

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

QD OXFORD UK LIMITED, and
QUANTUM DESIGN INTERNATIONAL INC.,
Petitioners,

v.

MAYBELL QUANTUM INDUSTRIES, INC.,
Patent Owner.

Case No. IPR2026-00291
U.S. Patent No. 12,313,320
Issue Date: May 27, 2025
Title: INTEGRATED DILUTION REFRIGERATORS

**DECLARATION OF ANDREW CASEY, PH.D. IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW OF
U.S. PATENT NO. 12,313,320**

Exhibit 1002

TABLE OF CONTENTS

I.	ENGAGEMENT.....	1
II.	BACKGROUND AND QUALIFICATIONS.....	2
	A. Materials Reviewed.....	2
	B. Qualifications	2
III.	MY UNDERSTANDING OF CERTAIN LEGAL STANDARDS.....	3
	A. Standard of Proof.....	4
	B. Anticipation	4
	C. Obviousness.....	5
IV.	THE '320 PATENT AND ITS PROSECUTION	8
	A. The '320 Patent	8
	B. Priority Date of Claims 3 and 19 of the '320 Patent.....	14
	C. Prosecution History of the '320 Patent	15
V.	The PRIOR ART AND THE LEVEL OF SKILL IN THE ART	22
	A. Level of Ordinary Skill in the Art.....	22
	B. The Considered Prior Art References	23
	1. Batey (Ex.1009)	27
	2. Dain (Ex.1010).....	32
	3. Pressure Wave Systems ("PWS") (Ex.1012 and Ex.1013)	35
	4. Chow (Ex.1011).....	36
	5. Garside (Ex.1007)	40

6.	Wikus (Ex.1008)	44
VI.	CLAIM CONSTRUCTION	49
A.	“Sample Stage” (Claims 2, 3)	50
B.	“Radiation shield” (Claims 3 and 19)	51
C.	“Hermetic opening” (Claim 5)	51
VII.	GROUND 1: CLAIMS 1-6, 8, AND 17-19 ARE OBVIOUS OVER BATEY IN VIEW OF DAIN.....	51
A.	Claim 1	51
1.	1[pre] – “a dilution refrigerator comprising:”	51
a.	“Dilution Refrigerator” Recited in the Preamble Is Not Limiting (Claims 1-6, 8, and 17-19).....	51
b.	Batey Discloses a Dilution Refrigerator.....	53
2.	1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”	55
3.	1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”	58
B.	Claim 2 is Obvious	60
C.	Claim 3 is Obvious	63
D.	Claim 4 is Obvious	66
E.	Claim 5 is Obvious	67
F.	Claim 6 is Obvious	68
G.	Claim 8 is Obvious	69

H.	Claim 17 is Obvious	70
1.	17 [pre] – “a dilution refrigerator comprising:”	70
2.	17[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”	71
3.	17[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber, wherein:”	72
4.	17[c] “the at least one substantially planar surface of the outer housing comprises a first surface disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator”	73
I.	Claim 18 is Obvious	74
1.	18[pre] – “a dilution refrigerator comprising:”	74
2.	18[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”	74
3.	18[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an interior of the outer vacuum chamber,”	74
4.	18[c] “wherein the opening comprises a hinged door.”	74
J.	Claim 19 is Obvious	75
VIII.	GROUND 2: CLAIMS 1-4 ARE OBVIOUS OVER BATEY IN VIEW OF PWS	76
A.	Claim 1 Is Obvious	76
1.	1[pre] – “a dilution refrigerator comprising:”	76
2.	1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”	76

3.	1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”	80
B.	Claim 2 is Obvious	82
C.	Claim 3 is Obvious	82
D.	Claim 4 is Obvious	82
IX.	GROUND 3: CLAIMS 1-6, 8, AND 17-19 ARE OBVIOUS OVER CHOW IN VIEW OF DAIN.....	86
A.	Claim 1 Is Obvious.....	86
1.	1[pre] – “a dilution refrigerator comprising:”.....	86
2.	1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”	87
3.	1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”	89
B.	Claim 2 is Obvious	91
C.	Claim 3 is Obvious	93
D.	Claim 4 is Obvious	95
E.	Claim 5 is Obvious	97
F.	Claim 6 is Obvious	98
G.	Claim 8 is Obvious	100
H.	Claim 17 is Obvious	100
1.	17 [pre] – “a dilution refrigerator comprising:”	100

2.	17[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”	101
3.	17[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber, wherein:”	102
4.	17[c] “the at least one substantially planar surface of the outer housing comprises a first surface disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator”	102
I.	Claim 18 is Obvious	104
1.	18[pre] – “a dilution refrigerator comprising:”	104
2.	18[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”	104
3.	18[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an interior of the outer vacuum chamber,”	104
4.	18[c] “wherein the opening comprises a hinged door.”	104
J.	Claim 19 is Obvious	105
X.	GROUND 4: GARSIDE ANTICIPATES CLAIMS 1-3, 5-6, AND 8	106
A.	Claim 1	106
1.	1[pre] – “a dilution refrigerator comprising:”	106
2.	1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”	108
3.	1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”	110

B.	Claim 2	113
C.	Claim 3	115
D.	Claim 5	118
E.	Claim 6	119
F.	Claim 8	121
XI.	GROUND 5: WIKUS ANTICIPATES OR RENDERS OBVIOUS CLAIMS 1-3, 5, and 17-19.....	122
A.	Claim 1	122
1.	1[pre] – “a dilution refrigerator comprising:”.....	122
2.	1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”	124
3.	1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”	125
B.	Claim 2	128
C.	Claim 3	130
D.	Claim 5	133
E.	Claim 17	134
1.	17[pre] – “a dilution refrigerator comprising:”	134
2.	17[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”	134
3.	17[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber, wherein:”	134

4.	17[c] “the at least one substantially planar surface of the outer housing comprises a first surface disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator.”	134
F.	Claim 18	135
1.	18[pre] – “a dilution refrigerator comprising:”	135
2.	18[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”	135
3.	18[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber,”	136
4.	18[c] “wherein the opening comprises a hinged door.”	136
G.	Claim 19	137
XII.	SUMMARY OF OPINIONS	138

PETITIONER’S EXHIBIT LIST

Exhibit	Description
Ex. 1001	U.S. Patent No. 12,313,320 (the “’320 Patent”)
Ex. 1002	Declaration of Andrew Casey, Ph.D.
Ex. 1003	Principles of dilution refrigeration: A brief technology guide, Oxford Instruments (2015)
Ex. 1004	Prosecution History of the ’320 Patent
Ex. 1005	U.S. Provisional Application No. 63/319,428
Ex. 1006	U.S. Provisional Application No. 63/219,795
Ex. 1007	U.S. Application Publication No. 2012/0102975 (“Garside”)
Ex. 1008	<i>Dilution Refrigeration of Multi-Ton Cold Masses</i> (“Wikus”)
Ex. 1009	U.S. Patent No. 9,816,750 (“Batey”)
Ex. 1010	U.S. Patent Application Publication No. 2009/0113899 (“Dain”)
Ex. 1011	U.S. Patent Application Publication No. 2022/0221105 (“Chow”)
Ex. 1012	International Patent Application Publication No. WO2020/182671 (“PWS”)
Ex. 1013	Certified English Translation of PWS
Ex. 1014	Integration of Superconducting Magnets with Cryogen-Free Dilution Refrigerator Systems, <i>Cryogenics</i> 49 (2009) 727-734
Ex. 1015	Confirmation by Technische Universität Wien Library
Ex. 1016	EURECA Conceptual Design Report, <i>Physics of the Dark Universe</i> (2014) 3:41-74
Ex. 1017	<i>Curriculum Vitae</i> of Andrew Casey, Ph.D.

I, Andrew Casey, hereby declare as follows:

I. ENGAGEMENT

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

2. I have been retained by QD Oxford UK Limited and Quantum Design International Inc. (collectively, “Petitioners”) in connection with the above-captioned petition for *Inter Partes* Review (“IPR”) of U.S. Patent No. 12,313,320 (the “’320 Patent” or “Ex.1001”). I understand the ’320 Patent is currently assigned to Maybell Quantum Industries, Inc. (“Patent Owner”).

3. I have been asked by Petitioners to offer opinions regarding the ’320 Patent, including whether the claims (which I may refer to subsequently as the “Challenged Claims”) are valid in view of certain prior art. This declaration sets forth the opinions I have reached to date regarding these matters.

4. I am being compensated by Petitioners at my standard hourly consulting rate of \$300 for my time spent on this matter. My compensation is not contingent on the outcome of the IPR or on the substance of my opinions.

5. I have no financial interest in Petitioners or Patent Owner.

II. BACKGROUND AND QUALIFICATIONS

A. Materials Reviewed

6. In forming my opinions, I have reviewed the '320 Patent, its prosecution history/file wrapper, and considered each of the documents listed in the Exhibit List above and the other references cited in my declaration.

7. In reaching my opinions, I have relied upon my experience in the field and also considered the viewpoint of a person of ordinary skill in the art at the time of the earliest claimed priority date of the '320 Patent, *i.e.*, July 8, 2021. As explained below, I am familiar with the level of skill of a person of ordinary skill in the art regarding the relevant technology at issue as of that time.

B. Qualifications

8. I am a Professor of Physics at Royal Holloway, University of London in Egham, England, where I am also the Director of Research for the Physics Department.

9. I have an MPhys Physics degree from Reading University (1993-1997), which was a four-year integrated Masters degree that combined a three-year Bachelor of Science degree with a one-year Masters of Science degree. I also have a Ph.D. in low temperature physics from Royal Holloway, University of London (1997-2001).

10. From 2001 through 2007, I worked as a Post-Doctoral Research

Associate at Royal Holloway, University of London. In 2007, I became an Engineering and Physical Sciences Research Council (EPSRC) Advanced Research Fellow at Royal Holloway, University of London. In 2012, I became a Lecturer at Royal Holloway, University of London. In 2016, I was promoted to Reader at Royal Holloway, University of London. From 2024 to the present, I have been a Professor of Physics at Royal Holloway, University of London.

11. I have published over 75 papers in the field of low temperature physics. I have designed and created products for use in the field of low temperature physics, including cryostats incorporating dilution refrigerators.

12. Additional information regarding my background, qualifications, publications, and presentations is included as part of my CV, which is provided as Ex.1017.

13. It is for at least these reasons that I am well qualified to opine on the matters covered in this declaration and to testify as one skilled in the art with respect to cryostats and dilution refrigerators.

III. MY UNDERSTANDING OF CERTAIN LEGAL STANDARDS

14. I have been asked to provide my opinion as to whether the claims of the '320 Patent would have been obvious to a person of ordinary skill in the art ("POSITA") at the time of the alleged invention, in view of the prior art.

15. The opinions expressed in this declaration are based on an application of my training, technical knowledge, and experience to evaluate certain prior art to the '320 Patent.

16. I am not an expert in patent law. Counsel for petitioners have provided me with guidance as to the applicable patent law in this matter. The paragraphs below express my understanding of how I must apply current principles related to my analysis.

A. Standard of Proof

17. I understand that in an *inter partes* review proceeding, a claim's patentability is evaluated by the Board based on a preponderance of the evidence standard. In other words, Petitioners must demonstrate that it is more likely than not that each individual claim is invalid as being anticipated or obvious, or otherwise invalid under other grounds.

B. Anticipation

18. I have been instructed as to the definition of "anticipation" in the context of United States patent laws. I understand that for a patent claim to be anticipated (and thus rejected as not novel), every single element of that claim must be found, either expressly or inherently, in a single previous device/system or method that was known of, used, or described in a single previous printed publication or patent. To anticipate the invention, the prior art does not have to use

the same words as the claim, but all features of the claim must have been disclosed, either stated expressly or impliedly to a POSITA in the technology of the invention, so that looking at that one reference, that person could make and use the claimed invention.

C. Obviousness

19. I have been instructed as to the definition of “obviousness” in the context of U.S. patent laws. It is my understanding that in determining whether a patent claim is obvious in view of the prior art, the U.S. Patent Office construes the claim by giving the claim its ordinary and customary meaning ascribed to it by a person of ordinary skill in the relevant field at the time of the invention, consistent with the specification. I also understand that in reading the claim, I must not import limitations from the specification into the claim terms; in other words, I must not narrow the scope of the claim terms by implicitly adding disclosed limitations that have no express basis in the claims.

20. I understand that a claim is “obvious,” and therefore unpatentable, if the claimed subject matter as a whole would have been obvious to a POSITA at the time of the alleged invention. I also understand that an obviousness analysis takes into account the scope and content of the prior art, the differences between the claimed subject matter and the prior art, and the level of ordinary skill in the art at the time of the invention.

21. It is my understanding that to ascertain the scope of the prior art, one examines the field of the inventor's endeavor and the particular problem with which the inventor was faced. Two separate tests define the scope of analogous art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed and, (2) if the reference is not within the field of the inventor's endeavor, whether the reference is reasonably pertinent to the particular problem with which the inventor was faced. The purpose of both the invention and the prior art are important in determining whether the reference is reasonably pertinent to the problem the invention attempts to solve.

22. I also understand that in determining the differences between the prior art and the claims, the question under the obviousness inquiry is not whether the differences themselves would have been obvious, but whether the claimed invention as a whole would have been obvious. In considering whether a claimed invention is obvious, I understand that one may find obviousness if, at the time of the patent's alleged invention, there was a reason that would have prompted a POSITA to combine the known elements in a way the claimed invention does, taking into account factors that may include: (1) whether the claimed invention provides an obvious solution to a known problem in the relevant field; (2) whether the claimed invention was merely the predictable result of using prior art elements according to their known functions; (3) whether the prior art teaches away from

combining elements in the claimed invention; (4) whether the prior art teaches the desirability of combining elements in the claimed invention; (5) whether it would have been obvious to try the combination of elements, such as when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions; and (6) whether the change resulted more from design incentives or other market forces.

23. I understand that in order to find that the prior art renders the invention obvious, one must find the combination of prior art could have been completed by a POSITA with a reasonable expectation of success. I also understand that it is impermissible to find obviousness based on hindsight reasoning, *i.e.*, starting backwards from the patent's claims to combine the prior art.

24. I further understand that secondary considerations of non-obviousness include commercial success, long-felt but unsolved needs, failure of others, unexpected results, initial industry skepticism, acceptance and praise in the field, market impacts of seemingly minor technical differences, and evidence of third-party copying. I further understand that such factors must always be considered when present.

IV. THE '320 PATENT AND ITS PROSECUTION

A. The '320 Patent

25. I have reviewed the '320 Patent (Ex.1001) and its prosecution history before the United States Patent and Trademark Office (Ex.1004).

26. I understand the application that resulted in U.S. Patent No. 12,313,320 was filed as a utility application on July 8, 2022, as U.S. Application No. 17/860,950 (the "'950 application"). Ex.1001. I understand the '950 application claims the benefit of U.S. Provisional Application No. 63/319,248, filed on March 11, 2022, (herein the "'248 Provisional"), and U.S. Provisional Application No. 63/219,795, filed on July 8, 2021 (herein the "'795 Provisional"). Ex.1001; Exs.1005-06. I further understand the '950 application was filed with 20 claims, of which claim 1 was independent.

27. The '320 Patent names Corban I. Tillemann-Dick, Kyle J. Thompson, Bryan J. Choo, John Ogando Dos Santos Allan, and Jonathan Michael Byars as inventors. Ex.1001.

28. The '320 Patent's Abstract states:

A dilution refrigerator is provided. The dilution refrigerator includes an outer vacuum chamber comprising at least one substantially planar surface and an opening in the at least one substantially planar surface configured to provide access to an interior of the outer vacuum chamber.

Ex.1001, Abstract.

29. The Background section states that dilution refrigerators are cryogenic devices that rely on ^3He and ^4He isotopes to provide cooling down to 2 mK and 1 K. Ex.1001 at 1:18-21. The Background makes a distinction between “classic” or “wet” dilution refrigerators that precool the $^3\text{He}/^4\text{He}$ mixture using liquid nitrogen and ^4He baths before further cooling and “modern” or “dry” dilution refrigerators that precool the $^3\text{He}/^4\text{He}$ mixture using devices such as a cryocooler rather than cryogenic liquid baths. Ex.1001 at 1:21-27.

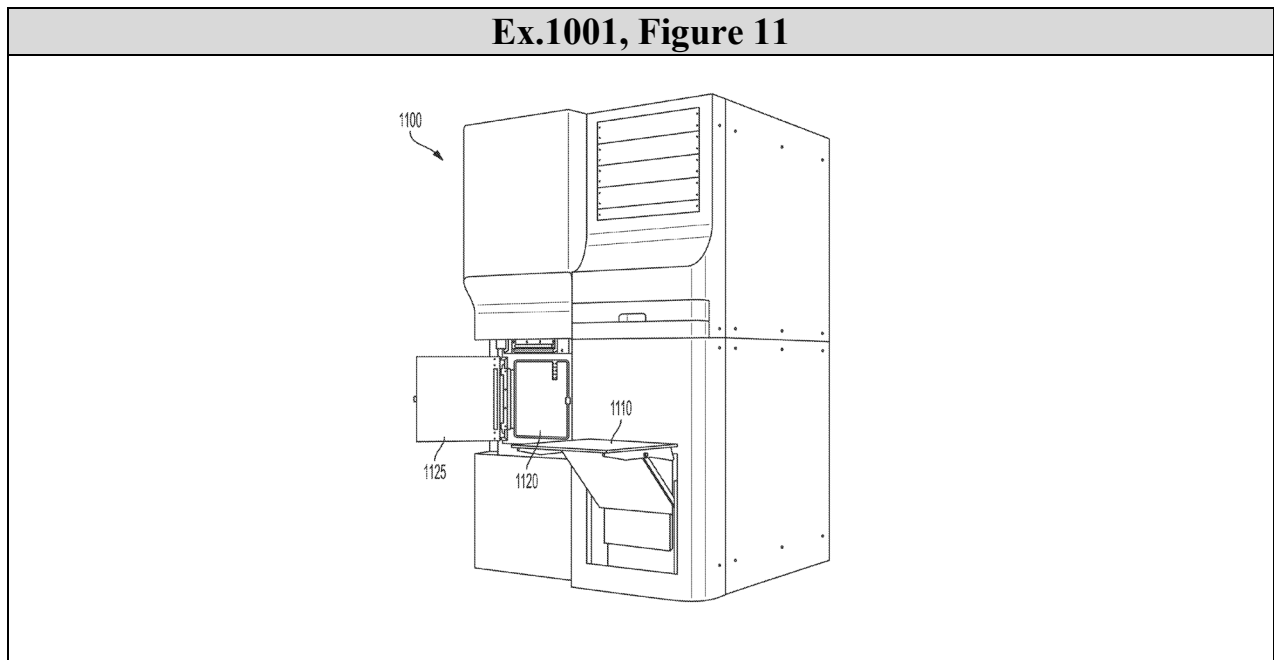
30. The Summary section describes a dilution refrigerator using the claim language. Ex.1001 at 1:31-2:31.

31. The '320 Patent relates to dilution refrigerators with features that “ease maintenance,” “speed cooling of the dilution refrigerators without the use of mechanical pumps,” and “to reduce the transmission of mechanical vibrations to the experimental volume of the dilution refrigerator.” Ex.1001, 4:30-36. I understand the inventors of the '320 Patent sought to address the need for “reliable, easy-to-use, easy-to-maintain, and compact dilution refrigerators.” Ex.1001, 4:23-27. “The Detailed Description describes several embodiments and focuses on many unclaimed features. For instance, the '320 Patent describes some embodiments in which a user may access the “experimental volume 124” when the “dilution refrigerator 100 is not in operation through an opening in the vacuum chamber 106 and door 125.” Ex.1001, 13:7-9. The '320 Patent also describes, in some

embodiments, “door 125 ... is a removable panel (e.g., secured with mechanical fasteners) or may be a hinged door that a user may open using a clamped handle (e.g., as shown in the example of FIG. 10A[]).” Ex.1001, 13:9-13. Figure 10A of the ’320 Patent shows a vacuum chamber 106 which “may include an external opening to provide access to an internal volume within the refrigerator 100” and the opening may “provide access to a sample stage or experimental volume of the dilution refrigerator 100, or any other interior portion of the refrigerator 100.” Ex.1001, 19:11-14. “In some embodiments, the opening may be sealed by a hermetic seal” and “[i]n some embodiments, the opening may be sealed by a door 1070.” Ex.1001, 19:14-16. The door 1070 may be “sealed using a hinge and/or a clamp that may be manually engaged and disengaged.” Ex.1001, 19:17-19.

32. The specification further describes Figure 11 as showing an outer housing 1100 which “may include an integrated horizontal surface 1110,” such as a “desk or support surface when the user interacts with the dilution refrigerator.” Ex.1001, 19:44-49. The specification also describes how “the outer housing 1100 may further include a door 1125 providing access through an opening 1120 to the experimental volume of the dilution refrigerator 100.” Ex.1001, 19:56-59. Door 1125 “may open to provide access to the experimental volume through the vacuum chamber 106 and the radiation shields inside of the vacuum chamber 106.” Ex.1001, 19:59-62. The radiation shields “may be coupled to door 1125 such that

when a user opens the door 1125, the user opens the vacuum chamber exterior 106 and/or the radiation shields.” Ex.1001, 19:62-66. The specification states that the radiation shields “may alternatively be slidably and/or hingedly movable such that the user may move the radiation shields ... [to] no longer block access to the experimental volume.” Ex.1001, 19:66-20:3. Figure 11 is shown below.



33. The specification also describes an inverted dilution refrigerator 1200, as shown in Figure 12. The inverted dilution refrigerator 1200 is described to “include a pump system 1202 configured to circulate the $^3\text{He}/^4\text{He}$ mixture.” Ex.1001, 20:26-30. The inverted dilution refrigerator 1200 may also “include a cryocooler 1204” that “is coupled to a cryocooler support” and may “include an outer vacuum chamber 1206 and a series of thermal stages 1208*a*-1208*f* disposed inside of the outer vacuum chamber 1206.” Ex.1001, 20:30-38. “The series of

thermal stages 1208a-1208f may be held at same or similar temperatures as thermal stages 108a-108f described in connection with FIG. 1,” namely, “an outer vacuum chamber 106 at room temperature (e.g., approximately 300K) and a number of thermal stages 108a-108f (e.g., thermalization plates) held at decreasing temperature intervals (e.g., approximately 50 K, 9-10 K, 3 K, etc.).” Ex.1001, 4:40-45, 20:38-41.

34. The specification indicates that dilution refrigerator 1200 may include an opening in the outer vacuum chamber 1206 and/or through the inner radiation shields to provide ease of access to the coldest stage of the inverted dilution refrigerator 1200, i.e. the experimental volume. For instance, the specification describes additional embodiments where “the inverted dilution refrigerator 1200 may include an opening in the outer vacuum chamber 1206 and/or through the inner radiation shields to provide ease of access to the coldest stage of the inverted dilution refrigerator 1200” and “the opening may comprise hermetic seals and/or an opening mechanism 1225 that may withstand the vacuum within the outer vacuum chamber when the inverted dilution refrigerator 1200 is in operation.” Ex.1001, 20:42-50. Examples of opening mechanism 1225 “may include a hinged door and/or a removable panel.” Ex.1001, 20:50-51.

35. The inverted dilution refrigerator 1200 may also “include a number of components arranged along the length of the refrigerator (e.g., from within the

vacuum chamber 1206 to within the sixth thermal stage 1208f)” and these components “may be arranged with the coldest thermal stage, the mixing chamber 1224, disposed above warmer thermal stages (e.g., still 1214, impedance stages 1212 and 1216, heat exchangers 1218, 1219, 1220, etc.).” Ex.1001, 20:52-59. The inverted dilution refrigerator 1200 may also include a de-mixing chamber 1222 that “may be coupled to the mixing chamber 1224,” for example, “thermally coupled to the mixing chamber 1224 by a heat exchanger 1223 (e.g., a co-flow heat exchanger).” Ex.1001, 20:60-65.

36. The Challenged Claims of the '320 Patent relate generally to dilution refrigerators with certain features that are accessible through the opening, certain arrangements of the surface of the dilution refrigerator, certain types of openings, and certain sections of the dilution refrigerator. For instance, I understand that claims 1, 17, and 18 relate to dilution refrigerators that include a vacuum chamber with an outer housing having at least one substantially planar surface with an opening configured to provide access to the experimental volume within the vacuum chamber's interior. In addition, I understand that claims 2 and 3 relate to a dilution refrigerator with a sample stage and whether it is accessible through the opening. I also understand claims 4 and 17 relate to the arrangement of the surface of the dilution refrigerator and whether it has surfaces that are perpendicular and parallel to the plane of the floor. Claims 5 and 18, which I understand are related to

the opening of the dilution refrigerator, require that the opening be a hermetic opening or a hinged door. I further understand claims 6 and 8 to be directed to the dilution refrigerator having a first and second section while claims 3 and 19 relate to radiation shields within the dilution refrigerator being slidable or removable to provide access to the sample stage or interior of the vacuum chamber.

B. Priority Date of Claims 3 and 19 of the '320 Patent

37. With respect to effective filing dates, it is my opinion that claims 3 and 19 of the '320 Patent have an earliest effective filing date of March 11, 2022. The '795 Provisional, filed July 8, 2021, included claim B14, which recited:

The dilution refrigerator of claim B12, wherein the *one or more openings comprise hinged doors and/or removable panels*.

Ex.1006, 18:26-27.

38. The '795 provisional application also provided:

The inverted dilution refrigerator 800 may include an *opening 810 in the outer vacuum chamber 806 and/or through the inner radiation shields 808a-808c to provide ease of access to the coldest stage of the inverted dilution refrigerator 800*.

Ex.1006, 11:11-14.

39. In my opinion, the '795 Provisional does not explicitly disclose that “portions of the *one or more radiation shields proximate the sample stage are slidable and/or removable to provide access* to the sample stage” as recited in

claim 3 of the '320 Patent, and does not disclose that “portions of the *one or more radiation shields proximate the hinged door are slidable and/or removable to provide access* to the interior of the outer vacuum chamber” as recited in claim 19 of the issued '320 Patent.

40. Therefore, it is my opinion that claims 3 and 19 are not entitled to an effective filing date of July 8, 2021.

41. I note that in the '248 Provisional which was filed on March 11, 2022, claim D42 states:

The dilution refrigerator system of claim D40, wherein *one or more radiation shields of the dilution refrigerator may be slidably and/or hingedly moveable to provide access to the experimental volume.*

Ex.1005, 38:10-12.

42. In my opinion, this is the first explicit mention of slidable or movable radiation shields in the priority filings for the '320 Patent. Therefore, it is my opinion that claims 3 and 19 are entitled to the March 11, 2022 effective filing date of the '248 Provisional.

C. Prosecution History of the '320 Patent

43. As I noted previously, I understand the application that resulted in the '320 Patent was filed on July 8, 2022 with the United States Patent and Trademark Office (“USPTO”). Ex.1004 at 476. On November 7, 2024, the USPTO Examiner issued a non-final Office Action rejecting claims 1-2, 4, 6-7, and 16-20 on several

grounds and objecting to claims 8, 12, and 14-15. Ex.1004 at 106-14. Claims 16-20 were rejected under 35 U.S.C. § 112 as being indefinite as to the language “server rack-type container.” Ex.1004 at 109. Claims 1-2 and 4-6 were rejected under 35 U.S.C. § 102(a)(1) as being anticipated by Hart (U.S. Patent Application Publication No. 2021/0076530). Ex.1004 at 110. Claims 1-2 were rejected under 35 U.S.C. § 102(a)(1) as being anticipated by Mikheev (U.S. Patent No. 6,202,439). Ex.1004 at 111. Claim 7 was rejected under 35 U.S.C. § 103 as being unpatentable over Hart. Ex.1004 at 112-13.

