provided . . . ."); *id*. at 30:29-31 ("The present invention relates to a portion capsule for making a beverage or food, having a cavity, in which raw beverage material is provided."). Later in the general description, the second German application describes "a membrane for closing the basic element [which] may be arranged on this peripheral region once the raw material has been introduced into the portion capsule." *Id*. at 34:18-21. Claim 1 provides further support for claim element [1.a] of the '430 Patent. *Id*. at cl. 1 ("A portion capsule (1) for making a beverage, having a basic element (2) with a cavity (3), in which a raw beverage material is provided . . . .").

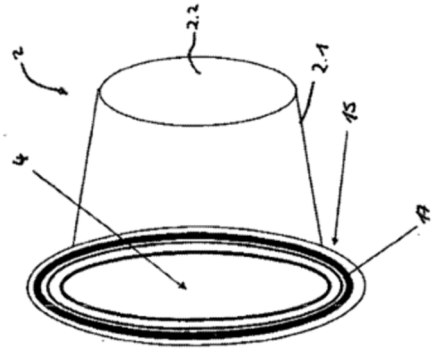
69. The limitation [1.b], "a flange extending outwardly from the base element, the flange comprising a top side and an opposing bottom side;" is supported by the application's disclosure of "***[a]n annular peripheral region 2.4***, onto which for example a cover sheet is sealed, is arranged at that end of the basic element which is ***located opposite the base region 2.2***" in its description of Figure 16. Ex. 1047 at 41:13-35. Additionally, the limitation [1.b] is supported by several drawings in the second German application. For example, Figure 16(b) depicts a view of the capsule from the side, showing that the peripheral region has an upper side and an opposing bottom side and Figure 2 depicts a flange extending outwardly from the base element.



Ex. 1047 at FIG. 16.



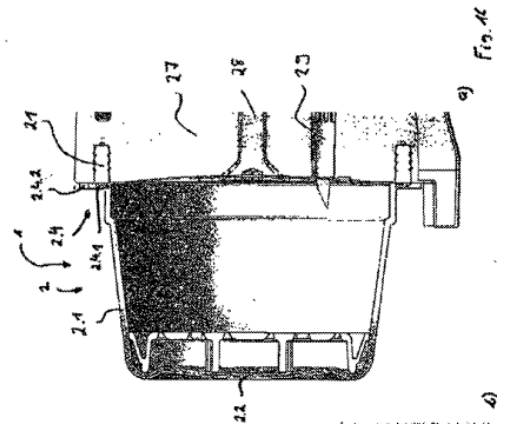
Ex. 1047 at FIG. 16(b).



Ex. 1047 at FIG. 2.

70. The second German application also provides support for the capsule "having a cover that is fastened to the top side of the flange to close the cavity" (element [1.c]) by disclosing "[a]n annular peripheral region 2.4, ***onto which for example a cover sheet is sealed, is arranged at that end of the basic element which is located opposite the base region 2.2***" in its description of Figure 16. Ex. 1047 at 41:13-35.

71. The second German application's support for element [1.c] is shown in Figure 16 below.



Ex. 1047 at FIG. 16.

72. The second German application provides support for the capsule having "a barcode provided on the bottom side of the flange" (element [1.d]) by disclosing that the "peripheral region 2.4 has, in its outer region, a form-fitting and/or friction-fitting means ***and/or a detection means 2.4.2.***" Ex. 1047 at 41:13-35. A POSITA would have understood that "means 2.4.2" can be a toothed ring as depicted in Figures 16 and 17(a)-(c) ***or*** another "detection means" stated in the claims, such as the barcode disclosed with respect to Figure 2. *See id.* at 38:11-27, 41:13-35. The application continues that the Figure 2 "capsule has a barcode in the region of the upper side of the membrane." *Id*. at 38:11-27. The application alternatively discloses that "as symbolized by the arrow 15, for the barcode to be provided on that side of the peripheral region of the basic element which is directed away from the membrane" (*id.*), *i.e.*, the underside of the flange. Accordingly, the application

supports placing a barcode under the flange, and a POSITA would have understood that the placement of the detector could be moved depending on the placement of the identifier. *See, e.g.*, *id.* at Figures 11-13, 15.

73. Moreover, in a description of the different identifiers that could be used with the portion capsule, the application describes that "[t]he identifier is further preferably a machine-readable print," and the "print is preferably a barcode, a logo or a repeat pattern." Ex. 1047 at 33:1-7. As such, a POSITA would have understood that ***either*** a repeated toothed ring identifier ***or*** other detection means could be placed on the bottom side of the flange at Figure 17(a) 2.4.2. *Id.* at Figure 17(a). In fact, Mr. Jobin ***agrees*** (1) element 2.4 depicts the flange; (2) element 2.4.2 depicts the toothed ring; and (3) that Fig. 17C depicts a view of the bottom of the capsule. *See* Ex. 2018 at 169:5-170:4, 186:10-20 (agreeing that a POSITA would have understood Figure 17a (and the other drawings) to be a view of the bottom of a portion capsule, or base region 2.2, looking up at the toothed ring on the bottom side of the flange). Figure 2 also depicts the barcode on the bottom side of the flange which further informs the understanding of a POSITA reviewing the application. Ex. 1047 at Fig. 2. While the means 2.4.2 can be a toothed ring as depicted in Figures 16 and 17(a)-(c), a POSITA would have understood that other "detection means" such as the barcode disclosed with respect to Figure 2 could be located on the bottom side of the flange instead of the toothed ring.

74. I understand that in the Institution Decision, the Board questioned whether the second German priority application supports placing a barcode under the flange. Institution Decision at 14 n.9. It does. Specifically, a POSITA would understand that the application discloses the membrane 4 is provided to close the cavity once it is filled with a raw beverage material. Ex. 1047 at 37 ("This cavity, once filled, is closed by a membrane, which is connected preferably to the peripheral region 2.3 of the basic element for example by sealing or adhesive bonding."). Thus, the membrane as depicted in Figure 2 is applied to the upper side of the capsule. The application continues that the Figure 2 "capsule has a barcode in the region of the upper side of the membrane." *Id*. at 38. The application alternatively discloses that "as symbolized by the arrow 15, for the barcode to be provided on that side of the peripheral region of the basic element which is directed away from the membrane" (*id*.), *i.e.*, the underside of the flange. Accordingly, the application supports placing a barcode under the flange. Moreover, a POSITA would have understood that the placement of the detector could be moved depending on the placement of the identifier. This is illustrated in the second German application by its depictions of various detector locations. *See, e.g.*, Figs 1-3, 11-13, 15.

75. A POSITA would have understood that the barcode on the bottom side of the flange can also be combined with the toothed rings. Ex. 1047 at 30 ("It has therefore been ***an object of the present invention*** to provide a portion capsule which

is suitable just for a quite specific coffee machine. The object is achieved by a portion capsule for making a beverage, having a basic element with a cavity, … in which the portion capsule has an identifier, which makes it possible to individualize the respective portion capsule."), 34 ("According to ***a further, or a preferred, subject matter of the present invention***, the portion capsule has a peripheral region, which is preferably provided on the basic element."), 34-35 ("The portion capsule preferably has a form-filling means, friction-fitting means, and/or detection means in the peripheral region, in particular on the outer circumference thereof, at least in certain regions."). From these portions of the second German application, a POSITA would have understood that it is an object of the present invention to have a portion capsule with an identifier. And a further subject matter of the present invention is to include a peripheral region that preferably has a form-filling means, friction-fitting means, and/or detection means in the peripheral region. Thus, the identifier would have been understood to always be present and a further aspect may include also having a peripheral region.

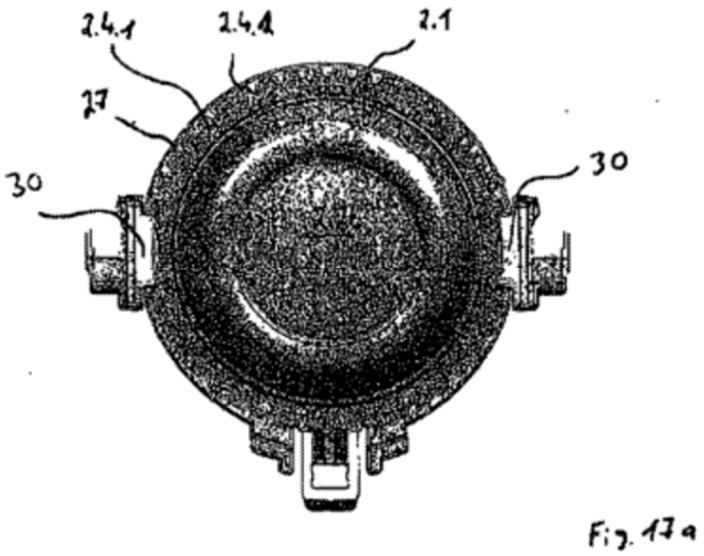


Fig. 17a

Ex. 1047, Figure 17(a).

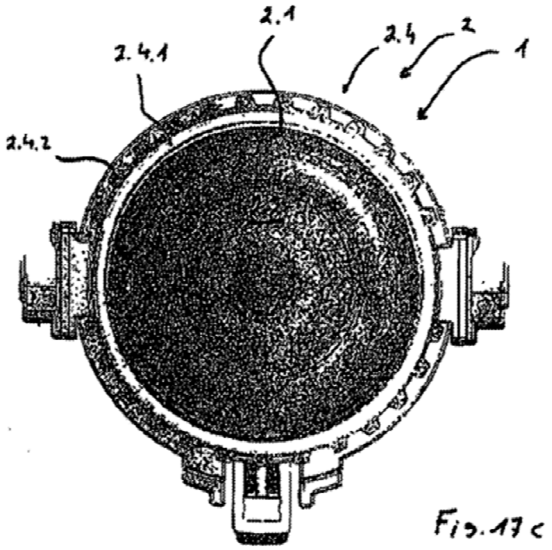


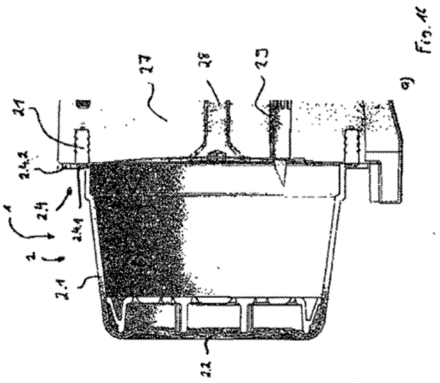
Fig. 17c

Ex. 1047, Figure 17(c).

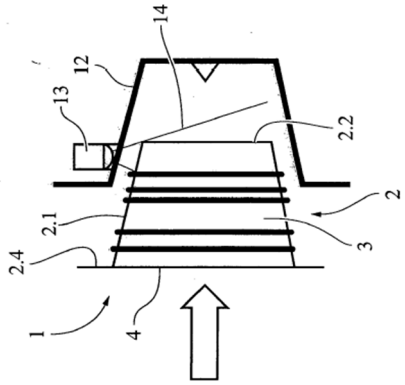
76. The second German application provides support for "a beverage machine comprising: a sensor/detector configured to read the barcode" (element [1.e]) by disclosing that the detection means are "to be sensed by a detector, in order

to establish whether the respective portion capsule is suitable for the respective coffee machine." Ex. 1047 at 35:1-6. With respect to the embodiment of Figures 16 and 17, the application further states, "[a] person skilled in the art is also aware that for example the insertion shaft may also contain a sensor, for example a camera, which senses the shape of the means 2.4.2." *Id*. at 43:11-19; *see also id.* at 35:31 ("Figure 2 shows a portion capsule with a barcode").

77. The second German application provides support for "a brewing chamber configured to receive the base element of the single-serve capsule and having an end portion that opposes the bottom side of the flange" (element [1.f]) by disclosing that, under the description for Figure 16, "[p]referably a sealing surface 2.4.1 is provided in the peripheral region 2.4, on the inside in respect of this toothed ring, and interacts with sealing action with a seal 21, which is arranged on the brewing chamber 27." Ex. 1047 at 41:13-35. As shown below, Figure 16 depicts a brewing chamber 27. *Id.* at Fig. 16. Additionally, Figure 1 provides a further description disclosing this limitation by stating that "[t]his coffee capsule is introduced into a brewing chamber 12 (illustrated schematically here)." *Id.* at 37:1-38:6.



Ex. 1047 at Figure 16



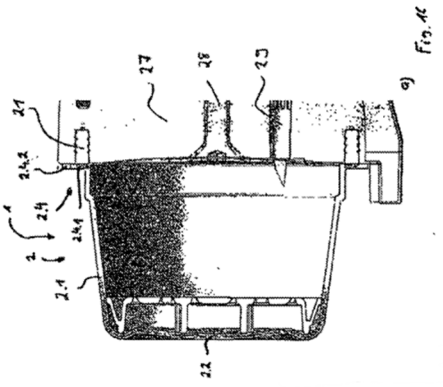
Ex. 1047 at Figure 1.

78. The second German application provides support for "a pump controlled to supply water into the single-serve capsule" (element [1.g]) by disclosing that "[t]he coffee machine, in particular, the pressure pump thereof, which makes the water available, can preferably be operated only when the identifier determined coincides with the reference identifier. Otherwise, the coffee machine cannot be operated" in the general description in the application. Ex. 1047 at 31:13-36. Moreover, the description for Figure 16 describes the flow of water through a water inlet 28 and into the capsule, and then out through the opening made by a

mandrel or piercing spike. *Id.* at 41:13-35. A POSITA would have understood that this description in Figure 16 was describing a pump controlled to supply water.

79. The second German application provides support for a "single-serve capsule [that] is free of a filter that is located inside of the cavity" (element [1.h]) by disclosing that "[t]he raw material and, ***if appropriate***, inserts, in this case a filter, are provided in this basic element" in the description of Figure 16. Ex. 1047 at 41:13-35.

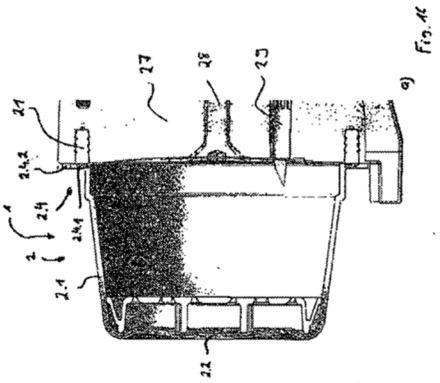
80. The second German application provides support for a single-serve capsule that comprises "(i) an upper end portion that has an annular convexity and a lower end portion that has an annular concavity relative to the central axis of the base element" (element [1.i]) by displaying/depicting an outwardly bowed cover at the upper end of the portion capsule in the image of Figure 16. Ex. 1047 at Fig, 16. A POSITA would have understood that Figure 16 depicts a convex (not flat) cover and a bottom region with concavity.



Ex. 1047 at Figure 16.

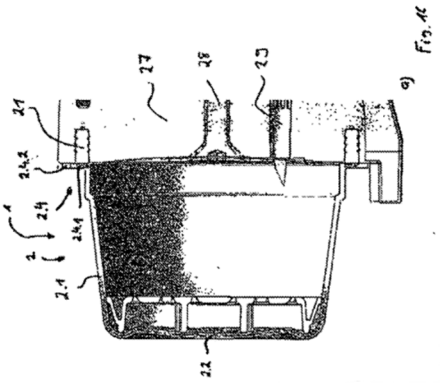
81. The second German application provides support for a single-serve capsule that comprises "(ii) a barrier layer to prevent moisture or aroma from escaping out of the single-serve capsule" (element [1.j]) by describing that a "barrier layer" may be present in the portion capsule, which "prevents moisture or aroma from escaping from the capsule, and/or steam or oxygen from penetrating into the capsule." Ex. 1047 at 32:14-27. Regarding Figure 16, the application similarly describes, "[a]n annular peripheral region 2.4, onto which for example ***a cover sheet*** is sealed, is arranged at that end of the basic element which is located opposite the base region 2.2." *Id.* at 41:13-35.

82. The second German application provides support for a beverage machine that comprises "(i) a mandrel that is configured to pierce the cover in a region that is offset from the central axis of the base element" (element [1.k]) by depicting/displaying in Figure 16 a "spike" for piercing the cover at a location offset from the central longitudinal axis. See also Ex. 1047 at 41 ("an opening . . . produced by the piercing spike 29"). A POSITA would have known that a spike is also known as a mandrel, and therefore, the second German application discloses this limitation.



Ex. 1047 at Figure 16.

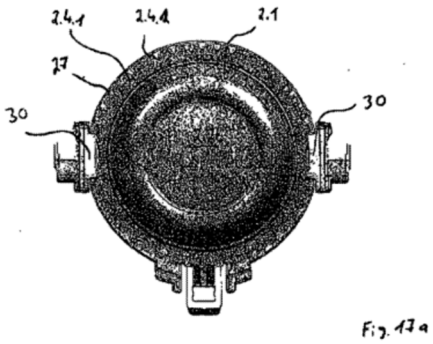
83. The second German application provides support for a beverage machine that comprises "(ii) a seal that is configured to seal against the cover in a region between a peripheral edge of the flange and the region of the cover that is pierced by the mandrel" (element [1.l]) by depicting/displaying the seal 21 in Figure 16 that is between the region of the cover pierced by the "spike" or mandrel, and the peripheral edge of the cover. *See* Ex. 1047 at 44:30.



Ex. 1047 at Figure 16.

84. The second German application provides support for a beverage machine that comprises (iii) a pair of holding arms for engaging the single-serve

capsule" (element [1.m]) by displaying/depicting the holding arms in Figures 17(a)-17(c), which "show how the portion capsule 1 is retained on a part of the brewing chamber 27 by means of two retaining arms 30. These retaining arms 30 interact with the means 2.4.2." Ex. 1047 at 41:37-42:14.



Ex. 1047 at Fig. 17(a).

85. The second German application provides support for a beverage machine that comprises "(iv) a dropping box for the single-serve capsule to fall into" (element [1.n]) by describing the machines of Figure 17 with the "waste container" or dropping box that capsules "would drop through." Ex. 1047 at 41:37-42:14.

86. The second German application provides support for "a pump [that] is controlled to push the water into the single-serve capsule only upon a determination that the read barcode agrees with a stored reference" (element [1.o]) by stating that "an identifier is the "form-fitting, friction-fitting and/or detection means to be sensed by a detector," such as a toothed ring or barcode" with respect to Figure 16. Ex. 1047 at 41:13-35. Moreover, the insertion shaft may also contain a sensor to detect the

shape of the form-fitting, friction-fitting, and/or detection means, and "[t]his signal, in turn, is passed to a control means, which frees, for example, the brewing chamber if the capsule is the correct one." *Id.* at 43:11-19. Moreover, the general description in the application states that "[a] sensor/detection means provided on the coffee machine preferably senses this identifier and compares it preferably with a stored identifier. The coffee machine, in particular, the pressure pump thereof, which makes the water available, can preferably be operated only when the identifier determined coincides with the reference identifier. Otherwise, the coffee machine cannot be operated." *Id.* at 31:13-36; *see also id.* at 38:3-6 ("For the case where these identifiers do not coincide, in particular operation of the pump which forces, for example, hot water through the brewing is prevented."); *id.* at 33:22-30 ("the identifier makes it possible for the coffee machine…to set the beverage-making or food-making process, *i.e.* for example the quantity of water, the pressure thereof and/or the temperature thereof."). A POSITA would have understood, by reviewing the second German application (specifically the description for Figure 16), that the application discloses the claimed limitation.

87. Thus, for the reasons I explained above, it is my opinion that a POSITA reading the second German application would have understood each limitation of claim 1 of the '430 Patent to be recited in at least Figure 16, 17, and 18 and/or their associated descriptions. In my opinion, each and every one of the claim limitations

in the ’430 Patent are supported by a single embodiment depicted in Figures 16, 17, and 18 and their accompanying descriptions. To the extent that one might argue that a single embodiment does not show all of the claim limitations, it is my opinion that a POSITA reading the second German application would have understood that it describes a capsule having various features that are intended to work in each of the described embodiments.

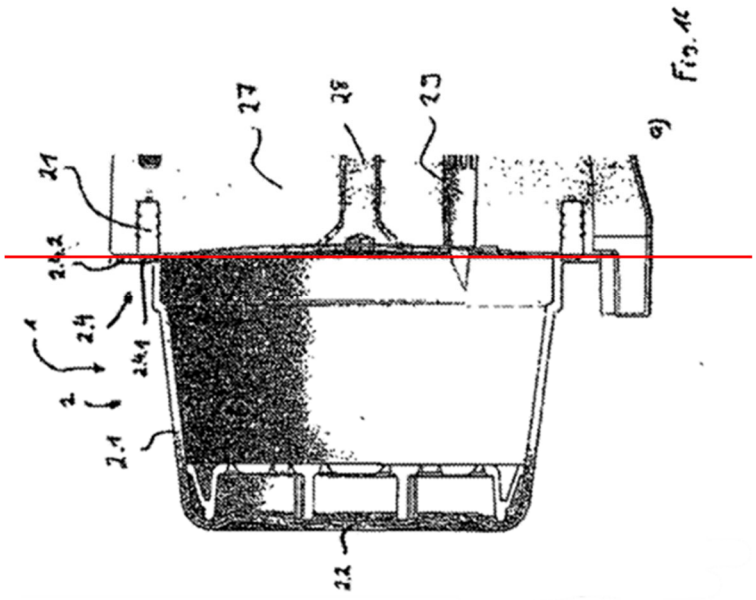
88. As such, I believe that the claims of the ’430 Patent are entitled to the priority date of at least the second German application, September 2, 2010. It is my understanding that the second German application pre-dates the Jarisch reference; therefore, I believe that the Jarisch reference is not applicable prior art in this case.