44. Application claims 8, 12, and 14-15 were objected to as being dependent upon a rejected base claim, but the Office Action stated the claims “would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.” Ex.1004 at 113. Application claim 8 was directed to hinged/removable radiation shields housed within the outer vacuum chamber. *See* Ex.1004 at 471. Claim 12 was directed to removable sections of the refrigerator. *See* Ex.1004 at 471. Claims 14-15 were directed to external systems for lifting or lowering respective sections of the refrigerator. *See* Ex.1004 at 471-72.

45. In rejecting application claim 7, the examiner provided:

Although Hart discloses wherein the opening comprises a door #425, Hart does not disclose wherein said door is a hinged door. Nonetheless, going from a door closed by fasteners to a door closed by hinged would have been

obvious to an ordinary skill artisan, as hinged doors are well known in the art (official notice).

Ex.1004 at 113.

46. On January 28, 2025, I understand the applicant and the Examiner conducted an Applicant-Initiated Interview. Ex.1004 at 78. The Interview Agenda states:

Applicant's representatives would like to discuss the rejection of independent claim 1 under 35 U.S.C. § 102 over cited reference Hart and how the Office is reading Hart to disclose "an opening in the at least one substantially planar surface" of the outer vacuum chamber when Hart fails to describe any vacuum chamber, as conceded in the Office Action (p. 4). Rather, the enclosure 320 described in Hart is mounted directly to mixing chamber plate 210 internal to the cryogenic device to thermalize enclosure 320 and the quantum computing devices housed therein, and thus, does not relate to an opening through an outer vacuum chamber of the cryogenic device (Hart ¶ 35).

Ex.1004 at 78.

47. The Interview Summary indicates that agreement was reached on the 35 U.S.C. §112 issues and that:

Agreement appeared to be reached that reciting that "the opening is provided on the housing of the vacuum chamber", "the planar surface is part of the outer housing of the vacuum chamber", or similar language would over the rejection by Hart.

Agreement appeared to be reached that reciting that "the opening extending through the vacuum chamber", or "the opening operable to open and close so as to provide access to the vacuum chamber", or similar language would

overcome the rejection by Mikheev.

Ex.1004 at 78.

48. On February 7, 2025, I understand applicant filed its response to the non-final Office Action. Ex.1004 at 62. Claim 1 was amended to recite:

A dilution refrigerator comprising: an outer vacuum chamber comprising an outer housing having at least one substantially planar surface; and an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”

Ex.1004 at 63 (amendments underlined).

49. Claim 2 was amended to recite:

The dilution refrigerator of claim 1, further comprising a sample stage housed within the experimental volume ~~outer vacuum chamber~~, wherein the opening is configured to provide access to the sample stage through the outer vacuum chamber.” (Amendments shown underlined and stricken-through).

Ex.1004 at 63 (amendments shown underlined or stricken).

50. Claims 16 through 19 were amended to change the language from “rack-type” to “rack”. Ex.1004 at 65-66.

51. Claim 4 was amended to recite:

A dilution refrigerator comprising:

an outer vacuum chamber comprising an outer housing
having at least one substantially planar surface; and

an opening in the at least one substantially planar surface
of the outer housing configured to provide access to an

experimental volume disposed within an interior of the outer vacuum chamber,

wherein the at least one substantially planar surface of the outer housing comprises a first surface disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator.

Ex.1004 at 63-64 (amendments underlined).

52. Claim 7 was also amended as follows:

A dilution refrigerator comprising:

an outer vacuum chamber comprising an outer housing having at least one substantially planar surface; and

an opening in the at least one substantially planar surface configured to provide access to an interior of the outer vacuum chamber,

wherein the opening comprises a hinged door.

Ex.1004 at 64 (amendments underlined).

53. The February 7, 2025, Amendment also added claim 21, which recites:

The dilution refrigerator of claim 8, wherein:
the portions of the one or more radiation shields that are
slidable and/or removable are coupled to the hinged door.

Ex.1004 at 66.

54. In the Remarks to the February 7, 2025 Amendment, the applicant stated that Hart and Mikheev do not describe an outer vacuum chamber comprising an outer housing and an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber. *See* Ex.1004 at 70. The Remarks

state:

Hart describes an enclosure 320 for thermalizing and securing a quantum computing device directly to the mixing chamber plate 210 on the interior of a cryogenic device (Hart, Abstract, ¶ 34). While enclosure 320 includes an opening covered by cover 425, enclosure 320 is fully internal to the cryogenic device 400, and would be fully enclosed by the outer vacuum chamber, as conceded by the Office Action (Hart, FIG. 4, ¶ 44; Office Action, p. 5). Because the enclosure is fully internal to the cryogenic device, Hart fails to describe any “opening in the at least one substantially planar surface of the outer housing,” as required by amended claim 1.

...

Mikheev describes a cryogenic device including a cryostat 1 and a dilution refrigerator inserted along the central axis of the cryostat (Mikheev, see FIGs. 1 and 2 (reproduced below) and Col. 5, Lines. 14-33). When the dilution refrigerator is inserted into an opening on the top of the cryostat 1 (Col. 5, Lines 29-30), the cited opening (through plate adjacent the port 8A) fails to “provide access to an experimental volume disposed within the interior of the outer vacuum chamber” as required by claim 1. Rather, the experimental volume of Mikheev, depicted in FIGs. 2 and 3 as extension tail 27, is accessible only through bore 11 “which defines a probe access path” (Col. 5, Line 34)... However, as shown in FIG. 1, tube 60 is not an opening in outer wall 2 or an opening in the cited plate adjacent port 8A. Mikheev therefore does not describe an “opening in the at least one substantially planar surface of the outer housing” as required by amended claim 1.

Ex.1004 at 70-71.

55. The February 7, 2025, Remarks also addresses the Office Action’s official notice that “going from a door closed by fasteners to a door closed by hinge[s] would have been obvious to an ordinary skill[ed] artisan,” and states:

The outer vacuum chamber for a dry dilution refrigerator is a specialized device designed to maintain an internal pressure several orders of magnitude below typical atmospheric pressure. Proper sealing of the outer vacuum chamber is needed to maintain the low internal pressure within the vacuum chamber, to prevent atomic and molecular contaminants from entering the vacuum chamber, and to prevent valuable purified ³He or ⁴He from leaking out of the vacuum chamber. It cannot be said that the use of hinged doors rather than fasteners is beyond dispute or “capable of instant and unquestionable demonstration as being well-known” within the *specialized technical area of cryogenic vacuum devices*. As such, the Office’s reliance on taking official notice of this purported fact is improper, and Applicant respectfully requests citation to evidentiary support in the record if the rejection under 35 U.S.C. § 103 is to be maintained, as required. See *In re Zurko*, 258 F.3d 1379, 1385 (Fed. Cir. 2001).

Ex.1004 at 73 (emphasis added).

56. The USPTO issued a Notice of Allowance and Notice of Allowability on April 3, 2025. Ex.1004 at 12-18. I understand the Reasons for Allowance did not address the “hinged” door argument in the February 7, 2025, Remarks and instead stated:

The prior art does not anticipate nor render obvious the combination set forth in the independent claims, and specifically does not disclose an outer vacuum chamber comprising an outer housing having at least one substantially planar surface; and an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber. There is no teaching in the prior art of record that would, reasonably and absent impermissible hindsight, motivate

one of ordinary skill in the art to modify the teachings of Hart to incorporate the aforementioned limitations.

Ex.1004 at 17.

57. Accordingly, I understand U.S. Patent No. 12,313,320 issued on May 27, 2025 from U.S. Patent Application No. 17/860,950, filed July 8, 2022, with claims 1-21. Ex.1004 at 3. Application claims 5 and 6 became patent claims 4 and 5. Application claims 10-18 became patent claims 6-13 and 16. Application claims 19 and 20 became patent claims 14 and 15. Independent application claim 4 became independent patent claim 17, while independent application claim 7 became independent patent claim 18. Application claims 8, 9, and 21 became patent claims 19, 21, and 20, respectively.

V. THE PRIOR ART AND THE LEVEL OF SKILL IN THE ART

A. Level of Ordinary Skill in the Art

58. Based on my review of the '320 Patent and its prosecution history, it is my opinion that a person having ordinary skill in the relevant art at the time of the invention would have a Ph.D. in low-temperature physics or similar educational background, or a mechanical or electrical engineering degree (or similar education) and approximately two years on-the-job experience in designing or manufacturing low-temperature cryocoolers or similar equipment.

59. In light of my education, particularly my education in low-temperature physics, and my familiarity and experience with devices for

maintaining a low temperature, I am a person of ordinary skill in the art of the '320 Patent.

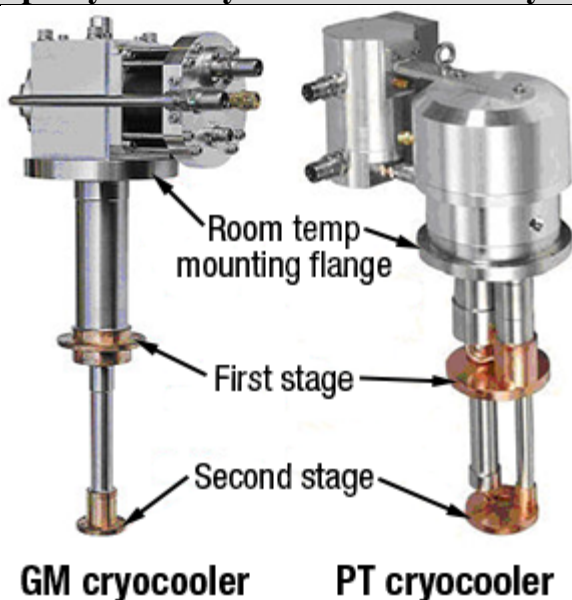
B. The Considered Prior Art References

60. In general, the term “cryostat” refers to a device for maintaining a low temperature, typically containing a vacuum space to thermally isolate the low temperature part from room temperature. Cryostats can range in complexity, from an insulated bucket of liquid nitrogen at 77 K (least complex), to an adiabatic nuclear demagnetization cryostat reaching well below 1 mK (most complex).

61. A dilution refrigerator is a specific realization of a cryostat that typically can reach a temperature of 10 mK. At the time the '320 Patent was filed, over a thousand dilution refrigerators were already manufactured, with the first commercial system having been manufactured in the 1960s.

62. Until the early 2000s, dilution refrigerators required an outer vacuum vessel (called a “dewar”) holding a *liquid* Helium-4 bath, which enclosed an inner vacuum can surrounding the dilution unit. This configuration is known as a “wet fridge.” Since 2004, commercially available “dry fridges” that replace the helium bath with a mechanical cryo-cooler, such as the Gifford-McMahon (GM) coolers or pulse tube (PT) coolers seen below, have been available. “Dry fridges” typically have a single vacuum space with a vacuum housing at room temperature.

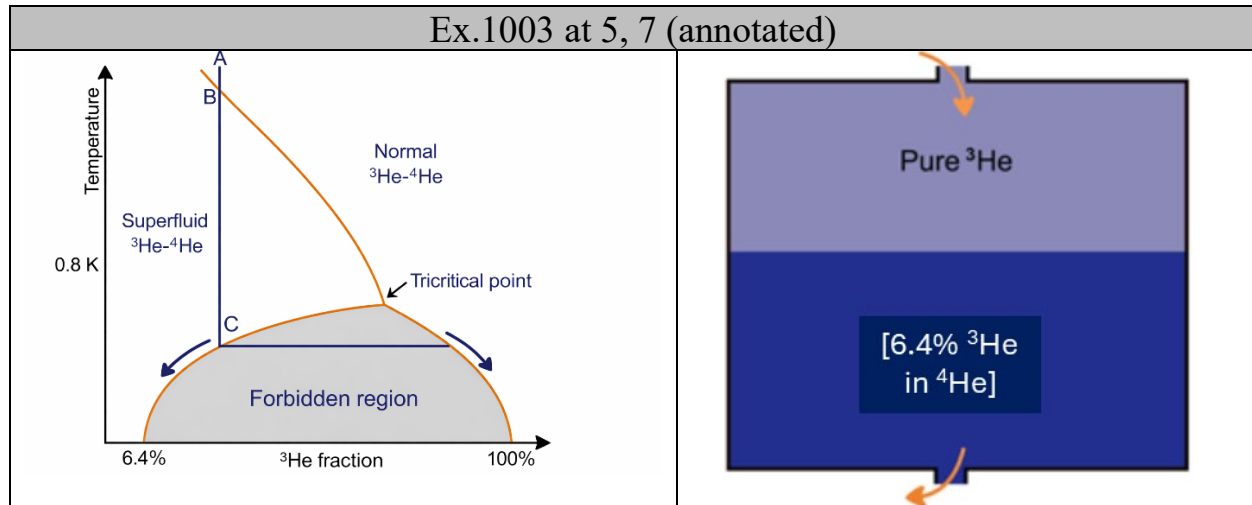
Exemplary GM cryocooler and PT cryocooler¹



63. The distinguishing feature of a “dilution refrigerator” is that the cryostat contains a mixing chamber with a phase boundary between the dilute and concentrated phase of helium mixtures. Cooling in a dilution refrigerator is achieved through spontaneous phase separation of ^3He and ^4He . When a mixture of ^3He and ^4He is cooled below approximately 0.87K, the mixture separates into a concentrated phase (where ^3He is high in concentration) and a dilute phase (where ^3He is low in concentration), as seen below. To illustrate this, I have used figures from “Principles of dilution refrigeration: A brief technology guide” (Ex. 1003) published by Oxford Instruments in 2015. This phase separation is also called demixing, and the dilution refrigerator is also known as a demixing cryostat.

¹ <https://qd-uki.co.uk/what-are-the-differences-between-pulse-tube-and-gifford-mcmahon-cryocoolers/>

64. Removing ^3He atoms from the dilute phase causes ^3He atoms from the concentrated phase to cross the boundary between phases and into the dilute phase. This is an endothermic process that absorbs heat and results in temperatures as low as 10 mK.



65. Although the term “dilution refrigerator” can be used to describe the entire cryogenic system, the “dilution unit” is the part of the system from the still to the mixing chamber. The still of a dilution refrigerator separates ^3He from the mixture using a distilling process based on the difference in vapor pressure between ^3He and ^4He . The higher temperature parts can be identical to those in other cryogenic systems, such as Dry 4K, 1K systems or 300 mK Helium-3 systems. Dilution refrigerators can vary in size from compact (e.g., 50-millimeter diameter) systems that load into a dewar or cryocooler to systems for cooling multi-ton samples or enclosing cubic meter volumes.

66. The advent of dry fridges made access to the interior of a cryostat simpler because the vacuum vessels are not surrounded in liquid Helium-4. As such, where wet fridges are typically cylindrical and allow access to the experimental region from the top or bottom of the outer vacuum vessel, dry fridges permit all sides of the outer vacuum vessel to be used to access the internal volume of the cryostat.

67. To change experimental samples and components in a dry dilution refrigerator, it is common practice to fully remove the multi-part vacuum cans and radiation shields at room temperature, giving access to all spaces inside the cryostat. Different cryostats have a variety of mechanisms to provide ease of access to commonly accessed regions of the cryostat. Here, the major time delay comes from warming the system to room temperature, breaking the vacuum, performing any necessary work, then pumping the system back down to low pressure and cooling back to 10 mK, a process that can take several days for a standard sized cryostat such as the Oxford Instruments Triton 200 or the Bluefors SD system.

68. In examples such as Garside and Batey, discussed below, access to the experimental space was achieved without warming to room temperature, or breaking the cryostat atmosphere. These systems typically have a load lock and mechanical mechanisms to open and close radiation shields while providing the ability to replace a sample in the experimental region. This achievement was much

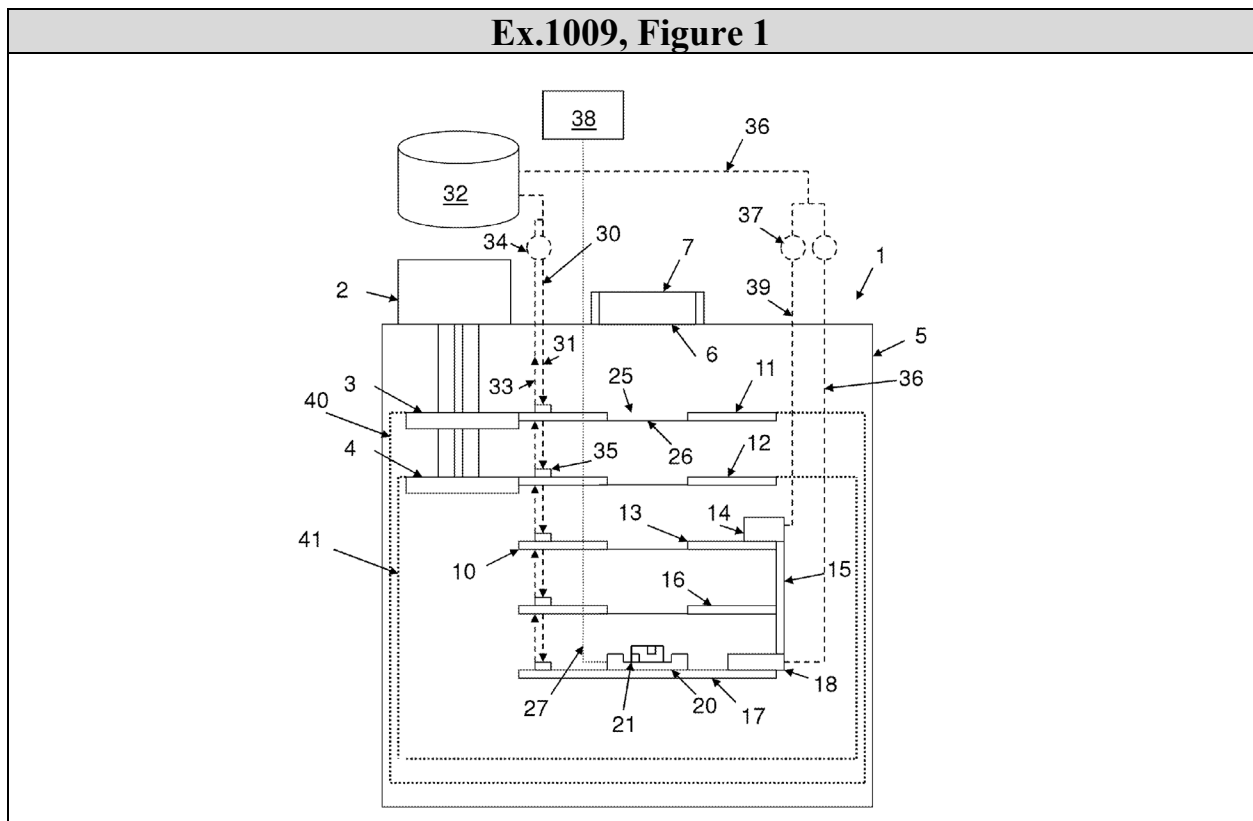
more challenging than that described in the '320 Patent, in which access to an experimental space is achieved at room temperature, after the vacuum chamber has been opened to atmospheric pressure. There are many examples of cryostats with doors or access panels into the vacuum space. If the doors/access panels are operated at room temperature, there is no practical difference between the cryostat being a dilution refrigerator or any other cryogen-free system.

1. Batey (Ex.1009)

69. Batey et. al., U.S. Patent No. 9,816,750, issued on November 14, 2017 and was assigned at the time to Oxford Instruments Nanotechnology Tools Limited (herein “Batey”). Ex.1009. In my opinion, Batey is analogous art to the '320 Patent because it discloses a cryogenic cooling system, in which a target region for receiving a sample is cooled by a dilution refrigerator containing an operational fluid. Ex.1009, 2:27-31. Like the '320 Patent, Batey discusses how cryogenic equipment operating at “low temperatures (less than 100 kelvin) or ultra low temperatures (less than 4 kelvin),” often require changing a sample at the cold part of the equipment. Ex.1009, 1:21-24. Batey also addresses the same unmet need to “speed cooling” because “the cooling power of commercially available coolers ... typically take longer to warm up, change the sample, and cool down.” *Id.*, 1:50-53.

70. Batey issued before the earliest priority date of the '320 Patent, namely, July 8, 2021. I understand Batey is prior art to the '320 Patent under 35 U.S.C. § 102(a)(1).

71. The invention in Batey provides for the “warm” loading of the sample to the target region by removal of the operational fluid from the dilution refrigerator and the pre-cooling of the target apparatus. Ex.1009, 2:41-48. The operational fluid is then returned to the dilution refrigerator once much or all of the pre-cooling has been achieved. Ex.1009, 2:48-50. The dilution refrigerator thereafter further cools the target apparatus to an operational base temperature. Ex.1009, 2:50-52. Batey’s structure is shown in Figure 1 below:



72. Batey discloses cryostat 1 formed as a large hollow stainless steel cylinder with an outer vacuum vessel 5 having an access opening via a central port 6 in a top surface of the vessel 5. Ex.1009, 7:3-7. Batey further describes the port 6 is fitted with a gate valve 7 that is positioned within the port 6 to allow an experimental “probe” to pass into the interior of the cryostat 1 while maintaining the vacuum within the vacuum vessel 5. Ex.1009, 7:7-11. Several consecutive cooling stages 11-16 are disclosed, and a third stage 13, positioned beneath the first and second stages 11, 12, is used as a platform for supporting the still 14 of a dilution refrigerator 15. Ex.1009, 7:25-51. The fifth stage 17 holds a mixing chamber 18 and typically reaches an operational temperature of about 7 to 10 millikelvin when the dilution refrigerator 15 is fully operational. Ex.1009, 7:57-65. Outer 40 and inner 41 radiation shields substantially enclose the third to fifth stages of the multi-stage assembly. Ex.1009, 7:39-44.

73. Batey discloses that each of the first to fourth stages contains an aperture 25 that are positioned “centrally in each disc such that each of the apertures 25 aligns to provide a central bore passing through each of the upper four stages.” Ex.1009, 8:4-8. The apertures in Batey also align with gate valve 7 of port 6. Ex.1009, 8:8-9. Batey describes the purpose of these apertures is to “allow for the insertion of a loading assembly which contains the sample retained in a sample carrier.” Ex.1009, 8:9-11. When the apertures 25 align, bore is provided from the

“coldest part of the system in a “target region” (which contains the docking station 20) and the warmer part of the system adjacent to the gate valve 7.” Ex.1009, 8:13-17. Batey also describes how “each of the apertures 25 is provided with a corresponding baffle 26.” Ex.1009, 8:17-19. The apertures in Batey are described to be “generally circular in shape and each baffle 26 is also in the form of a disc.” Ex.1009, 8:17-19. Batey explains that “[e]ach baffle is hinged to a region adjacent to the edge of the aperture 25 and is biased to a closed position, for example using a spring, such that the baffle 26 covers the aperture 25 in each case.” Ex.1009, 8:19-23. With the aperture 25 covered by the baffle 26, any possible convection or radiation heat load between the port and the target region is reduced. Ex.1009, 8:23-24. Batey also describes an alternative mechanism where “the baffles may be manually rotated away from their apertures by turning a drive rod that has a rotating seal mounted on the top of the cryostat.” Ex.1009, 8:24-27.

74. Batey further discloses that the arrangement within the chamber may take a number of different forms. Ex.1009, 5:10-11. Preferably, the apparatus “comprises a plurality of spatially dispersed stages to which parts of the mechanical and dilution refrigerators are coupled.” Ex.1009, 5:11-13. The stages may be “spaced vertically above one another and held in relative position by very low thermal conductivity supports.” Ex.1009, 5:13-16. One or more of the plurality of stages in Batey has an aperture for receiving the target apparatus. Ex.1009, 5:17-

18. The one or more apertures “defin[e] a bore through which [a] target apparatus” passes prior to arriving at the target region. Ex.1009, 5:18-21. Batey describes that typically, “at least one of the apertures is provided by a baffle that is movable between an open position and a closed position.” Ex.1009, 5:21-24. The baffles “may be moveable using a drive mechanism (such as a rod) or may be biased into a closed position and only [] open when the target apparatus is present to deflect them.” Ex.1009, 5:24-27.

75. Batey discloses that various cryostat and sample loading configurations may be used. Ex.1009, 6:3-4. For example, the system may be a top-loading system, which is the primary system described in Batey, or may alternatively be configured to be a bottom-loading system, in which case the apertures with baffles may be provided through the radiation shields to allow the sample to be loaded. Ex.1009, 6:4-9. Batey also contemplates other configurations, ***including side-loading systems***. Ex.1009, 6:10-11. Batey discloses that “[t]he choice of loading configuration is dependent upon a number of factors including performance, intended functionality and engineering requirements.” Ex.1009, 6:11-13.

76. Batey also discloses a pre-cool circuit 30 where a cooling line 31 provides a path for coolant from an external storage vessel 32 into the cryostat 1. Ex.1009, 9:61-66. Coolant in the cooling line 31 exchanges heat with each of the

first through fifth stages of the cryostat. Ex.1009, 9:66-10:17. The pre-cooled system transmits the cooling power of the pulse tube refrigerator (PTR) stages 3 and 4 to each of the stages 11, 12, 13, 16, 17. Ex.1009, 10:17-19. The pre-cooling system cools the lower stage discs to a temperature approximately equal to that of the second stage of the PTR (between 3.5 and 4 Kelvin). Ex.1009, 10:19-22. Notably, these low temperatures ensure that “the dilution refrigerator 15 may operate [because] it is sufficient to cool a mixture of ^3He and ^4He ,” which is the operational fluid of the dilution refrigerator 15, and cold enough to maintain the mixture in the required liquid phases. Ex.1009, 10:22-26. Batey further describes that, “[f]ollowing the use of the pre-cooling system, a second coolant circuit is used in association with the dilution refrigerator 15 to cool the sample down to millikelvin temperatures.” Ex.1009, 10:26-30.

2. Dain (Ex.1010)

77. U.S. Patent Application Publication No. 2009/0113899 (herein, “Dain”) was filed on November 2, 2007 and published on May 7, 2009. I understand that Dain is prior art to the ’320 Patent under 35 U.S.C. § 102(a)(1). Dain discloses systems and methods “to provide an ultra low temperature (ULT) cryogenic processor apparatus.” Ex.1010 at Abstract. Specifically, Dain discloses an invention for the “storage of samples at ULT ... typically lower than -90 degrees C.” Ex. 1015 at [0001]. Dain also addresses similar unmet needs in the art that the

'320 Patent identifies, such as storage systems “need[ing] to be able to reach the required low temperature, but to continuously maintain that temperature accurately and reliably since even temporary loss of cooling could weaken, damage or even destroy existing supplies ...” *Compare* Ex.1010 at [0002] *with* Ex.1001 at 4:23-27 (describing need for “reliable, easy-to-use, easy-to-maintain, and compact dilution refrigerators.”). Dain describes how refrigeration and cryopreservation systems in the art “have limitations in temperature range and uniformity, capacity and reliability that would preclude their utilization ...” Ex.1010 at [0003]. Dain further describes how “[d]epending on their configuration the open-door time required for loading or unloading samples could allow an unacceptable rise in temperature. Conventional ULT systems without redundant evaporators and/or highly efficient thermal insulation have a very short survival time, typically only a few hours, before loss of set point temperature, in the event of failure due to leakage of refrigerant, line blockage, motor or pump failure, electrical power outage or many other potential causes.” Ex.1010 at [0003].

78. The invention in Dain is described to have multiple advantages, including “a ULT chamber which is made in compact *rectangular* form, as opposed to circular or cylindrical form,” “a *substantially flat vertical door* serving as the front panel of the chamber,” “provid[ing] long term processing of biological material at ultra-low temperature, e.g., down to -90 deg.C, with an ultimate target of

-150 deg.C,” “provid[ing] temperature accuracy independent of ambient conditions of temperature and humidity while maintaining uniformity of temperature throughout the chamber,” “an optimal chamber size and shape and requires minimal floor space,” “low operating costs [] achieved through the cryogenic refrigeration method and insulation efficiency,” “the insulation provid[ing] additional reliability in event of failure of internal tube or external refrigeration source,” “components of the system can be easily accessed for maintenance purposes with minimal side effects,” “design allows for ease of manufacturability and assembly,” and “the preferred embodiments of the system can be flexibly manufactured to different sizes and requirements at a low cost.” Ex.1010 at [0008].

Ex.1010, Figure 7A

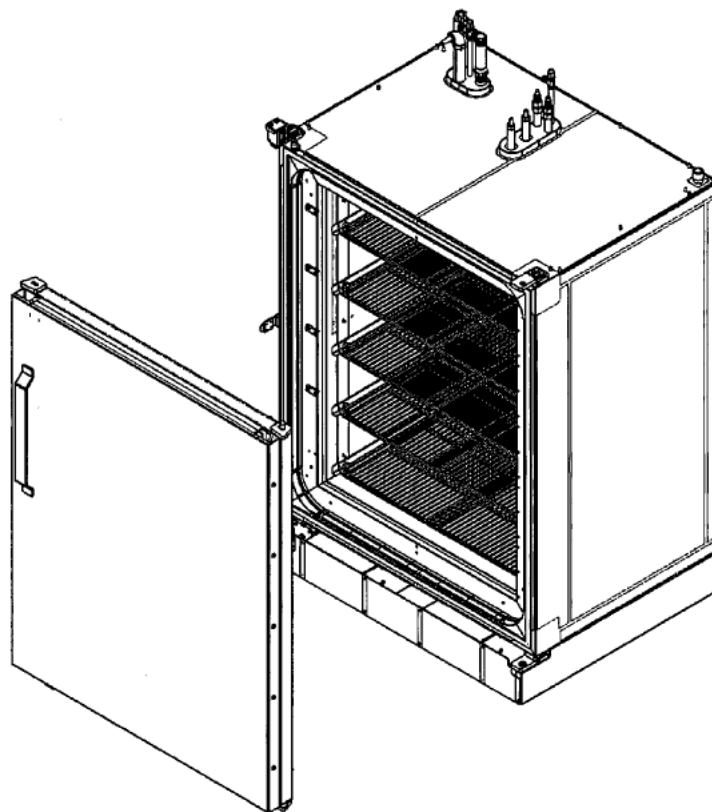


FIG. 7A

3. Pressure Wave Systems (“PWS”) (Ex.1012 and Ex.1013)

79. International Patent Publication No. WO2020/182671 (“PWS”) was filed March 6, 2020, and published on September 17, 2020. PWS claims priority to a German patent application No. 10 2019 203 341.5, filed March 12, 2019. PWS was published before the earliest priority date claimed by the ’320 Patent. I understand that PWS is prior art under §102(a)(1).

80. PWS was published in German, and I was provided with a certified English translation of PWS. My understanding of PWS is based on my review of both the original German patent publication and its English translation.

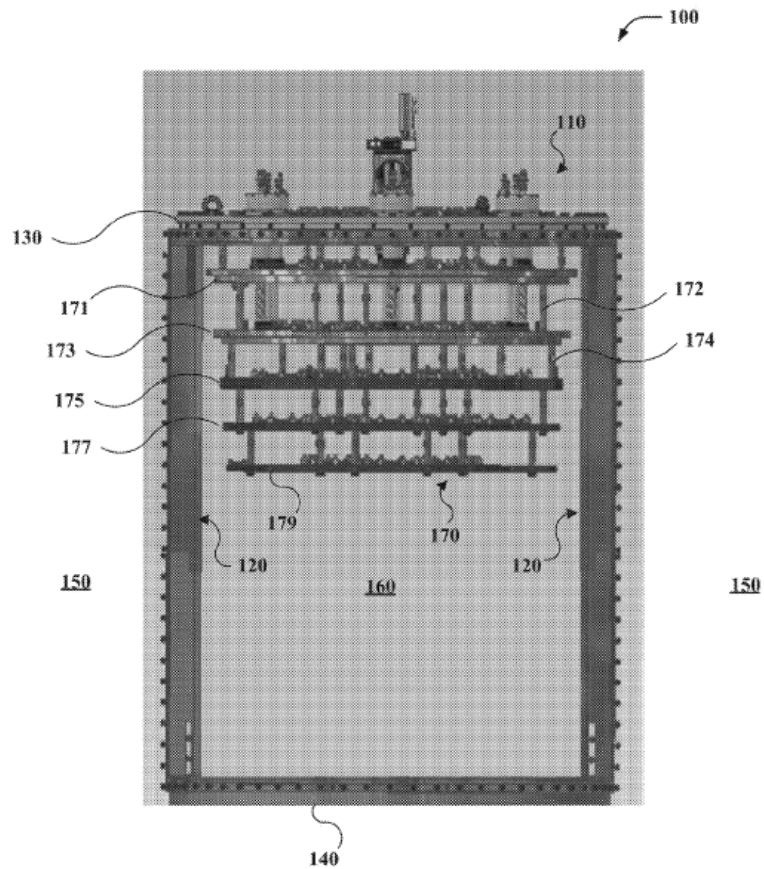
81. PWS discloses a cryostat for experiments at different temperatures, including a temperature below 2K. Ex.1012, Abstract. PWS's cryostat permits improved accessibility for the experimentation places while maintaining a small construction volume. *Id.* PWS also discloses configurations in which experimentation places are arranged next to one another instead of one below the other. *Id.*

4. Chow (Ex.1011)

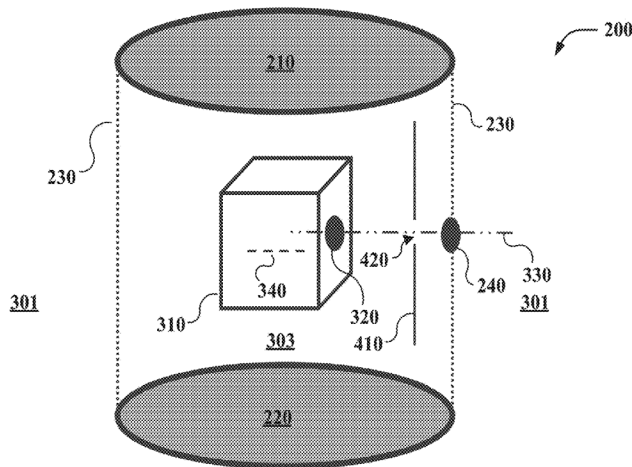
82. U.S. Application Publication No. 2022/0221105 (herein, "Chow") was filed January 8, 2021, and published on July 14, 2022. Chow discloses transfer port systems for cryogenic environments and is analogous art. The application that resulted in the Chow publication was filed before the earliest priority date of the '320 Patent (July 8, 2021), and I understand that Chow is prior art to the '320 Patent under § 102(a)(2).

83. Chow discloses an outer vacuum chamber of a cryostat comprising a sidewall encompassing an inner chamber having a sample mounting surface. (Ex.1011, [0006]). The sidewall comprises a feedthrough port providing access to the sample mounting surface from a region external to the outer vacuum chamber.

(*Id.*). An exemplary embodiment of the Chow system is shown below in cross-section and schematically:



Chow, Fig. 1



Chow, Fig. 4

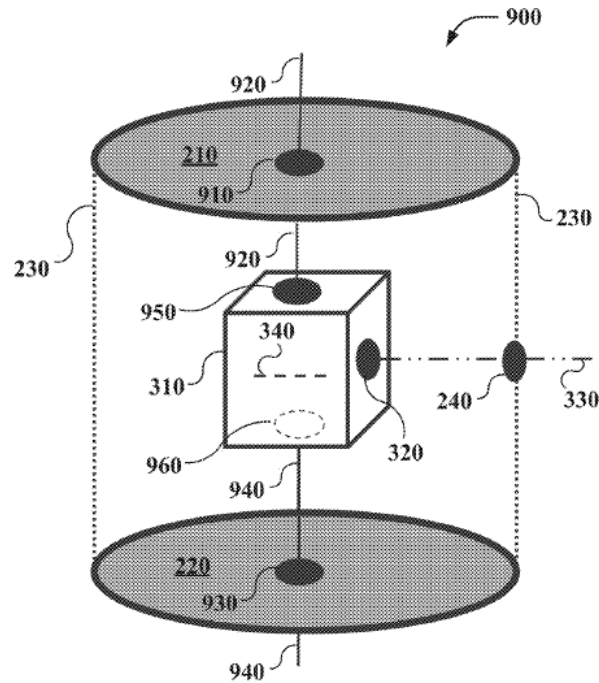
84. Chow discloses cryostat 100 with outer vacuum chamber 110 formed by sidewall 120 intervening between a top plate 130 and a bottom plate 140. (*Id.* [0026]). In operation, outer vacuum chamber 110 maintains a pressure differential between an ambient environment 150 of outer vacuum chamber 110 and an interior 160 of outer vacuum chamber 110. (*Id.*). A plurality of thermal stages 170 are disposed within interior 160, including a still stage 175 and a mixing chamber stage 179. (*Id.*). Chow also discloses that the mixing chamber stage 179 “can be associated with a temperature of 10 mK.” (*Id.*).

85. Chow discloses a thermal shield 410 between feedthrough port 240 and sample mounting surface 340. *See* Ex.1011, [0031] and Fig. 4. The thermal shield 410 can be mechanically coupled to a thermal plate associated with a thermal stage of a cryostat. By virtue of intervening between feedthrough port 240 and sample mounting surface 340, thermal shield 410 can interrupt line of clearance

330. As such, thermal shield 410 can comprise a feedthrough port 420 to facilitate access to sample mounting surface 340 from the region 301 external to outer vacuum chamber 200. In an embodiment, feedthrough ports 240, 320, and/or 420 can be aligned such that those feedthrough ports form a line of clearance 330 between sample mounting surface 340 and the region 301 external to outer vacuum chamber 200.

86. Chow discloses feedthrough port 240 depicted as being positioned approximately equidistant from top plate 210 and bottom plate 220 and describes other possible positions of the port. *See* Ex.1011, [0029]. Chow discloses that feedthrough port 240 can provide access to sample mounting surface 340 of inner chamber 310 from region 301 external to outer vacuum chamber 200. *See* Ex.1011, [0030]. The sample mounting surface 340 can be thermally coupled to a Mixing Chamber stage of a cryostat (e.g., cryostat 100 of FIG. 1). Chow further discloses that inner chamber 310 can comprise feedthrough ports 950 and 960 that align with feedthrough port 910 of top plate 210 and feedthrough port 930 of bottom plate 230, respectively. *See* Ex.1011, [0040]. Feedthrough ports 910 and 950 can be aligned such that those feedthrough ports form a line of clearance 920 between sample mounting surface 340 and the exterior of outer vacuum chamber 900. Feedthrough ports 930 and 960 can be aligned such that those feedthrough ports form a line of

clearance 940 between sample mounting surface 340 and the exterior of outer vacuum chamber 900, as shown below:



Chow, Fig. 9

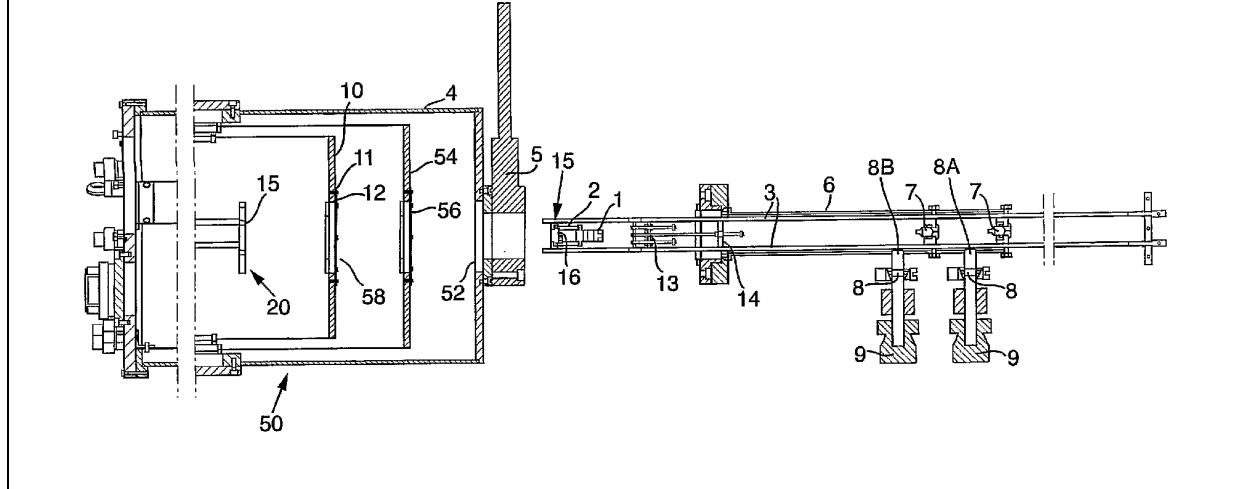
5. Garside (Ex.1007)

87. Garside et al., U.S. Application Publication No. 2012/0102975 was published on May 3, 2012 assigned to Oxford Instruments Nanotechnology Tools Ltd. (herein “Garside”). Ex.1007. I understand Garside is analogous art to the ’320 Patent because it discloses a cryogen free cooling system. Ex.1007, ¶¶ Abstract, [0001], [0002] (“cryogenic equipment for low temperatures (less than 100 Kelvin) or ultra low temperatures (less than 4 Kelvin)”), [0005-6], [0008]. Garside also

addresses the same need to “speed cooling” as the ’320 Patent. *Compare* Ex.1007, [0003] (cryogen free systems “typically take longer to warm up, change the sample and cool down”) *with* Ex.1001, 4:30-36 (“Additionally, the inventors have developed a number of features, described herein, to ease maintenance of the dilution refrigerators, speed cooling of the dilution refrigerators without the use of mechanical pumps ...”). Garside was published before the earliest priority date of the ’320 Patent, namely, July 8, 2021, and I understand it is prior art to the ’320 Patent under 35 U.S.C. § 102(a)(1).

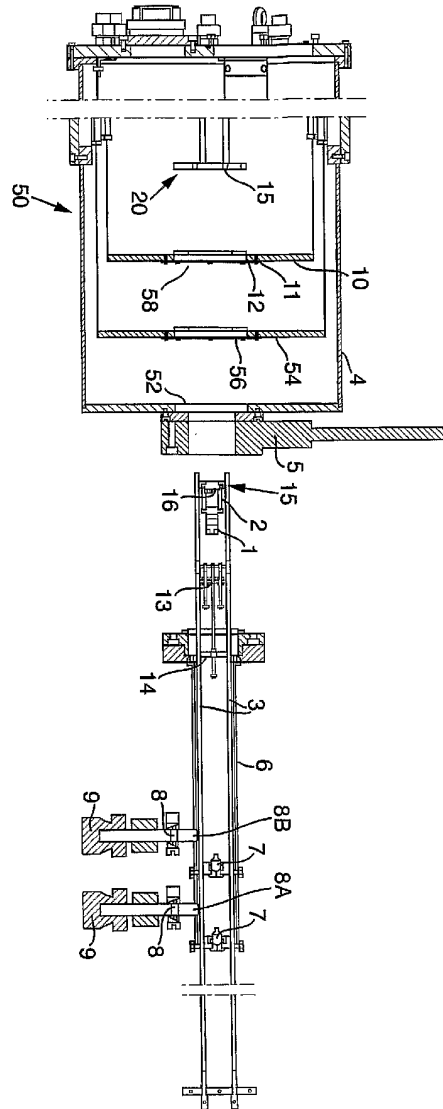
88. Garside discloses a cryogen free cooling system that has a cooling stage coupled to the heat radiation shield. Ex.1007, ¶ [0006]. Aligned apertures are provided in the heat radiation shield and vacuum chamber walls. Ex.1007, ¶ [0006]. A sample loading apparatus has a sample holding device attached to one or more elongate probes for inserting the sample holding device through the aligned apertures to the working region. Ex.1007, ¶ [0006]. A thermal connector enables the sample holding device to be releasably coupled for heat conduction via the connector to a cold body or cold bodies within the vacuum chamber to pre-cool a sample on or in the sample holding device. Ex.1007, ¶ [0006]. An exemplary embodiment of the Garside system is shown in Figure 1 below:

Ex.1007, Figure 1



89. In my opinion, the embodiment shown in Figure 1 of Garside is rotated 90 degrees from the orientation of the system in operation. To illustrate this, I have rotated Figure 1 of Garside by 90 degrees to illustrate the orientation in operation. In this orientation, the sample is loaded from the bottom.

Ex.1007, Figure 1 (rotated 90 degrees)



90. Garside also discloses that the cryostat 50 comprises an outer vacuum vessel 4 which is closed except for port 52 covered by a large diameter gate valve 5. Ex.1007, ¶ [0038]. Within the vacuum vessel 4 is a first radiation shield 54 having an aperture 56 aligned with the aperture 52 of the vacuum chamber, and within the first radiation shield 54 is located a second radiation shield 10 having an

aperture 58 aligned with the apertures 52,56. Ex.1007, ¶ [0038]. The radiation shields 10,54 surround a working region 20 at which is located a cold mounting body 15. Ex.1007, ¶ [0038].

91. Garside discloses the operation of the system at ¶¶ [0042-44]:

In operation, a sample 1 is loaded on to the sample carrier 2 and electrical or optical connections are made. The sample carrier 2 is then mounted on the end of the rod assemblies 3. The rod assemblies 3 are then retracted through the sliding o-ring seals 7 until the sample carrier is fully within the vacuum vessel 6. The vacuum vessel 6 is then attached to the gate valve 5 and air is pumped out of the vacuum vessel 6 through ports 8A,8B and valves 8. When a vacuum is established on both sides of the gate valve 5, the gate valve is opened. The rod assemblies 3 are then pushed to move the sample carrier through the gate valve and to the first pre-cool position.

...

Once the sample carrier is suitably pre-cooled, the rod assemblies 3 are pushed to their final position to allow connection of the sample carrier 2 to the cold body 15 which could by way of example be connected to the mixing chamber of a dilution refrigerator or a sample plate of a cryostat.

6. Wikus (Ex.1008)

92. The thesis *Dilution Refrigeration for Multi-Ton Cold Masses* was published in September of 2007 by Patrick Wikus (herein “Wikus”). Wikus discloses a refrigeration system for the multi-ton cold mass experiment EURECA and is analogous art to the ’320 Patent. Ex.1008 at Abstract, 121, 144 (“A high performance dilution refrigeration system is required to absorb a heat load of 20

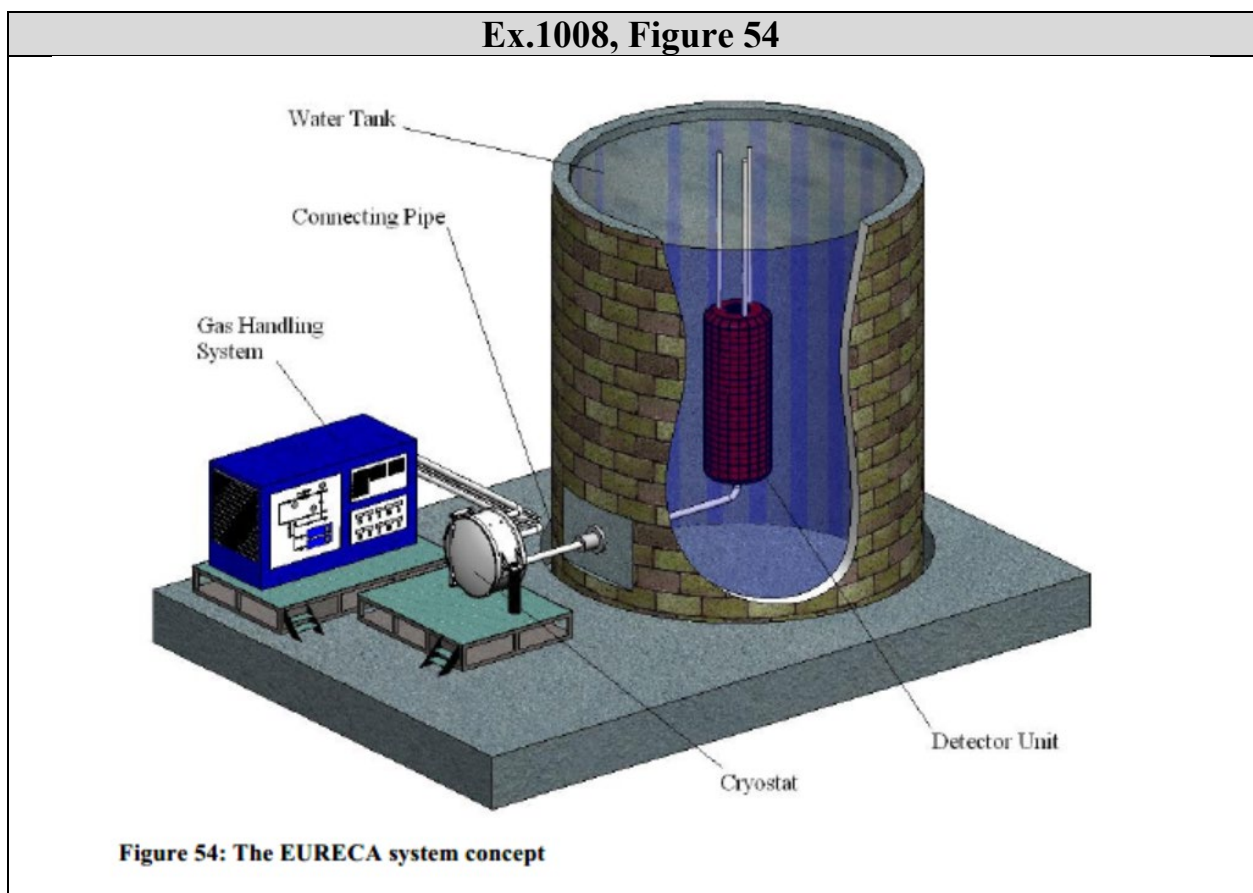
μ W at a temperature of 7 mK. The underlying concept serves as a baseline for EURECA, a future European dark matter search.”). Wikus also addresses the same problem for “eas[ing] maintenance of the dilution refrigerator” as the ’320 Patent. *Compare* Ex.1008 at 130 (“The EURECA cryostat has been designed to facilitate maintenance and enhance reliability.”) *with* Ex.1001, 4:30-32 (“Additionally, the inventors have developed a number of features, described herein, to ease maintenance of the dilution refrigerators ...”).

93. Wikus was distributed to multiple libraries and repositories. I have reviewed the repository of CERN, the European Organization for Nuclear Research, which indicates that Wikus was published May 15, 2007.² I also understand that Wikus was submitted to the library of Technische Universität Wien, where Dr. Wikus received his doctorate degree, and Mr. Boris Ofer, an employee of the Technische Universität Wien library, has confirmed that Wikus was added to the library’s collection on September 13, 2007, and should have been available for public access around September 20, 2007. Ex.1015. Wikus was subsequently cited in another scientific article entitled “EURECA Conceptual Design Report” (Ex.1016) published in 2014. Ex.1016 has 97 authors from academic and research institutions across France, Russia, Germany, Ukraine, United Kingdom, Spain, and Slovakia. Therefore, Wikus was made publicly

² <https://repository.cern/records/a75z4-f6n40>

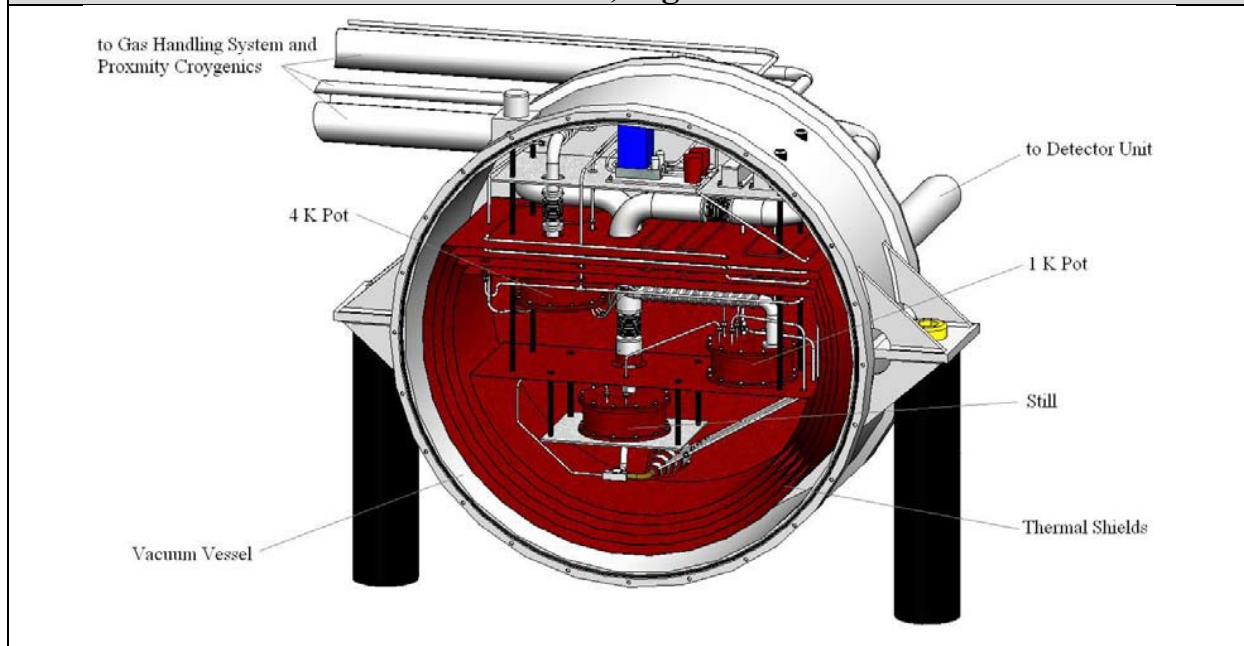
available before the earliest priority date of the '320 Patent, namely before July 8, 2021. I understand that Wikus is prior art to the '320 Patent under 35 U.S.C. § 102(a)(1).