B. The Second German Application Covers “an upper end portion that has an annular convexity and a lower end portion that has an annular concavity relative to the central axis of the base element.”

89. It is my understanding that the Petitioner believes that the second German application does not disclose “an upper end portion that has an annular convexity and a lower end portion that has an annular concavity relative to the central axis of the base element.” Not only does the second German application clearly disclose this element, but also, a POSITA would have known and understood the second German application to disclose this element.

90. The second German application explicitly discloses “an upper end portion that has an annular convexity and a lower end portion that has an annular

concavity relative to the central axis of the base element" in Figure 16 (annotated below), which depicts a "cover [that] is bowed outwardly." Ex. 1047 at 41:13-35. A POSITA would have understood that a bowed cover, as shown below in the annotated Figure 16, depicts "an upper end portion that has an annular convexity." The red reference line shows that the upper end of the portion capsule, as shown in Figure 16, is not flat. However, a POSITA would have understood that upon the cover being pierced by the mandrel, the once-convex cover would be flattened as the volume of air inside the capsule decreases. Moreover, a POSITA would have understood that an intact portion capsule would have an outwardly-bowed cover because of, for example, differential pressure inside and outside of the capsule. Therefore, the water inlet 28 and brewing head 27 are ***not*** flush with the flat top of the capsule membrane, as Petitioner argues.



Ex. 1407 Figure 16.

91. With respect to his opinions relating to Jarisch, Mr. Jobin's testimony similarly relies on a single drawing. *See* Ex. 1003 at ¶234. Mr. Jobin ***admits*** that the image shown below is ***not*** described in the written description of the reference and does not explain how the image below is distinguished from the curved outwardly-bowed cover of the second German application's Figure 16. *Id.* In fact, a POSITA would have interpreted the bowed shape in the single image Mr. Jobin references in a similar fashion to the outwardly-bowed cover in Figure 16 of the second German application because both images depict "an upper end portion that [have] an annular convexity."

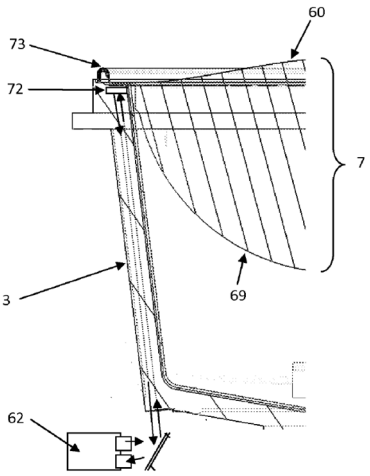


Fig. 4

Ex. 1005 at Fig. 4.

C. The Second German Application Covers a Barcode Located on the Bottom Side of the Flange

92. Petitioner challenges Figures 16-18 and argues that "[t]his embodiment does not disclose a capsule with a barcode located on the bottom side of the flange." But as described with respect to the embodiment depicted in Figure 16, "[a]ccording to a further, or a preferred, subject matter of the present invention," the identifier can be "a…detection means to be sensed by a detector," which indicates "whether the respective portion capsule is suitable for the respective coffee machine." Ex. 1047 at 34-36, 41, Fig. 16; *see also id*. at 30. A POSITA would immediately and readily understand that the barcode on the underside of the flange of the capsule disclosed and described with respect to Figure 2, could be applied to the capsule disclosed and described with respect to Figures 16-18. This is explicitly supported by the statement in the application that, "[w]hat has been said in relation to the identifier applies to all the other examples." Ex. 1047 at 38:8-9. For example, as supported by the second German application, an identifier on the portion capsule may encompass various features – one such identifier is a barcode and another is a concavity and/or convexity. *Id.* at 33:1-7 ("The identifier is further preferably a machine-readable print…. The print is preferably a barcode…"); *id.* at 32:14-27. In the case of Figures 16-18, a POSITA would have understood that the inventor possessed an identifier, such as the barcode, that could be in place of or in combination with the "form-filling means, friction-fitting means, and/or detection means in the peripheral region." *See*

id. at 41:22-24; *id.* at 34:27-35:1 ("The portion capsule preferably has a firm-fitting means, friction-fitting means and/or detection means in the peripheral region, in particular on the outer circumference thereof…"); *id.* at 43:3-8 (describing the form-fitting means in Figure 18 by stating that "[a] person skilled in the art is aware that the capsule periphery may also have provided on it friction-fitting means"); *id.* at 42:16-35 (describing means in Figure 18).

93. A barcode is one such detection means that can be applied to Figures 16-18. With respect to the embodiment depicted in Figure 16, "[a]ccording to a further, or a preferred, subject matter of the present invention," the identifier can be "a…detection means to be sensed by a detector," which indicates "whether the respective portion capsule is suitable for the respective coffee machine." Ex. 1047 at 34-36, 41, Fig. 16; *see also id.* at 30. In fact, Mr, Jobin himself admits that the form-fitting means located on the underside of the flange is an identifier. *See* Ex. 2018 at 185:10-186:9; Ex. 2019 at 127:16-22 (Mr. Jobin admitting that in his sworn declaration in IPR2023-00502 he said the gear-shaped rim or flange is an identifier), 128:7-14.

94. The disclosure with respect to Figures 16-18 specifically states that alternative detection means could be employed with that embodiment. Mr. Jobin himself testified that a POSITA would have been well aware of numerous types of capsule identifiers and how they could be interchangeably used in a capsule and

agreed that a POSITA would have understood that all of the aforementioned types of identifiers, including "[s]hapes, ribs, screws, bosses[,] receptacles, barcodes and RFID tags," would be available for use as identifiers of beer cartridges. *See* Ex. 2018 at 63:11-64:10; 64:11-16; 64:18-65:6, 67:16-68:4; 69:23-70:19. In particular, with respect to Figure 16, the application discloses that the "peripheral region 2.4 has, in its outer region, a form-fitting and/or friction-fitting means ***and/or a detection means 2.4.2***." Ex. 1047 at 41:33:1-7. While the means 2.4.2 can be a toothed ring, as depicted in Figures 16 and 17(a)-(c), a POSITA would have understood that other "detection means" such as the barcode disclosed with respect to Figure 2 could be located on the bottom side of the flange instead of the toothed ring. Ex. 1047 at 33:1-7. I understand that, in the Institution Decision, the Board preliminarily found that "element 2.4.2 is not an identifier, but rather a "a form-fitting and/or friction-fitting means and/or a detection means." Institution Decision at 15 (emphasis in original). But reading the German application as a whole, a POSITA would have understood that element 2.4.2 can serve as an identifier. Ex. 2018 at 185:6-186:9 (agreeing that 2.4.2 is a mechanical identifier). The second German application's specific intention and guidance to combine the teachings regarding the identifier with all other examples, demonstrates that the inventor had possession of the claims at the time of the second German application's filing.

95. As such, the application is clear that the barcode detection means described with respect to Figure 2 is an identifier that "applies to all other examples." A POSITA would have understood this teaching to encourage combining and substituting the different elements, and especially the identifiers, of the clearly closely-related capsule embodiments and would have readily understood the inventor to have been in possession of the claimed invention. *See* Ex. 2015 at 2. Therefore, the second German application's specific intention and guidance to combine the teachings regarding the identifier with all other examples, demonstrates that the inventor had possession of the claims at the time of the second German application's filing.

96. A barcode is one such detection means that can be applied to Figures 16-18. The disclosure with respect to Figures 16-18 specifically states that alternative detection means could be employed with that embodiment. In particular, with respect to Figure 16, the application discloses that the "peripheral region 2.4 has, in its outer region, a form-fitting and/or friction-fitting means and/or a detection means 2.4.2." Ex. 1047 at 41; *see* Ex. 2018 at 186:10-20. While the means 2.4.2 can be a toothed ring, as depicted in Figures 16 and 17(a)-(c), a POSITA would have understood that other "detection means" such as the barcode disclosed with respect to Figure 2 could be located on the bottom side of the flange instead of the toothed ring. Ex. 2018 at 186:10-20; Ex. 1047 at 33:1-7. The application is clear that the

barcode detection means described with respect to Figure 2 is an identifier that "applies to all other examples."

97. Moreover, while the figures particularly depict a toothed ring "form-fitting means" located on the underside of the flange, which Mr. Jobin himself admits is an identifier, the application specifically discloses and a POSITA would have understood that other "detection means" (such as a barcode, logo, repeat pattern, or other machine-readable print) could be used in the same location and for the same purpose. *See* Ex. 2018 at 185:10-186:9. Indeed, Mr. Jobin agreed that the machine-readable print identifiers are not associated with particular embodiments of the second German application, but rather part of the "overview section" of the specification and "not referring to the figures." Ex. 2018 at 184:22-185:4. This is yet further reinforced by the teaching that the embodiment of Figs. 16-18 teach to use a camera as a detector. Mr. Jobin agrees that a camera can be used to read a barcode. Ex. 2019 at 20:17-25.

98. Petitioner argues that the second German application discloses several "distinct embodiments," arguing that it would be beyond a POSITA to understand that the identifier disclosed with respect to the beverage capsule of Figure 2, could be readily employed with the beverage capsule of Figure 16. Pet. at 41-42. But the second German application teaches that "[w]hat has been said in relation to the identifier applies to all other examples," thereby providing specific disclosure of

how the identifier element can be combined with other embodiments. Ex. 1047 at 38. Indeed, Examiner Chou withdrew a drawing objection for the related '765 Application based on this very teaching. *See* Ex. 2015 at 2. Here, the second German application's specific intention and guidance to combine the teachings regarding the identifier with all other examples, demonstrates that the inventor had possession of the claims at the time of the second German application's filing.

99. I understand that to satisfy the written description requirement the test for sufficiency is whether the disclosure of the earlier application relied upon reasonably conveys to those skilled in the art that the inventor had possession of the claimed subject matter as of that earlier filing date. That test is easily met here where the application instructs the reader that "[w]hat has been said in relation to the identifier applies to all other examples;" the disclosure associated with Figures 16-18 plainly describe that a "detection means" can be used as an alternative to the described form-fitting means; there are a but a small number of multiple-dependent claims that show combinations of features from across the scope of examples, which demonstrates possession of subject matter arising from combinations of embodiments; and there is an absence of any teachings discouraging the combination. Ex. 1047 at 38. A POSITA would have readily understood the inventor to have been in possession of the claimed invention.

100. For example, in describing Figures 16, 17, and 18, the second German application states that "a form-fitting and/or friction-fitting means and/or a detection means 2.4.2" is located on the outer region of the peripheral region 2.4. Ex. 1047 at 41:22-24. As another example, in describing the form-fitting means in Figure 18, the application specifically recites that "[a] person skilled in the art is aware that the capsule periphery may also have provided on it friction-fitting means." Ex. 1047 at 43:3-8. This friction-fitting means movement is sensed and the brewing chamber is released, similarly to the process described with respect to the toothed ring. Ex. 1047 at 43:3-8.

101. A POSITA would have further understood that the capsule periphery could also have provided on it a detection means located on the bottom of the flange, just like the form-fitting and friction-fitting means described in Figures 16, 17, and 18. *See* Ex. 2018 at 186:10-20. A POSITA would have understood that one example of a detection means could be a barcode. See Ex. 1047 at 33:1-7. The second German application's specific intention and guidance to combine the teachings regarding the identifier with all other examples, demonstrates that the inventor had possession of the claims at the time of the second German application's filing. Indeed, Mr. Jobin, a POSITA himself, testified that a POSITA would have been well aware of numerous types of capsule identifiers and how they could be interchangeably used in a capsule. For example, Mr. Jobin testified that in his experience with consulting

on the design of identification means for a home beer-dispenser system, he evaluated several ways of identifying and verifying that the correct beer cartridge was being used, including through the use of barcodes and the shape of the capsule or its "ribs or features" that would result in "physical exclusion related to deactivation of the valve to prevent dispensing." *See* Ex. 2018 at 63:11-64:10; 64:11-16; 64:18-65:6, 67:16-68:4. Mr. Jobin agreed that a POSITA would have understood that all of the aforementioned types of identifiers, including "[s]hapes, ribs, screws, bosses[,] receptacles, barcodes and RFID tags," would be available for use as identifiers of beer cartridges. *See* Ex. 2018 at 69:23-70:19.

102. In the case of Figures 16-18, a POSITA would have also understood that the inventor possessed an identifier, such as the barcode, that could be in combination with the "form-filling means, friction-fitting means, and/or detection means in the peripheral region." Ex. 2018 at 184:22-185:4 (confirming that both mechanical and optical identifiers described could be used as the identifier placed on the bottom side of the capsule's flange); Ex. 2019 at 127:16-22 (Mr. Jobin admitting that in his sworn declaration in IPR2023-00502 he said the gear-shaped rim or flange is an identifier), 128:7-14 ("Q. And you agree that that gear shape is found on the flange of the capsule, correct? A. The way that it's described is that it is – let's see where it says it here. My understanding is that the tooth-ringed feature is formed in the outer circumference of the flange. That's what I recall form this

disclosure."). As the second German application makes clear, such "form-filling means, friction-fitting means, and/or detection means in the peripheral region" is "a further, or a preferred, subject matter of the preferred invention." Ex. 1047 at 34:27-35:1.

103. Finally, a POSITA would have understood the claims of the second German application to show how features from across the scope of examples could be included in the various examples. For example, claim 11 of the application recites "The portion capsule (1) ***as claimed in one of the preceding patent claims***, characterized in that the identifier is a barcode (17)." Ex. 1047 at cl. 11. A POSITA would have understood this claim to encourage replacing the identifier in any previously-claimed embodiment with a barcode identifier. The claims thus demonstrate possession of subject matter arising from combinations of embodiments, and in particular the identifier element. By its express terms, claim 14 recites a combination with claim 2, 6 and/or 11, and thus supports a link among the identifier of the various embodiments.

104. The claimed elements of the '430 Patent are linked together in the specification of at least the second German application, including Figures 16, 17, and 18 in particular. Petitioner's challenge hinges on Jarisch. *See, e.g.*, Pet. at 57, 63, 71-74, 77. Accordingly, Petitioner's ground fails without Jarisch as prior art. Overall, it is my opinion that a POSITA reading the second German application

would have understood each limitation of claim 1 of the ’430 Patent to be recited in at least Figure 16, 17, and 18 and/or their associated descriptions. In my opinion, each and every one of the claim limitations in the ’430 Patent are supported by a single embodiment depicted in Figures 16, 17, and 18 and their accompanying descriptions. To the extent that one might argue that a single embodiment does not show all of the claim limitations, it is my opinion that a POSITA reading the second German application would have understood that it describes a capsule having various features that are intended to work in each of the described embodiments.

IX. The ’430 Patent Is Not Unpatentable As Obvious

105. In my opinion, there is little to no evidence that a POSITA would have arrived at the claimed inventions merely through the combined teachings of Yoakim, Jarisch, Rossi, and Castellani (Ground 1) presented in the Petition.

A. Yoakim Fails to Disclose a Capsule Free of a Filter (Claims 1, 7)

106. In my opinion, a POSITA would not have found that Yoakim teaches a capsule free of a filter, as required by independent claims 1 and 7 of the ’430 Patent.

107. Claim elements [1.h] and [7.h] of the ’430 Patent require “the single-serve capsule is free of a filter that is located inside of the cavity.” I have reviewed Petitioner’s evidence for why Yoakim allegedly discloses this element and have concluded that Petitioner is incorrect to contend that Yoakim discloses a capsule that *does not include a filter* because the opposite is true – Yoakim *expressly teaches* that

his capsules contain a filter inside the cavity for the purpose of filtering the brewed liquid from the solid particles in the capsule. Petitioner cites only 2 paragraphs and 2 figures of Yoakim. Pet. at 62 (citing Ex. 1004 at [0171], [0343], Figs. 42, 54). These portions of Yoakim fail to show that Yoakim discloses a capsule free of a filter. Indeed, this is evident from the passages and figures Petitioner cites, which lack any express statement that Yoakim's capsule lacks a filter.

108. Yoakim teaches a filter inside the capsule made of "a series of slits" where "the brewed liquid can pass through the slits whereas the solid particles are retained in the capsule." Ex. 1004 at [0171]; *see also id.* at [0131] ("[T]he capsule comprises a plastic lid welded on a cup-shaped body whereas a series of premade peripheral outlets are provided in the lid and/or body for the brewed liquid to leave the capsule under the effect of the centrifugal forces. The premade peripheral outlets may be a series of small slits of small size to also filter the brewed liquid and maintain solid particles of the substance in the capsule"), [0334] ("Depending on the size of the openings, the plurality of openings may also be given a function to filter the liquid from the solid particles that may be contained in the enclosure such as coffee particles."), [0337]-[0338] ("Preferably, each of the outlet openings has a diameter or width which is smaller than the average size of the particles forming the food substance….Therefore, the openings can have a filtering function 'per se'"), [0343] ("In a possible mode, the portion of wall with the outlet openings can be

formed from a paper filter or woven, non-woven fibres, meshed material, porous polymer membrane or combination thereof"), [0375]-[0376] ("Preferably, the outlet openings of the enclosure of the capsule have an average diameter or width which is smaller than the average size of the particles forming the food substance….Therefore, the openings can have a filtering function 'per se'"), [0444] ("These outlet openings 118 of the enclosure of the capsule are sized as a function of the substance stored in the capsule. Small openings such as slots of small width or holes of small diameter tend to provide a filtering function to retain the solid particles in the enclosure of the capsule while allowing only the liquid extract to pass the openings"), [0448] ("[T]he outlet openings are formed by a filter paper, a woven or non-woven filtering portion or another meshed or porous membrane 720. Thus, the lid 108 which is inserted in the dished body 102 comprises a circumferential band of a porous material. The porous material provides restriction of the flow, creating a certain pressure drop, *e.g.*, between 0.5 and 4 bar, and leading to a filtering of the solid particles…. The lid also comprises an annular recess 116 for collecting the centrifuged liquid which travels through the peripheral filter band").

109. Yoakim further teaches that "[a]n *additional* filtering layer can be used to filter liquid depending on the size of the outlets." Ex. 1004 at [0171] (emphasis added). A POSITA would have understood this "additional filtering layer" to be additive to the slits already described in the same paragraph. Indeed, Yoakim

explains that "depending on the size of the outlets," it may be necessary to provide additional filtering to ensure the solid particles are retained in the capsule. *Id.* at [0171]. Smaller outlets would not need such additional filtering, whereas larger outlets likely would in order to separate (filter) brewed liquid from the solid particles. *Id.* at [0210] ("The slits are sized so as to act as a filter for retaining the solid particles such as the ground coffee particles but let the liquid leave the capsule."). In fact, Mr. Jobin testified that "[a]ccording to 0171 [of Yoakim] and my general understanding in Yoakim, it depends on the size of the holes and that one can add a filter to -- to change the characteristics of the -- of the filtering function." Ex. 2019 at 59:17-22.

110. As a practical matter, larger outlets without an additional filtering layer would result in particles of beverage material in the final beverage product—which would negatively impact the drinking experience and would be contrary to Yoakim's stated purpose of "better … controlling quality of the final brewed beverage or food liquid product" (filter brewed liquid from the solid particles. Ex. 1004 at [0010]; *see also id.* at [0011], [0012], [0210]).