94. Wikus describes the refrigeration system for the multi-ton cold mass experiment, EURECA. Ex.1008 at 117-41. An overview of the Wikus system is shown below:

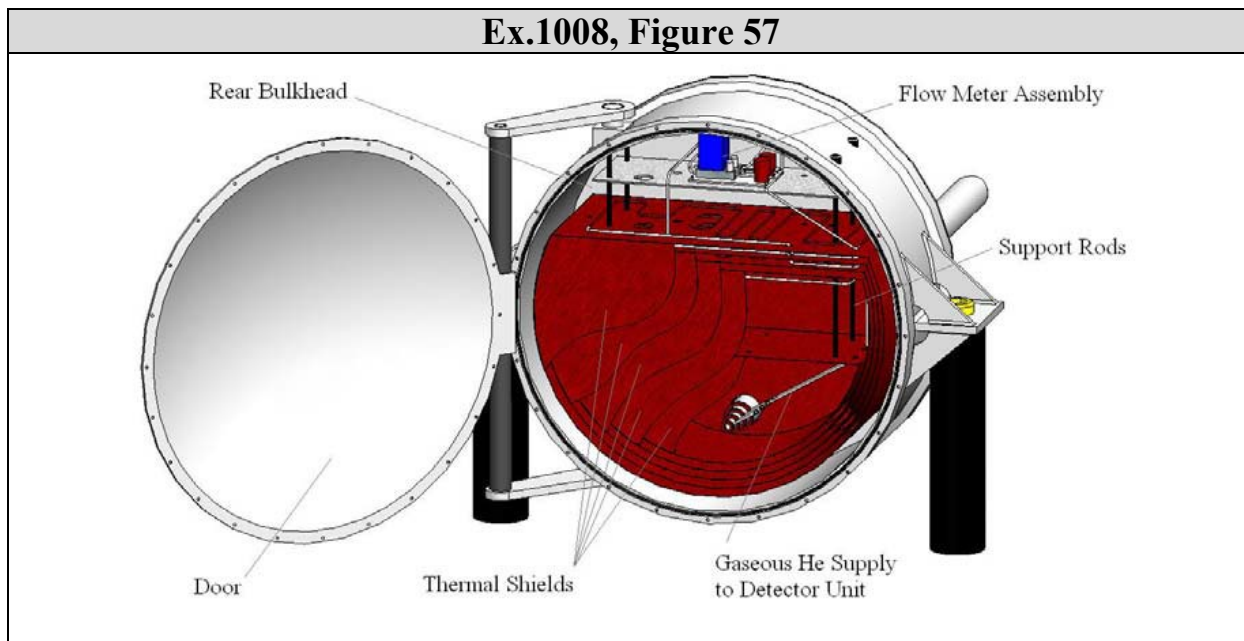


95. The cryostat of Wikus is shown in further detail in Figures 56 and 57 below:

Ex.1008, Figure 56



Ex.1008, Figure 57



96. Referring to the cryostat, Wikus discloses that “[a]ll components are accommodated in a single vacuum space of cylindrical shape such that all parts can be maintained through the front hatch without performing any disassembly work.”

Ex.1008 at 130. “On its front side, a door allows for access to the subsystems

installed inside.” Ex.1008 at 130. Figure 56, above, shows that the opening is configured to provide access to the 4 K Pot, 1 K pot and still through the outer vacuum chamber. Wikus explains that “[t]he three outermost thermal shields of the cryostat and the detector unit are cooled by a continuous flow of gaseous ^4He ” Ex.1008 at 128. “For simplicity, leak tightness of the vacuum vessel’s door is ensured by an elastomer gasket. Diffusion through the gasket will not permit to reach ultra-high vacuum levels.” Ex.1008 at 131. The description of Figure 56 further explains that the EURECA cryostat has a “vacuum tight front cover” and removable “lids of the thermal shields.” Ex.1008 at 130 (“Figure 56: The EURECA cryostat, which – for clarity – is depicted with the vacuum tight front cover and the lids of the thermal shields removed”).

97. Wikus also discusses a traditional dilution refrigerator, the CERN Cryolab Dilution Refrigerator (CCDR), which is shown in Figure 4 (below). Ex.1008 at 12-13. The CCDR has a Tube-in-Tube H/X, a sintered H/X, and a mixing chamber located immediately below the still. Ex.1008 at 13.

Ex.1008, Figure 4

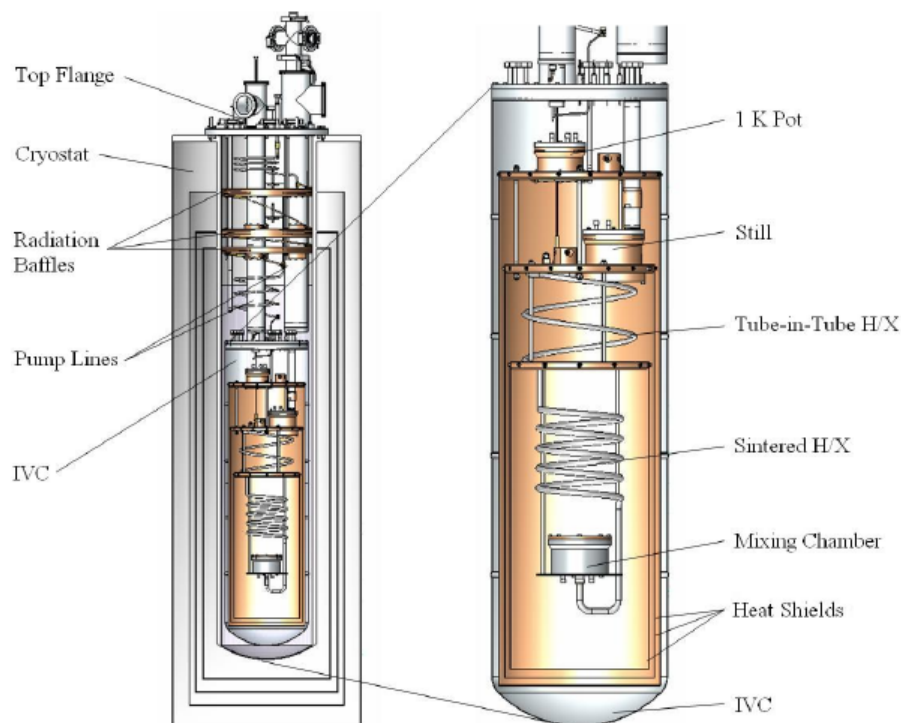


Figure 4: Layout of the CCDR

98. Wikus also notes:

As dark matter searches are low background experiments, they have to be thoroughly shielded from sources leaving a trace similar to the one of a WIMP in the detector modules.... Inside this shielded volume, only extremely radiopure materials may be used.

Ex.1008 at 121.

VI. CLAIM CONSTRUCTION

99. I have been instructed by counsel that claim construction is a matter of law.

100. I understand that in an *inter partes* review, claims “shall be construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b), including construing the claim in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.” I understand that under this standard, “words of a claim are generally given their ordinary and customary meaning,” which is “the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, *i.e.*, as of the effective filing date of the patent application.”

101. I understand that the patent specification is “the single best guide to the meaning of a disputed term and... acts as a dictionary when it expressly defines terms used in the claims or when it defines terms by implication.”

102. I also understand that the prosecution history is a source of intrinsic evidence that can be used to construe claim terms. Extrinsic evidence, such as dictionaries, treatises, and expert testimony, can also be used to determine what a person of ordinary skill in the art would have understood a claim term to mean.

A. “Sample Stage” (Claims 2, 3)

103. I note that the ’320 Patent does not explicitly define the term “sample stage,” but provides that, “In some embodiments, an experimental volume 124 (e.g., a sample stage or plate) **may** be thermally coupled to the mixing chamber 122 and

configured to **support a sample** and/or quantum device.” Ex.1001, 12:66-13:2. In my opinion, a POSITA would understand the term “sample stage” to mean “a region configured to support a sample.”

B. “Radiation shield” (Claims 3 and 19)

104. I note that the ’320 Patent does not define a “radiation shield.” In my opinion, a POSITA would understand the term “radiation shield” to mean “a component or components that reduces radiant heat transfer.”

C. “Hermetic opening” (Claim 5)

105. I note that the ’320 Patent does not define the term “hermetic opening.” In my opinion, an opening cannot be hermetic or airtight without specifying a sealable structure to close the opening. That said, in my opinion, as best understood, a POSITA would understand the term “a hermetic opening” to mean that the opening comprises a hermetic seal.

VII. GROUND 1: CLAIMS 1-6, 8, AND 17-19 ARE OBVIOUS OVER BATEY IN VIEW OF DAIN

A. Claim 1

1. 1[pre] – “a dilution refrigerator comprising:”

a. “Dilution Refrigerator” Recited in the Preamble Is Not Limiting (Claims 1-6, 8, and 17-19)

106. I understand that whether to treat a preamble as a limitation is a determination resolved only on review of the entire patent to gain an understanding of what the inventors actually invented and intended to encompass by the claim. I

understand that a preamble limits the invention if it recites essential structure or steps, or if it is “necessary to give life, meaning, and vitality” to the claim.

107. I further understand that clear reliance on the preamble during prosecution to distinguish the claimed invention from the prior art transforms the preamble into a claim limitation because such reliance indicates use of the preamble to define, in part, the claimed invention. But without that reliance, a preamble generally is not limiting when the claim body describes a structurally complete invention such that deletion of the preamble phrase does not affect the structure or steps of the claimed invention.

108. It is my opinion that the recitation of a “dilution refrigerator” in the preamble of the claims of the ’320 Patent is not a claim limitation. The body of each claim sets forth all of the structural elements of each claimed invention, and the preamble merely states that the intended use of the structural elements is as a dilution refrigerator.

109. During prosecution of independent claims 1 and 17 (the latter at the time being application claim 4), as well as claim 18 (at the time application claim 7) of the ’320 Patent, I understand the applicant did not rely on the preamble to distinguish the claimed inventions. Although the patent applicant stated that “[t]he outer vacuum chamber for a dry dilution refrigerator is a specialized device designed to maintain an internal pressure several orders of magnitude below typical

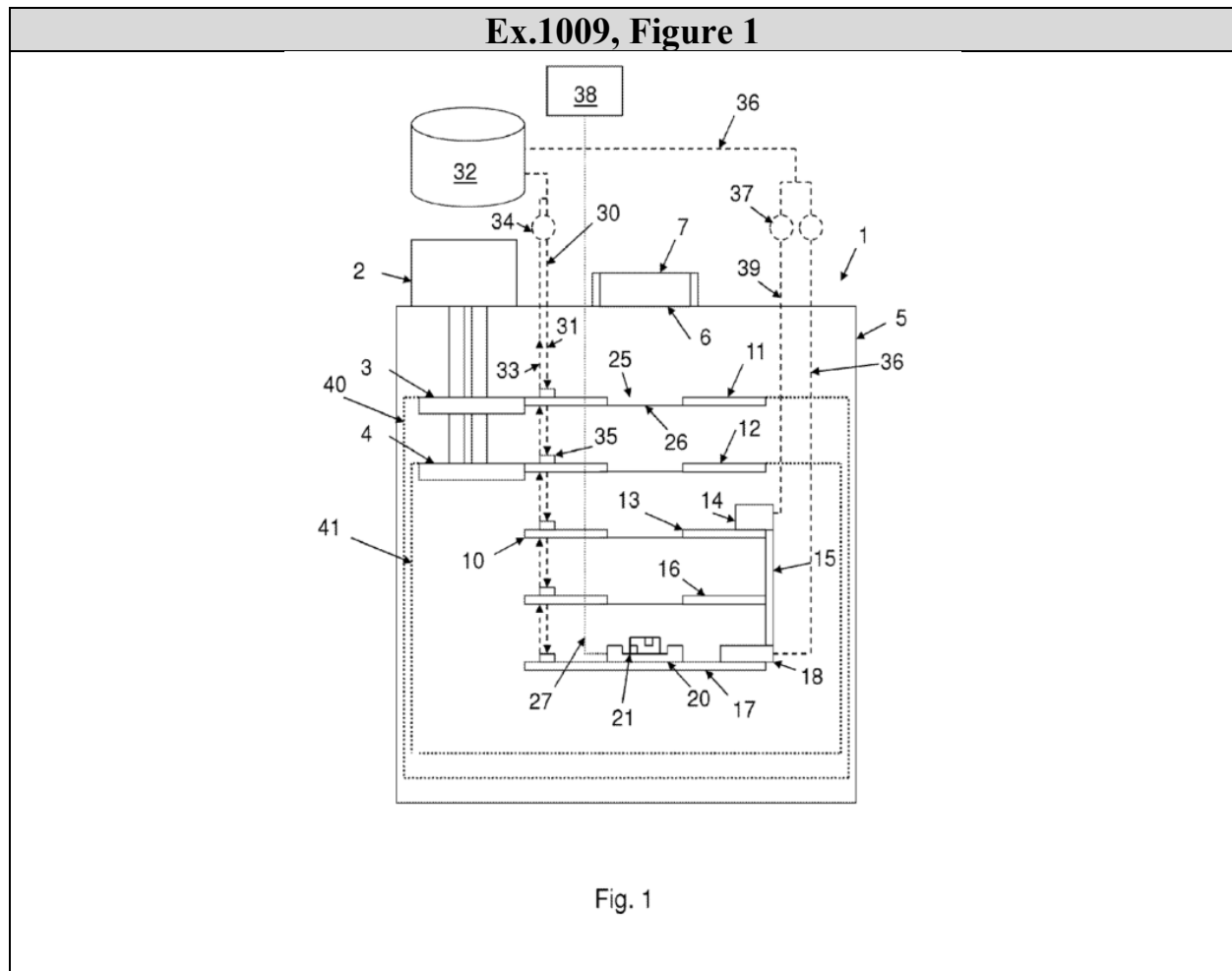
atmospheric pressure,” I understand the patent applicant then broadened their characterization of the invention as being related to the “specialized technical area of cryogenic vacuum devices.” Ex.1004 at 63-73. The “specialized technical area of cryogenic vacuum devices” is broader than the preamble’s recitation of a “dilution refrigerator.” In my opinion, the patent applicant did not rely on the preamble’s recitation of a “dilution refrigerator” to distinguish the invention from the prior art.

110. I further understand that the patent applicant’s arguments during prosecution with respect to application claim 7 (patent claim 18) were made not with respect to distinguishing the invention from the prior art, but with respect to the Examiner taking official notice that “going from a door closed by fasteners to a door closed by hinge[s] would have been obvious to an ordinary skill[ed] artisan.” Ex.1004 at 112-13. Further, there are no terms in claims 1-3, 5-6, 8, or 18-19 that require the recitation of a “dilution refrigerator” in the preamble for antecedent basis. Thus, it is my opinion that the preamble’s recitation of a “dilution refrigerator” is not a claim limitation.

b. Batey Discloses a Dilution Refrigerator

111. To the extent the Board finds the preamble to be limiting, Batey discloses “a dilution refrigerator.” Ex.1009, 2:27-30 (“In accordance with a first aspect of the present invention we provide a method of operating a cryogenic

cooling system, in which a target region for receiving a sample is cooled by a dilution refrigerator...”). Batey also has a third stage 13 which “is used as a platform for supporting the still 14 of a dilution refrigerator 15” and a fifth stage 17 which “functions as a platform for supporting a sample when in use and for holding a mixing chamber 18 of the dilution refrigerator 15.” Id., 7:48-65.



112. In my opinion, a POSITA would understand that Batey’s cryostat is a dilution refrigerator.

113. In my opinion, the combination of Batey and Dain teaches “a dilution

refrigerator.”

2. 1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”

114. Batey discloses that cryostat 1 is “typically formed as a large hollow stainless steel cylinder which comprises an outer vacuum vessel 5.” Ex.1009, 7:3-

5. Because outer vacuum vessel 5 is in the shape of a steel cylinder, in my opinion, a POSITA would understand that outer vacuum vessel 5 has at least one substantially planar surface (top and bottom surfaces).

Ex.1009, Figure 1 (colored)

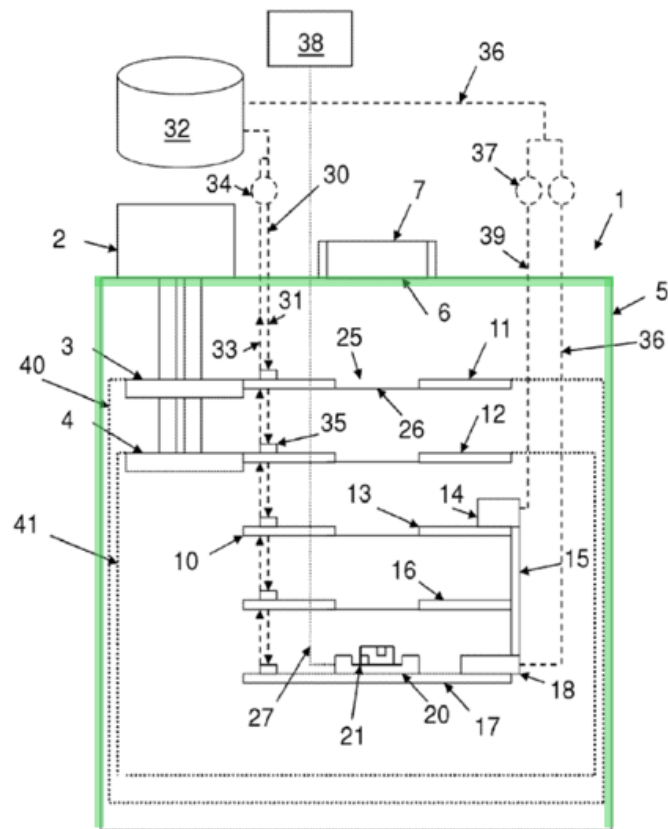
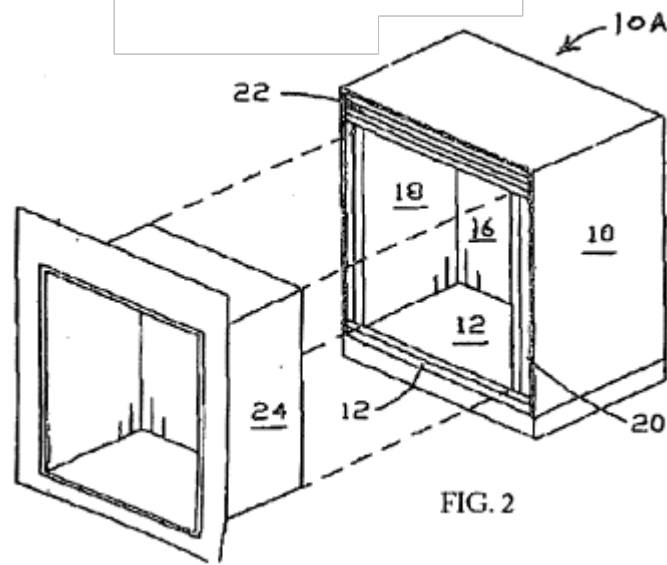


Fig. 1

115. If the Board determines that Batey does not disclose this limitation, Dain discloses “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface.” Ex.1010, Fig. 2, [0008] (“a ULT [ultra low temperature] chamber which is made in compact rectangular form”).

Ex.1010, Figure 2



116. In my opinion, a POSITA would be motivated to modify outer vacuum vessel 5 of Batey to have the rectangular form as taught in Dain. The combination would involve the simple substitution of the cylinder-shaped outer vacuum vessel 5 of Batey with a rectangular chamber as described in Dain. Given different choices in shape of the vacuum vessel were known, the combination would have been within the knowledge and skill of a POSITA and would yield predictable results.

117. In addition, as described in Dain, the rectangular form, as opposed to circular or cylindrical form, is more compact. Ex.1010, [0008]. The rectangular shape and proportions also provide convenient front access through the door. *Id.*, [0032]. In my opinion, a POSITA would have been motivated to modify the cylindrical vacuum vessel of Batey to have a rectangular shape as described in Dain

to provide a more compact configuration.

118. In my opinion, the combination of Batey and Dain teaches “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface.”

3. **1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”**

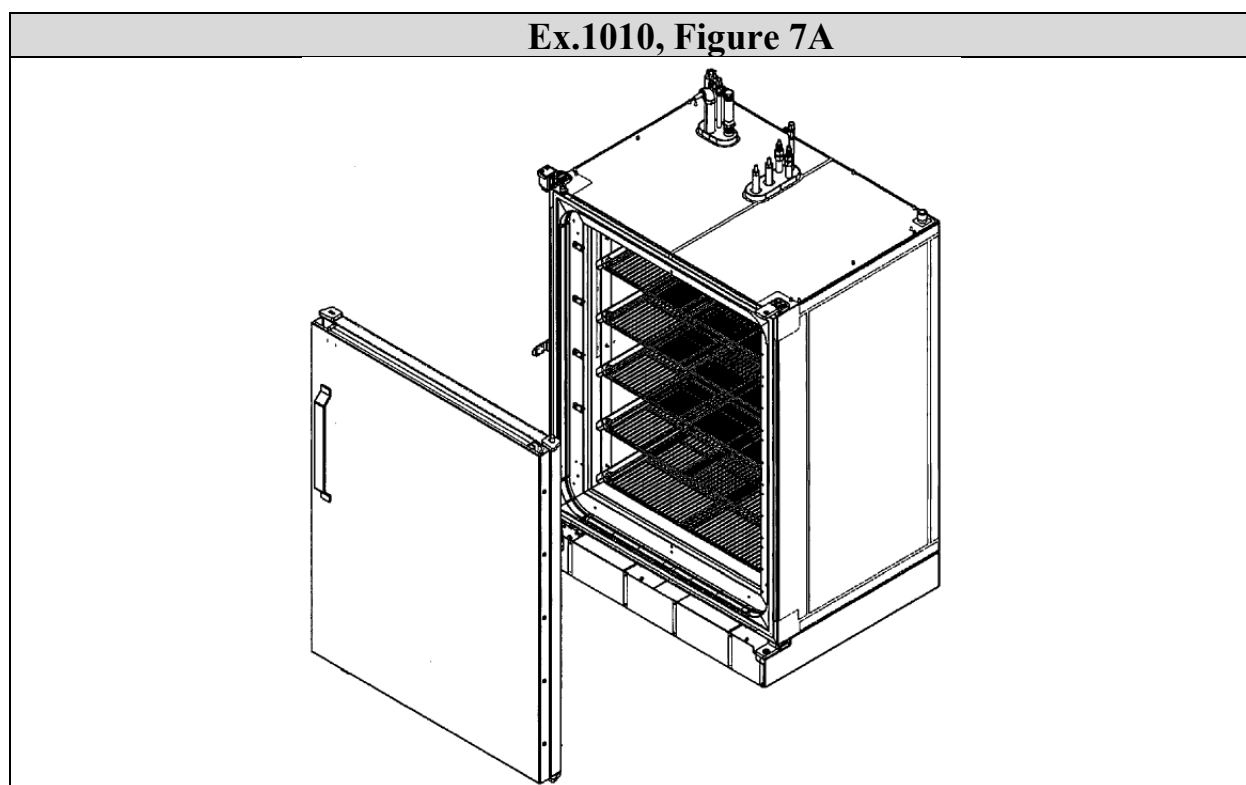
119. In my opinion, Batey discloses this limitation because outer vacuum vessel 5 has a central port 6. Ex.1009, 7:3-7. Batey describes central port 6 as an “access opening” in a “top surface” of outer vacuum vessel 5. *Id.*, 7:3-7. As seen in Figure 1 annotated below, Batey’s central port 6 (purple) in a “top surface” of outer vacuum vessel 5 (green) provides access to the interior (blue) of cryostat 1. In my opinion, Batey discloses an opening (*e.g.*, central port 6) in the at least one substantially planar surface configured to provide access to an experimental volume within an interior of the outer vacuum chamber (*e.g.*, outer vacuum vessel 5).

[illegible]

120. In my opinion, a POSITA modifying the outer vacuum vessel 5 of Batey to have a rectangular shape as described in Dain would leave Batey's port 6 (e.g., an opening) in the housing to "allow suitable apparatus, such as an experimental 'probe' to pass into the interior of the cryostat 1." *Id.*, 7:7-11.

121. In my opinion, this is also consistent with the teaching of Dain, which teaches an opening in a planar surface of the outer shell 10 to provide access to its interior. Ex.1010, Figure 7A. Furthermore, in my opinion, the interior of the cryostat 1 that can be reached by the experimental probe is an experimental volume.

122. Alternatively, Batey also discloses that the cryostat system may be configured as a side-loading system. Ex.1009, 6:10-11. In my opinion, a POSITA would provide the opening on the front planar surface of the rectangular vacuum chamber, as described in Dain, because the front access through the door is convenient. Ex.1010, [0032].



123. In my opinion, claim 1 is obvious over Batey in view of Dain.

B. Claim 2 is Obvious

124. Claim 2 depends from claim 1, which Batey and Dain render obvious for the reasons I discussed above in Section VII.A, which I incorporate herein. Claim 2 adds: “a sample stage housed within the experimental volume, wherein the opening is configured to provide access to the sample stage through the outer

vacuum chamber.”

125. In my opinion, Batey discloses the limitation of claim 2 because cryostat 1 has a fifth stage with a docking station 20 (yellow). Ex.1009, 7:66. The fifth stage with the docking station 20 is “arranged to receive target apparatus in the form of a sample carrier which supports a sample.” *Id.*, 7:66-8:1. In my opinion, a POSITA would understand the fifth stage with docking station 20 to be the “sample stage” required by claim 2.

126. Batey also discloses that each of the first through fourth stages that sit above docking station 20 on the fifth stage have apertures 25 that align with gate valve 7 of central port 6. *Id.*, 8:1-9. The apertures align to provide a “central bore passing vertically through each of the upper four stages” and “allow for the insertion of a loading assembly which contains the sample retained in a sample carrier.” *Id.*, 8:1-11, 8:13-17 (“[T]he alignment of the apertures 25 provides a bore from the coldest part of the system in a ‘target region’ (which contains the docking station 20) and the warmer part of the system adjacent to the gate valve 7...”). Batey further describes this system as a “top-loading” system. In my opinion, a POSITA would understand that with a “top-loading” system, central port 6 is configured to provide access to docking station 20 from outside outer vacuum vessel 5.

Ex.1009, Figure 1 (colored)

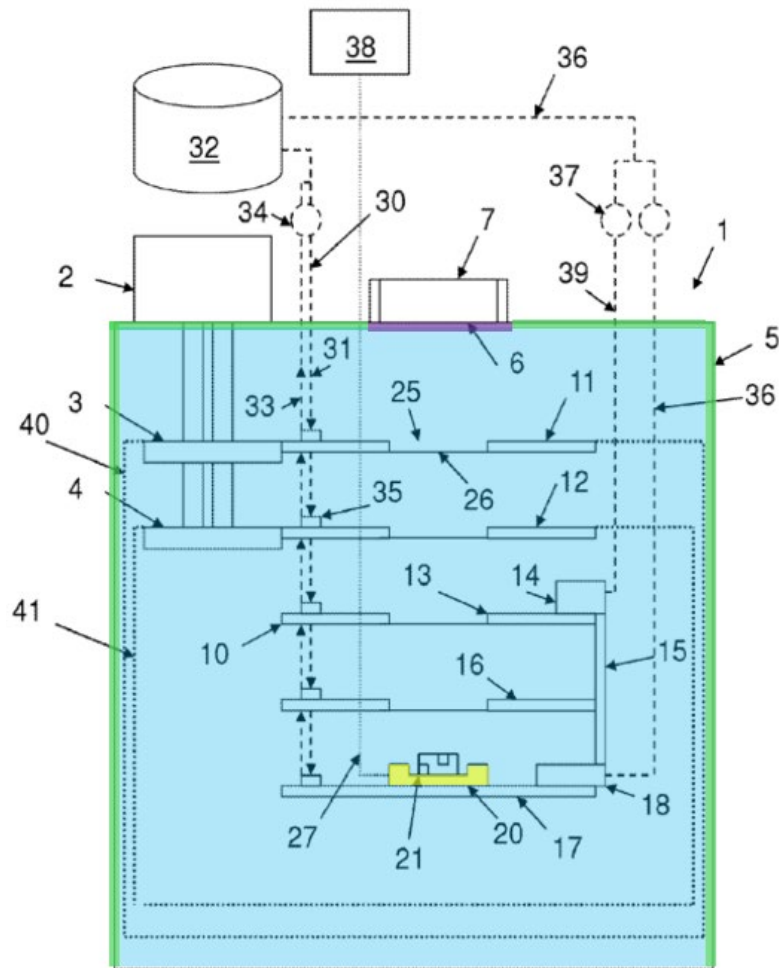


Fig. 1

127. In my opinion, Batey discloses “[t]he dilution refrigerator of claim 1 [e.g., cryostat 1], further comprising a sample stage [e.g., docking station 20] housed within the experimental volume, wherein the opening [e.g., central port 6] is configured to provide access to the sample stage through the outer vacuum chamber [e.g., outer vacuum vessel 5].”

128. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 2.

C. Claim 3 is Obvious

129. Claim 3 depends from claim 2, which Batey and Dain render obvious for the reasons I discussed above in Section VII.B, which I incorporate herein.

Claim 3 adds: “one or more radiation shields housed within the outer vacuum chamber, and wherein portions of the one or more radiation shields proximate the sample stage are slidable and/or removable to provide access to the sample stage.”

130. Batey discloses in cryostat 1, there is an outer radiation shield 40 (orange) that is held at 50 to 70 Kelvin and an inner radiation shield 41 (orange) that can achieve a temperature between 3.5 and 4 Kelvin. Ex.1009, 7:29-47. In my opinion, a POSITA would understand that radiation shields 40-41 are the “one or more radiation shields” required by claim 3.

131. Radiation shield 40 is connected thermally with the topmost stage 11 of the cryostat. *See* Ex.1009, 7:25-32. Radiation shield 41 is connected to second stage 2. *Id.*, 7:37-39. As I discussed above with respect to claim 2, “each of the first to fourth stages” contain an aperture 25 (pink) that aligns with gate valve 7 and central port 6 to allow “top-loading” of a sample to docking station 20. *Id.*, 8:4-12. Batey further teaches that each of apertures 25 have a corresponding baffle 26 that “is hinged ... to a region adjacent to the edge of the aperture 25 and is biased to a

closed position.” *Id.*, 8:13-23. In order to “reduce[] any possible convection or **radiation heat** load between the port and the target region,” the baffle may use a spring mechanism or may be “manually rotated away from their apertures by turning a drive rod that has a rotating seal mounted on the top of the cryostat.” *Id.*, 8:19-27. In my opinion, a POSITA would understand that each of radiation shields 40 and 41 has an aperture 25 and a corresponding baffle 26 that is “slidable and/or removable” (e.g., movable) to provide access to docking station 20. Alternatively, respective portions of the radiation shields 40 and 41 have been removed to define apertures (e.g., aperture 25). Therefore, a POSITA would understand that portions of the radiation shields 40 and 41 are removable to provide access to the sample stage.

Ex.1009, Figure 1 (colored)

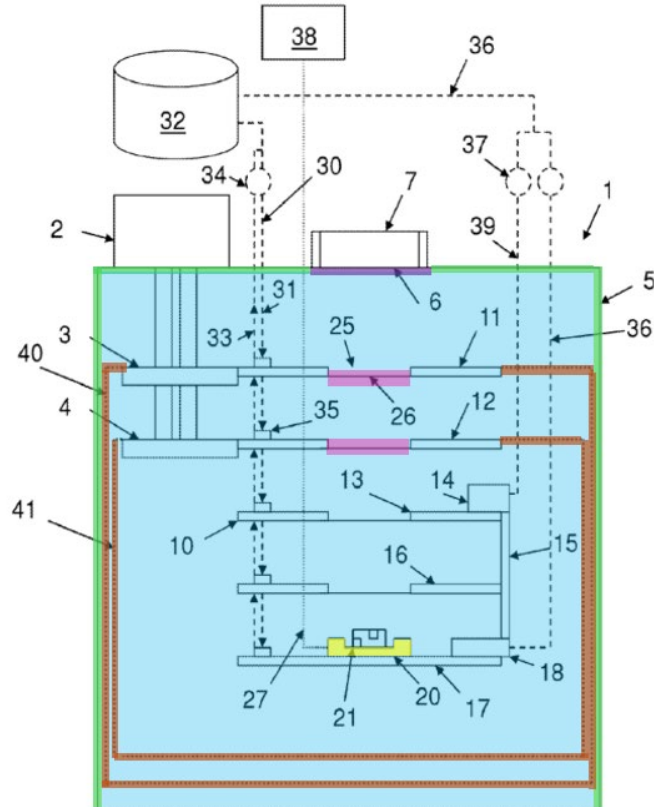


Fig. 1

132. In my opinion, Batey discloses “[t]he dilution refrigerator of claim 2 [e.g., cryostat 1], further comprising one or more radiation shields [e.g., outer radiation shield 40 and inner radiation shield 41] housed within the outer vacuum chamber [e.g., outer vacuum vessel 5], and wherein portions of the one or more radiation shields proximate the sample stage [e.g., aperture 25 with baffle 26] are slidable and/or removable to provide access to the sample stage [e.g., docking station 20].”

133. In my opinion, it would have been obvious to combine the teachings

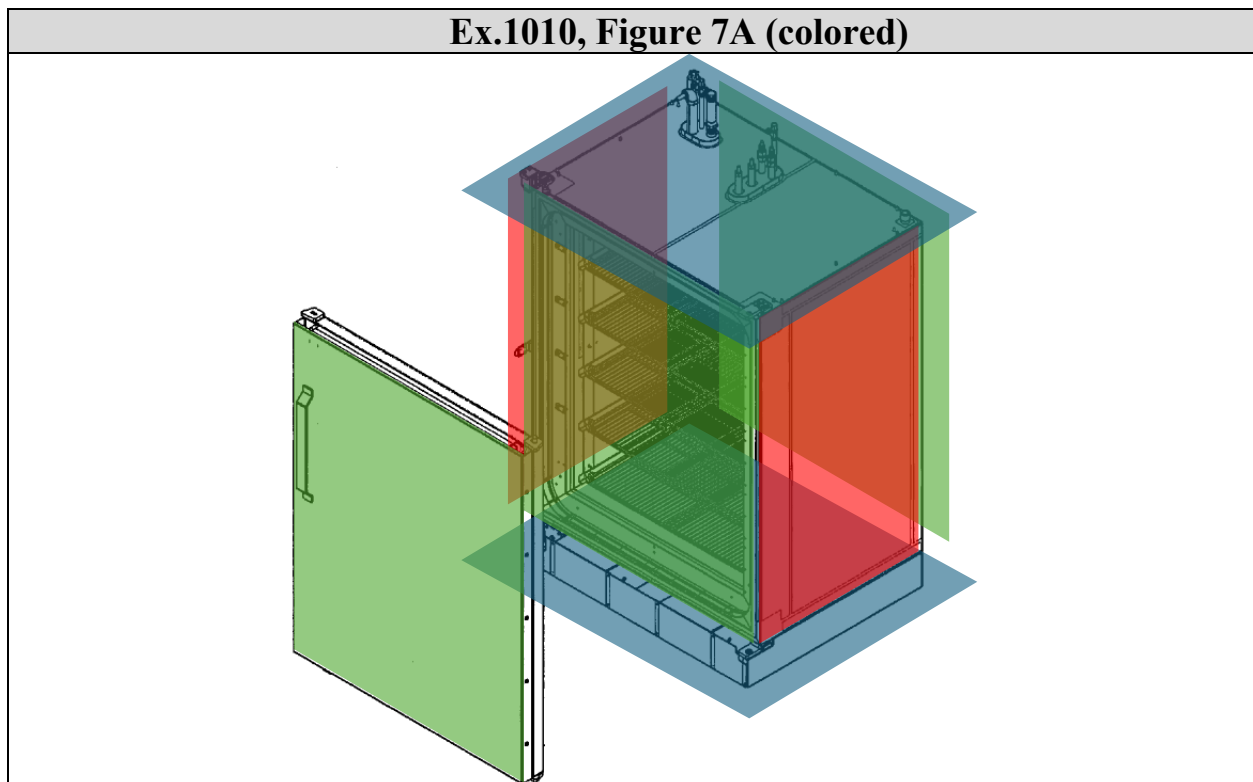
of Batey and Dain to arrive at the subject matter of claim 3.

D. Claim 4 is Obvious

134. Claim 4 depends from claim 1, which Batey and Dain render obvious for the reasons I discussed above in Section VII.A, which I incorporate herein.

Claim 4 adds: “wherein the at least one substantially planar surface comprises: first surfaces disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator; and second surfaces disposed within a plane parallel to the plane of the floor, wherein the first surfaces and the second surfaces are arranged as a rectangular prism.”

135. As I discussed above with respect to limitation 1[a], Dain teaches a vacuum chamber having a rectangular form. Ex.1010, Figure 7A and [0008].



136. In my opinion, a POSITA would understand that the rectangular vacuum chamber of Dain is placed on a floor like most types of refrigerators. In my opinion, a POSITA would also understand that the rectangular vacuum chamber has “first surfaces [green front and back surfaces or red side surfaces] disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator; and second surfaces [blue top and bottom surfaces] disposed within a plane parallel to the plane of the floor, wherein the first surfaces and the second surfaces are arranged as a rectangular prism.”

137. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 4.

E. Claim 5 is Obvious

138. Claim 5 depends from claim 1, which Batey and Dain render obvious for the reasons I discussed above in Section VII.A, which I incorporate herein. Claim 5 adds: “wherein the opening comprises a hermetic opening.”

139. Batey discloses that central port 6 is “fitted with a gate valve 7 positioned within the port 6.” Ex.1009, 7:7-11. This allows an experimental probe to “pass into the interior of the cryostat 1 whilst maintaining the vacuum within the vacuum vessel 5.” *Id.* Batey also describes how the gate valve is only opened when a “vacuum is established on both sides of the gate valve 7.” *Id.*, 9:53-55. In my opinion, a POSITA would understand that gate valve 7 positioned within central

port 6 corresponds to an opening with a hermetic seal, *i.e.*, a hermetic opening, in order to maintain the vacuum within vacuum vessel 5.

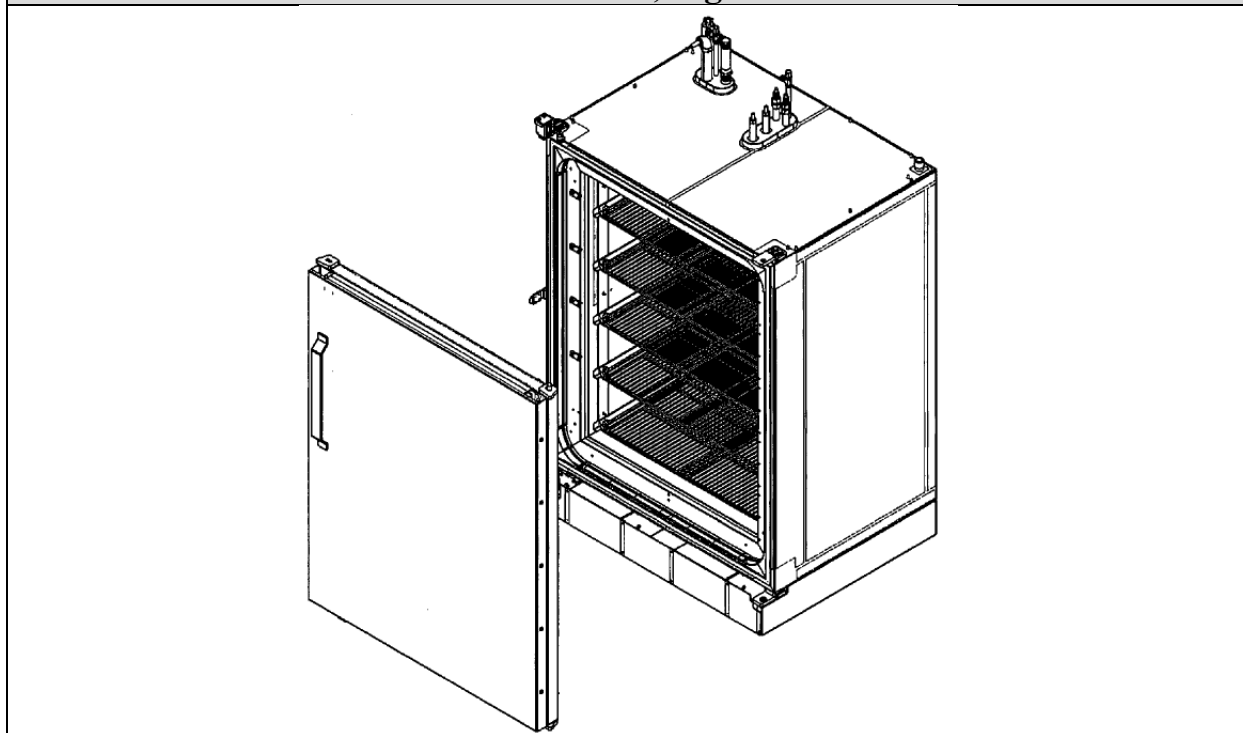
140. I note that Dain also teaches “the door assembly includes door-sealing gasket” and the negative pressure inside the payload bay of the vacuum chamber is maintained by “pneumatic seals on the main door assembly.” Ex.1010, [0007]. [0026]. In my opinion, Dain also discloses a hermetic opening, an opening with a hermetic seal.

141. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 5.

F. Claim 6 is Obvious

142. Claim 6 depends from claim 1, which Batey and Dain render obvious for the reasons I discussed above in Section VII.A, which I incorporate herein. Claim 6 adds: “wherein the outer vacuum chamber comprises: a first section; and a second section suspended from the first section.”

Ex.1010, Figure 7A



143. Dain discloses a rectangular vacuum chamber with a hinged door.

Ex.1009, Figure 7A, [0028], [0030]. In my opinion, a POSITA would understand that the door (*e.g.*, the second section) is suspended from the chamber (*e.g.*, the first section).

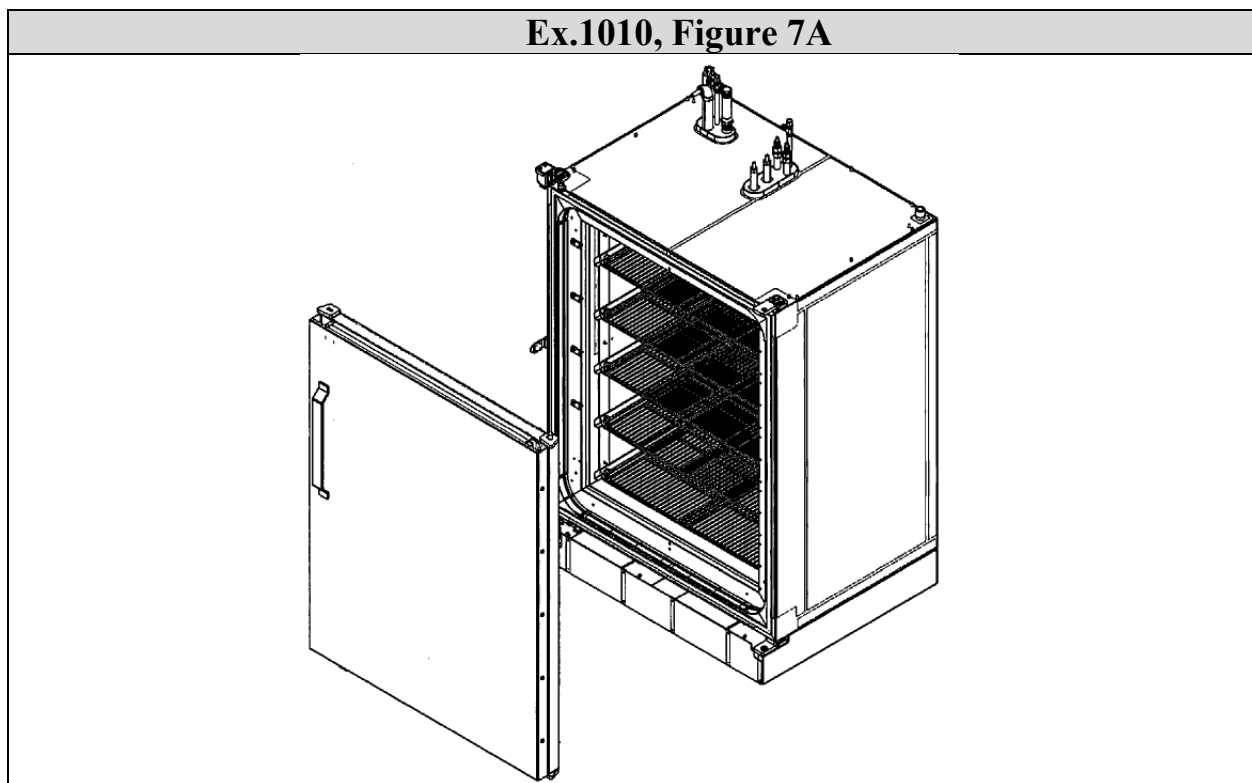
144. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 6.

G. Claim 8 is Obvious

145. Claim 8 depends from claim 6, which Batey and Dain disclose for the same reasons I discussed above in Section VII.F, which I incorporate herein. Claim 8 adds: “wherein the first and/or second section of the outer vacuum chamber are configured to be at least partially removed from the dilution refrigerator to provide

access to an interior of the outer vacuum chamber.”

146. As I discussed above with respect to claim 6, Dain discloses a hinged door suspended from a vacuum chamber. Ex.1009, Figure 7A, [0028], [0030]. In my opinion, a POSITA would understand that the door (*e.g.*, the second section) can be removed, as shown in Figure 7A, to provide access to an interior of the vacuum chamber.



147. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 8.

H. Claim 17 is Obvious

1. 17 [pre] – “a dilution refrigerator comprising:”

148. In my opinion, the combination of Batey and Dain teaches the

2. 17[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”

Ex.1010, Figure 2

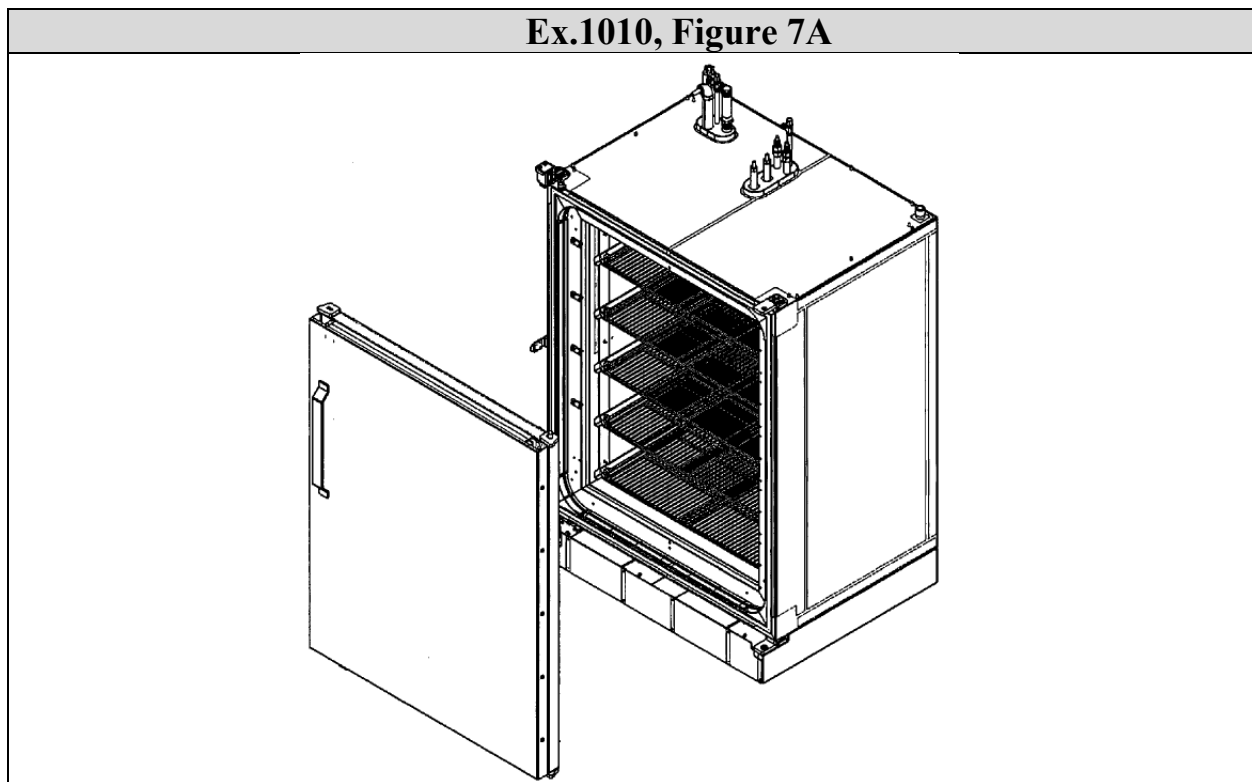
FIG. 2

71

rectangular form as taught in Dain.

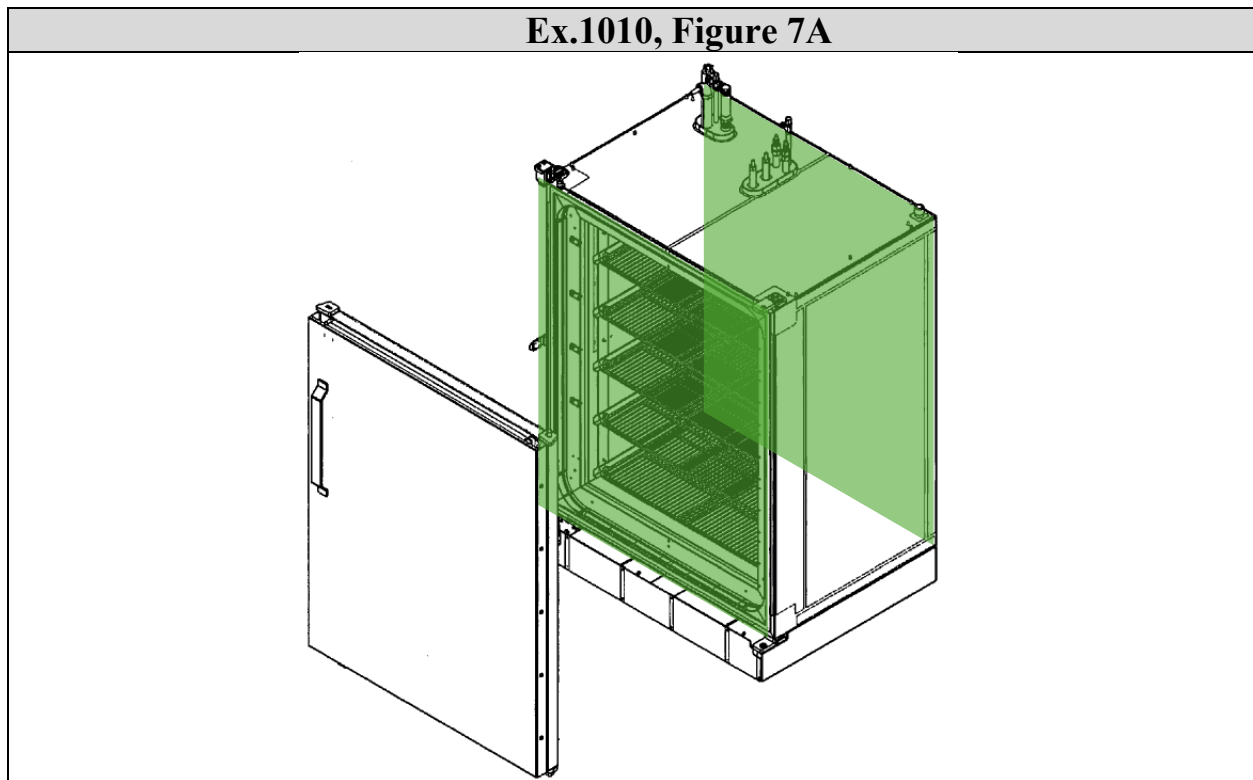
3. **17[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber, wherein:”**

151. The combination of Batey and Dain teaches limitation 17[b] for the same reasons I described above with respect to limitation 1[b]. For example, in my opinion, a POSITA would provide the opening on the front planar surface of the rectangular vacuum chamber, as described in Dain, because the configuration provides convenient front access through the door. Ex.1010, [0032].



4. 17[c] “the at least one substantially planar surface of the outer housing comprises a first surface disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator”.

152. The combination of Batey and Dain teaches limitation 17[c] for the same reasons as described above with respect to claim 4. In particular, in my opinion, a POSITA would understand that the rectangular vacuum chamber of Dain is placed on a floor like most types of refrigerators. In my opinion, a POSITA would also understand that the rectangular vacuum chamber has “a first surfaces [any of green front and back surfaces] disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator.”



153. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 17.

I. Claim 18 is Obvious

1. 18[pre] – “a dilution refrigerator comprising:”

154. In my opinion, the combination of Batey and Dain teaches the preamble of claim 18 for the same reasons I described above with respect to claim 1.

2. 18[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”

155. In my opinion, the combination of Batey and Dain teaches limitation 18[a] for the same reasons I described above with respect to limitation 17[a].

3. 18[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an interior of the outer vacuum chamber,”

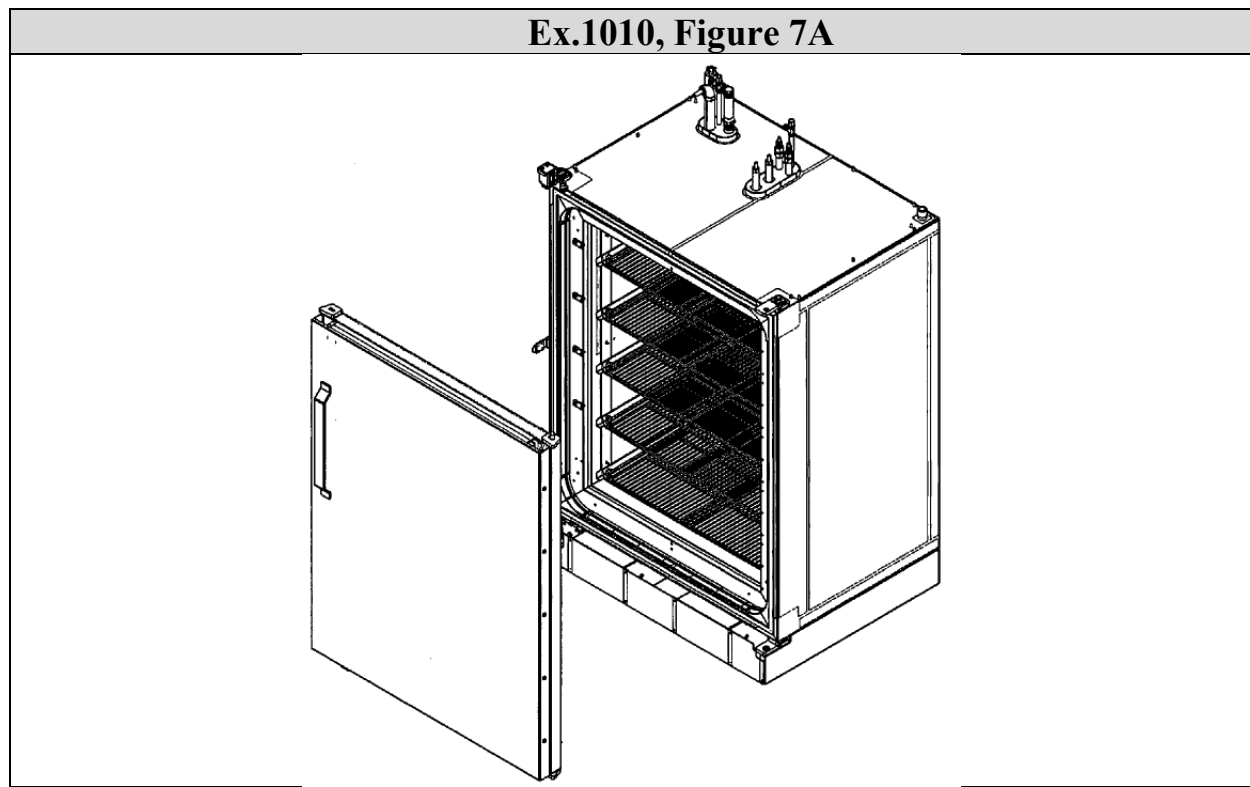
156. In my opinion, the combination of Batey and Dain teaches limitation 18[b] for the same reasons I described above with respect to limitation 17[b].