111. The fact that Yoakim's capsules use filters is confirmed by other paragraphs in Yoakim. *See, e.g.*, Ex. 1004 at [0271] ("Preferably, the capsule comprises an ***internal filter portion*** placed at the periphery of the enclosure. The ***internal filter portion*** can be an internal perforated lid and/or a portion of porous

material."), [0375]-[0376] ("the outlet openings of the enclosure of the capsule have an average diameter or width which is smaller than the average size of the particles forming the food substance….Therefore, ***the openings can have a filtering function*** 'per se'"), , [0255] ("The liquid delivered from the capsule can also be ***filtered by filtering means provided in the capsule***. Such a configuration has many advantages because the device is simplified, the filter does not require cleaning since it is discarded with the capsule."), [0265] ("In order to ***filter*** the liquid in the capsule before it is centrifuged out through the (*e.g.*, pierced) outlets, a ***filter part*** is positioned in the capsule to separate a cavity containing the substance and a cavity for collecting the centrifuged liquid."), [0272] ("The capsule can also comprise a collecting recess forming an annular portion below the puncturable membrane. The collecting recess is positioned to collect the centrifuged liquid passing through the ***filter portion***."), [0300] ("The capsule may comprise a ***filter means to filter*** the centrifuged before the liquid is released from the outlets at the sidewall. Preferably, the ***filter*** is distant from the sidewall along the median transversal plane inside the capsule. The ***filter*** can be a ***cylindrical filter*** extending from the upper wall to the lower wall."), [0424] ("It can also be noticed that a ***filter wall*** can also be placed inside the enclosure against the inside surface 112 of the lid. A ***filter wall can provide an improved filtration***, for example, for substance of very thin particle size and/or for delaying the release of the centrifuged liquid out of the enclosure by

creating a higher pressure drop. A ***filter wall*** can be a paper filter or thin plastic film which is glued onto the surface 112 of the lid"), [0460] ("In FIG. 44…[a]n internal lid 1810 is also provided to demarcate an internal enclosure with the body 102 and secure a ***filter part in the capsule***"), [0461] (Describing Fig. 45 as showing that "the capsule may comprise a ***filter part*** 708 delimiting the cavity 709 for the substance and a collecting recess 710 peripherally placed relative to the central cavity. The ***filter part*** may, for instance, be an integral part of the body 705 or a part which is added in the capsule, *e.g.*, a ***filter cylinder***"), [0462] (Describing Fig. 46 as including "***a filter part*** 807 [that] can be provided in the capsule which also delimits a cavity 808 for receiving the substance and a collecting recess 809 for the centrifuged liquid"), [0465] ("A ***filter part*** 912 can be inserted in the capsule to delimit the enclosure for the substance 913 and the collecting recess 914. For instance, ***the filter part*** can be a porous tubular member which can form a support ring for maintaining the upper and lower walls of the shelves at distance"), [0107] ("the invention provides for a method for preparing a beverage or food liquid from a food substance contained in a ***filtering receptacle*** by passing water through the substance using brewing centrifugal forces"); [0113] ("The method more particularly relates to the preparation of a food liquid or beverage, in a beverage preparation device, from a food substance contained in a ***filtering receptacle*** by passing water through the substance using brewing centrifugal forces"), [0139], [0173] ("The invention also

concerns a system for preparing a beverage or food liquid from a food substance contained in a ***filtering receptacle*** by passing water through the substance using centrifugal forces"), [0288] ("The capsule may comprise a ***filter means to filter the centrifuged before the liquid is released from the outlets at the sidewall***"), [0016] (describing a "capsule further comprising a collecting cavity for receiving the prepared liquid food with the cavity positioned adjacent to the largest perimeter of the flared design of the enclosure, and a ***filter part*** separating the extractable or infusible ingredient(s) and the collecting cavity food with the ***filter part*** optionally spaced from the top wall by a gap"), [0266] ("In order to promote the exit of the liquid through the capsule, the ***filter part*** can be inclined relative to the widening sidewall. In a particular mode, for a larger filtering area, the ***filter part*** can extend across the whole thickness of the enclosure. For instance, the ***filter part*** can be substantially cylindrical. More specifically, the ***filter part*** can be an integral extension part of an internal lid of the capsule. The capsule can be designed with a limited number of pieces and can be assembled in a more economical and simpler manner. In a different mode, the ***filter part*** is substantially parallel to the upper wall. In this case, the ***filter part*** is spaced from the upper wall by a small gap"), [0210] ("The brewed liquid that is centrifuged is allowed to pass through a series of slits 810 provided on the upwardly protruding edge 880 of the body. ***The slits are sized so to act as a filter for retaining the solid particles such as the ground coffee***

particles but let the liquid leave the capsule."), [0450] ("In another preferred embodiment, the lid comprises a recess 116 which can be filled by a porous compressible material to ***provide a filtering function*** as well. For example, the material could be sponge or fabric"); *see also* Figs. 16-19, 28, 29, 39, 41, 42, 44.

112. The figures in Yoakim further teach a filter inside the capsule – for example, Figures 41 and 42 include a porous wall 180, which is a filter and depicted within the cavity of the capsule. Ex. 1004 at [0451] ("According to FIGS. 41 and 42, the capsule in the system of the invention may also comprise an enclosure which is formed of a dished body 102 and a porous wall 180. The dished body comprises a main cavity 182 for storing the food substance and a peripheral recess 181 for receiving the liquid extract that traverses the porous wall 180 during the centrifugation process."), [0452] ("The porous wall 180 can have openings (i.e., pores) along its whole surface…"). Porous wall 180 is shown in both Figures 41 and 42 (annotated in yellow below) and is within the cavity.

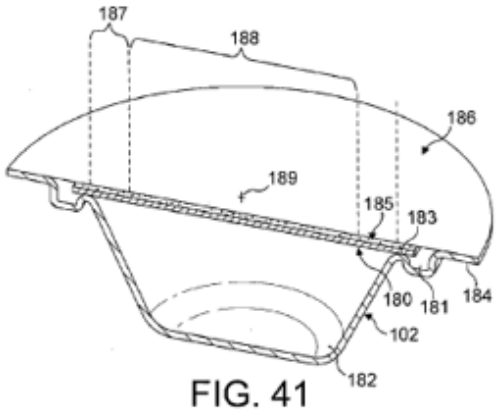


FIG. 41

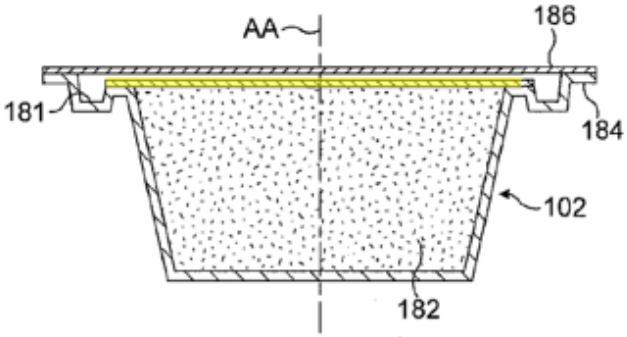


FIG. 42

113. Finally, Figure 54—the final disclosure of Yoakim relied upon by Petitioner—is provided to illustrate "the centrifugal device into which is inserted the capsule of Fig. 51." [0083]. Figure 54 depicts one of many different capsule shapes for Yoakim's brewing system, but its primary purpose is to teach aspects of the brewing system. A POSITA would have understood the capsules depicted in Figure 54 (as well as Figs. 52, 55, 61, 62, 63) are the same as those in the rest of Yoakim's teachings and thus exhibit the same filter. They each depict a "schematic" view, which does not contain every detail. *See* Ex. 2019 at 50:24-56:1 (Mr. Jobin admitting that Yoakim's schematic views are "at a very high level," "drawn with less detail," and "there are details which are excluded in this view because it's intended to represent particular information"). In the case of Yoakim's schematic views of the capsules, they generally illustrate the size/dimensions rather than the internal details. For example, Figure 54 reflects a "schematic side view of a capsule of small volume" (i.e., a simplified view) and not a cross sectional view like figures 41 and 42. *See* Ex. 1004 at [0080], [0083]. Indeed, it does not depict any of the detailed features of the capsule, such as the food substance and lid. Other "schematic" views in Yoakim are similarly lacking details. For example, Figure 1 features "black boxes" without detailed features. *See* Ex. 1004 at Fig. 1, [0030]. A POSITA would thus have not concluded from Figure 54 that Yoakim's capsules are free of a filter. As such, Petitioner's argument that Figure 54 reflects no filter is a baseless argument. *See* Ex.

1004 at [0070], [0071], [0080], [0083]. Moreover, any suggestion by Petitioner that the figures teach a capsule free of a filter is inconsistent with the disclosures of Yoakim that consistently and repeatedly describe a capsule having a filter.

114. In Mr. Jobin's November 28, 2023 deposition, he testified that his declaration (¶215) in the '923 Patent IPR proceeding incorrectly identified Figure 42 of Yoakim (and should have instead included Figure 52) for the free of filter limitation. He characterizes this as a "typo." Ex. 2019 at 11:22-12:7. Notably, Mr. Jobin did not testify to the same correction for the present '430 Patent IPR proceeding. Therefore, I understand that he does not rely on Figure 52 here. Nonetheless, to the extent that Petitioner or Mr. Jobin relies on Figure 52 instead of Figure 42 in this proceeding, Figure 52 is also a schematic view. Ex. 1004 at [0081], Fig. 52. The shortcomings described above with respect to Figure 54 apply equally to Figure 52.

115. Overall, Petitioner's disclosure argument fails on this ground because Yoakim teaches a filter inside the cavity of the portion capsule, and nowhere does Yoakim state that his capsule is without a filter inside the cavity.

B. Neither Yoakim Nor Rossi Disclose or Render Obvious a Pump Control Limitation (Claims 1, 7)

116. In my opinion, a POSITA would have found that neither Yoakim nor Rossi teaches/discloses pump control, as required by independent claims 1 and 7 of the '430 Patent.

117. Claim element [1.o] requires a "pump [] controlled to push the water into the single-serve capsule only upon a determination that the read barcode agrees with a stored reference." Claim [7.p] requires that, after "reading or detecting the identifier with the sensor/detector," "only if the beverage machine determines that the single-serve capsule belongs to the group of single serve capsules operable for use with the beverage machine is the pump controlled to push the water into the single-serve capsule." The claims therefore require a pump controlled to supply water into the single-serve capsule only upon (1) detection of a barcode or identifier, and (2) determination by the beverage machine that the single-serve capsule is operable for use (or the detected barcode agrees with a stored reference). Neither of the references that Petitioner relies on disclose this limitation.

118. Yoakim alone fails to teach these limitations. Petitioner argues that Yoakim discloses a pump controlled to push water into the single-serve capsule, and alleging that Yoakim also discloses that the pump is controlled based on the detection of barcode identification means by the sensor/detector. Yoakim does not disclose a pump controlled to push water into the single-serve capsule and Petitioner does not point to any disclosure in Yoakim that suggests relying upon identifier detection for the purposes of controlling a pump, particularly as a safety measure. Therefore, Petitioner's arguments to the contrary fail, and Yaokim does not disclose or render obvious that the pump supplies water into the capsule only when a sensor

or detector detects it. In fact, Yoakim expressly recognizes a need for a safety function, achieving that need specifically by the complementary shape of the capsule holder. Ex. 1004 at [0205] ("a safety function for ensuring that only capsules adapted to the system can be used and brewed successfully"). Yoakim's description of an "identification means for identifying the different capsules, and control means capable of operating the device… according to predetermined liquid food preparation parameters, including the flow rate and the volume of liquid to be injected into the capsule, with the identification means comprising capsule recognition means which are recognized by sensing means connected to the control means of the device to control the preparation parameters accordingly" does not disclose or render obvious that the pump supplies water into the capsule only when a sensor or detector detects it and thereby**.** *See* Ex. 1004 at [0025]. Yoakim states that "flow rates [] are influenced by two key parameters: the rotational speed of the capsule in the device and the back-pressure exerted on the centrifuged liquid" – neither parameter is tied to the operation of a pump, as required by the '430 claims. *See* Ex. 1004 at [0521]. "The back-pressure can be varied by varying the closing force of a flow restriction valve placed downstream of the enclosure of the capsule and/or by varying the cross-section of the restriction outlets." *Id*.; *see also id*. at [0523] [0136]; [0429]; [0501]. Yoakim discusses metering water and controlling valves throughout the application. *Id.* at [0191], [0250], [0506], [0522]. These are

independent operations relative to controlling a pump and cannot necessarily be concluded that controlling a pump affects them. Therefore, a POSITA would not have understood controlling the flow rate of liquid to occur by control of the machine's water pump. Additionally, upon reviewing Yoakim claims 1 to 17, Yoakim does not suggest that an identifier is required for the pump to operate. A POSITA would agree that nothing in the Yoakim reference discloses or renders obvious the claim phrase.

119. In Yoakim, the volume of the liquid supplied to the capsule does not necessarily occur by control of the pump. Yoakim describes a method in which "hot water is introduced into the capsule at substantially no pressure. Water can be brought by a hot water feed mechanism using a principle of aspiration or vaporization," without a pump. Ex. 1004 at [0132], [0180]. Yoakim also does not teach that its pump, when it is used, is controlled to supply water into the capsule only when an identifier is detected. Indeed, many embodiments described in Yoakim lack an identifier, *see* Ex. 1004 at cls. 1-17, and there is nothing to suggest that an identifier is required for the pump to operate. Yoakim also discloses numerous controllable features, including, for example, a restriction valve, a heater, flow rate, rotational speed, etc. *See* Ex. 1004 at [0521]. It is only with hindsight and the benefit of the present '491 Patent that a POSITA is given any indication to select using an identifier to activate a pump.

120. Petitioner's second cited reference – Rossi – also does not disclose a pump or the use of a pump to supply water into the capsule. Rossi's teachings do not overcome Yoakim's shortcomings. Petitioner argues that where Yoakim falls short, Rossi discloses the complete limitation – controlling a pump to supply water upon both detection of the identifier and a determination by the machine that the barcode agrees with a stored reference. Of course, both the Rossi and Yoakim references were before the Examiner during prosecution, and therefore the Examiner previously found this limitation to be missing from the Rossi and Yoakim references.

121. Rossi teaches two elements recognized in two steps. Like Yoakim, Rossi discloses an identification element that is used to select the appropriate brewing conditions. Rossi also discloses a validation element. Rossi confirms that a separate validation element, that has nothing to do with the operation of the machine, controls whether the machine will be unlocked. Rossi states, "[t]he edible-product making machine is only allowed to take further steps if it in the first step also recognizes on the load element a validation element to be validated. In practice, this may take the form of unlocking the machine when both the identification element and the unvalidated validation element are recognized." Ex. 1041 at 9. But Petitioner has not shown how the validation element has anything to do with the operation of the machine, and certainly not the control of a pump. Instead, the validation element is used to ensure that the load element is used a single time, and

only serves to unlock the machine so that it can be used at all. *Id*. at 7, 9. Indeed, Petitioner overlooks its obligation to cite a disclosure of a pump in Rossi, and states without evidentiary support that "Rossi discloses that both the identifying element and validation element can be a barcode." Pet. at 72.

122. Moreover, Petitioner does not explain how Rossi's two elements—one for identifying and one for validation—that are used in two separate steps to teach or render obvious the invention of the '430 Patent. The '430 Patent claims require a barcode – a single identifier – that agrees with a stored reference and enables pump operation. In contrast Rossi teaches two elements that must be separately read compared with pre-stored data. Rossi at 11. In fact, Rossi reads the second element for validation "only if it also recognizes the load element" from the first step of reading the identifying element. Ex. 1041 at Abstract. Having two elements read at two separate steps does not render obvious a single identifier read in a single step. In the Institution Decision, the Board relied upon Rossi's teaching that "[t]he validation element could be identical to the identification element." Rossi at 7. But having two elements that are identical is not the same as having a single element that performs both functions of identifying and validation. Indeed, nowhere does Rossi teach using only one element for identification and validation. *See generally* Ex. 1041. The Petition lacks any evidence on this point and fails to show how or why a POSITA would modify Yoakim's capsule to add a second code to where Yoakim

and Jarisch teach having only one code. The Examiner was correct, and Petitioner has not fulfilled its burden to show where that feature is disclosed in Rossi.

123. Rossi does not teach pump activation only upon determination by the beverage machine. Moreover, Rossi does not disclose a pump, and a pump is not inherent in view of other techniques for supplying heated water under pressure. *See, e.g.*, Ex. 2022, 2023, 2024, 2025. Indeed, Mr. Jobin readily admits that during his work on coffee machines design, he worked on a machine that did not use a pump to move fluid from the reservoir to the brew basket. Ex. 2018 at 50:12-25. While Rossi describes that "the load element is generally pierced to allow water to pass through it," and "[t]he contents of the load element are brewed or dissolved in the water in order to make the edible product," nowhere does it use the word "pump." *See* Ex. 1041 at 3. And as Yoakim states, a pump is not necessary to supply water into a capsule, because other means such as vaporization are sufficient.

124. Rossi does not teach the claimed activation of the pump only upon determination by the beverage machine that the single-serve capsule is operable for use (or the detected barcode agrees with a stored reference). Specifically, the first step may consist of "unlocking the machine when both the identification element and the unvalidated validation element are recognized." Ex. 1041 at 9. This step does not teach the use of a pump to supply water into the capsule. *See also id*. at 6 ("allowing said edible-product making machine to take further steps only if it also

recognises on said load element a validation element to be validated"), cl. 1 ("a first step of recognition wherein said edible-product making machine recognises an identifying element on said load element allowing said edible-product making machine to take further steps only if it also recognises on said load element a validation element to be validated.")

125. The process described in Rossi consists of a first step of recognizing an identifying element and validation element on the capsule; a second step of validating the validation element; and a third step of activating a cycle of production only after recognizing the identifying element and the now-validated validation element. Ex. 1041 at 6, 9. The use of a validation element is described to "help to prevent the use of an already-used single load element," and the identification element "preferably contains information about the contents of the load element." *Id*. at 7-8.

126. The first step may consist of "unlocking the machine when both the identification element and the unvalidated validation element are recognized." Ex. 1041 at 9. This step does not teach the use of a pump to supply water into the capsule. *Id.* at 6 ("allowing said edible-product making machine to take further steps only if it also recognises on said load element a validation element to be validated"); cl 1 ("a first step of recognition wherein said edible-product making machine recognises an identifying element on said load element allowing said edible-product making

machine to take further steps only if it also recognises on said load element a validation element to be validated.").

127. The second step of validating the validation element may consist of "mechanical destruction of the validation element," which ensures that the validation element cannot be re-recognized. *See* Ex. 1041 at 9. This step also does not teach the use of a pump to supply water into the capsule.

128. In the third activation step, the machine "activates a cycle of edible-product production" after it recognizes on the capsule the same identifying element and the validated validation element. Ex. 1041 at 8-9. "The use of an activation step of automatically activating the cycle of edible-product production only when the same identifying element is recognized in combination with the validated validation element ensures that the operating condition actually used are the correct conditions as selected by the machine in the first recognition step" so as to "help to prevent the user from making the mistake of inserting into the machine a different load element to the one that was first recognized, for which the operating conditions are set." *Id*. at 8. None of these steps listed actually describe a pump.

129. That "the activation means 10, connected to the barcode reader 7 through the control unit 9, automatically activate[s] a cycle of production of the edible product" does not necessarily suggest that a pump is controlled to supply water into the capsule. Ex. 1041 at 13; *see also id.* at 11 ("The checking means allow

the machine activation means 10 to be engaged only if the barcode reader 7 recognises the identification barcode 4 and the validation barcode 5."), 12 ("This automatically activates the machine, but only if the identifying element is recognized, and in combination with the validation element as validated."). Indeed, Yoakim teaches that centrifugal rotation, a step of the production cycle, can occur even before water is introduced into the capsule. *See, e.g.*, Ex. 1004 at [0440] ("The start of the centrifugal operation can be carried out at the same time as water injection start being introduced in the capsule or slightly after or before this water injection operation starts."). "[I]n order to allow the machine to proceed to ***activation***," the machine must "recognise[] the identifying element and the unvalidated validation element." *Id*. at 11. Thus, activating the cycle of production does not necessarily involve controlling the pump to supply water to the capsule.

130. Overall, Petitioner's obviousness argument fails on this ground because neither Yoakim nor Rossi disclose the pump features.

C. Yoakim Does Not Disclose or Render Obvious A Side Wall Having Indentations (Claims 5, 7)

131. In my opinion, Petitioner has not demonstrated that Yoakim teaches a capsule having a side wall with indentations, as required by dependent claim 5 and independent claim 7 of the '430 Patent.

132. Independent claim element [7.k] requires the single-serve capsule comprise "a side wall having indentations." Dependent claim 5 requires "the side

wall of the base element includes indentations." Petitioner argues that Yoakim discloses or renders obvious these elements. I disagree.

133. Petitioner identifies the "toothed structure around [the capsule's] perimeter." Pet. at 75. Petitioner's annotated Figure 23, depicting the so-called indentations at the green dashes is reproduced below.

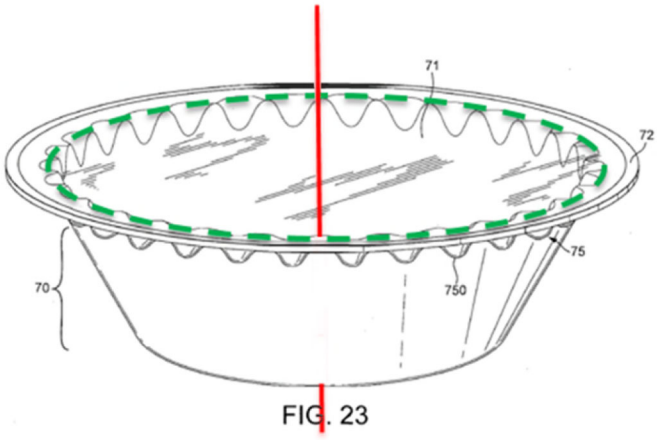


FIG. 23

Pet. at 75-76.

134. But Petitioner fails to demonstrate that these teeth are on the side wall. Specifically, Yoakim teaches the enclosure has "a widening side wall located between top and bottom walls, and an outer surface or structure for engaging external rotational driving means of a centrifugal device with the outer surface or structure configured to offer resistance…." Ex. 1004 at [0016]. The toothed structure Petitioner relies upon is expressly taught to be on the outer surface, which Yoakim teaches is a different surface from the side wall. *See* Ex. 1004 at [0215] ("For this,

capsule has a toothed structure 75 on at least one of its outer surface."); *see also* Ex. 2019 at 69:19-70:17 (Petitioner's expert, Mr. Jobin, admitting the outer surface "is different from the wall itself"). Petitioner never explains how Yoakim's outer surface taught in paragraphs [0016] and [0215] satisfies the claimed side wall. Accordingly, Petitioner has failed to show that Yoakim discloses this element.