4. 18[c] “wherein the opening comprises a hinged door.”

157. In my opinion, the combination of Batey and Dain teaches limitation 18[c].

158. Dain discloses “a substantially flat vertical door serving as the front panel of the chamber.” Ex.1010, [0008], [0030] (“the door 41 adapted to seal a payload bay”), Figure 7A. Furthermore, Dain discloses that “the door 41 has a

piano hinge 45 to allow the door to move for access purposes.” Ex.1010, [0028].



159. In my opinion, a POSITA modifying the outer vacuum vessel 5 of Batey to the rectangular shape described in Dain would be motivated to implement Dain’s door to “provide convenient front access through the door.” Ex.1010, [0032].

160. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 18.

J. Claim 19 is Obvious

161. Claim 19 depends from claim 18, which Batey and Dain render obvious for the same reasons I discussed above. Claim 19 adds “one or more radiation shields housed within the outer vacuum chamber, and wherein portions of

the one or more radiation shields proximate the hinged door are slidable and/or removable to provide access to the interior of the outer vacuum chamber.”

162. In my opinion, Batey discloses the limitation of claim 19 for the same reasons as claim 3.

163. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 19.

VIII. GROUND 2: CLAIMS 1-4 ARE OBVIOUS OVER BATEY IN VIEW OF PWS

A. Claim 1 Is Obvious

1. 1[pre] – “a dilution refrigerator comprising:”

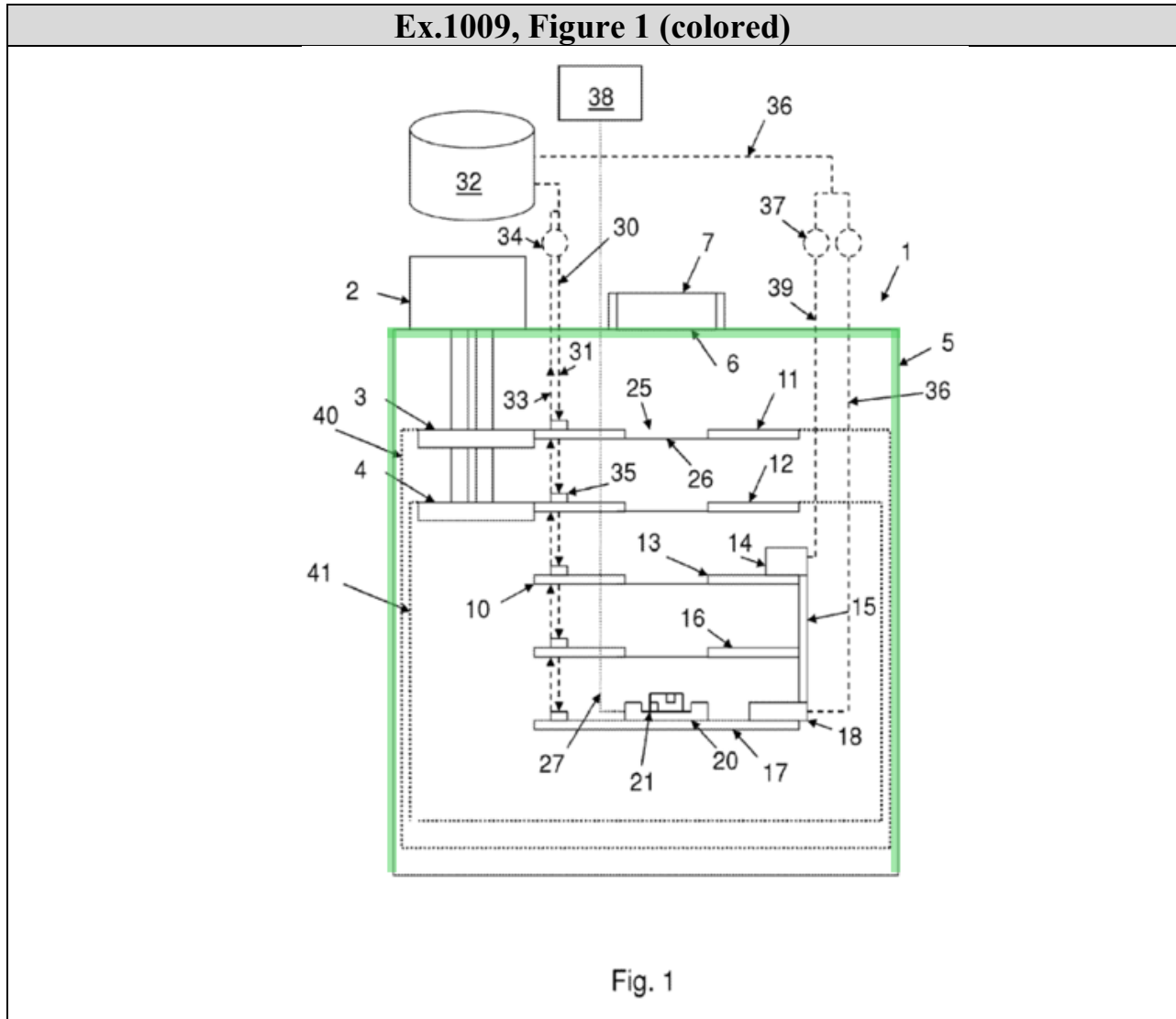
164. As I discussed above in Section VII.A.1.a, the preamble is not limiting.

165. To the extent the Board finds the preamble to be limiting, Batey discloses “a dilution refrigerator,” as I discussed above in Section VII.A.1.b.

2. 1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”

166. As I discussed above in Section VII.A.2, Batey discloses “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface.” In particular, Batey discloses cryostat 1 is “typically formed as a large hollow stainless steel cylinder which comprises an outer vacuum vessel 5.” Ex.1009, 7:3-5. Because outer vacuum vessel 5 is in the shape of a steel cylinder,

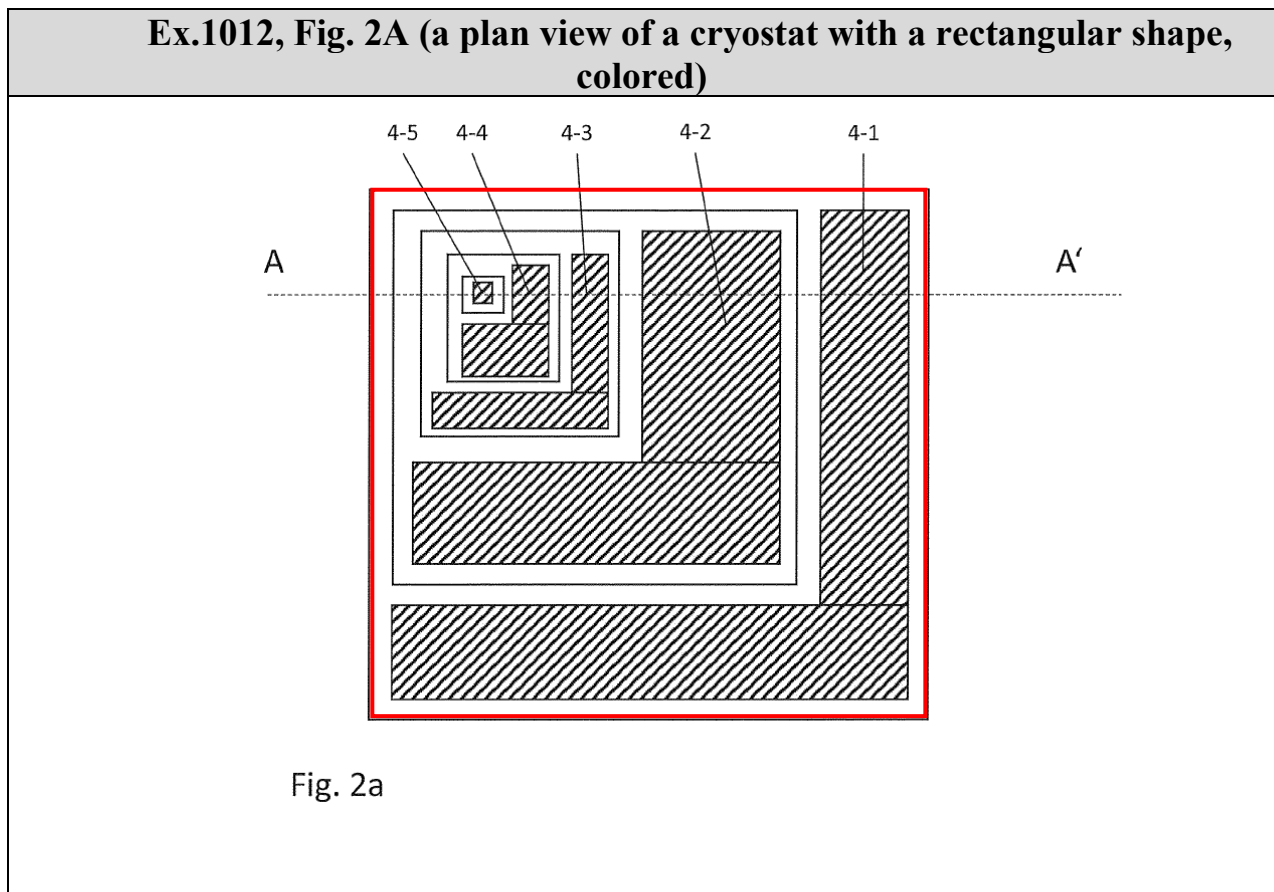
in my opinion, a POSITA would understand that outer vacuum vessel 5 has at least one substantially planar surface (top and bottom surfaces).



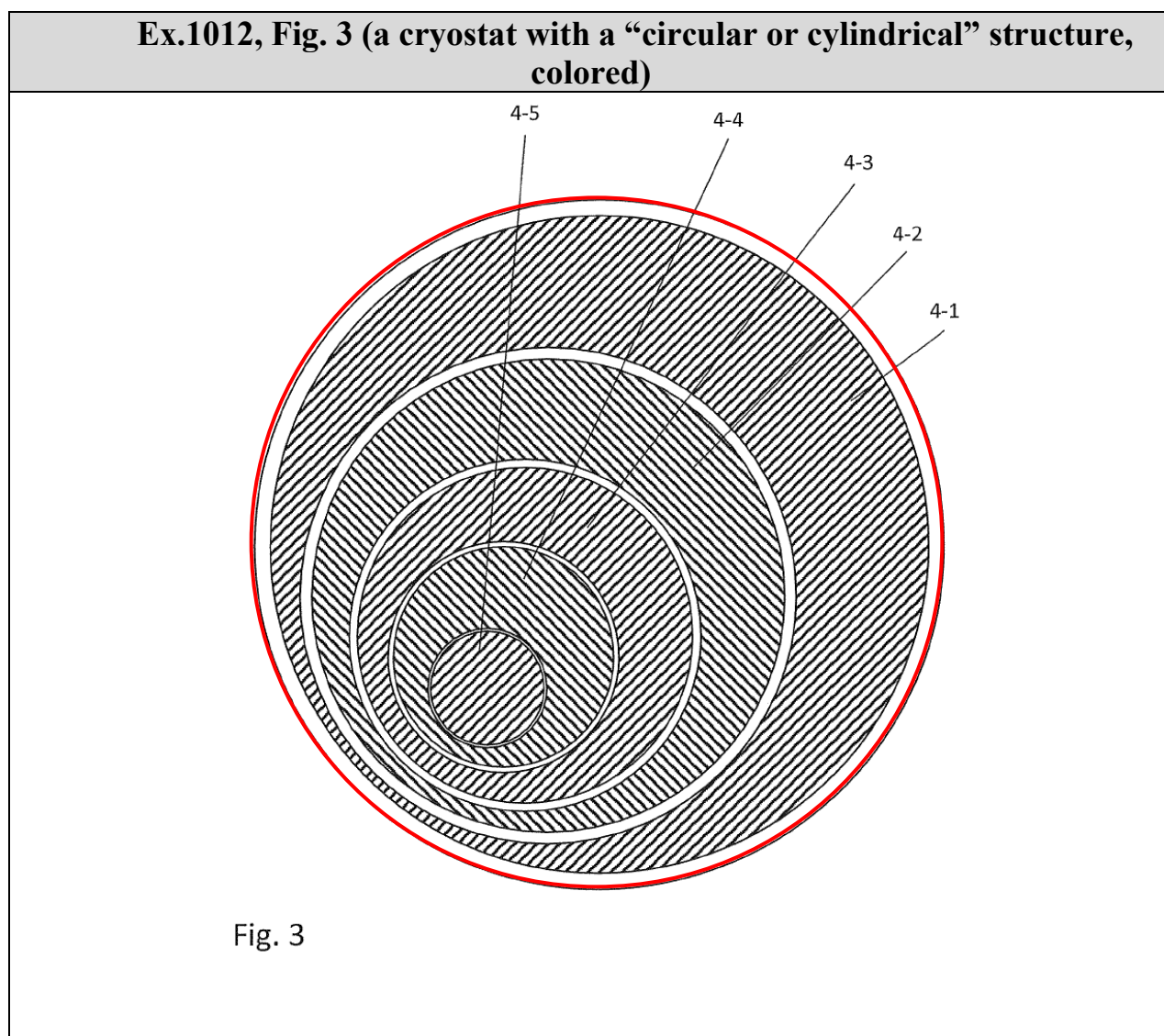
167. PWS also discloses a dilution refrigerator with “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface.” Ex.1012, Figs. 2A, 2B. Specifically, PWS discloses cryostats with a $^3\text{He}/^4\text{He}$ demixing cooler 34, which includes a still 36 and a mixing chamber 40. Ex.1013, 4:7-10; 9:17-18. PWS’s cryostats can achieve a temperature of

approximately 30 mK. *Id.*, 7:12-14. In my opinion, demixing coolers is a different name for dilution refrigerators. In my opinion, PWS’s cryostats are dilution refrigerators.

168. Fig. 2A of PWS is a plan view of the cryostat, showing “a rectangular cross-sectional shape” of the cryostat. Ex.1013, 5:18-21. Fig. 2A of PWS shows experimental stations 4-1 through 4-5 within respective heat shields, and PWS provides that “the entire vacuum container 10 constitutes the first heat shield 32-1.” Ex.1013, 6:11-12. In my opinion, the outer heat shield shown in Fig. 2A corresponds to a vacuum chamber (red) with a rectangular cross-sectional shape.



169. Fig. 3 of PWS shows a plan view of a different embodiment, a cryostat with a “circular or cylindrical” structure. Ex.1012, Figure 3 and Ex.1013, 8:1-2. Thus, in my opinion, PWS teaches that whether to make dilution refrigerators with a “rectangular shape” (Fig. 2A) or a “circular or cylindrical” shape (Fig. 3) is a mere design choice.



170. It would have been obvious for a POSITA to modify outer vacuum vessel 5 of Batey to have the rectangular form as taught in PWS. The combination

would involve the simple substitution of the cylinder-shaped outer vacuum vessel 5 of Batey with a rectangular shaped vacuum chamber as taught in PWS. In my opinion, given different choices in shape of the vacuum vessel were known, the combination would have been within the knowledge and skill of a POSITA and would yield predictable results.

171. In my opinion, the combination of Batey and PWS teaches “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface.”

3. **1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”**

172. As I described in Section VII.A.3, Batey discloses this limitation because outer vacuum vessel 5 has central port 6. Ex.1009, 7:3-7.

Ex.1009, Figure 1 (colored)

Fig. 1

174. In my opinion, claim 1 is obvious over Batey in view of PWS.

B. Claim 2 is Obvious

175. Claim 2 depends from claim 1, which Batey and PWS render obvious for the reasons I discussed above in Section VIII.A, which I incorporate herein. Claim 2 adds: “a sample stage housed within the experimental volume, wherein the opening is configured to provide access to the sample stage through the outer vacuum chamber.”

176. As I discussed above in Section VII.B, Batey discloses this limitation.

177. In my opinion, it would have been obvious to combine the teachings of Batey and PWS to arrive at the subject matter of claim 2.

C. Claim 3 is Obvious

178. Claim 3 depends from claim 2, which Batey and PWS render obvious for the reasons I discussed above in Section VIII.B, which I incorporate herein. Claim 3 adds: “one or more radiation shields housed within the outer vacuum chamber, and wherein portions of the one or more radiation shields proximate the sample stage are slidable and/or removable to provide access to the sample stage.”

179. As I discussed above in Section VII.C, Batey discloses this limitation.

180. In my opinion, it would have been obvious to combine the teachings of Batey and PWS to arrive at the subject matter of claim 3.

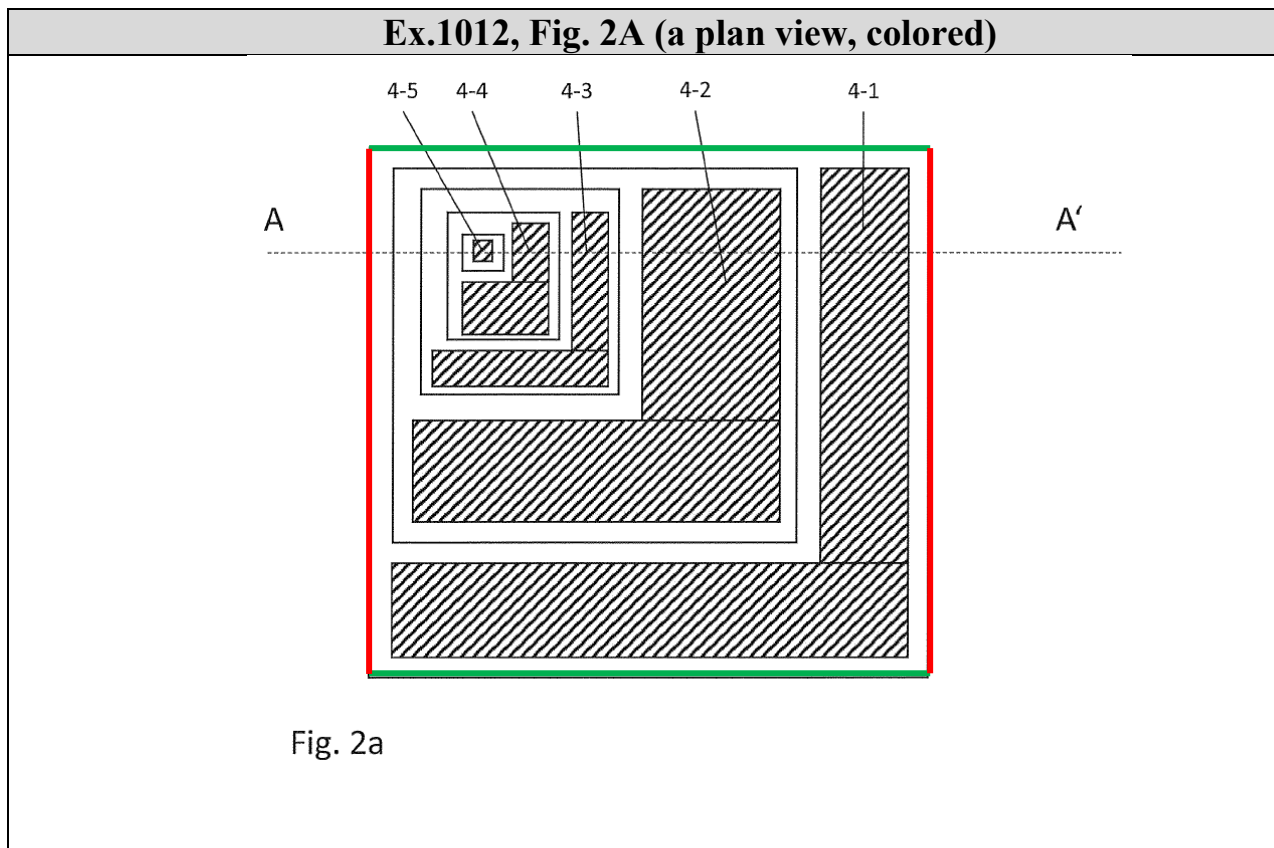
D. Claim 4 is Obvious

181. Claim 4 depends from claim 1, which Batey and PWS render obvious

for the reasons I discussed above in Section VIII.A, which I incorporate herein.

Claim 4 adds: “wherein the at least one substantially planar surface comprises: first surfaces disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator; and second surfaces disposed within a plane parallel to the plane of the floor, wherein the first surfaces and the second surfaces are arranged as a rectangular prism.”

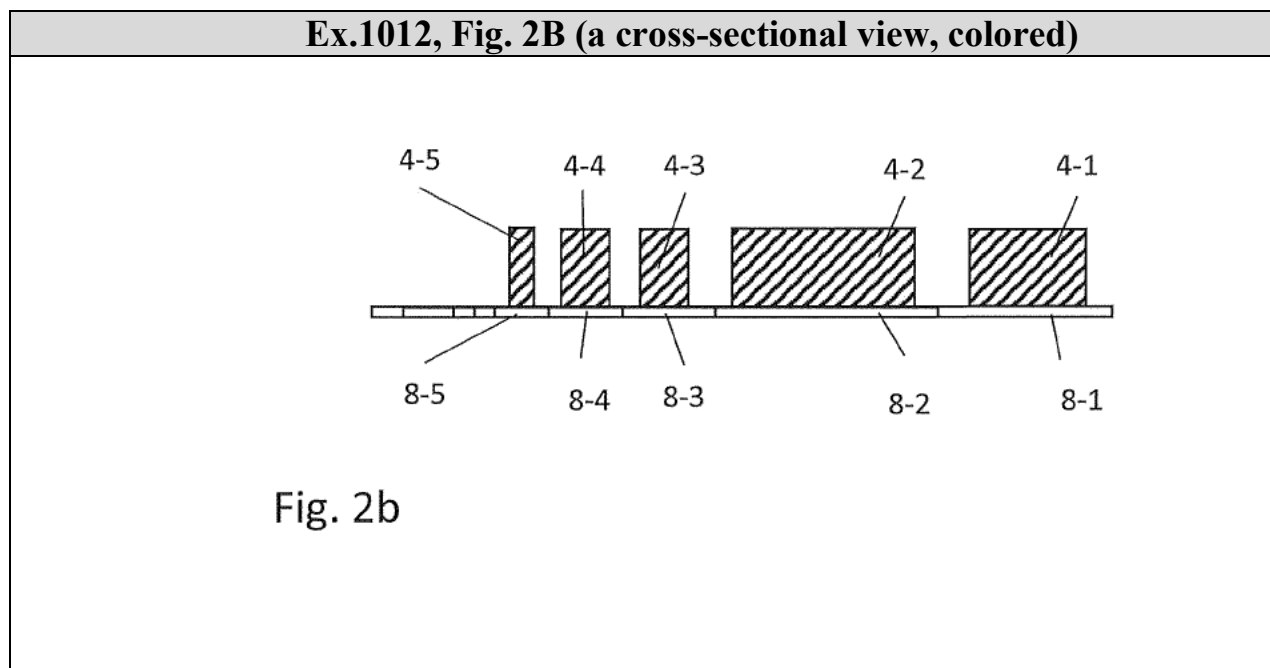
182. As I discussed above with respect to limitation 1[a], PWS teaches a vacuum chamber having a rectangular form. Ex.1012, Figure 2A and Ex.1013, 5:18-21.



183. According to the plan view of the cryostat shown in Fig. 2A of PWS,

the vacuum chamber has four planar surfaces (two red surfaces and two green surfaces) that are perpendicular to a plane of a floor supporting the dilution refrigerator.

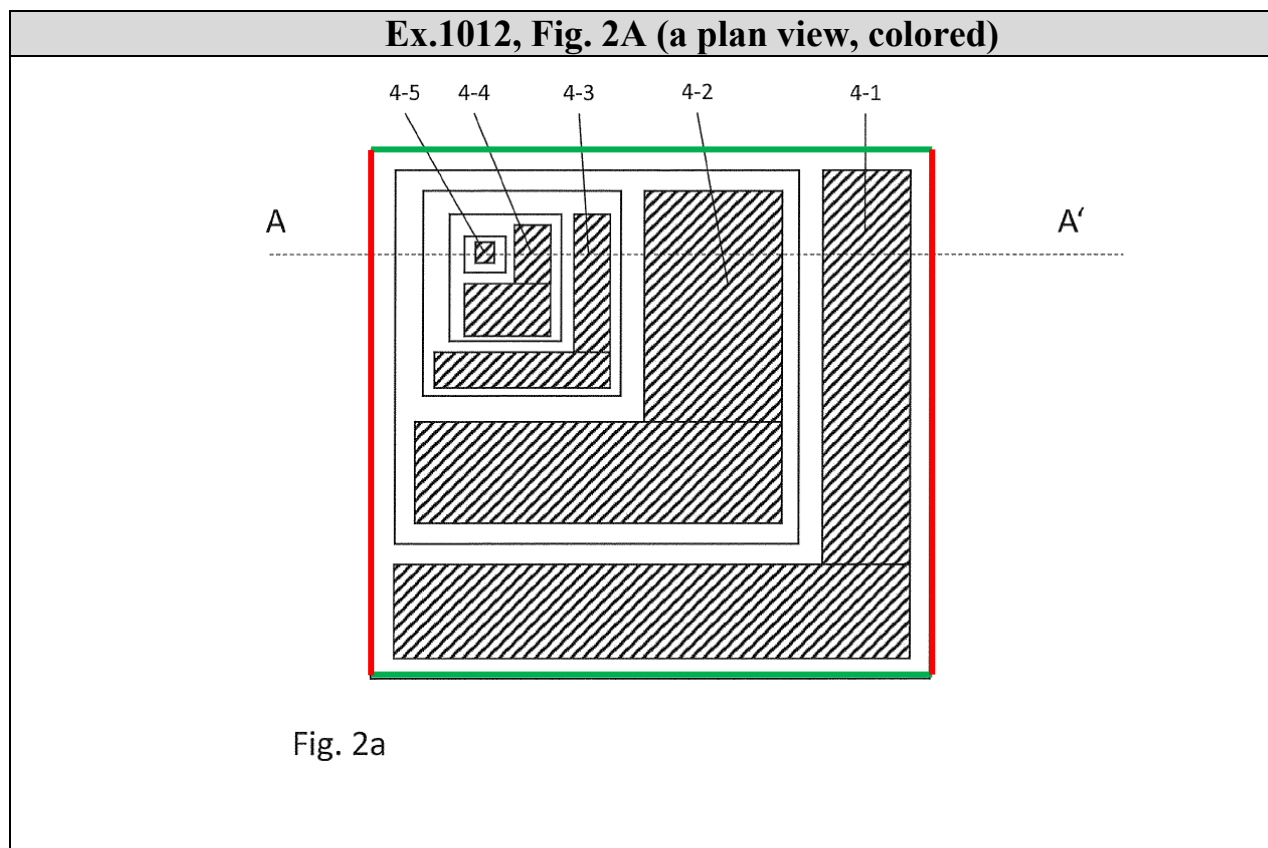
184. PWS does not explicitly illustrate the top and bottom surfaces of the vacuum chamber. However, the cross-sectional view of the cryostat, in Fig. 2B, shows that the experimental stations 4-1 through 4-5 are arranged next to each other, over cooling plates 8-1 through 8-5 located on a common surface.



185. In addition, PWS provides that the vacuum container 10 comprises “a base plate 20.” Ex.1013, 6:6-7. A POSITA would understand that the rectangular vacuum chamber of PWS has a planar bottom surface that is parallel to the plane of the floor supporting the dilution refrigerator. In addition, in my opinion, a POSITA would be motivated to provide a planar top surface, because PWS provides

motivation to keep the height of the cryostat low. Ex.1013, 8:8-10 (“The low height of the cryostat makes it possible to operate the cryostat in laboratories with standard ceiling heights.”). In addition, Fig. 4 of PWS shows a vacuum chamber with planar top and bottom surfaces. In my opinion, PWS teaches “surfaces disposed within a plane parallel to the plane of the floor.”