135. I understand that an obviousness determination requires finding that a person of ordinary skill in the art would have been motivated to combine or modify the teachings in the prior art and would have had a reasonable expectation of success in doing so. Moreover, I understand that a reasonable expectation of success must be established even in a single-reference obviousness challenge. I also understand that a clear, evidence-supported account of the contemplated workings of the combination is a prerequisite to adequately explaining and supporting a conclusion that a relevant skilled artisan would have been motivated to make the combination and reasonably expect success in doing so.

136. As such, I believe that Petitioner failed to make the requisite evidence-supported account of the contemplated workings of its proposed modification of Yoakim, and thus has failed to demonstrate that a POSITA would have been motivated to and had a reasonable expectation of success in modifying Yoakim as Petitioner proposed.

137. Neither the Petition nor Mr. Jobin's Declaration describe ***how*** a POSITA would have implemented indentations on the side wall of Yoakim's capsule. Moreover, Mr. Jobin's conclusory opinions to use indentations to facilitate controlled rotation during beverage extraction are unsupported. Mr. Jobin does not explain at all why or how a POSITA would have been motivated to modify Yoakim with such indentations. He fails to explain what impact this proposed modification would have on his proposed combination for placement of a barcode under the flange. And he still fails to account for the added complexity that would be required of the capsule holders of Yoakim and Jarisch in order to address the optical aberrations that would inevitably result due to such factors as birefringence, internal reflection, Fresnel effects, etc. Not only would this discourage any such motivation, to make the combination would require skills that well exceed the POSITA.

138. Yoakim also does not render obvious a side wall with indentations. Specifically, Yoakim teaches the toothed structure on the ***outer surface***, which is taught by Yoakim as a different surface from the ***side wall*** and Mr. Jobin does not explain at all ***why or how*** a POSITA would have been motivated to modify Yoakim with such indentations.

D. A Person of Ordinary Skill in the Art Would Not Have Been Motivated To Combine the References

1. A Person of Ordinary Skill in the Art Would Not Have Been Motivated to Combine Rossi with Yoakim and Jarisch

139. In my opinion, a POSITA would not have been motivated to combine Rossi with Yoakim and, Jarisch.

140. As an initial matter, and in my opinion, a POSITA would not have combined the teachings of Yoakim (namely the embodiments of Figures 23, 61, and 62) and Jarisch (Figure 4).

141. The "bit code" described in the Jarisch reference teaches away from Petitioner's proposed combination. Here, Yoakim uses the bare term "barcode," without providing any information as to what that code would actually be. In contrast, Jarisch teaches "[a] problem with identifying a capsule in a beverage preparation machine," including those that use "barcodes," "is that retrieving or reading information from the capsule is not always reliable or convenient." Ex. 1005 at [0008], [0009], [0011], [0013]. Jarisch's solution is to use a "bit code." *Id*. at [0017], [0064]. Indeed, Jarisch makes no mention of barcodes in describing "the present invention." A POSITA would therefore be left with the "bit code" described in Jarisch, which Petitioner agrees is not a "barcode." As a result, a POSITA would not have been motivated to combine the Yoakim and Jarisch references to achieve K-fee's claimed inventions. Even if a POSITA was so motivated, the outcome

would be the employment of a "bit code," which does not meet the "barcode" limitation of the claim.

142. Moreover, a POSITA would not have combined the teachings of Yoakim and Jarisch, as Petitioner suggests. Petitioner is the owner of Jarisch. As noted by Petitioner, Yoakim and Jarisch have a common owner, Societe des Produits Nestle S.A., an affiliate of Petitioner, and a common inventor, Alexandre Perentes. Pet. at 47. I note that Jarisch's priority document was filed days after Yoakim. But Jarisch make no mention of Yoakim in the background or otherwise. This suggests to a POSITA that the inventors of those references did not themselves see any clear relation between the two references. During prosecution of a similar Jarisch reference (U.S. Patent No. 10,800,600), a parent application to Yoakim was cited by the Examiner (WO 2008/148601, "Yoakim '601"). In attempting to overcome a rejection based on Yoakim '601, Petitioner disparaged the ability of Yoakim '601 to be combined with other references describing single-serve coffee capsules, stating that "the skilled artisan would not have combined these cited references [including Yoakim '601] to arrive at a capsule comprising a code arranged on a bottom of the flange-like rim." IPR2021-01222, Paper 6, EX2002-1 at 393.

143. Petitioner's argument that the other references do not "provide any reason or motivation for the skilled artisan to modify Yoakim ['601] alone or in combination with *Boyd* (even if they are combinable) to include the claimed code on

bottom of the flange-like rim of a capsule as required by independent claim 1" fails. IPR2021-01222, Paper 6, EX2002-1 at 395-96. Patent Owner acknowledges that Yoakim (Ex. 1004) is a continuation-in-part of the Yoakim '601 reference and that Figure 23 of Yoakim '601 is identical to Figure 23 of Yoakim. When prosecuting its own application, Petitioner argued that different references describing single-serve coffee capsules were non-combinable. As such, the Petitioner should not be permitted to argue the opposite now.

144. As further evidence a POSITA would not have combined the teachings of Yoakim (namely the embodiments of Figures 23, 61, and 62) and Jarisch (Figure 4) as Petitioner suggests. Petitioner suggests Jarisch's placing of the code on the bottom of the flange would result in the reading being more reliable. Pet. at 47-48. But Petitioner does not explain why such teachings in Jarisch would have motivated a POSITA to modify Yoakim in that way. Indeed, there is no reason to believe Yoakim's placement of a "barcode" on the top of the membrane would suffer from readability issues given Yoakim's device reads the "barcode" before brewing when a capsule would not be soiled by beverage residues. Ex. 1004 at [0525], [0526]. Moreover, the barcode (ID4 in the yellow region) is inboard of the outlet perforators 221 (annotated in red) so the centrifugal forces when the capsule is spinning would drive the fluid away (annotated in green) from the barcode—not towards it. *See id.* at Figs. 61, 62, [0507].

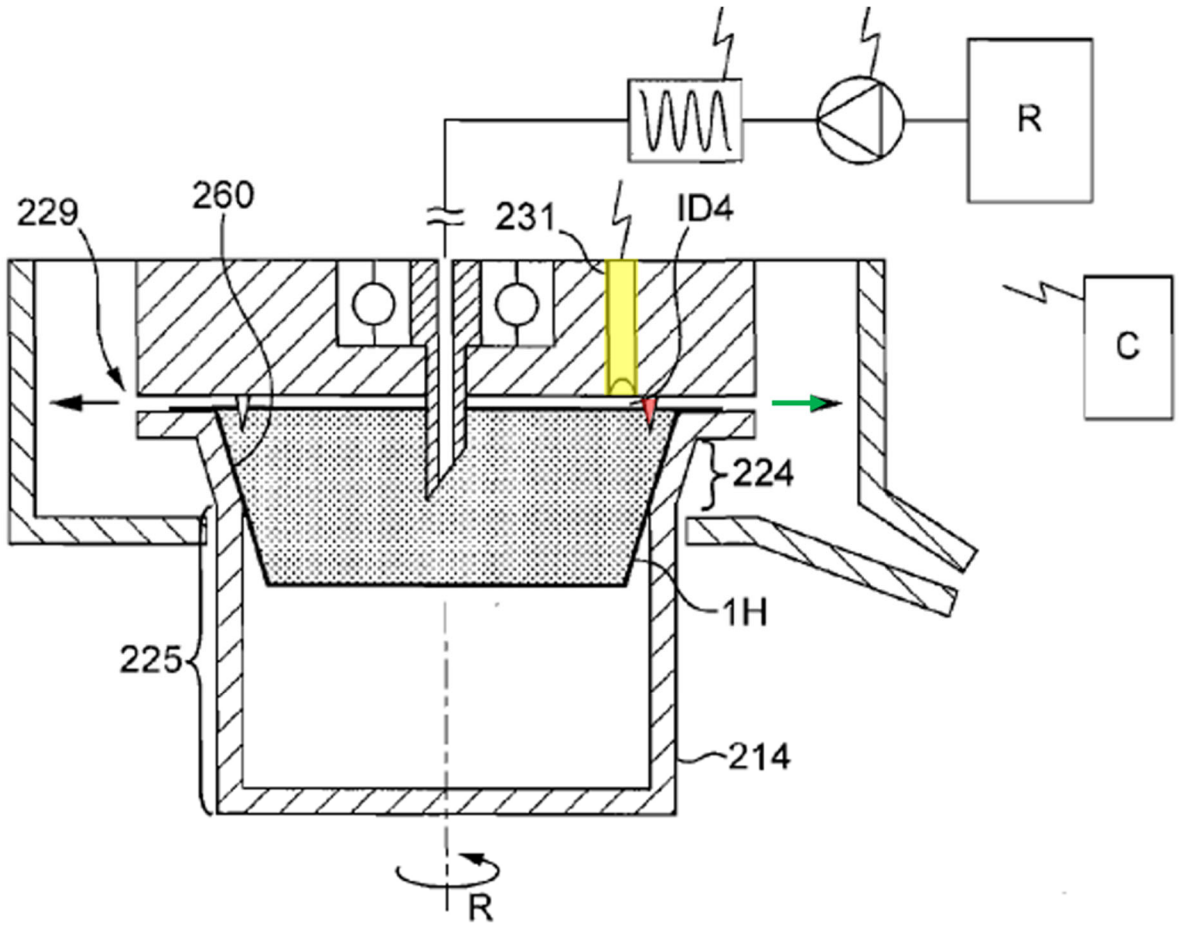
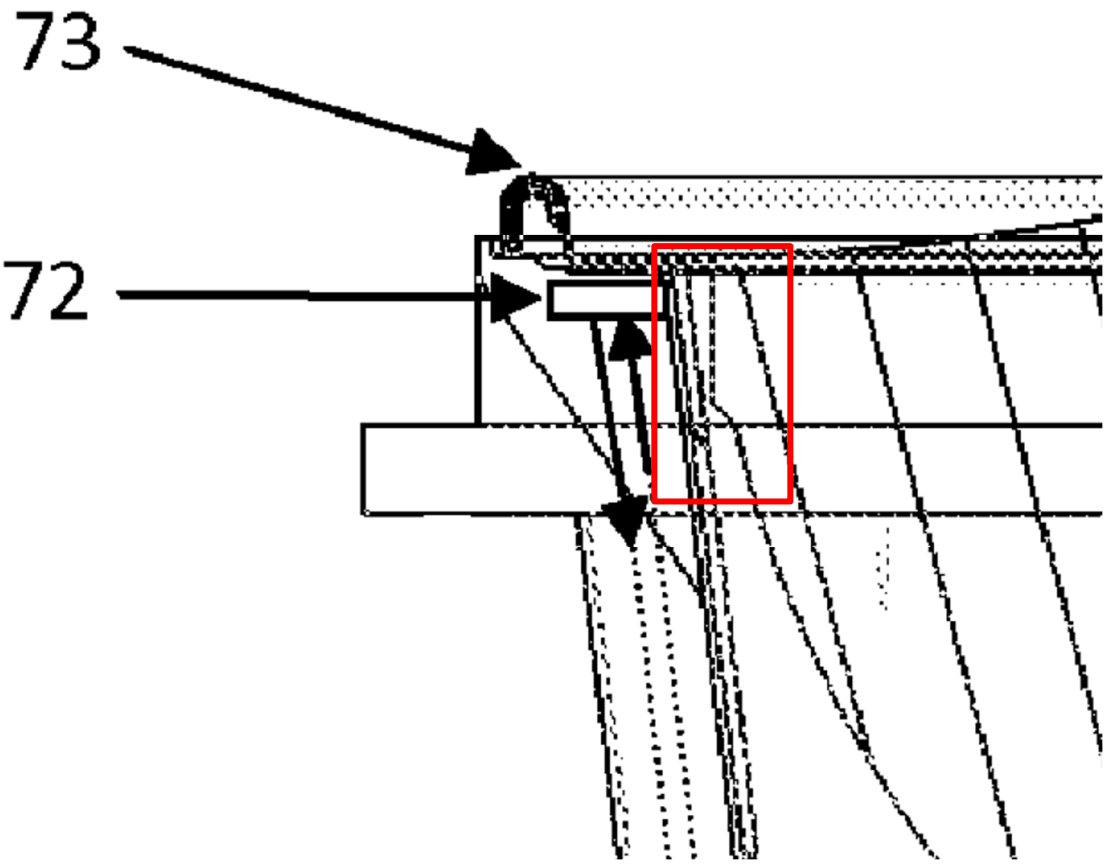


FIG. 61

145. Thus, the barcode would not be soiled and such a modification would be unnecessary in Yoakim's brewing system. Petitioner's argument thus should be rejected.

146. There are other important differences between Yoakim and Jarisch that undermine the combination of the two that Petitioner fails to address. For example, Yoakim teaches that the capsule side wall advantageously engaging with the capsule

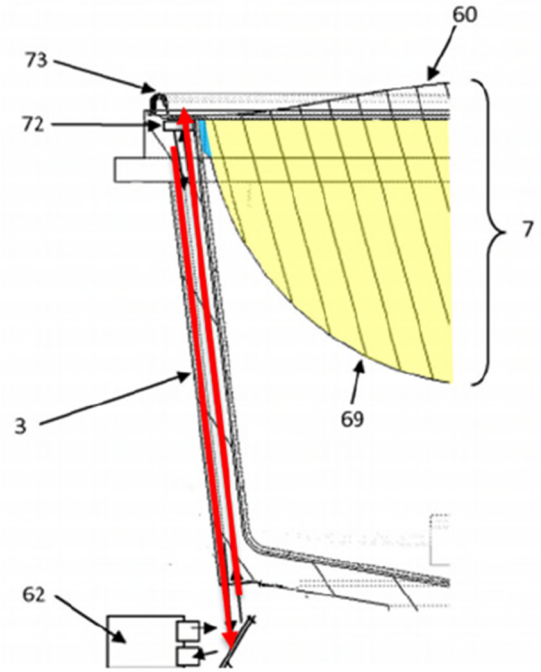
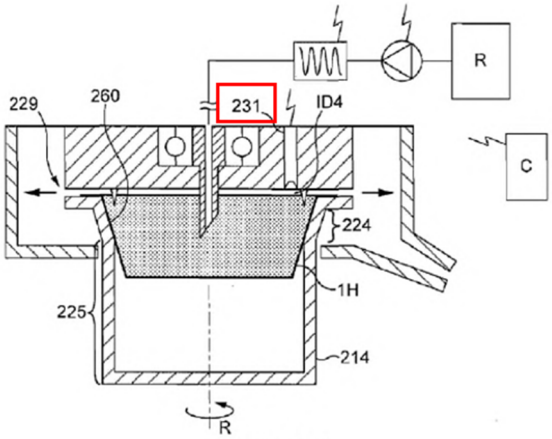
holder. Ex. 1004 at [0024]; *see also id.* at [0205], [0216], [0512], Figs. 61, 62. In contrast, Jarisch's capsule does not engage with the interior of cell 3. Ex. 1005 at Fig. 4. These differences are not insignificant. Petitioner has not demonstrated how (or why) Yoakim and Jarisch could be combined without a substantial reconstruction and redesign of elements within the skill level of a POSITA.



147. Further, Petitioner has not demonstrated how (or why) Yoakim and Jarisch could be combined without a substantial reconstruction and redesign of elements within the skill level of a POSITA. As Petitioner explains, "[t]he Jarisch

optical reader configuration is depicted below [in the annotated Figure 5] in order to read the code on the capsule (yellow) with the light path (red) shown from detector (62) to capsule rim (73)." Pet. at 48-49. However, the "sensor/detector (231) [] enabled to identify and read a barcode" as described in Yoakim is positioned to read a code on the opposite side of the capsule. Pet. at 58; *see also* Ex. 1004 at [0525], Figs. 61, 62. A POSITA would not have combined the teachings of Yoakim and Jarisch because they cannot be combined without a substantial reconstruction and redesign of elements, despite having the same owner and listed inventor. For example, to combine the reference, once would have to move the location of the sensor or detector (ostensibly directly into a flow path of the brewed coffee). The table below illustrates how the Jarisch optical reader configuration is depicted below [in the annotated Figure 5] in order to read the code on the capsule (yellow) with the light path (red) shown from detector (62) to capsule rim (73); however, the sensor/detector (231) enabled to identify and read a barcode as described in Yoakim is positioned to read a code ***on the opposite side of the capsule***. Pet. at 58; *see also* Ex. 1004 at [0525], Figs. 61, 62.

Comparison of Sensor Placement in Jarisch and Yoakim

Jarisch	Yoakim
 Ex. 1005, Fig. 4	 FIG. 61 Ex. 1004 at Fig. 61.

148. A POSITA would not have had a reasonable expectation of success in moving the sensor to the bottom of Yoakim's brewing device. For example, unlike the cell 3 in Jarisch which has a straight chamber between the code and the sensor, Yoakim's capsule holder 214 (above right) is comprised of lower portion 225 and first portion 224, which are connected by a bend (flare) in the structure. Ex. 1004 at Fig. 61, [0512]. For the sensor/detector to pass light through this flare, Yoakim would require extensive modifications, including mirroring or index-of-refraction

matching within the flared structure. This would have been particularly challenging given the fact that the barcode of Yoakim would be read while the capsule holder is rotated. This combination would thus require extensive experience with optics and more than ordinary skill. At his deposition, Mr. Jobin stated that "[b]odily incorporation is not required, in my understanding" to combine Jarisch and Yoakim. Ex. 2019 at 108:13-14. But he fails to demonstrate that a POSITA would have had the requisite experience to utilize those teachings with a reasonable expectation of success. In fact, in my opinion, it would take *extraordinary skill* to achieve the combination for at least the reasons presented above. The modification would necessitate a complex reconstruction of the Yoakim capsule holder side wall 224, 225 – not a mere substitution. In Figs. 61/62 of Yoakim, the capsule holder wall has a lower part 225 and an outwardly angled upper part 224. Projecting a beam through the lower part 225 and then the outwardly angled upper part 224 would likely not reach a code on a bottom of a flange and then return the beam to a detector positioned at the bottom of wall 225. A POSITA with the requisite skill level required in this matter would not have the proper training and familiarity with complex optics, light guides, material science and physics to have the knowledge or understanding to combine Jarisch and Yoakim as Mr. Jobin proposes. In fact, Mr. Jobin provides no details on how a POSITA may come to the conclusion that these references are combinable such that the present invention is rendered obvious.

149. A POSITA would have recognized that Fig. 4 of Jarisch shows that the transparent material (*see* Ex. 1005 at [0082]) is the same about the circumference of the capsule holder. It is generally a transparent structure that is much longer than it is thin, has a thickened base relative to the side walls, and is conical. A detector in such system, to be effective, would necessarily have required (among other things) that it be able to avoid optical aberrations during the transmission of light along its length, to the capsule rim and then back to the detector. In such a system, some examples of effects that could influence the quality of the light received by the detector are undesired birefringence, Fresnel effects, internal reflection and scatter, and transmission loss.

150. Using the proposed structure of the capsule holder of Jarisch would have added significant costs and complexity. This is due to selection of the proper material, the method of making the capsule holder, and how it could be incorporated into a harsh environment of a coffee making machine.

151. By way of example, though it was known at the relevant time that some plastics having transparency could have been machined or molded, in order to achieve precision necessary for detecting a code while a capsule was rotating, it would have been required that there be no anomalies within the transparent body and on its surfaces. However, it was also known at the time that optical properties of a molded transparent material were dependent upon (for example) residual internal

stresses (e.g., caused by the thicker volume lower left corner of the holder in Fig. 4 of Jarisch and by flow and solidification differences during a molding operation and dependent on the mold sprues, runners, and gates) causing internal refraction differences, surface roughness occasioned by a molding tool, air traps, surface waviness resulting from any shrinking during cooling of a molded part, distortion occasioned by repetitive thermal expansion and contraction from exposure to thermal cycling in an environment near hot water in a coffee machine) any sub-surface deformation occasioned by secondary processing (e.g., machining or polishing). Any or all of the above would have contributed to undesired refraction from anisotropy in the material, Fresnel effects, internal reflection, transmission loss along the wall of the holder, and other impairment to the light available for detection. Further, an attempt to introduce the externally located Jarisch capsule holder into the embodiment of Figs. 61 and 62 of Yoakim would also require an expensive special sealed system that would protect the detector from the harsh environment of the machine during coffee making.

152. While it is possible that such a solution could have been realized in the relevant time frame, it is my opinion that to arrive at it would have taken hundreds of hours or more and would have required enlisting a person with skills well beyond those of the POSITA. Further, the manufacturing process alone to develop and

implement such a specific type of capsule holder, would have involved significant complexity, with mold design, polymer processing parameters.

153. Thus, any attempts to combine Yoakim and Jarisch would lead a POSITA *away* from combining these two references as Mr. Jobin claims.