186. In my opinion, the side surfaces (red and green) and the planar top and bottom surfaces would be arranged as a rectangular prism.



187. In my opinion, it would have been obvious to combine the teachings of Batey and PWS to arrive at the subject matter of claim 4.

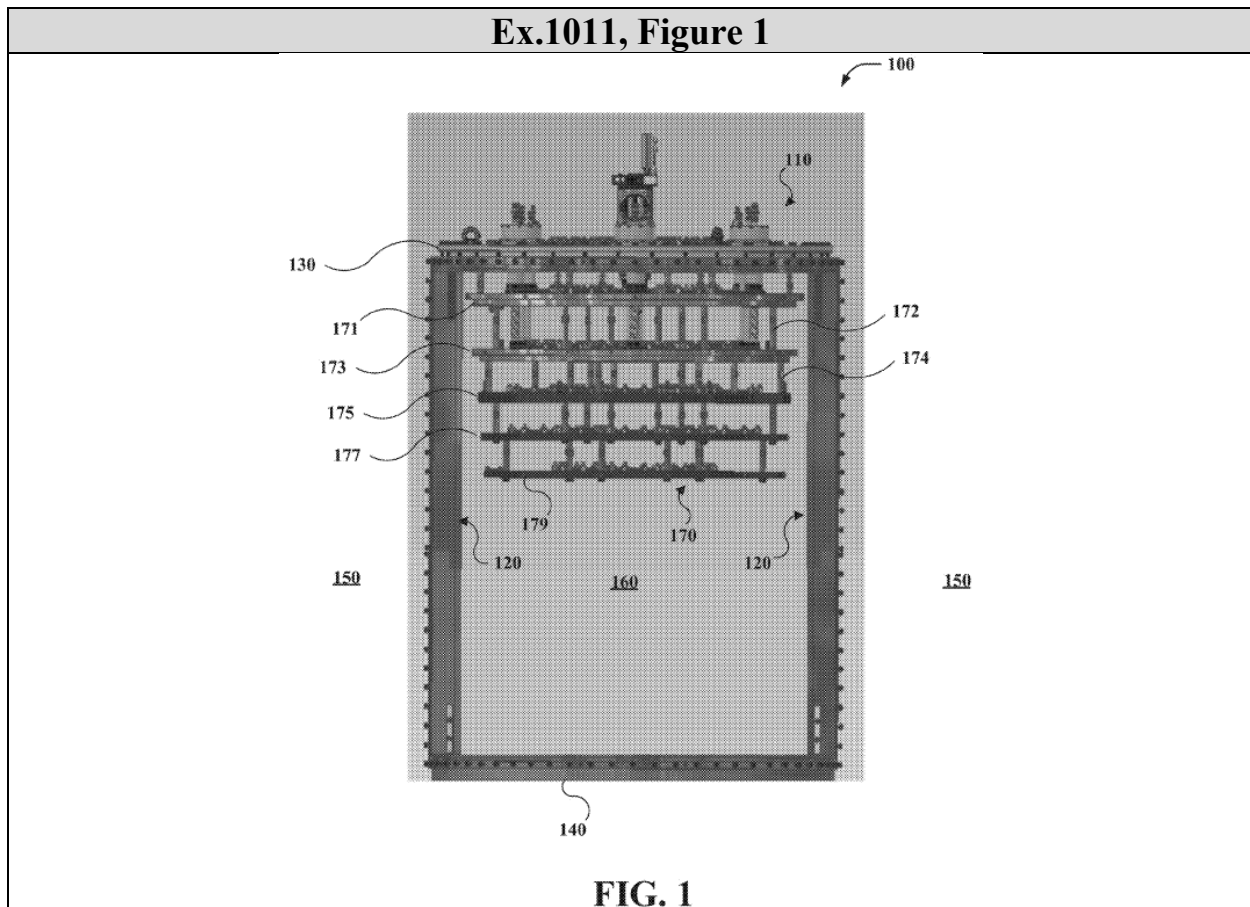
IX. GROUND 3: CLAIMS 1-6, 8, AND 17-19 ARE OBVIOUS OVER CHOW IN VIEW OF DAIN

A. Claim 1 Is Obvious

1. 1[pre] – “a dilution refrigerator comprising:”

188. As I discussed above in Section VII.A.1.a, the preamble is not limiting.

189. To the extent the Board finds the preamble to be limiting, Chow discloses “a dilution refrigerator.” Chow discloses a cryostat 100 with an outer vacuum chamber that includes a Still stage and a Mixing Chamber stage. Ex.1011, [0026].



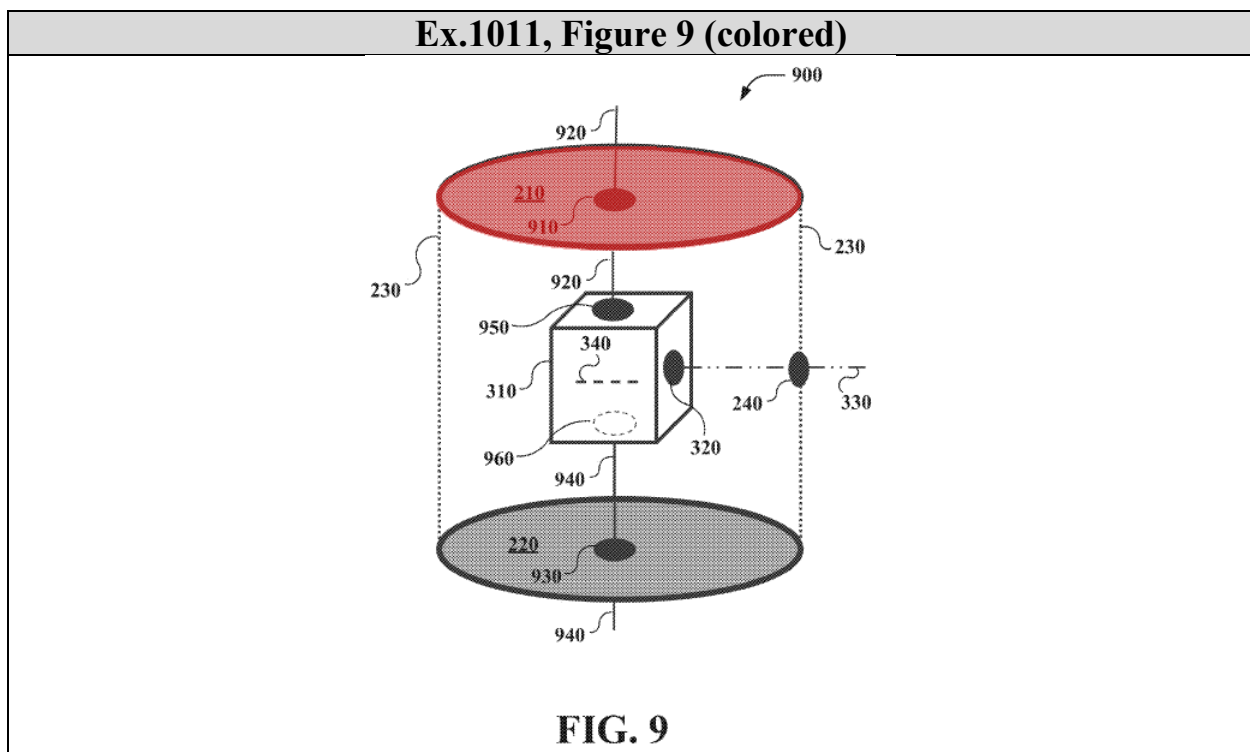
190. In my opinion, a POSITA would understand that Chow's disclosures of a cryostat with an outer vacuum chamber having thermal stages that include a still and mixing chamber is a dilution refrigerator.

191. In my opinion, Chow discloses "a dilution refrigerator."

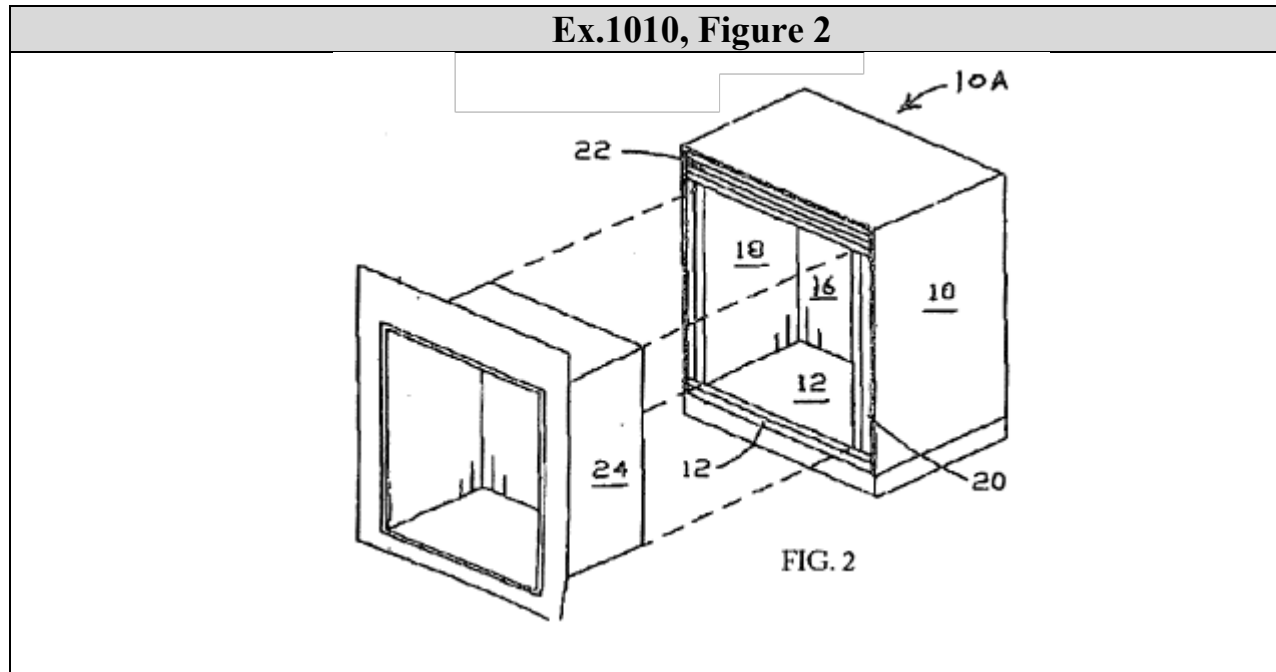
2. 1[a] – "an outer vacuum chamber comprising an outer housing having at least one substantially planar surface"

192. Chow discloses a cryostat with an outer vacuum chamber 900.

Ex.1011, [0038], Fig. 9. The outer vacuum chamber 900 includes a housing with planar surfaces (including the top surface 210 (red) and bottom surface 220 with feedthrough ports 910 and 930). The outer vacuum chamber 900 also includes side wall 230 with feedthrough port 240.



193. Dain also discloses “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface.” Ex.1010, Fig. 2.



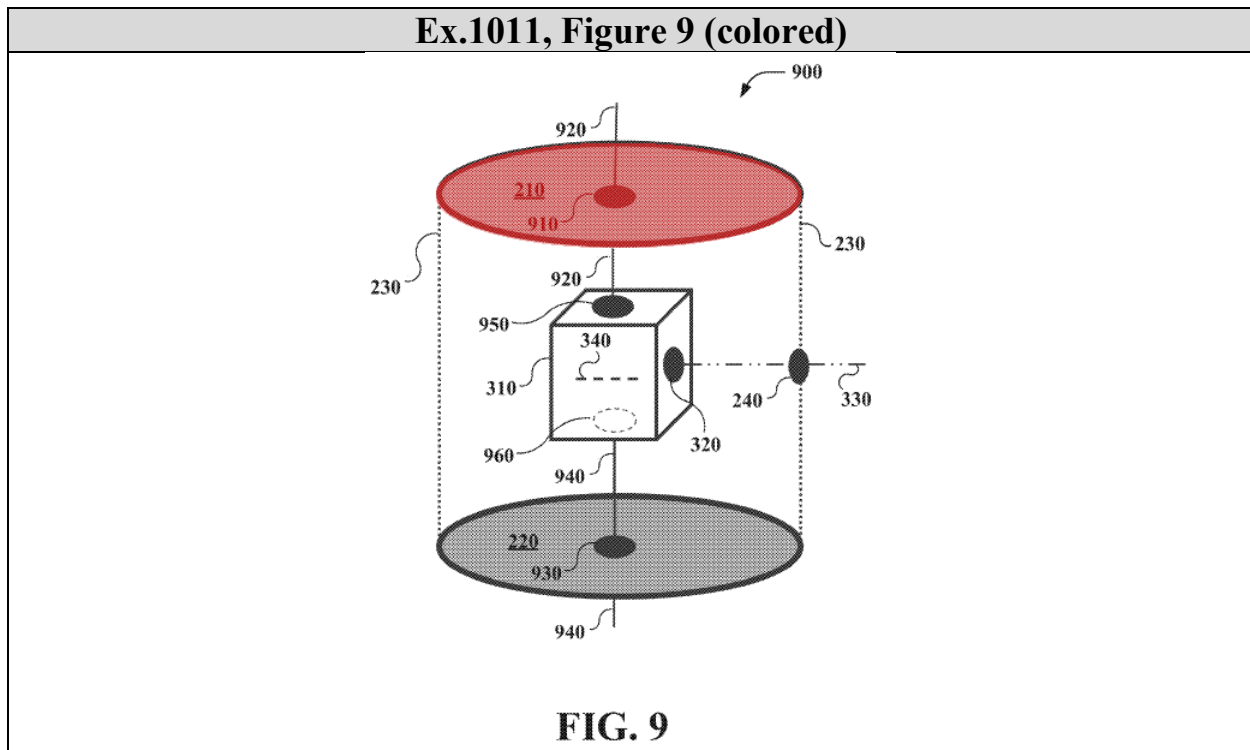
194. Similar to the reasons I explained in Section VII.A.2, a POSITA would have been motivated to modify the cylindrical vacuum vessel 900 of Chow to have a rectangular shape as described in Dain. Because Chow discloses a dilution refrigerator with a side-loading port, in my opinion, a POSITA modifying the cylindrical vacuum vessel 900 of Chow to have a rectangular shape does not need to change the direction of sample loading.

195. In my opinion, the combination of Chow and Dain teaches “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface.”

3. 1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”

196. Chow discloses this limitation because the top surface 210 has feedthrough port 910. Ex.1011, [0038]. Feedthrough ports 910 and 930 provide access to sample mounting surface 340 from an exterior of outer vacuum chamber 900. Id., [0039].

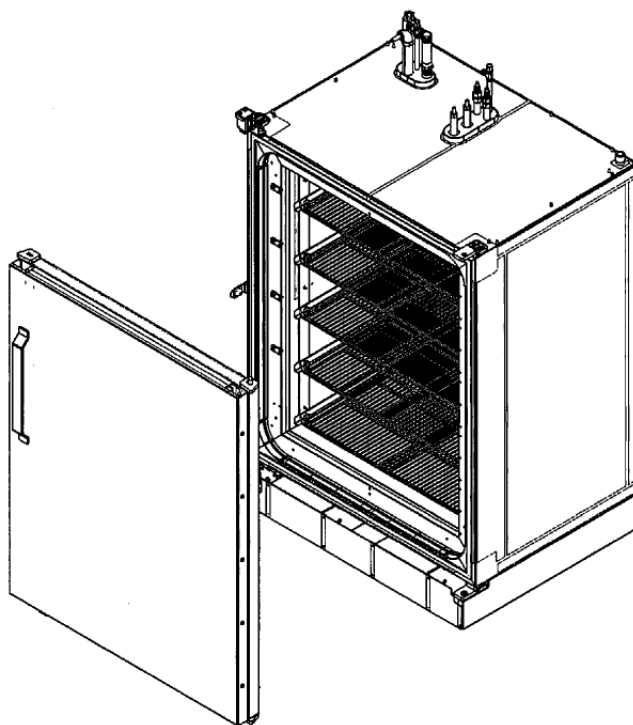
197. In my opinion, Chow discloses an opening (e.g., feedthrough port 910) in the at least one substantially planar surface (e.g., top surface 210) configured to provide access to an experimental volume (e.g., sample mounting surface 340) within an interior of the outer vacuum chamber.



198. In my opinion, a POSITA modifying the outer vacuum vessel 900 of Chow to have a rectangular shape as described in Dain would leave Chow's feedthrough port 910 (e.g., an opening) in the housing to provide access to sample mounting surface 340 from an exterior of outer vacuum chamber 900. *Id.*, [0039]. In my opinion, sample mounting surface 340 is in an experimental volume because a sample mounted on the sample mounting surface 340 is used for experiments.

199. In my opinion, the cylindrical outer vacuum vessel 900 modified to have the rectangular shape as described in Dain would also have the feedthrough port 240 on a planar front surface. In my opinion, this is consistent with the teaching of Dain, which teaches an opening in a planar surface of the rectangular outer shell 10 to provide access to its interior. Ex.1010, Figure 7A. Alternatively, in my opinion, a POSITA would provide the opening on the front planar surface of the rectangular vacuum chamber, as described in Dain, because the front access through the door is convenient. Ex.1010, [0032].

Ex.1010, Figure 7A



200. In my opinion, claim 1 is obvious over Chow in view of Dain.

B. Claim 2 is Obvious

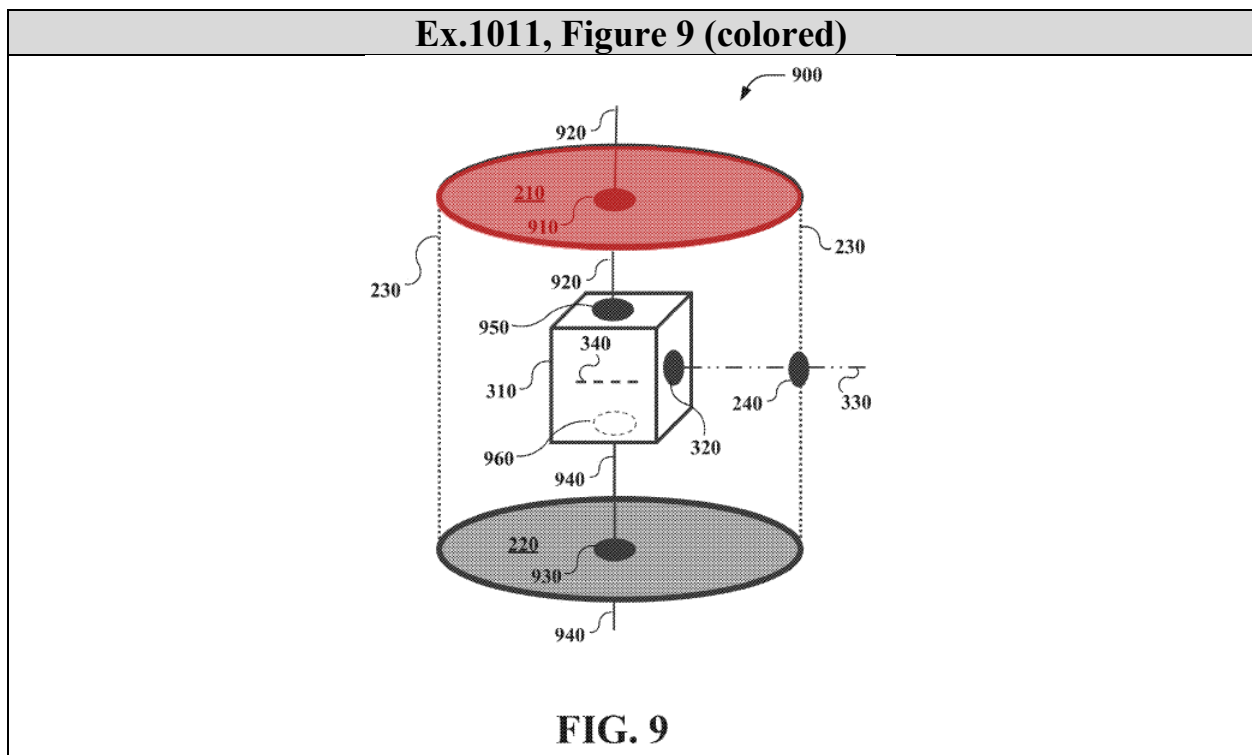
201. Claim 2 depends from claim 1, which Chow and Dain render obvious for the reasons I discussed above in Section IX.A, which I incorporate herein. Claim 2 adds: “a sample stage housed within the experimental volume, wherein the opening is configured to provide access to the sample stage through the outer vacuum chamber.”

202. Chow discloses the limitation of claim 2 because outer vacuum chamber 900 1 has a sample mounting surface 340. Ex.1011, Figure 9. As I discussed with respect to limitation 1[b], feedthrough ports 910 and 930 provide access to sample mounting surface 340 from an exterior of outer vacuum chamber

900. *Id.*, [0039].

203. In addition, the cylindrical outer vacuum vessel 900 modified to have the rectangular shape as described in Dain would also have feedthrough port 240 on a planar surface. Feedthrough port 240 allows loading of a sample onto sample loading surface 340. Ex.1011, [0039].

204. In my opinion, a POSITA would understand that sample mounting surface 340 can be “accessed” from outside of outer vacuum chamber 900 through feedthrough ports 910, 930, and 240.



205. In my opinion, it would have been obvious to combine the teachings of Chow and Dain to arrive at the subject matter of claim 2.

C. Claim 3 is Obvious

206. Claim 3 depends from claim 2, which Chow and Dain render obvious for the reasons I discussed above in Section IX.B, which I incorporate herein.

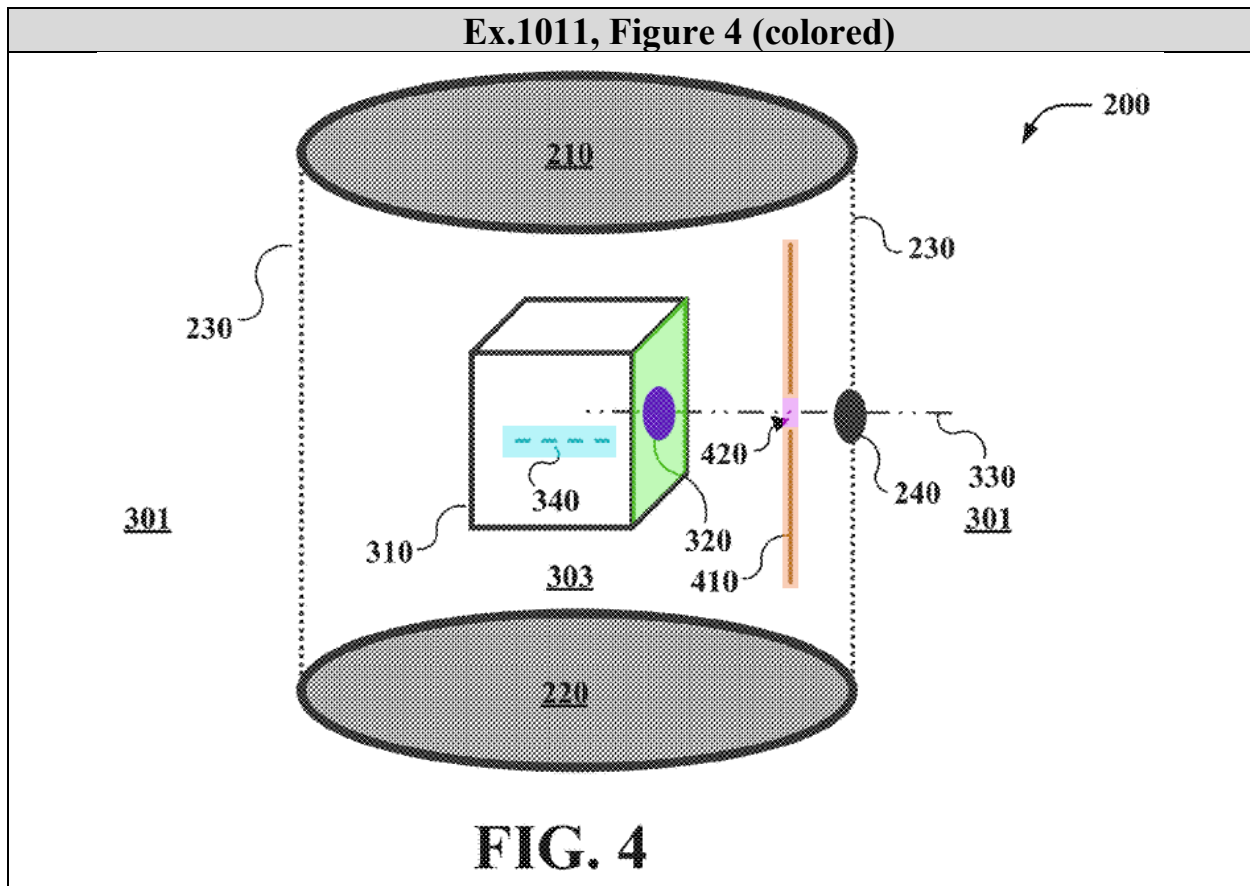
Claim 3 adds: “one or more radiation shields housed within the outer vacuum chamber, and wherein portions of the one or more radiation shields proximate the sample stage are slidable and/or removable to provide access to the sample stage.”

207. Chow discloses that a thermal shield 410 (orange) can “intervene between” feedthrough port 240 and sample mounting surface 340 (blue). Ex.1011, [0031]. Thermal shield 410 “can be mechanically coupled to a thermal plate associated with a thermal stage of a cryostat,” such as “a 50-K stage, a 4-K stage, a Still stage, or a Cold Plate stage.” *Id.* In my opinion, thermal shield 410 is “a component that reduces radiant heat transfer” (*i.e.*, a radiation shield). In my opinion, a POSITA would understand, based on Chow’s disclosures, that thermal shield 410 is the radiation shield required by claim 3.

208. Chow also describes thermal shield 410 “can comprise a feedthrough port 420 (pink) to facilitate access to sample mounting surface 340 from the region 301 external to outer vacuum chamber 200.” Ex.1011, [0031]. From the disclosure that a portion of thermal shield 410 has been removed to form the feedthrough port 420 (pink), in my opinion, a POSITA would understand that one or more portions of thermal shield 410 are removable to provide access to sample mounting surface

340 (blue).

209. Although Chow describes thermal shield 410 with respect to the embodiment involving vacuum chamber 200, in my opinion, it would be obvious for a POSITA to modify outer vacuum chamber 900 to include thermal shield 410 as well. Ex.1011, [0053].



210. In my opinion, Chow discloses “[t]he dilution refrigerator of claim 2 [e.g., Chow cryostat], further comprising one or more radiation shields [e.g., thermal shield 410] housed within the outer vacuum chamber, and wherein portions of the one or more radiation shields proximate the sample stage [e.g., a portion

removed to form feedthrough port 420] are slidable and/or removable to provide access to the sample stage [e.g., sample mounting surface 340].”

211. In my opinion, it would have been obvious to combine the teachings of Chow and Dain to arrive at the subject matter of claim 3.