154. Because the combination of Jarisch and Yoakim would have required a significant redesign of the elements, including in moving the location of the sensor or detector (ostensibly directly into a flow path of the brewed coffee), a POSITA would not have been motivated to combine the teachings of the two references. A POSITA would further have not sought to go through such efforts to implement a feature that is unnecessary in light of no apparent concern in Yoakim of reading the barcode on the top of the capsule.

155. A POSITA would not be motivated to add the separate validation element of Rossi to the centrifugal brewing systems of Yoakim and Jarisch. This is particularly true in light of the Petitioner's failure to take into account the nature of the validation element disclosed in Rossi, which is (1) separate from the identification element used to control the operation of the machine, (2) used to determine whether a load element has already been used, (3) preferably takes the form of the mechanical destruction of the validation element, (4) is described as advantageous if the validation is visible to the user, such that it is clear the load element is validated and cannot be reused, (5) is generally described as taking place outside of the machine, and (6) is

used for purposes of "unlocking" the machine. The Petition is silent in assessing how a skilled person would consider Rossi as a whole, and how Rossi could be reconciled with the systems of Yoakim and Jarisch. Overall, a POSITA would not have combined the teaching of Yoakim and Jarsich, let alone combined the teachings of Rossi with Yoakim and Jarisch.

2. A Person of Ordinary Skill in the Art Would Not Have Been Motivated to Combine Yoakim, Jarisch, Rossi, and Castellani

156. Independent of Petitioner's failure to cite any prior art disclosure of the recited pump feature, it is my opinion that Petitioner also fails to demonstrate motivation to combine the prior art teachings for the same reasons as I explained in paragraphs 139-155 above – there is no motivation to combine Yoakim, Jarisch, Rossi and Castellani, and Petitioner's conclusory statements regarding motivation to combine are insufficient. Pet. at 73-76; Ex. 1003 at ¶¶293-300.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made herein on information and belief are believed to be true. Further, these statements were made with the knowledge that willful false statements and the like so made are punishable by fine, imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the above-identified patent.

Laurens Howle, Ph.D., P.E.

12/04/2023
Date

Appendix A

LAURENS "LARS" EDWARD HOWLE, PH.D., P.E., F.ASME, F.UHM

Professor of Mechanical Engineering
Box 90300
Duke University
Durham, NC 27708-0300
+1 919.660.5331
laurens.howle@duke.edu

Manager-Member
BelleQuant Engineering, PLLC
5119 Bogue Sound Drive
Emerald Isle, NC 28594 USA
+1 919.210.3056
www.bellequant.com
leh@bellequant.com

GOOGLE SCHOLAR LISTING

https://scholar.google.com/citations?hl=en&user=iu7Z18YAAAAJ

PROFESSIONAL HISTORY

2020-present	Professor of Mechanical Engineering, Duke University
2000-2020	Associate Professor of Mechanical Engineering, Duke University
1993-2000	Assistant Professor of Mechanical Engineering, Duke University
1989-1993	Research Assistant, Duke University
1983-1989	V.P. of Manufacturing and Plant Manager, Kaye Products, Hillsborough, NC
1980-1983	U.S. Army, 82nd Airborne (Honorable discharge 1986)

ADDITIONAL EXPERIENCE (PARTIAL LISTING)

2008-present	Owner/CEO, BelleQuant Engineering, PLLC, Mebane, NC
2020-2022	Professor of Radiology, Duke University Medical Center, Durham, NC
2018-2022	Associate Professor of Marine Science and Conservation, Duke University, Beaufort, NC
2013-2020	Associate Professor of Radiology, Duke University Medical Center, Durham, NC
2013-2020	Founding Member, Pelagic Scientific, PLLC, Durham, NC
2008-2015	Founding Member, Technovation Consulting Group, Durham, NC
2007-2010	Chief Science Officer, Whalepower Corp, Toronto, ON, Canada
2007-2008	Visiting Professor, United States Naval Academy, Annapolis, MD
2003-2004	Chairman, Engineering Faculty Council, Duke University, Durham, NC
2001-2004	Associate Chair & DGS, Mechanical Engineering, Duke University, Durham, NC
2001-2002	Visiting Professor, United States Naval Academy, Annapolis, MD

1995-present Board of Directors, Franklin Sis Corporation, Durham, NC

Honors and Awards

2020	Fellow in Undersea and Hyperbaric Medicine
2012	Fellow of the American Society of Mechanical Engineers
2011	New Product Award, HVLS Fan Design for Envira-North, MCEE, Montreal.
2009	INDEX: Design Award, Finalist, Design to Improve Life, Copenhagen.
1999	Office of Naval Research Young Investigator Award, $328,071.

Education

Ph.D.	Mechanical Engineering	Duke University	1993
M.S.	Mechanical Engineering	Duke University	1991
B.S.E.	Mechanical Engineering	Duke University	1989

Professional Certifications

Professional Engineer, North Carolina, 035790
Professional Engineer, Maryland, 37985 (inactive)
Dive Master (PADI)
Master Diver (PADI)
Technical Deep Diver (DSAT)

Professional Memberships

Fellow of the American Society of Mechanical Engineers
American Physical Society
Underwater and Hyperbaric Medical Society
Professional Engineers of North Carolina
National Society of Professional Engineers

Research Interests

Transport in thermal, chemical, and biological systems. Probabilistic pharmacokinetics and pharmacodynamics. Decompression sickness. Oxygen toxicity. Experimental and computational fluid dynamics. Nonlinear and complex systems. Stability of fluid motions. Econophysics. Wind

power. Advanced computational methods for big data, complex systems, and stochastic systems. Expert witness testimony.

Refereed Publications

Total Citations: 3031
h-index: 25
i10-index: 40

1. Wu, C.-Y., Nowacek, D.P., Nousek-McGregor, A.E, McGregor, R. & Howle, L.E. "Computational fluid dynamics of a 10m North Atlantic right whale (*Eubalaena glacialis*). *Marine Mammal Science*. 2021: 1-17. https://doi.org/10.1111/mms.12798 [IF 2.018, 1 citation]

2. Schwartz, F.R., Douglas, S.L., King, A.E., Murphy, F.G., Howle, L.E., Kim, C.Y. & Nelson, R.C. "Hemodialysis catheter integrity during mechanical power injection of iodinated contrast medium for computed tomography angiography". *Abdominal Radiology.* 2021. doi.org/10.1007/s00261-020-02905-9. [IF 2.429]

3. Di Muro, G., Murphy, G.F., Vann, R.D. & Howle, L.E. "Are interconnected compartmental models more effective at predicting decompression risk?". *Informatics in Medicine Unlocked*. 2020. doi.org/10.1016/j.imu.2020.100334 [IF 2.110, 2 citations]

4. King, A.E. & Howle, L.E. "Tetranomial decompression sickness model using serious, mild, marginal, and non-event outcomes". *Informatics in Medicine Unlocked.* 2020. doi.org/10.1016/j.imu.2020.100371. [IF 2.110, 1 citation]

5. King, A.E., Andriano, N.R. & Howle, L.E. "Trinomial decompression sickness model using full, marginal, and non-event outcomes". *Computers in Biology and Medicine.* 2020. doi.org/10.1016/jcompbiomed.2020.103640. [IF 2.408, 2 citations]

6. Dunford, R.G., Denoble, P.D., Forbes, R., Peiper, C.F., Howle, L.E. & Vann, R.D. "A study of decompression sickness using recorded depth-time profiles". *Undersea and Hyperbaric Medicine.* 2020. **47(1)**: 83-98. [IF 0.822, 1 citation]

7. Howle, L.E., Nowacek, D.P., Kraus, S.D. & Werner, T.B. "Simulation of the entanglement of a North Atlantic right whale (*Eubalaena glacialis*) with fixed fishing gear". *Marine Mammal Science.* 2019. **35(3)**: 760-778. [IF 2.018, 17 citations]

8. Murphy, F.G., Swingler, A.J., Gerth, W.A. & Howle, L.E. “Iso-risk air no decompression limits after scoring marginal decompression sickness cases as non-events”. *Computers in Biology and Medicine.* **92**: 110-117. 2018. [IF 2.408, 5 citations]

9. Murphy, F.G., Hada, E.A., Doolette, D.J. & Howle, L.E. “Probabilistic pharmacokinetic models of decompression sickness in humans, Part 2: Coupled perfusion-diffusion models”. *Computers in Biology and Medicine*. **92**: 90-97. 2018. [IF 2.408, 5 citations]

10. King, A.E., Murphy, F.G. & Howle, L.E. “Bimodal decompression sickness onset times are not related to dive type or event severity”. *Computers in Biology and Medicine*. **91**: 59-68. 2017. [IF 2.408, 6 citations]

11. Murphy, F.G., Hada, E.A., Doolette, D.J. & Howle, L.E. “Probabilistic pharmacokinetic models of decompression sickness in humans, Part 1: Coupled perfusion-limited compartments”. *Computers in Biology and Medicine*. **86**: 55-64. 2017. [IF 2.408, 7 citations]

12. Howle, L.E., Weber, P.W., Hada, E.A., Vann, R.D. & Denoble, P.J. “The probability and severity of decompression sickness”. *PLoS ONE.* **12(3)**: e0172665 doi:10.1371/journal.pone.0172665 2017. [IF 3.234, 31 citations]

13. Fiore, G., Anderson, E., Garborg, C.S., Murray, M., Johnson, M., Moore, M., Howle, L. & Shorter, K.A. “From the track to the ocean: Using flow control to improve marine bio-logging tags for cetaceans”. *PLoS ONE.* 12(2): e0170962 doi:10.1371/journal.pone.0170962. 2017. [IF 3.234, 19 citations]

14. Howle, L.E., Weber, P.W. & Nichols, J. “Bayesian approach to decompression sickness model parameter estimation”. *Computers in Biology and Medicine.* **82:** 3-11. 2017. [IF 2.408, 12 citations]

15. Weber, P.W., Howle, L.E., Murray, M.M., Reidenberg, J.S. & Fish, F.E. “Hydrodynamic performance of the flipper of large-bodied cetaceans in relation to locomotor ecology”. *Marine Mammal Science.* **30(2):** 413-432. 2014. [IF 2.018, 23 citations]

16. Shorter, K.A., Murray, M.M., Johnson, M., Moore, M. & Howle, L.E. “Drag of suction cup tags on swimming animals: modeling and measurement”. *Marine Mammal Science*. **30(2):** 726-746. 2014. [IF 2.018, 34 citations]

17. Balmer, B.C., Wells, R.S., Howle, L.E., Barleycorn, A.A., Irvine, A.B., McLellan, W.C., Pabst, D.A., Rowles, T.K., Schwacke, L.H., Townsend, F.I., Westgate, A.J. & Zolman, E.C.

"Advances in cetacean telemetry: a review of single-pin transmitter attachment techniques on small cetaceans". *Marine Mammal Science*. **30(2):** 656-673. 2014. [IF 2.018, 12 citations]

18. Howle, L.E. “Analytic gain in probabilistic decompression sickness models”. *Computers in Biology and Medicine.* **43(11)**: 1738-1747. 2013. [IF 2.408, 12 citations]

19. Howle, L.E., McGehee, C. & Mann, B.P. “An object-oriented library for real-time processing of NASDAQ order book data”. *Journal of Computer Engineering & Information Technology*. **1(2):** 1-5, 2012. [4 citations]

20. Husarik, D.B., Bashir, M.R., Weber, P.W., Nichols, E.B., Howle, L.E., Merkle, E.M. & Nelson, R.C. "Contrast-enhanced MR angiography: First pass arterial enhancement as a function of gadolinium-chelate concentration, and the saline chaser volume and injection rate". *Investigative Radiology*. **47(2):** 121-127, 2012. [IF 5.460, 9 citations]

21. Bashir, M. R., Weber, P.W., Husarik, D.B., Howle, L.E. & Nelson, R. C. "Improved aortic enhancement in CT angiography using slope-based triggering with table speed optimization: A pilot study". *International Journal of Cardiovascular Imaging.* **28(6)**: 1533-1543, 2012. [IF 2.648, 4 citations]

22. Fish, F.E., Weber, P.W., Murray, M.M. & Howle, L.E. "Marine applications of the biomimetic humpback whale flipper". *Marine Technology Society Journal*. **45(4):** 198-207, 2011. [53 citations]

23. Fish, F.E., Weber, P.W., Murray, M.M. & Howle, L.E. “The tubercles on humpback whales’ flippers: Application of bio-inspired technology. *Integrative and Comparative Biology.* **51(1):** 203-213, 2011. [IF 3.023, 317 citations]

24. Weber, P.W., Howle, L.E., Murray, M.M. & Miklosovic, D.S. "Computational evaluation of the performance of lifting surfaces with leading edge protuberances". *Journal of Aircraft*. **48(2):** 591-600. 2011. [IF 0.591, 137 citations]

25. Weber, P.W., Howle, L.E., Murray, M.M. & Corless, J.M. "A simplified mass transfer model for visual pigments (opsins) in amphibian retinal cone outer segments". *Biophysical Journal*. **100:** 525-534. 2011. [IF 4.390, 2 citations]

26. Weber, P.W., Howle, L.E. & Murray, M.M. "Lift, drag, and cavitation onset on rudders with leading-edge tubercles". *Marine Technology and SNAME News*. **47(1):** 27-36. 2010. [IF 0.419, 111 citations]

27. Coursey, C.C., Nelson, R.C., Weber, P.W., Howle, L.E., Nichols, E.B., Marin, D. & DeLong, D. "Contrast material administration protocols for 64-MDCT Angiography: Altering volume and rate and use of a saline chaser to better match the imaging window - physiologic flow phantom study". *American Journal of Roentgenology*. **193(6):** 1568-1575. 2009. [IF 2.897, 21 citations]

28. Weber, P.W., Murray, M.M., Howle, L.E. & Fish, F.E. "Comparison of real and idealized cetacean flippers". *Bioinspiration & Biomimetics*. **4(4):** 046001. 2009. [IF 2.412, 16 citations]

29. Macha, D., Howle, L.E., Nelson, R., Hollingsworth, J.W. & Schindera, S.T. "Central venous catheter integrity during mechanical power injection of iodinated contrast media". *Radiology*. **253(3):** 870-878. 2009. [IF 6.867, 23 citations]

30. Howle, L.E., Weber, P.W. & Vann, R.D. "A computationally advantageous system for fitting probabilistic decompression models to empirical data". *Computers in Biology and Medicine.* **39(12):** 1117-1129. 2009. [IF 2.408, 15 citations]

31. Weber, P.W., Coursey, C.C., Howle, L.E., Nelson, R.N., Nichols, E.B. & Schindera, S.T. "Modifying peripheral IV catheters with side holes and side slits results in favorable changes in the fluid dynamic properties during the injection of iodinated contrast materials". *American Journal of Roentgenology*. **193(4):** 970-977. 2009. [IF 2.897, 37 citations]

32. Howle, L.E., Weber, P.W., Vann, R.D. & Campbell, M.C. "Marginal DCS events: Their relation to decompression and use in DCS models". *Journal of Applied Physiology*. **107(5):** 1539-1547. 2009. [IF 3.732, 24 citations]

33. Weber, P.W., Howle, L.E., Murray, M.M. & Fish, F.E. "Lift and drag performance of odontocete cetacean flippers". *Journal of Experimental Biology*. **212(14):** 2149-2158. 2009. [IF 3.200, 59 citations]

34. Vann, R.D., Denoble, P.J., Howle, L.E., Weber, P.W., Freiberger, J.J. & Pieper, C.F. "Resolution and severity in decompression illness". *Aviation Space and Environmental Medicine*. **80(5):** 466-471. 2009. [IF 0.990, 44 citations]

35. Schindera, S.T., Nelson, R.C., Howle, L.E., Nichols, E., Delong, D.M. & Merkle, E.M. "Effect of varying injection rates of saline chaser on aortic enhancement in CT

angiography: phantom study". *European Radiology.* **18(8):** 1683-1689. 2008. [IF 4.014, 33 citations]

36. Fish, F.E., Howle, L.E. & Murray, M.M. "Hydrodynamic flow control in marine mammals". *Integrative and Comparative Biology*. **48(6):** 788-800. 2008. [IF 3.023, 208 citations]

37. Miklosovic, D.S., Murray, M.M. & Howle, L.E. "Experimental evaluation of sinusoidal leading edges". *AIAA Journal of Aircraft.* **44(4):** 1404-1408. 2007. [IF 1.207, 285 citations]

38. Miklosovic, D.S., Murray, M.M., Howle, L.E. & Fish, F.E. "Leading-edge tubercles delay stall on humpback whale (*Megaptera novaeangliae*) flippers". *Physics of Fluids*. **16(5):** L39-L42. 2004. [IF 2.232, 675 citations]

39. Murray, M.M. & Howle, L.E. "Spring stiffness influence on an oscillating propulsor". *Journal of Fluids and Structures.* **17(7):** 915-926. 2003. [IF 2.051, 57 citations]

40. Wagner, B.A., Bertozzi, A.L. & Howle, L.E. "Positive feedback control of Rayleigh-Bénard convection". *Discrete and Continuous Dynamical Systems. – Series B.* **3(4):** 619-642. 2003. [IF 1.099, 4 citations]

41. Hasik, M., Kim, D. Howle, L. Needham, D. & Frush, D. "Evaluation of synthetic phospholipid contrast agents". *Ultrasonics*. **40(9):** 973-982. 2002. [IF 2.028, 46 citations]

42. Howle, L.E. "The effect of boundary properties on controlled Rayleigh-Bénard convection". *Journal of Fluid Mechanics*. **411:** 39-58. 2000. [IF 2.82, 32 citations]

43. Craciunescu, O.I., Howle, L.E. & Clegg, S.T. "Experimental evaluation of the thermal properties of two phase equivalent phantom materials". *International Journal of Hypertherma*. **15(6):** 509-518. 1999. [IF 2.645, 21 citations]

44. Gustafson, M.R. & Howle, L.E. "Effects of anisotropy and boundary plates on the critical values of a porous medium heated from below". *International Journal of Heat and Mass Transfer.* **42(18):** 3419-3430. 1999. [IF 2.315, 5 citations]

45. Howle, L., Schaeffer, D.G., Shearer, M., & Zhong, P. "Lithotripsy: The treatment of kidney stones with shock waves". *SIAM Review.* **40(2):** 356-371. 1998. [IF 5.757, 24 citations]

46. Howle, L.E. "Linear stability analysis of controlled Rayleigh-Bénard convection using shadowgraphic measurement". *Physics of Fluids*. **9(11):** 3111-3113. 1997. [IF 2.232, 44 citations]

47. Howle, L.E. “Active control of Rayleigh-Bénard convection”. *Physics of Fluids*. **9(7):** 1861-1863. 1997. [IF 2.232, 74 citations]

48. Howle, L.E. “Control of Rayleigh-Bénard convection in a small aspect ratio container”. *International Journal of Heat and Mass Transfer.* **40(4):** 817-822, 1997. [IF 2.315, 62 citations]

49. Howle, L.E., Behringer, P.R., & Georgiadis, J.G. “Convection and flow porous media, Part 2: Visualization by shadowgraph”. *Journal of Fluid Mechanics.* **332:** 247-262. 1997. [IF 2.82, 33 citations]

50. Murray, M.M., Tong, H., Howle, L.E. & Zhong, P. “Response to a lithotripter shock wave of a cavitation bubble surrounded by a viscoelastic membrane”. *Proceedings of the 1997 ASME Fluids Engineering Division Summer Meeting*. Seattle, WA. 1997.

51. Gustafson, M.R., Murray, M.M. & Howle, L.E. “Active control of Rayleigh-Bénard convection is a moderate aspect ratio container”. *Proceedings of the 1997 ASME Fluids Engineering Division Summer Meeting*. Seattle, WA. 1997.

52. Howle, L.E. “A comparison of the reduced Galerkin and pseudo-spectral methods for simulation of two-dimensional Rayleigh-Bénard convection”. *International Journal of Heat and Mass Transfer.* **39(12):** 2401-2407. 1996. [IF 2.315, 21 citations]

53. Gustafson, M.R. & Howle, L.E. “Control of Rayleigh-Bénard convection in small aspect ratio container”. *Unsteady Flows*. W.L. Keith et al. (eds.), AMSE FED, 216**:** 77-81. 1995.

54. Howle, L.E. “Efficient implementation of a finite difference Galerkin method for simulation of large aspect ratio convection”. *Numerical Heat Transfer, B: Fundamentals*. **26:** 105-114. 1994. [IF 1.282, 5 citations]

55. Howle, L.E. & Georgiadis, J.G. “Natural convection in porous media with anisotropic dispersive thermal conductivity”. *International Journal of Heat and Mass Transfer.* **37(7):** 1081-1094. 1994. [IF 2.315, 23 citations]

56. Howle, L.E., Behringer, R.P. & Georgiadis, J.G. “Visualization of convective fluid flow in a porous medium”. *Nature.* **362(7):** 230-232. 1993. [IF 40.137, 48 citations]

57. Howle, L.E., Behringer, J.G. & Georgiadis, J.G. “Visualization of natural convection in ordered and disordered porous layers”. *Experimental and Numerical Flow Visualization*, B. Khalighi et al. (eds.), ASME FED, **172:** 387-395. 1993. [2 citations]

58. Howle, L.E., Georgiadis, J.G. & Behringer, J.G. “Shadowgraphic visualization of natural convection in rectangular-grid porous layers”. *Topics in Heat Transfer*. M. Keyhani et al. (eds.), ASME HTD, **206:** 17-23. 1992. [17 citations]

PEER-REVIEWED PAPERS IN PRESS

PEER-REVIEWED PAPERS IN REVIEW

1. Wu, C.-Y., Nowacek, D.P. & Howle, L.E. “Computational fluid dynamic analysis of gliding North Atlantic right whale models with variable body shapes”. *Marine Mammal Science.* 2021. [IF 2.018]

BOOK CHAPTERS

1. Howle, L.E. "Convection in ordered and disordered porous layers". Transport Phenomena in Porous Media, Second Edition. D.B. Ingham and I. Pop (eds). Pergamon. 2002. [3 citations].

CONTRIBUTED PAPERS

1. Vann, R., Hada, E., Murphy, G., Swingler, A. & Howle, L. “Vascular gas emboli and probabilistic decompression models”. *Patent Foramen Ovale and Fitness to Dive Workshop Consensus Workshop Proceedings.* Undersea and Hyperbaric Medical Society. Jun. 2015, 64-73. Montreal, Canada.

2. Vann, R.D., Howle, L.E., Dunford, R.G. & Denoble, P.D. "The optimal path". *Decompression and the Deep Stop Workshop Proceedings.* P.B. Bennett, B. Wienke & S.J. Mitchell (eds.) Undersea and Hyperbaric Medical Society (invited). Jun. 2008, 235-248. Salt Lake City, UT.

3. Murray, M.M., Fish, F.E., Howle, L.E. & Miklosovic, D.S. “Stall delay by leading edge tubercles on humpback whale flipper at various sweep angles”. *14th International Symposium on Unmanned Untethered Submersible Technology*. Aug. 2005. Durham, NH. [5 citations]

4. Murray, M.M., Miklosovic, D.A., Fish, F. & Howle, L.E. “Effects of leading edge tubercles on a representative whale flipper model at various sweep angles”. *14th International Symposium on Unmanned Untethered Submersible Technology*. Aug. 2005. Durham, NH. [39 citations]

5. Martin, J.I., Howle. L.E. & Murray, M.M. “Optimization of undulatory flap propulsors”. *12th International Symposium on Unmanned Untethered Submersible Technology*. Aug. 2001. Durham, NH.

6. Moore, N.J., Howle. L.E. & Murray, M.M. “Controlling an output wave shape during undulatory swimming”. *12th International Symposium on Unmanned Untethered Submersible Technology*. Aug. 2001. Durham, NH.

7. Murray, M.M. & Howle, L.E. “Response of compliant foils to dynamic loadings produced by oncoming vorticies”. *12th International Symposium on Unmanned Untethered Submersible Technology*. Aug. 2001. Durham, NH.

8. Howle, L.E. “Undulatory Flap Propulsion”. *11th International Symposium on Unmanned Untethered Submersible Technology.* pp. 487-493. Aug. 1999. Durham, NH. [2 citations]

9. Chen, D., Wang, H.O. & Howle, L.E. “Bifurcation control of Rayleigh-Bénard convection”. *1999 IEEE International Conference on Control Applications.* Aug. 1999. Hawaii, HI. [3 citations]

10. Chen, D., Wang, H.O., Howle, L.E., Gustafson, M.R. & Meressi, T. “Amplitude control of bifurcations and chaos with applications to Rayleigh-Bénard convection”. *37th IEEE Conference on Decision and Control* pp. 1951-1956. Dec. 1998. Tampa, FL. [16 citations]

Reports (Excluding Expert Witness Reports)

1. Howle, L.E., Freiberger, J.J., Diehl, S., Natoli, M., King, A.E., Vann, R.D. “Transfer of Duke Dive Trial Data to U.S. Navy – Vol. 1 MK15 UBA Dive Trials – Rev. A.” Report to Deep Submergence Biomedical R&D Program, Naval Sea Systems Command, 00CM, U.S. Navy. 2019. **1049 pages**.

2. Howle, L.E., Freiberger, J.J., Diehl, S., Natoli, M., King, A.E., Vann, R.D. “Transfer to Duke Dive Trial Data to U.S. Navy – Vol. 2 – Fife Deep Air Dive Trials – Rev. A”. Report to Deep Submergence Biomedical R&D Program, Naval Sea Systems Command, 00CM, U.S. Navy. 2019. 14 pages.

3. Howle, L.E., Freiberger, J.J., Diehl, S., Natoli, M., King, A.E., Vann, R.D. “Transfer to Duke Dive Trial Data to U.S. Navy – Vol. 3 – SIO2 Dive Trials – Rev. A”. Report to Deep Submergence Biomedical R&D Program, Naval Sea Systems Command, 00CM, U.S. Navy. 2019. 44 pages.

4. Howle, L.E., Freiberger, J.J., Diehl, S., Natoli, M., King, A.E., Vann, R.D. “Transfer to Duke Dive Trial Data to U.S. Navy – Vol. 4 – NOAA Dive Trials – Rev. A”. Report to Deep Submergence Biomedical R&D Program, Naval Sea Systems Command, 00CM, U.S. Navy. 2019. 29 pages.

5. Howle, L.E., Freiberger, J.J., Diehl, S., Natoli, M., King, A.E., Vann, R.D. “Transfer to Duke Dive Trial Data to U.S. Navy – Vol. 5 – Ascent Rate Trials – Rev. A”. Report to Deep Submergence Biomedical R&D Program, Naval Sea Systems Command, 00CM, U.S. Navy. 2019. 38 pages.

6. Howle. L.E., Dunford, R., Denoble, P., King, A.E., Vann, R.D. “Transfer to Duke Dive Trial Data to U.S. Navy – Vol. 6 – Project Dive Exploration – Rev. A”. Report to Deep Submergence Biomedical R&D Program, Naval Sea Systems Command, 00CM, U.S. Navy. 2019. **8675 pages**.

7. Howle, L.E., King, A.E., Vann, R.D. “Transfer to Duke Dive Trial Data to U.S. Navy – Vol. 7 – NMRC-99 augmented with Perceived Severity Index – Rev. A” Report to Deep Submergence Biomedical R&D Program, Naval Sea Systems Command, 00CM, U.S. Navy. 2019. 19 pages.

8. Howle, L.E. “Water Tunnel Testing and Computational Fluid Dynamics Simulations of Wildlife Computers Dart Tags – Final Report”. Alaska SeaLife Center. 2013. 20 pages.

9. Howle, L.E. “Modeling of Right Whale Entanglement Events – Progress Report”. New England Aquarium. 2013. 9 pages.

10. Howle, L.E. & Nowacek, D.P. “Modeling Right Whale Entanglement – NOAA Grant 2571 Final Report”. New England Aquarium. 2012. 19 pages.

11. Howle, L.E. “Comparative Efficiency Analysis of Small Fan Models BQE18, BQE26, BQE32, BQE34 with Baseline Fan”. WhalePower Corp. 2011. 18 pages.

12. Howle, L.E. “Fan Law Comparison of Small Fan Models BQE18, BQE26, BQE32, BQE34, and Baseline”. WhalePower Corp. 2011. 13 pages.

13. Howle, L.E. “Performance Measurement of a Baseline (unmodified) Computer Cooling Fan”. WhalePower Corp. 2011. 13 pages.

14. Howle, L.E. “Performance Measurement of BQE18 Computer Cooling Fan Design”. WhalePower Corp. 2011. 14 pages.

15. Howle, L.E. “Performance Measurement of BQE26 Computer Cooling Fan Design”. WhalePower Corp. 2011. 14 pages.

16. Howle, L.E. “Performance Measurement of BQE32 Computer Cooling Fan Design”. WhalePower Corp. 2011. 14 pages.

17. Howle, L.E. “Performance Measurement of BQE34 Computer Cooling Fan Design”. WhalePower Corp. 2011. 14 pages.

18. Di Muro, G., Howle, L.E. & Vann, R.D. "Partitioned risk analysis of NAVY decompression dives". NAVSEA. 2010. **818 pages**.

19. Howle, L.E. "Computational Fluid Dynamics Comparison of a Tubercle and Smooth 48 Inch Diameter Cooling Fan – A final report documenting computational fluid dynamics simulations of large fans with and without leading edge tubercles. American Cooling Systems. 2010. 12 pages.

20. Howle, L.E. "Computational Fluid Dynamics Simulations of Fans in the American Cooling Systems Wind Tunnel - A final report documenting computation fluid dynamics simulations of large fans in the American Cooling Systems wind tunnel facility. American Cooling Systems. 2010. 16 pages.

21. Howle, L.E. & Weber, P.W. "Experimental evaluation of sinusoidal leading edges (tubercles) on computer fan blades. WhalePower Corporation. 2010. 16 pages.

22. Howle, L.E. "American Cooling Systems - WhalePower 48 Inch Fan Design - A report documenting the design of a 48 in nominal diameter cooling fan incorporating leading edge tubercles". American Cooling Systems. 2010. **635 pages**.

23. Howle, L.E. "WhalePower Wenvor Blade. A report in the efficiency of a WhalePower Corp. 5-meter prototype wind turbine blade". WhalePower Corporation. 2009. 16 pages. [28 citations].

PUBLISHED ABSTRACTS

1. Blogg, S.L., Lance, R., Tillmans, F., Brent, K., Bouak, F., Howle, L., Medson, K., Moon, R., Papadopoulou, V. & Lindholm, P. *An echo from the past; building a Doppler repository for big data in diving research*. Undersea and Hyperbaric Society Scientific Meeting. Reno, NV. 2022.

2. Wu, C., Howle, L.E. & Nowacek, D.P. *Minimum drag on a three-dimensional North Atlantic right whale model via neutral trim pose.* Society for Integrative & Comparative Biology. Washington, DC. 2021.

3. Werner, T.B., Howle, L.E. & Nowacek, D.P. *Applications of a virtual computer model for studying fishing gear modifications to prevent large whale entanglements*. World Marine Mammal Science Conference. Barcelona, Spain. 2019.

4. Wu, C.-Y., Howle, L.E., Nousek, A.E., McGregor, R. & Nowacek, D.P. *Computational fluid dynamics analysis of gliding North Atlantic right whale with variable body shape*. World Marine Mammal Science Conference. Barcelona, Spain. 2019.

5. King, A.E., Andriano, N.R., Howle, L.E. & Vann, R.D. *Tetranomial probabilistic modeling of serious, mild, marginal, and no decompression sickness*. Undersea and Hyperbaric Society Scientific Meeting. Rio Mar, Puerto Rico. 2019.

6. Howle, L.E. *Probabilistic models of oxygen toxicity*. ONR Undersea and NAVSEA Deep Submergence Biomedical Development Program Review. Durham, NC. 2019.

7. Howle, L.E., Freiberger, J.J., Diehl, S., Natoli, M., King, A.E. & Vann, R.D., *Transfer of Duke dive trial data to U.S. Navy*. ONR Undersea and NAVSEA Deep Submergence Biomedical Development Program Review. Durham, NC. 2019.

8. Moon, R.E., Weis, T.W., Natoli, M.J., Freiberger, J.J., Lance, R.M., Derrick, B.J. & Howle, L.E. *Altitude Diving*. ONR Undersea and NAVSEA Deep Submergence Biomedical Development Program Review. Durham, NC. 2019.

9. Wu, C.-Y., Howle, L.E., Nousek-McGregor, A.E., McGregor, R. & Nowacek, D.P. *Computational fluid dynamics simulations of a 10m North Atlantic right whale (Eubalaena glacialis)*. North Atlantic Right Whale Consortium Annual Meeting. New Bedford, MA. 2018.

10. Howle, L.E. *Advances in Probabilistic Decompression Models and Decompression Scheduling.* Undersea Medicine Program Review. San Diego, CA. 2017.

11. Howle, L.E. *Evaluation of and Advances in Oxygen Toxicity Models.* Undersea Medicine Program Review. San Diego, CA. 2017.

12. Howle, L.E., Murphy, F.G. & King, A.E. *Fast, near-optimal ascent algorithm for air and enriched air dives*. 2017 Annual Scientific Meeting of the Undersea and Hyperbaric Medical Society. Naples, FL. 2017.

13. Murphy, F.G., Swingler, A.J., Gerth, W.A. & Howle, L.E. *Probabilistic models for predicting the incidence and onset time of DCS after scoring marginal DCS cases as non-events*. 2017 Annual Scientific Meeting of the Undersea and Hyperbaric Medical Society. Naples, FL. 2017.

14. King, A.E., Murphy, F.G. & Howle, L.E. *Decompression sickness onset time bimodality is not related to dive type or severity*. 2017 Annual Scientific Meeting of the Undersea and Hyperbaric Medical Society. Naples, FL. 2017.

15. Werner, T.B., Howle, L.E., Nowacek, D.P. & Kraus, S.D. *Using the Virtual Whale Entanglement Simulator to model collisions between a North Atlantic right whale and fishing buoy lines of variable breaking strength*. 22nd Biennial Conference on the Biology of Marine Mammals. Halifax, Nova Scotia. 2017.

16. Wu, C.-Y., Howle, L.E. & Nowacek, D.P. *Estimating the induced forces on an entangled North Atlantic right whale (Eubalaena glacialis)*. 22nd Biennial Conference on the Biology of Marine Mammals. Halifax, Nova Scotia. 2017.

17. Lewis, D.S., King, A., Murphy, F.G., Kim, C.Y., Nelson, R.C. & Howle, L.E. *Hemodialysis catheter integrity during mechanical power injection of iodinated contrast medium*. Scientific Assembly and Annual Meeting of the Radiological Society of North America. Chicago, IL. 2017.

18. Wilbur, J., Knaus, D., Ramsey, M., McEnaney, K., Magari, P., Moon, R., Vann, R., Howle, L., Buckey, J., Anderson, A., Fellows, A., Sevick, J., Stump, D. & Deal, D. *Advanced technologies for reducing decompression obligation in extreme dives.* ONR-NAVSEA Program Review Meeting. Buffalo, NY. 2015.

19. Howle, L.E. *Advances in probabilistic decompression models and decompression modeling.* ONR-NAVSEA Program Review Meeting. Buffalo, NY. 2015.

20. Howle, L.E., *Probabilistic decompression modeling.* ONR-NAVSEA Program Review Meeting. Buffalo, NY. 2015.

21. Vann, R.D., Hada, E.A., Murphy, F.G. & Howle, L.E. *Arterial gas emboli and probabilistic decompression modeling*. 2015 Annual Scientific Meeting of the Undersea and Hyperbaric Medical Society. Montreal, Canada. 2015.

22. Hada, E.A., Murphy, F.G. & Howle, L.E. *Delay differential equations as an explicit method of aligning DCS model prediction with dive trial outcome.* 2015 Annual Scientific Meeting of the Undersea and Hyperbaric Medical Society. Montreal, Canada. 2015.

23. Murphy, F.G., Hada, E.A. & Howle, L.E. *The case for mixed pharmacokinetic models as a descriptor of decompression sickness.* 2015 Annual Scientific Meeting of the Undersea and Hyperbaric Medical Society. Montreal, Canada. 2015.

24. Marin, D., Howle, L.E., Murphy, F.G., Hada, E.A., Nichols, E.B. & Nelson, R.C. *Comprehensive evaluation of the correlation between anatomical variates and enhancement in contrast-enhanced abdominal MDCT.* Annual Meeting of the Society of Abdominal Radiology. Coronado, CA. 2015.

25. Hada, E.A., Howle, L.E. & Murphy, F.G. *Depth scaling of several gas super-saturation models.* Proceedings of the 2014 Undersea and Hyperbaric Medical Society Meeting. St. Louis, MO. 2014.

26. Murphy, F.G., Hada, E.A. & Howle, L.E. *Perfusion-diffusion gas content models as a predictor of decompression sickness.* Proceedings of the 2014 Undersea and Hyperbaric Medical Society Meeting. St. Louis, MO. 2014.

27. Nelson, R.D., Howle, L.E. & Nichols, E. *Comprehensive evaluation of a novel patient-specific algorithm for determining the dose of iodinated contrast material for abdominal CT.* 100th Scientific Assembly and Annual Meeting of the Radiological Society of North America. Chicago, IL. 2014.

28. Nowacek, D.P., Bowers, M. Cannon, A., Hindell, M., Howle, L.E., Murray, M.M., Rittschof, D., Shorter, K.A. & Moore, M. *The next generation of multi-sensor acoustic tags: sensors, applications, and attachments.* 5th International Bio-Logging Science Symposium. Strasbourg, France. 2014. [cited 1 time].

29. Shorter, K.A., Giovanni, F., Murray, M.M., Johnson, M., Moore, M. & Howle, L.E. *Reducing impact: design features to minimize hydrodynamic forces for suction cup tags*

on swimming animals. 5th International Bio-Logging Science Symposium. Strasbourg, France. 2014.

30. Andrews, R.D., Baird, R., Hanson, B.M., Howle, L., Mittal, R., Schorr, G. & Wilton, S. *Improving attachments of remotely-deployed dorsal fin-mounted tags: tissue structure, hydrodynamics, in-situ performance, and tagged-animal follow-up.* Proceedings of the 5th International Bio-Logging Science Symposium. Strasbourg, France. 2014.

31. Howle, L.E. & Nowacek, D.P. *Virtual Simulation of Right Whale Entanglement in Fishing Gear*. Proceedings of the 2013 North Atlantic Right Whale Consortium Meeting. New Bedford, MA. 2013.

32. Nowacek, D.P., Hindell, M., Shorter, K.A., Bowers, M., Rittschof, D., Howle, L.E., Murray, M. & Moore, M. *The next generation for multi-sensor acoustic tags: sensors, applications attachments.* Proceedings of the 166th meeting of the Acoustical Society of America. San Francisco, CA. 2013.

33. Wells, R.S., Balmer, B.C., Howle, L.E., Scott, M.D., Fauquier, D.A., Barlycorn, A.A., McHugh, K.A., Allen, J.B., Irvine, A.B., Townsend, F.I., Sweeney, J.C. & Wilton, S. *Experimental tests of small electronic tags for dolphins*. Proceedings of the 2013 meeting of the Society for Marine Mammalogy. Denedin, New Zealand. 2013.

34. Wells, R.S., Balmer, B.C., Howle, L.E., Scott, M.D., Fauquier, D.A., Barlycorn, A.A., McHugh, K.A., Allen, J.B., Irvine, A.B., Townsend, F.I., Sweeney, J.C. & Wilton, S. *Experimental tests of small electronic tags for dolphins*. Proceedings of the 2013 meeting of the International Association for Aquatic Animal Medicine. Sausalito, CA. 2013.

35. Andrews, R.D., Baird, R.W., Durban, J.W., Hanson M.B., Howle, L.E., Matkin, C.O., Mittal, R., Raverty, S. & Schorr, G.S., *The limpet tag and its use on small to medium-sized cetaceans*. Proceedings of the 2013 meeting of the International Association for Aquatic Animal Medicine. Sausalito, CA. 2013.

36. Murray, M.M., Shorter, A.K., Howle, L.E., Johnson, M. & Moore, M. *Numerical and experimental analysis of suction cup bio-logging tag designs for marine mammals.* Proceedings of the 2012 American Physical Society Division of Fluid Dynamics Meeting. San Diego, CA. 2012.

37. Howle, L.E. & Nowacek, D.P. *Computer modeling of Right Whale entanglements*. Proceedings of the 2012 North Atlantic Right Whale Consortium Meeting. New Bedford, MA. 2012.

38. Howle, L.E., Di Muro, G., Doolette, D.J. & Vann, R.D. *New classes of interconnected compartmental DCS models.* Proceedings of the 2012 Undersea and Hyperbaric Medical Society Meeting. Phoenix, AZ. 2012.

39. Hobbs, G.W., Murphy, F.G., Gault, K.A., Hexdall, E., Howle, L.E. & Walker, J.R. *Decompression risk evaluation for trimix dives derived from commercially available desktop decompression algorithms*. Proceedings of the 2012 Undersea and Hyperbaric Medical Society Meeting. Phoenix, AZ. 2012.

40. Vann, R.D. & Howle. L.E. *Describing decompression sickness (DCS) of the brain, spine, and joints by multinomial probability.* Proceedings of the 2012 Undersea and Hyperbaric Medical Society Meeting. Phoenix, AZ. 2012.

41. Vann, R.D., Howle, L.E., Pollock, N.W. & Moon, R.D. *Do arterialized VGE initiate cerebral or spinal decompression sickness (DCS)?* Proceedings of the 2012 Undersea and Hyperbaric Medical Society Meeting. Phoenix, AZ. 2012.

42. Howle, L.E., Weber, P.W. & Nichols, J.M. *Bayesian approach to decompression sickness model parameter estimation*. Proceedings of the 2011 Undersea and Hyperbaric Medical Society Meeting. Fort Worth, TX. 2011.

43. Shorter, K., Howle, L., Johnson, M. Nowacek, D., Hurst, T., Bocconcelli, A. & Moore M. *Modeling and analysis of fluid flow around a suction cup bio-logging tag.* Society for Marine Mammalogy. 19th Biennial Conference on the Biology of Marine Mammals. Tampa, FL. 2011.

44. Fish, F.E., Weber, P.W., Howle, L.E., Murray, M.M. & Reidenberg, J.S. *Hydrodynamic performance of the flippers of large-bodied cetaceans.* Secondary Adaptation of Tetrapods to Life in Water. San Diego, CA. 2011.

45. Husarik, D.B.B., Mashir, M.S.R., Weber, P.W., Nichols, E.B., Merkle, E.M., Howle, L.E. & Nelson, R.C. *Gadolinium-enhanced MR angiography: Effects of the contrast media dose on peak signal intensity relative to the injection rate of saline chaser.* 97th Scientific Assembly and Annual Meeting of the Radiological Society of North America. Chicago, Il. 2010.

46. Husarik, D.B.B., Bashir, M.S.R., Weber, P.W., Nichols, E.B., Howle, L.E. & Nelson, R.C. *Gadolinium-enhanced MR Angiography: Effects of volume and rate of the saline chaser on peak aortic signal intensity.* 97th Scientific Assembly and Annual Meeting of the Radiological Society of North America. Chicago, Il. 2010.

47. Husarik, D., Nelson, R., Weber, P., Howle, L.E., Nichols, E., Boll, D. & Marin, D. *Low kVp contrast-enhanced CT: Can imaging closer to the k-edge of iodine allow for a reduction in contrast media?* 110th Annual Meeting of the American Roentgen Ray Society. San Diego, CA. 2010.

48. Walker, J.R., Hobbs, G.W., Gault, K.A., Howle, L.W. & Freiberger, J.J. *The effect of final oxygen decompression stop depth in DCS risk: 20fsw vs. 10fsw.* Proceedings of the 2010 Undersea and Hyperbaric Medical Society Meeting. St. Pete Beach, Florida, 2010.

49. Walker, J.R., Hobbs, G.W., Gault, K.A., Howle, L.W. & Freiberger, J.J. *Decompression risk analysis comparing oxygen and 50% nitrox decompression stops.* Proceedings of the 2010 Undersea and Hyperbaric Medical Society Meeting. St. Pete Beach, Florida, 2010.

50. Vann, R.D., Weber, P.W., Di Muro, G. & Howle, L.E. *Adding venous gas emboli (VGE) to the linear-exponential (LE) decompression model*. Proceedings of the 2010 Undersea and Hyperbaric Medical Society Meeting. St. Pete Beach, Florida, 2010.

51. Husarik, D.B., Weber, P.W., Bashir, M.S.R., Nichols, E.B., Merkle, E.M., Howle, L.E. & Nelson, R.C. *Gadolinium-enhanced MR angiography: Optimization of contrast media doses for imaging patients with compromised renal function.* Society of Computed Body Tomography and Magnetic Resonance Meeting. San Diego, California. 2010.

52. Murray, M., Weber, P., Howle, E. & Fish, F. *Comparison of real and idealized cetacean flippers* American Physical Society Division of Fluid Dynamics Meeting. Minneapolis, Minnesota. 2009.

53. Howle, L.E., Weber, P.W., Vann, R.D., Denoble, P.J. & Campbell, M.C. *Probabilistic DCS models using hierarchical outcome severity*. Proceedings of the 2009 Undersea and Hyperbaric Medical Society Meeting. Las Vegas, Nevada. 2009.

54. Howle, L.E., Weber, P.W., Vann, R.D., Denoble, P.J. & Campbell, M.C. *The role of marginal outcomes in the fitting of probabilistic DCS models*. Proceedings of the 2009 Undersea and Hyperbaric Medical Society Meeting. Las Vegas, Nevada. 2009.

55. Vann, R.D., Denoble, P.J., Howle, L.E., Weber, P.W., Freiberger, J.J., Pieper, C.F. & Nord, D. *Decompression illness (DCI) and survival analysis*. Proceedings of the 2009 Undersea and Hyperbaric Medical Society Meeting. Las Vegas, Nevada. 2009.

56. Coursey, C., Nelson, R.C., Weber, P.W., Nichols, E., Marin, D. & Howle, L.E. *Ultrafast multidetector CT angiography of the chest and abdomen: How do alterations in rates of contrast media and saline chaser injection and alterations in cardiac output effect peak aortic enhancement?* 94th Scientific Assembly and Annual Meeting of the Radiological Society of North America. Chicago, Il. 2008.

57. Murray, M., Weber, P., Howle, L. & Fish, F. *Lift and Drag of Cetacean Flippers* 61st Annual Meeting of the APS Division of Fluid Dynamics, San Antonio, Texas. 2008.

58. Nichols, E., Nelson, R.C., Schindera, S.T. & Howle, L.E. *Mechanical power injection of iodinates contrast media: quantitative assessment of angiocatheter exit jet dynamics*. 37th Annual Postgraduate Course and Scientific Meeting of the Society of Gastrointestinal Radiologists. Rancho Mirage, California. 2008.

59. Nichols, E., Nelson, R.C., Schindera, S.T. & Howle, L.E. *Mechanical power injection of iodinated contrast media: quantitative assessment of angiocatheter exit jet dynamics using different injection rates and catheter sizes*. 104th Annual Meeting of the American Roetgen Ray Society. Washington, DC. 2008.

60. Dunford, R.G., Denoble, P.J., Vann, R.D., Shannon, J.S., Pollock, N.W. & Howle, L.E. *The relationship of age and BMI to Doppler-detected bubble grades*. Proceedings of the 2008 Underwater and Hyperbaric Medical Society Meeting. Salt Lake City, Utah. 2008.

61. Vann, R.D., Dunford, R.G., Denoble, P.D. & Howle, L.E. *The probabilities of DCS and VGE after nitrogen-oxygen diving.* Proceedings of the 2008 Undersea and Hyperbaric Medical Society Meeting. Salt Lake City, Utah. 2008.

62. Howle, L.E., Weber, P.W. & Vann, R.D. *Is marginal DCS ("niggles") real or random noise?* Proceedings of the 2008 Undersea and Hyperbaric Medical Society Meeting. Salt Lake City, Utah. 2008.

63. Vann, R.D., Howle, L.E., Pieper, C.F., Denoble, P.D., Freiberger, J.J. & Moon, R.E. *Statistical prediction of residual DCI symptoms after decompression.* Proceedings of the 2008 Undersea and Hyperbaric Medical Society Meeting. Salt Lake City, Utah. 2008.

64. Howle, L.E., Weber, P.W. & Vann, R.D. *A parameter estimation system with computational advantages for fitting probabilistic decompression models to empirical data.* Proceedings of the 2007 Undersea and Hyperbaric Medical Society Meeting. Maui, Hawaii. 2007.

65. Weber, P.W., Howle, L.E., Vann, R.D. & Pieper, F.C. *Probability models of mild and serious decompression sickness (DCS).* Proceedings of the 2007 Undersea and Hyperbaric Medical Society Meeting. Maui, Hawaii. 2007.

66. Howle, L.E., Lebental, S. & Vann, R.D. *An object-oriented system for optimizing probabilistic decompression models to empirical decompression data.* Proceedings of the 2006 Undersea and Hyperbaric Medical Society Meeting. Orlando, Florida. 2006.

67. Vann, R.D., Lebental, S. & Howle, L.E. *The relative roles of surface tension and the oxygen window in bubble resolution.* Proceedings of the 2006 Undersea and Hyperbaric Medical Society Meeting. Orlando, Florida. 2006.

68. Murray, M. & Howle, L.E. *Cavitation inception on rudder models with smooth and scalloped leading edges*. APS Division of Fluid Dynamics Meeting, Chicago, Illinois. 2005.

69. Fish, F.E., Miklosovic, D.S., Murray, M.M. & Howle, L.E. *Delayed stall due to leading edge tubercles of the humpback whale flipper.* Integrative and Comparative Biology. 43(6): 903, 2003.

70. Murray, M., Miklosovic, D., Fish, F. & Howle, L. *Stall delay by leading edge tubercle in humpback whale flipper.* APS Division of Fluid Dynamics Meeting, East Rutherfordton, New Jersey. 2003.

71. Howle, L.E. *Undulatory Flap Pair Propulsion*. APS Division of Fluid Dynamics Meeting, New Orleans, Louisiana. 1999.

72. Hasik, M.J., Howle, L.E. & Needham, D. *Effect of Contrast Agent's Lipid Carbon Chain Length on Backscattered Ultrasound Amplitude*. APS Division of Fluid Dynamics Meeting, New Orleans, Louisiana. 1999.

73. Gustafson, M.R. & Howle, L.E. Experimental *Control of Horton-Rogers-Lapwood Convection using Shadowgraphic Input*. APS Division of Fluid Dynamics Meeting, New Orleans, Louisiana. 1999.

74. Murray, M.M. & Howle, L.E. *Translational Spring Stiffness Influence on an Oscillating Propulsor*. APS Division of Fluid Dynamics Meeting, New Orleans, Louisiana. 1999.

75. Gustafson, M.R. & Howle, L.E. *Boundary Effects on the Onset of Convection in Porous Media*. APS Division of Fluid Dynamics Meeting, Philadelphia, Pennsylvania. 1998.

76. Murray, M.M. & Howle, L.E. *Reduced Order Hydroelasticity Modeling of a Flexible Propulsor*. APS Division of Fluid Dynamics Meeting, Philadelphia, Pennsylvania. 1998.

77. Howle, L.E. *Boundary Effects in Controlled Rayleigh-Bénard Convection*. APS Division of Fluid Dynamics Meeting, Philadelphia, Pennsylvania. 1998.

78. Meressi, T. & Howle, L.E. *Linear and Nonlinear Control of Rayleigh-Bénard Convection*. APS Division of Fluid Dynamics Meeting, Philadelphia, Pennsylvania. 1998.

79. Howle, L.E. & Behringer, R.P. *Floquet Stability Analysis of the Onset of Convection in Periodic Porous Media*. APS Division of Fluid Dynamics Meeting, Syracuse, New York. 1996.

80. Howle, L.E. *Suppression of Natural Convection in Small Aspect Ratio Containers*. APS Division of Fluid Dynamics Meeting, Atlanta, Georgia. 1994.

81. Howle, L.E., Behringer, R.P. & Georgiadis, J.G. *Convection in Porous Media: Visualization by a Novel Shadowgraphic Technique.* APS Division of Fluid Dynamics Meeting, Tallahassee, Florida. 1992.

82. Howle, L.E., Behringer, R.P. & Georgiadis, J.G. *Shadowgraphic Visualization of Natural Convection in Rectangular-Grid Porous Media.* ASME National Heat Transfer Conference, San Diego, California. 1992.

Response to Letters to the Editor

1. Macha, D.B., Nelson, R.C., Howle, L.E., Hollingsworth, J.W. & Scindera, S.T. *Radiology*. **255(2)**: 662. 2010.

   In response to:

   Halpenny, D.F., Doody, O., McNeill, G. & Torreggiani, W.C. *Central venous catheter care during contrast-enhanced CT.* Radiology **255(2)**: 662. 2010.

FUNDING HISTORY

Number of Grants: 33
Total Funding: $6,572,188

02/01/21-01/31/24 NAVSEA/OOC. *Probabilistic Decompression Sickness Model Development.* $862,267. Lars Howle, P.I.

02/01/21-01/31/23 NAVSEA/OOC. *Perfluromethane to Reduce Decompression Sickness after Heliox Dives.* $894,910. Richard Moon, P.I.

10/01/17-09/30/18 NAVSEA/OOC. *Transfer of Duke University Dive Trial Data to U.S. Navy.* $147,069. Lars Howle, P.I.

10/01/17-09/31/20 NAVSEA/OOC. *Altitude Diving Tables.* $961,773. Richard Moon, P.I.

02/01/17-01/31/20 NAVSEA/OOC. *Evaluation of and Advances in Oxygen Toxicity Models.* $523,211. Lars Howle, P.I.

06/01/14-05/31/15 DARPA. *Advanced Technologies for Reducing the Probability of Decompression Sickness.* $280,000. Richard Moon, P.I.

10/01/13-09/30/17 ONR. *Pre-doctoral Fellowship to Strengthen Navy Capabilities in Probabilistic Decompression Modeling*. $313,542. Lars Howle, P.I.

07/08/13-07/06/16 NAVSEA/OOC. *Advances in Probabilistic Decompression Models and Decompression Scheduling.* $935,252. Lars Howle, P.I.

06/01/13-05/31/14 DARPA. *Accelerated Decompression with Multiple Inert Gases.* $10,000. Richard Moon, P.I.

12/01/10-05/31/12 MGT Nemoto International. *Innovative Catheter Designs for Reducing Extravasation Risk During Injection of Iodinated Contrast Media.* $90,703. Lars Howle, P.I.

04/01/09-07/31/09 NAVSEA/ONR. *Partitioned Decompression Risk Analysis.* $17,414. Lars Howle, P.I.

02/17/09-09/30/12 NAVSEA/ONR. *Probabilistic Models of Decompression Sickness (DCS).* $758,331. Lars Howle, P.I.

10/01/08-09/30/09 Bracco Diagnostics, Inc. *Comprehensive Evaluation of the Effects of the Sequential Power Injection of Iodinated Contrast Media and Saline with Vascular Enhancement: Further Studies*. $100,000. Rendon Nelson, P.I.

05/20/08-05/19/08 The Lord Foundation. *Generating Energy from Ocean Waves.* $13,345. Brian Mann, P.I.

05/08/07-05/09/09 DARPA. *Enhancement of Oscillatory Flap Propulsors in Low-Speed Flows in Water.* $99,999. Lars Howle, P.I.

04/01/07-03/31/09 National Science Foundation. *Comparative Experimental Hydrodynamics of Cetacean Flippers: Ecomorphology on an Aquatic Control Surface.* $270,000. Frank Fish, P.I.

04/17/06-10/16/07 Bracco Diagnostics, Inc. *Comprehensive Evaluation of the Effects of the Sequential Power Injection of Iodinated Contrast Media and Saline with Vascular Enhancement*. $100,000. Lars Howle, P.I.

04/01/06-03/31/09 NAVSEA/ONR. *Development of an Object-Oriented Numerical Modeling System for the Study and Development Decompression Models*. $414,575 Richard Vann, P.I.

01/01/03-12/31/03 DARPA. *Morphing Aircraft Structures.* $150,104. Robert Clark, P.I.

05/01/03-12/31/03 The Lord Foundation. *3rd Annual Engineering Design Contest*. $10,000. Robert Kielb, P.I.

05/01/02-12/31/02 The Lord Foundation. *Wing Test Stand and Instrumentation*. $5,000. Lars Howle, P.I.

05/01/00-12/31/01 The Lord Foundation. *Improving the Undergraduate Experience: Multipurpose Experimentation, Design and Presentations Laboratory Project.* $15,000. Michael Gustafson, P.I.

07/01/00-12/31/01 North Carolina Biotechnology Center. *Triggered Release of Contents from Liposomes using Ultrasound.* $55,000. David Needham, P.I.

01/01/00-12/31/00 National Science Foundation. *Investigations into Micro-Scale Heat Transfer and CAD Tools for Thermal Management in Deep-Submicron Integrated Circuits*. $30,421. Krish Chakrabarty, P.I.

07/01/99-06/30/00 The Lord Foundation. *Innovations in Medical Ultrasound Imaging*. $15,310. Lars Howle, P.I.

05/01/99-04/30/02 Office of Naval Research. *Undulatory Flap Propulsion - Reduction to Practice.* **ONR Young Investigator Award**. $328,071. Lars Howle, P.I.

04/01/99-03/31/02 The Whitaker Foundation. *Imaging Methods for Ultrasound Contrast Agents*. $205,895. Lars Howle, P.I.

05/01/98-09/30/98 North Carolina Space Grant Consortium. *Investigation of g-Jitter in Surface-Tension-Driven Convection in Micro-Gravity*. $5,000. Lars Howle, P.I.

03/03/98-03/02/99 Nekton Technologies, Inc. *Analytical Study of Nektor Propulsion*. $42,536. Lars Howle, P.I.

02/01/98-01/30/99 Mallinckrodt, Inc. *Stabilization of Ultrasound Contrast Agents*. $42,536. Lars Howle, P.I.

09/01/97-08/31/99 Petroleum Research Fund. *Active Control of Convection in Porous Media*. $25,000. Lars Howle, P.I.

05/01/97-09/30/97 North Carolina Space Grant Consortium. *Active Control of Surface-Tension-Driven Convection in Micro-Gravity*. $5,000. Lars Howle, P.I.

07/01/96-06/30/97 The Lord Foundation. *Undergraduate Laboratory Renovations*. $38,273. Lars Howle, P.I.

07/01/96-06/30/97 The Lord Foundation. *Duke University Mechanical Engineering Wind Tunnel Repairs*. $20,000. Lars Howle, P.I.

INVITED PRESENTATIONS

01/25/23 *Entanglement Risk Simulator Study.* Bureau of Ocean Energy Management Leadership Outreach Meeting.

01/19/22 *Entanglement Simulations to Inform Sustainable Aquaculture and Offshore Wind Energy Development.* Entanglement Expert Roundtable Meeting. **Plenary Presentation.**

06/10/21 *Decompression Modeling*. Undersea and Hyperbaric Medical Society Annual Scientific Meeting. **Plenary Presentation**.

05/04/21 *Probabilistic DCS Model Development*. 2021 ONR Undersea Medicine and NAVSEA Deep Submergence Biomedical Development Program Review.

05/04/21 *Update on Advances in Oxygen Toxicity Prediction Models*. 2019 ONR Undersea Medicine and NAVSEA Deep Submergence Biomedical Development Program Review.

06/19/19 *The Whale Simulator: A Potential Tool for Predicting Entanglement Risk for Offshore Aquaculture*. **Saltonstall Kennedy Lecture**. NOAA Southwest Fisheries Science Center. La Jolla, CA.

06/21/19 *The Whale Simulator: A Potential Tool for Predicting Entanglement Risk for Offshore Aquaculture*. NOAA Offshore Aquaculture Gear/Protected Species Interaction Workshop. NOAA Southwest Fisheries Science Center. La Jolla, CA.

05/16/19 *Transfer of Duke University Dive Trial Data to U.S. Navy*. 2019 ONR Undersea Medicine and NAVSEA Deep Submergence Biomedical Development Program Review. Durham, NC.

05/14/19 *Evaluation of and Advances in O2 Toxicity Models*. 2019 ONR Undersea Medicine and NAVSEA Deep Submergence Biomedical Development Program Review.

03/11/19 *The whale simulator: A tool for predicting entanglement risk for offshore aquaculture*. Aquaculture 2019. New Orleans, LA.

06/19/18 *Virtual Whale Entanglement Simulator.* **Lowell Lecture.** New England Aquarium. Boston, MA.

06/14/18 *Evaluation of and Advances in CNS Oxygen Toxicity and Decompression Sickness Models.* ONR-NAVSEA Undersea Medicine Program Review. Arlington, Washington, DC.

04/04/18 *Entanglement of Right Whales with Fixed Fishing Gear*. NOAA Whale release, Gear marking feasibility subgroup meeting. Warwick, RI.

06/31/17 *Fast, Near Optimal Iso-Risk Ascent Profile Algorithm for Air and Enriched Air Dives.* Naples, FL.

05/03/17 *Advances in Probabilistic Decompression Models and Decompression Scheduling*. ONR-NAVSEA Undersea Medicine Program Review. San Diego, CA.

05/01/17 *Evaluation of and Advances in Oxygen Toxicity Models.* Undersea Medicine Program Review. San Diego, CA.

05/12/16 *Decompression models – where are we? Where do we need to go from here?* Office of Naval Research Decompression Sickness and Hyperbaric Oxygen Toxicity Workshop. Arlington, VA.

08/05/15 *Probabilistic decompression modeling.* ONR-NAVSEA Undersea Medicine Program Review. Buffalo, NY.

08/06/15 *Advances in probabilistic decompression models and decompression modeling.* ONR-NAVSEA Undersea Medicine Program Review. Buffalo, NY.

08/05/14 *Patient-specific dosing for CT contrast studies.* Nemoto-Kyorindo Co, Ltd. Tokyo, Japan.

02/28/14 *Entanglement of North Atlantic right whales with fishing gear.* Maine Fishermen's Forum. Rockland, ME.

09/25/13 *Entanglement of North Atlantic right whales with fishing gear*. Duke University Marine Lab. Beaufort, NC.

03/25/12 *Modeling and analysis of fluid flow around a suction cup bio-logging tag.* Northwest Fisheries Service Center. Seattle, WA.

03/24/12 *Modeling and water tunnel testing of cetacean dart-mount data-logging tags.* Northwest Fisheries Service Center. Seattle, WA.

02/16/11 *Modeling Whale Entanglements (**Plenary Presentation**).* Dynamics of Large Whale Entanglements Workshop. Woods Hole Oceanographic Institution. Woods Hole, MA.

11/29/10 *Innovations in Contrast Enhanced Imaging.* MGT Nemoto International. Chicago, IL.

10/25/10 *Mathematical Modeling of Whale Entanglement Events*. New England Aquarium - Federal Reserve Bank. Boston, MA.

08/05/10 *Probabilistic Models of Decompression Sickness (DCS).* NAVSEA. ONR. NMRC (BUMED) Undersea Medicine Program Review. Seattle, WA.

11/16/09 *Hydro-biomimetics.* Chief of Naval Operations Strategic Studies Group. Durham, NC.

03/17/09 *Marine Hydromechanics.* ONR Cetacean Tagging Workshop. Arlington, VA.

07/15/08 *Predicted DCS probability, dive conditions, and DCS severity.* NAVSEA. ONR. NMRC (BUMED) Undersea Medicine Program Review. Arlington, VA.

04/30/08 *Technology Brief: Tubercle Technology.* General Dynamics - Electric Boat. Groton, CT.

01/10/08 *Fluid Dynamics Research Collaboration between Radiology and Engineering*. Department of Radiology Grand Rounds. Duke University Medical Center. Durham, NC.

07/18/07 *Predicted DCS Probability, Dive Conditions, and DCS.* NAVSEA. ONR. NMRC (BUMED). Undersea Medicine Program Review. Groton, CT.

04/27/07 *A Parameter Estimation System for fitting Probabilistic Decompression Models to Empirical Data*. University of Massachusetts at Dartmouth. Dartmouth, MA.

01/12/07 *Computer Aided Design and Manufacture of Hydrodynamic Control Surfaces*. Deka Research, LLC. Manchester, NH.

10/06/06 *Undulatory Propulsion*. Deka Research, LLC. Manchester, NH.

06/20/06 *Predicting DCS Severity, Dive Conditions and DCS*. ONR Underwater Medicine Program Review. Durham, NC.

05/30/06 *Hydrodynamic Propulsion*. Deka Research, LLC. Manchester, NH.

05/12/06 *Optimization of Probabilistic Decompression Sickness Models*. Oceanic, Inc. Durham, NC.

11/21/03 *Morphing Aircraft Structures – Systems integration and Control*. DARPA MAS. University review. Arlington, VA.

10/09/01 *Active control of convection*, United States Naval Academy. Annapolis, MD.

10/16/01 *Control of underwater gliding vehicles*. United States Naval Academy. Annapolis, MD.

10/20/00 *Biomimetic Propulsion Studies for Navy Applications*. United States Naval Academy. Annapolis, MD.

10/05/00 *Active control of Rayleigh-Bénard Convection*. CNCS-CNLS Workshop. Duke University. Durham, NC.

11/02/99 *Boundary Effects on Controlled Rayleigh-Bénard Convection*. Applied Math Seminar. Duke University. Durham, NC.

08/25/99 *Undulatory Flap Propulsion*. 11th International Symposium on Unmanned Untethered Submersible Technology. Durham, NH.

01/27/98 *Boundary Effects on Controlled Rayleigh-Bénard Convection*. Differential Equations Seminar. North Carolina State University. Raleigh, NC.

08/18/98 *Visualization and Control of Buoyancy-Driven Convection*. Shriners Burn Hospital, Massachusetts General Hospital, and Harvard Medical School. Boston, MA.

09/01/97 *Pattern Formation in Convection in Porous Media* Max Plank Institute. Dresden, Germany.

10/10/95 *Control of Rayleigh-Bénard Convection.* Center for Nonlinear and Complex Studies. Duke University. Durham, NC.

10/24/94 *Control of Buoyancy-Driven Convection*. University of Massachusetts at Dartmouth. Dartmouth, MA.

02/25/94 *Pattern Formation in Porous Media Convection.* Mechanics and the Environment. Duke University, Durham, NC.

CONFERENCE AND OTHER PRESENTATIONS

11/07/13 *Virtual Simulation of Right Whale Entanglement in Fishing Gear.* North Atlantic Right Whale Consortium Meeting. New Bedford, MA.

11/13/12 *Computer modeling of wright whale entanglements.* North Atlantic Right Whale Consortium Meeting. New Bedford, MA.

06/21/12 *New classes of interconnected compartmental DCS models.* Undersea and Hyperbaric Medical Society Meeting. Phoenix, AZ.

06/15/11 *Bayesian approach to decompression sickness model parameter estimation*. Undersea and Hyperbaric Medical Society Meeting. Fort Worth, TX.

11/03/10 *Computer modeling of right whale entanglement events.* North Atlantic Right Whale Consortium Meeting. New Bedford, MA.

06/25/09 *Probabilistic DCS models using hierarchical outcome severity*. Undersea and Hyperbaric Medical Society. Las Vegas, NV.

06/28/08 *Is marginal DCS ("niggles") real or random noise?* Undersea and Hyperbaric Medical Society. Salt Lake City, UT.

06/07/06 *Predicting DCS Severity, Dive Conditions and DCS*. Undersea and Hyberbaric Medical Society. Orlando, FL.

01/14/04 *Computational Fluid Dynamics in a Multidisciplinary context.* DARPA Helicopter Quieting Proposer's Day Meeting. Arlington, VA.

08/27/01 *Kinematics of Fish Midline Models*. Unmanned Underwater Submersible Technologies, 12th International Symposium. Durham, NH.

11/23/99 *Undulatory Flap Pair Propulsion*. APS Division of Fluid Dynamics Meeting. New Orleans, LA

11/23/98 *Boundary Effects in Controlled Rayleigh-Bénard Convection*. APS Division of Fluid Dynamics Meeting. Philadelphia, PA.

11/23/98 *Linear and Nonlinear Control of Rayleigh-Bénard Convection*. APS Division of Fluid Dynamics Meeting. Philadelphia, PA.

11/23/96 *Floquet Stability Analysis of the Onset of Convection in Periodic Porous Media*. APS Division of Fluid Dynamics Meeting. Syracuse, NY.

11/22/94 *Suppression of Natural Convection in Small Aspect Ratio Containers*. APS Division of Fluid Dynamics Meeting. Atlanta, GA.

11/30/93 *Visualization of Natural Convection in Ordered and Disordered Porous Layers*. ASME Winter Annual Meeting. New Orleans, LA.

11/23/92 *Convection in Porous Media: Visualization by a Novel Shadowgraphic Technique.* APS Division of Fluid Dynamics Meeting. Tallahassee, FL.

08/10/92 *Shadowgraphic Visualization of Natural Convection in Rectangular-Grid Porous Media.* ASME National Heat Transfer Conference. San Diego, CA.

PATENTS

Laurens Howle, Rendon Nelson, Eli Nichols, Sebastian Shindera, Courtney Coursey, & Paul Weber. *Jetless Intravenous Catheters and Mechanical Assist Devices for Hand-Injection of Contrast Media During Dynamic Computer Tomography and Methods of Using Same*. US 9,884,166. 02/06/2018.

CONSULTANT FOR (ABBREVIATED LISTING):

- Advanced Dynamics, Inc. Lexington, KY.
- Alaska Sealife Center. Seaward, AK.
- Alston & Bird, LLP. New York, NY, Charlotte, NC.
- American Cooling Systems, LLC. Grand Rapids, MI.
- Atlantic Productions, Ltd. London, UK.
- Bakos & Kritzer. New York, NY.
- Chicago Zoological Society. Brookfield, IL.
- DeLio, Peterson & Curcio, LLC. New Haven, CT.
- Defense Advanced Research Projects Agency. Alexandria, VA
- Envira-North Systems, Ltd. Seaforth, ON.
- Flexxaire. Edmonton, AB.
- Hendershot, Cannon & Hisey, P.C. Houston, TX.
- Lineage Logistics. Colton, CA.

- Lowe Graham Jones, PLLC. Seattle, WA.
- Mann Law Group. Seattle, WA.
- Mei & Mark, LLP. Washington, DC.
- Mote Marine Laboratory & Aquarium. Sarasota, FL.
- National Marine Fisheries Service. Washington, DC.
- National Oceanographic and Atmospheric Administration, Washington, DC.
- New England Aquarium. Boston, MA.
- Office of Naval Research. Alexandria, VA.
- PL MFG. Cooperstown, ND.
- SethLaw, LLP. Houston, TX.
- Shearwater Research, Inc. Vancouver, BC.
- SPX Cooling Technologies, Inc. Overland Park, KS.
- Strategic Analysis, Inc. Arlington, VA.
- Technology Development Associates, LLC. East Greenwich, RI.
- Triangle Research Labs. Raleigh, NC.
- University of Alabama – Huntsville. Huntsville. AL.
- Williams Mullen Hofheimer Nusbaum. Norfolk, VA.
- WhalePower Corporation. Toronto, ON.
- Wildlife Computers. Bellevue, WA.
- Woods Hole Oceanographic Institution. Woods Hole, MA.

Media Coverage (Abbreviated Listing)

- "These whales will be extinct in 25 years scientists say – unless we act now to save them". Sarah Kaplin. The Washington Post. https://www.washingtonpost.com/national/health-science/these-whales-will-be-extinct-in-25-years-scientists-say--unless-we-act-now-to-save-them/2018/04/20/57bf89b2-4320-11e8-8569-26fda6b404c7_story.html?utm_term=.00fff052d37a
- "Predicting how bad the bends will be". EurekAlert! https://www.eurekalert.org/pub_releases/2017-03/du-phb031517.php March 15, 2017.
- "Predicting how bad the bends will be. Model warns deep-sea divers on severity of decompression sickness". Duke University. http://pratt.duke.edu/about/news/predicting-how-bad-bends-will-be March 15, 2017,
- "Large Whale Entanglements". Consortium for Wildlife Bycatch Reduction. http://www.bycatch.org/research/consortium/large-whale-entanglements. 2014.
- The Field Museum, Chicago. Two wind tunnel models on eight-year loan for the traveling exhibition "*The Machine Inside: Biomechanics*". 2013.

- “Large Whale Entanglement Simulator”. http://www.youtube.com/watch?v=u7pa5XDqAgs. July 09, 2012.
- “How a whale’s fin inspired a better turbine blade”. *Globe and Mail.* Sharon Oosthek. April 20, 2012.
- “Single-pin satellite-linked transmitter design and testing”. *Sarasota Dolphin Research Program.* http://sarasotadolphin.org/2012/01/17/single-pin-satellite-linked-transmitter-design-and-testing/. January 07, 2012.
- B. Balmer, R. Wells, L. Howle “*Single-pin satellite-linked transmitter design and testing”. Nicks n Notches*: Annual summary of the activities and findings of the Sarasota Dolphin Research Program, a collaborative component of the Chicago Zoological Society’s Dolphin Research and Conservation Institute. Chicago Zoological Society. January 2012.
- “From Whales to Fans”. *Mechanical Engineering*. Alan S. Brown. **Cover Article**. May, 2011.
- "Engineers Are Designing Underwater Turbines Inspired by Whales". Design Corner. http://designcorner.blinkr.net/tag/whalepower/. December 01, 2010.
- "Whale of an Idea". Design Engineering. http://www.canadianmanufacturing.com/design-engineering/case-studies/11724-11724. November 01, 2010.
- "Mimicking Mother Nature". Wendee Holtcamp. National Wildlife. 48(1). Dec/Jan 2010 http://www.nwf.org/NationalWildlife/article.cfm?issueID=133&articleID=1789.
- "Dolphin's Flippers Act Like Aerofoils". The Journal of Experimental Biology Highlights 2009. Kathryn Knight.
- "Flipper Forms Follow Function". Natural History Magazine. http://www.naturalhistorymag.com/samplings/281763/flipper-forms-follow-function October 01, 2009.
- "Whale Fins Influence Wind Turbine Design". Windpower Engineering. http://www.windpowerengineering.com/2009/09/14/whale-fins-influence-wind-turbine-design/ September 14, 2009.
- "Wind Turbine that Imitates Flippers Could Increase Efficiency". Discover. http://discovermagazine.com/2008/sep/15-wind-turbine-that-imitates-flippers-could-increase-efficiency. August 15, 2009.
- "10 Wind Turbines That Push the Limits of Design". Popular Mechanics. http://www.popularmechanics.com/technology/industry/4324331.html?nav=RSS20&src=syn&dom=yah_buzz&mag=pop July 09, 2009.
- "The secret right under our (bottle) noses: What dolphins can teach us about hydrodynamics". Scientific American. http://www.scientificamerican.com/blog/60-second-science/post.cfm?id=the-secret-right-under-our-bottleno-2009-06-29 June 29, 2009.

- "Dolphins get a Lift from Delta Wing" National Science Foundation Science 360 News Service. Technology". http://news.science360.gov/archives/20090629.aspx June 29, 2009.
- "Dolphins get a Lift from Delta Wing Technology". The R&D Daily. http://www.rdmag.com/ShowPR.aspx?PUBCODE=014&ACCT=1400000101&ISSUE=0906&RELTYPE=TEST&PRODCODE=00000000&PRODLETT=PT&CommonCount=0 June 29, 2009.
- "Triangles go Underwater and Supersonic". Richard Merritt. http://www.dukenews.duke.edu/2009/06/flippers.html June 29, 2009
- "Dolphins get a Lift From Delta Wing Technology". Science Daily. http://www.sciencedaily.com/releases/2009/06/090626091127.htm June 28, 2009.
- "Dolphins' Flippers act like Aerofoils" Inside JEB. http://jeb.biologists.org/cgi/reprint/212/14/iii June 26, 2009.
- "Dolphins get a Lift From Delta Wing Technology". Eureka Alert. Katherine Knight. http://www.eurekalert.org/pub_releases/2009-06/tcob-dga061809.php June 26, 2009.
- INDEX: Design Award. Finalist. Community category. http://www.indexaward.dk/index.php?option=com_content_custom&view=article&id=168:whalepower-tubercle-technology&catid=10:finalists-2009&Itemid= May, 2009.
- "Predator X" History. Atlantic Productions, Limited. Lucie Ridout, Producer. March 29, 2009.
- "Promising Test Results From First Humpback Whale Inspired Air Foils". Reuters. http://www.reuters.com/article/pressRelease/idUS244054+22-Jan-2009+PRN20090122. January 22, 2009.
- "Defining Good or Bad Design". The New York Times. http://dealbook.blogs.nytimes.com/2009/01/31/defining-good-or-bad-design/.
- "Wind Turbine That Imitates Flippers Could Increase Efficiency". Discover. August 15, 2008. http://discovermagazine.com/2008/sep/15-wind-turbine-that-imitates-flippers-could-increase-efficiency.
- "Wind Turbine That Imitates Flippers Could Increase Efficiency". Now Public. http://www.nowpublic.com/tech-biz/wind-turbine-imitates-flippers-could-increase-efficiency. August 16, 2008.
- "Whale Fin Tech". Discovery Chanel Daily Planet. April 14, 2008.
- Whalepower - A Top 100 Energy Technology - http://peswiki.com/index.php/Directory:WhalePower_Corp.
- "A whale of a tale". The Star. Tyler Hamilton. http://www.thestar.com/article/213475.
- Directory: WhalePower Corp. http://peswiki.com/index.php/Directory:WhalePower_Corp.
- "Research on biomimetic application of humpback whale tubercle technology to wind turbine technology highlighted". Canadian Broadcasting Company telecast from Prince Edward Island.

- "WEICan begins tests on WhalpPower Corp's novel wind turbine blade, modeled on the fin of a humpback whale". North Cape. http://www.weican.ca/news/2007/070802-whalepower-tests.php.
- "Whale Flippers and Wings". Biomimicry Clips. WorldChanging. http://www.worldchanging.com/archives/006012.html. February 5, 2007.
- "Whale-Inspired Wind Turbines. Mimicking the bumps on humpback-whale fins could lead to more efficient wind turbines". MIT Technology Review. http://www.technologyreview.com/Energy/20379/?nlid=918
- Canadian Broadcasting Corporation radio interview on "Quirks and Quarks" http://www.cbc.ca/quirks/archives/03-04/jun12.html.
- Science Update radio interview http://www.scienceupdate.com/june04.html.
- "Designed for Flight". *The Herald-Sun.* May 30, 2004.
- "Ocean Envy". *Science News*. **166(10):** 154-156, September 4, 2004.
- "Bumpy Flying". *Scientific American.* **291(2):** 18-20, August, 2004.
- "Flippered Flight". *Science.* **304(5674):**1106, 21 May, 2004.
- "The shape of the humpback's flippers might hold the secret to more maneuverable submarines". *Natural History.* 24-25, June, 2004.
- "Hvalens luffer gav idé til ny flyvinge" *Illustreret VINDENSKAB* **15/2004:** 21, 14 Oct – 3 Nov, 2004.
- "Mimicking Humpback Whale Flippers May Improve Airplane Wing Design" *Science Daily* http://www.sciencedaily.com/releases/2004/05/040512044455.htm
- "Fluid Dynamics - Humpback's bumpy flippers". Journal of Experimental Biology **207(21):** iv, 2004.
- "Whale of a Rudder". PRISM – American Society of Engineering Education. **14(4):** 13, December, 2004.
- "Mimicking humpback whale flippers may improve airplane wing design". Eureka Alert http://www.eurekalert.org/pub_releases/2004-05/du-mhw051104.php
- "Mimicking humpback whale flippers may improve airplane wing design" *Innovations Reports* http://www.innovations-report.de/html/berichte/verfahrenstechnologie/bericht-29118.html
- "Wings Get Help From Whales" Science a GoGo. http://www.scienceagogo.com/news/20040412020237data_trunc_sys.shtml
- "New Airplane Wing Mimics Humpback Whale Flippers" AquaNews. http://www.vanaqua.org/aquanew/fullnews.php?id=1284
- "How Whales Swim" Abelard. http://www.abelard.org/news/science040515.asp
- "Biochemist: Mimicking Humpback Whale Flippers May Improve Airplane Wing Design; 'No One Had Ever Analyzed Them'" UnderwaterTimes.com http://www.underwatertimes.com/whales/whales.php

- "Mimicking Humpback Whale Flippers May Improve Airplane Wing Design" *Apologetics.org* http://www.apologetics.org/phpBB2/viewtopic.php?t=1215
- "Mimicking Humpback Whale Flippers May Improve Airplane Wing Design" Tell Me About Directory http://www.tellmeabout.co.uk/directory/m/mimicking/readme.htm.

Teaching Experience

ME555.03 Introduction to Scientific Computing (graduate)
ME639.01 Computational Fluid Dynamics and Heat Transfer (graduate)
ME555.08 Probabilistic Pharmacokinetics and Pharmacodynamics (graduate)
ME555.01 Design and Analysis of Wind Turbines (graduate)
ME490.07 Design and Analysis of Wind Turbines (undergraduate)
ME265.05 Introduction to Scientific Computing (graduate)
ME265.01 Advanced Computational Fluid Dynamics (graduate)
ME229 Computational Fluid Dynamics and Heat Transfer (graduate)
CNS201 Topics in Nonlinear Dynamics (graduate survey course)
ME391.04 Short time scale dynamics of the NASDAQ equities market (undergraduate)
ME321.01 Analysis for Mechanical Design (undergraduate, with recitation)
ME165.02 Advanced Manufacturing Engineering (undergraduate, with laboratory)
ME165.01 Manufacturing Engineering (undergraduate, with laboratory)
ME150L Heat and Mass Transfer (undergraduate, with laboratory)
ME141L Mechanical Design and Machine Components (undergraduate, with laboratory)
ME131R Analysis for Mechanical Design (undergraduate, with recitation)
ME126L Fluid Mechanics (undergraduate, with laboratory)
ME125L Modeling and Control of Dynamical Systems (undergraduate, with laboratory)

Research Center Activities

Center for Nonlinear and Complex Systems Seminar Series Organizer, 1997-1998.
Center for Nonlinear and Complex Systems steering committee, 1999-2003.

Reviewer For

National Science Foundation
Physica D
Journal of Aerospace Engineering
Journal of Applied Physiology

Journal of Applied Biotechnology & Bioengineering
Journal of Biomedical Engineering
International Journal of Heat and Mass Transfer
Numerical Heat Transfer
Journal of Heat Transfer
Physics of Fluids
Journal of Fluid Mechanics
Journal of Fluids & Structures
Euro Physics Letters
Experimental Thermal and Fluid Science
Experiments in Fluids
Undersea and Hyperbaric Medicine
Marine Mammal Science
PLoS One

Graduate Students Mentored and Degrees Awarded

Gianluca DiMuro, Ph.D.
Chen-Yi Wu, Ph.D. (co-advised with Prof. Doug Nowacek)
Amy King, Ph.D.
Francis Gregory Murphy IV, Ph.D.
Ashleigh Swingler, Ph.D.
Ethan Hada, Ph.D.
Clark McGehee, Ph.D. (co-advised with Prof. Brian Mann)
Paul Weber, M.S., Ph.D.
Rebecca Simmons, Ph.D.
Michael R. Gustafson, M.S., Ph.D.
Mark M. Murray, M.S., Ph.D.
Nicholas Andriano, M.S.
Jacob Cornman, M.S.
Han Li, M.S.
Mark Campbell, M.S.
Sidney Lebental, M.S.
Jessica McClay, M.S.
Jennifer Niedermeyer, M.S.
Matthew Hasik, M.S.

John Shannon, M.S.
Eric Frandrup, M.S.
Jason, Martin, M.S.
Nancy Moore, M.S.

Last update: 11/28/2023