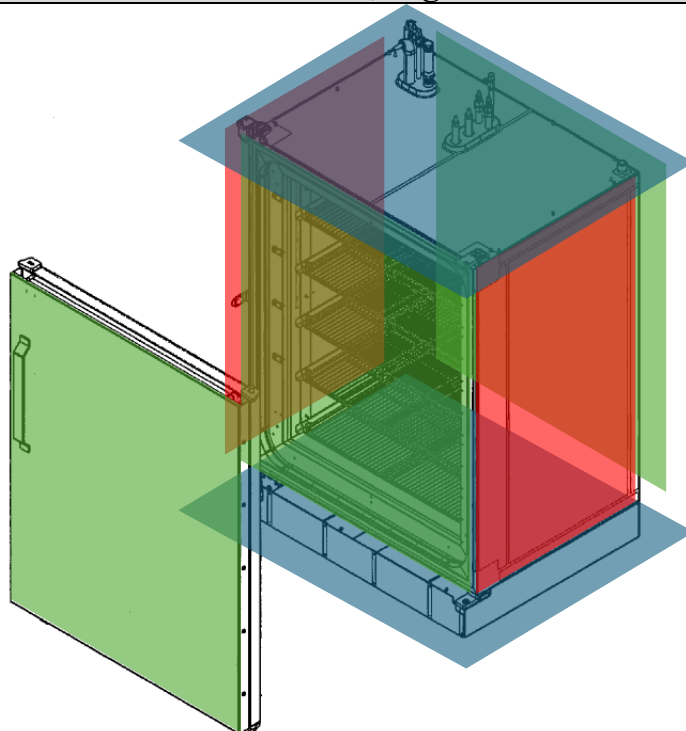
D. Claim 4 is Obvious

212. Claim 4 depends from claim 1, which Chow and Dain render obvious for the reasons I discussed above in Section IX.A, which I incorporate herein.

Claim 4 adds: “wherein the at least one substantially planar surface comprises: first surfaces disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator; and second surfaces disposed within a plane parallel to the plane of the floor, wherein the first surfaces and the second surfaces are arranged as a rectangular prism.”

213. As I discussed above with respect to limitation 1[a], Dain teaches a vacuum chamber having a rectangular form. Ex.1010, Figure 7A and [0008].

Ex.1010, Figure 7A



214. In my opinion, a POSITA would understand that the rectangular vacuum chamber of Dain is placed on a floor like most types of refrigerators. In my opinion, a POSITA would also understand that the rectangular vacuum chamber has “first surfaces [green front and back surfaces or red side surfaces] disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator; and second surfaces [blue top and bottom surfaces] disposed within a plane parallel to the plane of the floor, wherein the first surfaces and the second surfaces are arranged as a rectangular prism.”

215. In my opinion, it would have been obvious to combine the teachings of Chow and Dain to arrive at the subject matter of claim 4.

E. Claim 5 is Obvious

216. Claim 5 depends from claim 1, which Chow and Dain render obvious for the reasons I discussed above in Section IX.A, which I incorporate herein. Claim 5 recites: “The dilution refrigerator of claim 1, wherein the opening comprises a hermetic opening.”

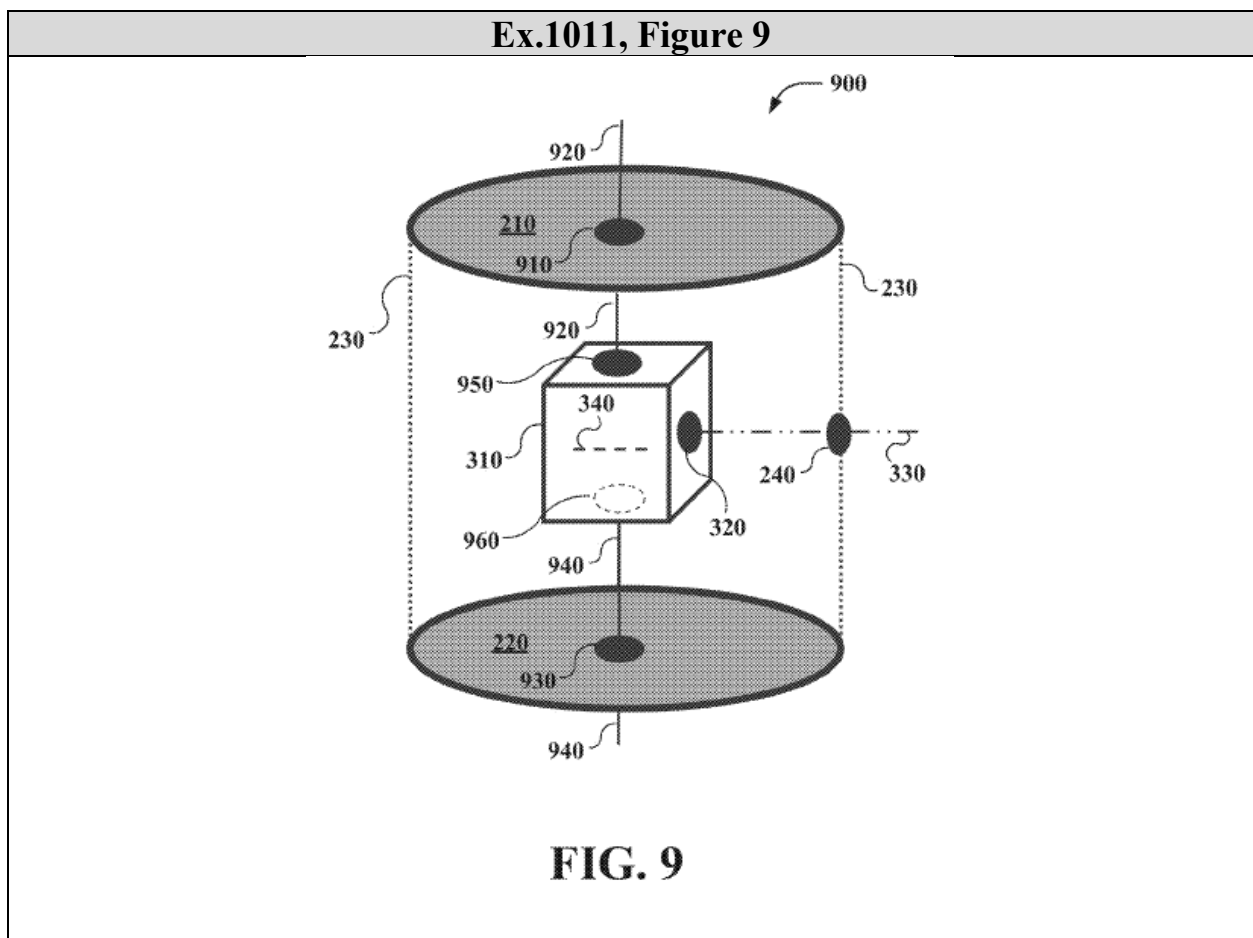
217. Chow discloses that “outer vacuum chamber 200 can further comprise a vacuum valve 510 coupled to feedthrough port 240. Vacuum valve 510 can maintain a pressure differential between an ambient environment [] and the interior 303 of outer vacuum chamber 200.” Ex.1010, [0032]. Chow also discloses that vacuum valve 510 can be implemented using a gate valve. *Id.* In my opinion, a POSITA would understand that vacuum valve 510 corresponds to an opening with a hermetic seal, *i.e.*, a hermetic opening.

218. Dain also teaches that “the door assembly includes door-sealing gasket” and the negative pressure inside the payload bay of the vacuum chamber is maintained by “pneumatic seals on the main door assembly.” Ex.1010, [0007]. [0026]. In my opinion, Dain also discloses a hermetic opening, an opening with a hermetic seal.

219. In my opinion, it would have been obvious to combine the teachings of Chow and Dain to arrive at the subject matter of claim 5.

F. Claim 6 is Obvious

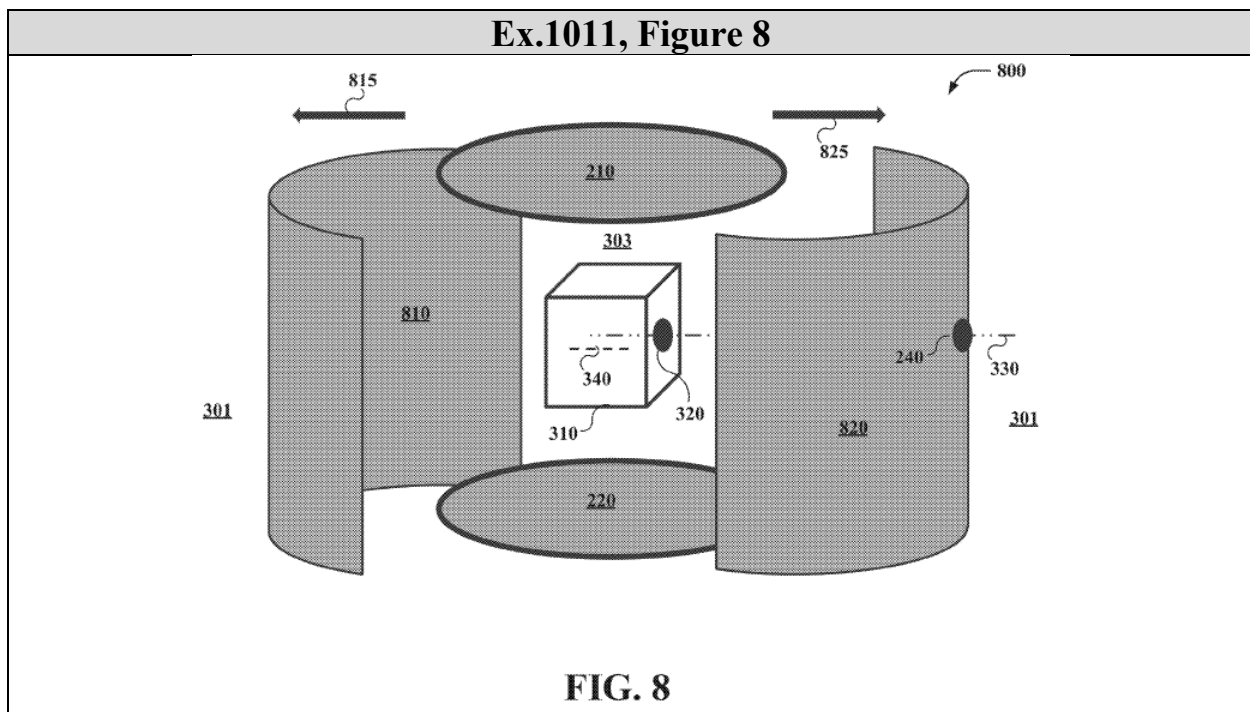
220. Claim 6 depends from claim 1, which Chow and Dain render obvious for the reasons I discussed above in Section IX.A, which I incorporate herein. Claim 6 recites: “The dilution refrigerator of claim 1, wherein the outer vacuum chamber comprises: a first section; and a second section suspended from the first section.”



221. Figure 9 of Chow illustrates the outer vacuum chamber 900 formed by sidewall 230 intervening between top plate 210 and bottom plate 220. Ex.1011, Figure 9, [0028]. Thus, in my opinion, Chow discloses a first section of the vacuum

chamber 200 (e.g., top plate 210) and a second section of the vacuum chamber 200 (e.g., sidewall 230) suspended from the first section.

222. In addition, Figure 8 of Chow teaches that the side wall can be partitioned into two sections 810 and 820 that are removably coupled from the vacuum chamber 800. Ex.1011, [0036]. In my opinion, this portion of Chow also teaches a first section of the vacuum chamber (e.g., top plate 210) and a second section of the vacuum chamber 200 (e.g., side wall partitions 810 and 820) suspended from the first section.



223. In my opinion, it would have been obvious to combine the teachings of Chow and Dain to arrive at the subject matter of claim 6.

G. Claim 8 is Obvious

224. Claim 8 depends from claim 6, which Chow and Dain disclose for the same reasons I discussed above in Section IX.F, which I incorporate herein. Claim 8 recites: “The dilution refrigerator of claim 6, wherein the first and/or second section of the outer vacuum chamber are configured to be at least partially removed from the dilution refrigerator to provide access to an interior of the outer vacuum chamber.”

225. As I discussed above with respect to claim 6, Chow discloses the vacuum chamber 800 with a sidewall having removable partitions “to facilitate employing side-loading sample exchange mechanisms.” Ex.1011, [0036]. In my opinion, a POSITA would understand that removing partition 810 or 820 of the side wall also provides access to an interior of the vacuum chamber 800.

226. In my opinion, it would have been obvious to combine the teachings of Chow and Dain to arrive at the subject matter of claim 8.

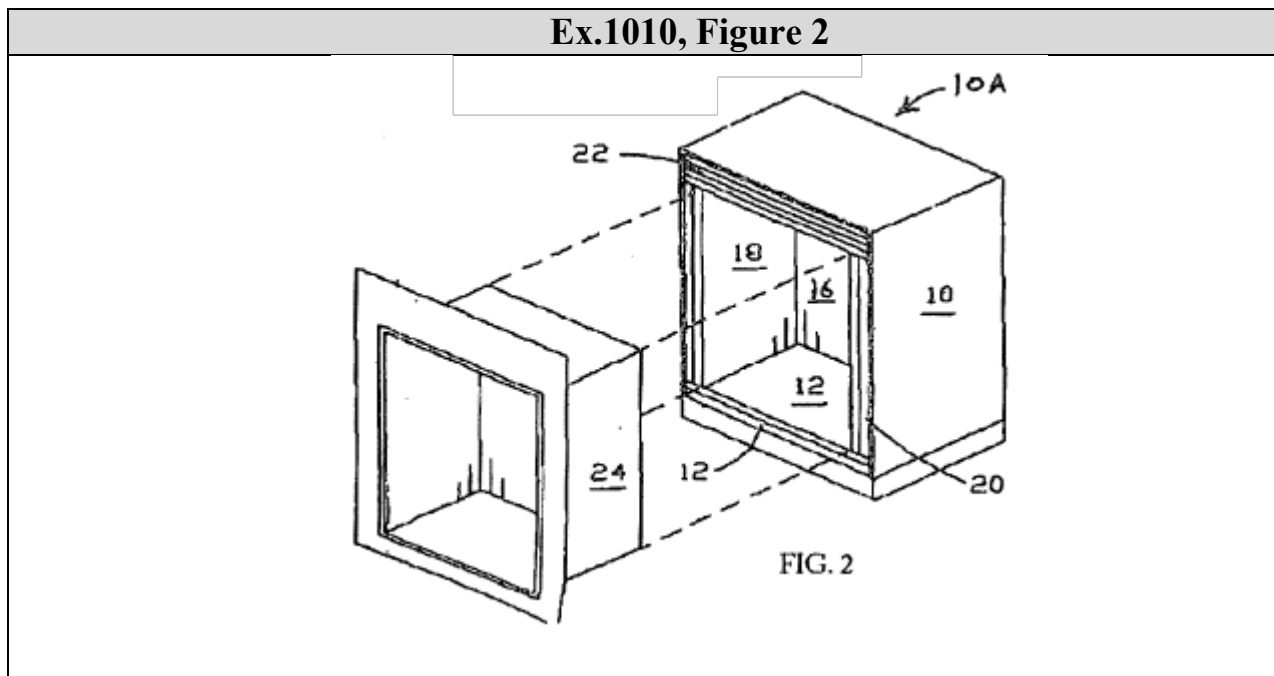
H. Claim 17 is Obvious

1. 17 [pre] – “a dilution refrigerator comprising:”

227. In my opinion, the combination of Chow and Dain teaches the preamble of claim 17 for the same reasons as I described above with respect to 1[pre].

2. 17[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”

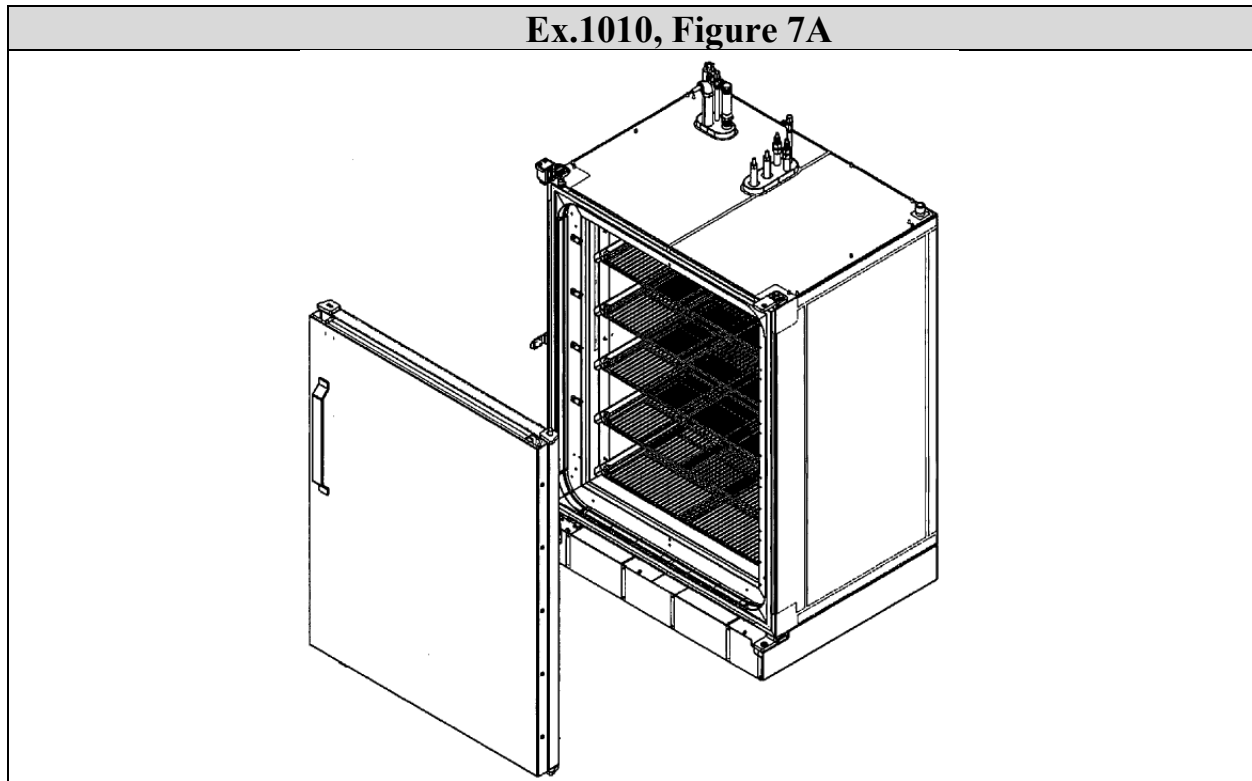
228. In my opinion, the combination of Chow and Dain teaches limitation 17[a] for the same reasons as I described above with respect to limitation 1[a]. In particular, Chow discloses a cryostat with an outer vacuum chamber 900. Ex.1011, [0038], Fig. 9. Dain discloses “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface.” Ex.1010, Fig. 2, [0008] (“a ULT [ultra low temperature] chamber which is made in compact rectangular form”).



229. Similar to the reasons I explained with respect to limitation 1[a], a POSITA would have been motivated to modify the cylindrical vacuum vessel 900 of Chow to have a rectangular shape as described in Dain.

3. **17[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber, wherein:”**

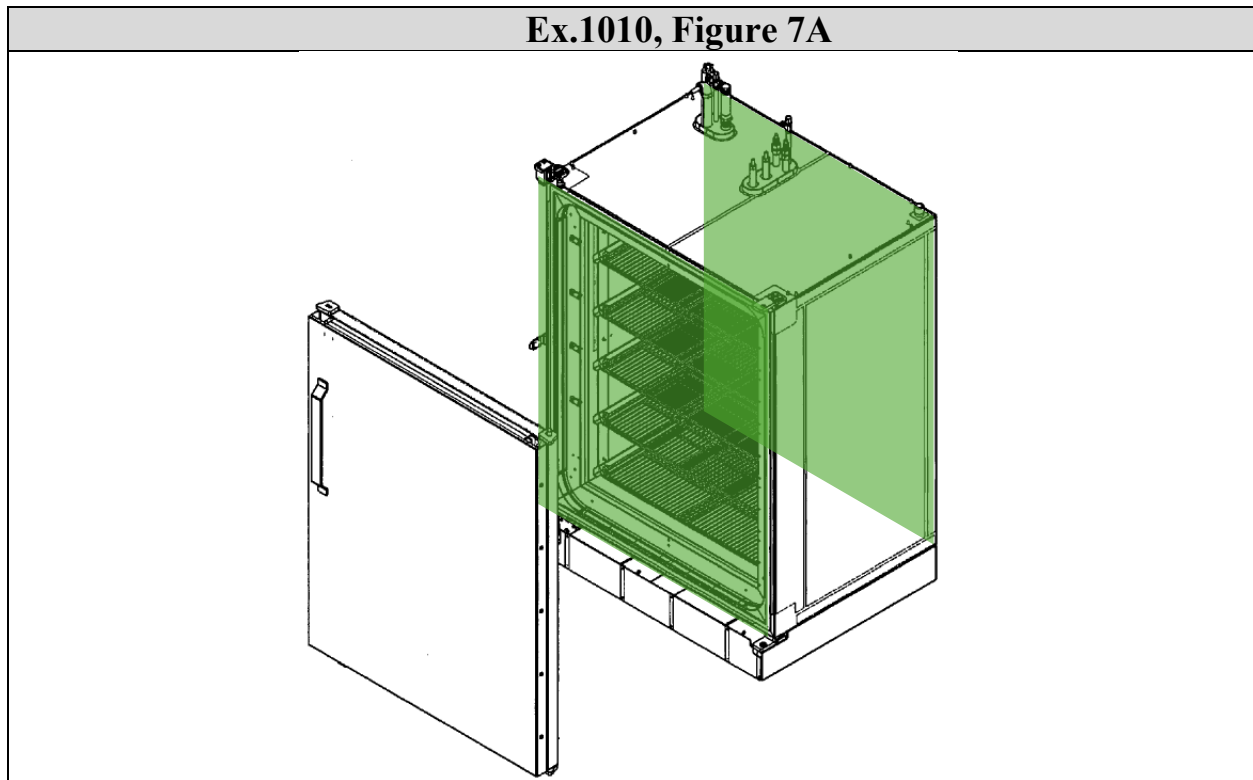
230. In my opinion, the combination of Chow and Dain teaches limitation 17[b] for the same reasons as I described above with respect to limitation 1[b]. For example, in my opinion, a POSITA would provide the opening on the front planar surface of the rectangular vacuum chamber, as described in Dain, because the configuration provides convenient front access through the door. Ex.1010, [0032].



4. **17[c] “the at least one substantially planar surface of the outer housing comprises a first surface disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator”.**

231. The combination of Chow and Dain teaches limitation 17[c] for the

same reasons as described above with respect to claim 4. In particular, in my opinion, a POSITA would understand that the rectangular vacuum chamber of Dain is placed on a floor like most types of refrigerators. In my opinion, a POSITA would also understand that the rectangular vacuum chamber has “a first surfaces [any of green front and back surfaces] disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator.”



232. In my opinion, it would have been obvious to combine the teachings of Batey and Dain to arrive at the subject matter of claim 17.

I. Claim 18 is Obvious

1. 18[pre] – “a dilution refrigerator comprising:”

233. In my opinion, the combination of Chow and Dain teaches the preamble of claim 18 for the same reasons as I described above with respect to claim 1.

2. 18[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”

234. In my opinion, the combination of Chow and Dain teaches limitation 18[a] for the same reasons as I described above with respect to limitation 17[a].

3. 18[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an interior of the outer vacuum chamber,”

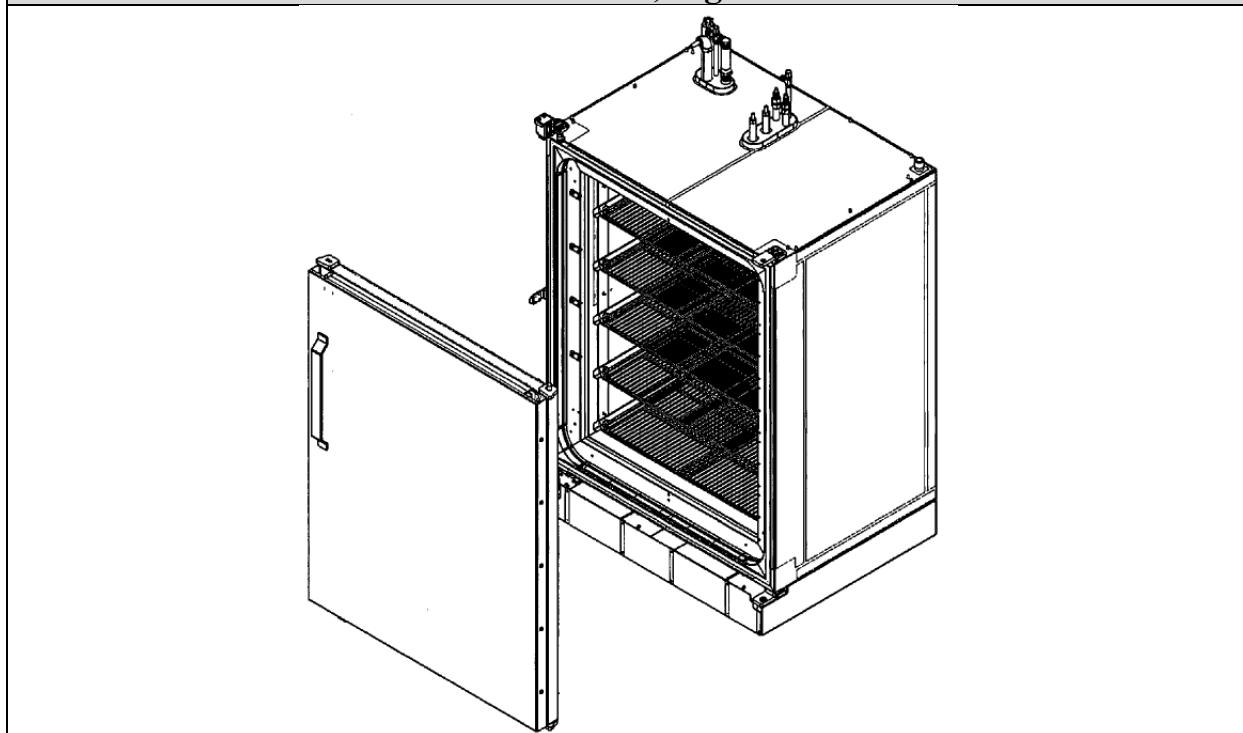
235. In my opinion, the combination of Chow and Dain teaches limitation 18[b] for the same reasons as I described above with respect to limitation 17[b].

4. 18[c] “wherein the opening comprises a hinged door.”

236. In my opinion, the combination of Chow and Dain teaches limitation 18[c].

237. Dain discloses “a substantially flat vertical door serving as the front panel of the chamber.” Ex.1010, [0008], [0030] (“the door 41 adapted to seal a payload bay”), Figure 7A. Furthermore, Dain discloses that “the door 41 has a piano hinge 45 to allow the door to move for access purposes.” Ex.1010, [0028].

Ex.1010, Figure 7A



238. In my opinion, a POSITA modifying the outer vacuum vessel 900 of Chow to the rectangular shape described in Dain would be motivated to implement Dain's door to "provide convenient front access through the door." Ex.1010, [0032].

239. In my opinion, it would have been obvious to combine the teachings of Chow and Dain to arrive at the subject matter of claim 18.

J. Claim 19 is Obvious

240. Claim 19 depends from claim 18, which Chow and Dain render obvious for the same reasons discussed above. Claim 19 recites "the dilution refrigerator of claim 18, further comprising one or more radiation shields housed within the outer vacuum chamber, and wherein portions of the one or more

radiation shields proximate the hinged door are slidable and/or removable to provide access to the interior of the outer vacuum chamber.”

241. In my opinion, Chow discloses the limitation of claim 19 for the same reasons as claim 3.

242. In my opinion, it would have been obvious to combine the teachings of Chow and Dain to arrive at the subject matter of claim 19.

X. GROUND 4: GARSIDE ANTICIPATES CLAIMS 1-3, 5-6, AND 8

A. Claim 1

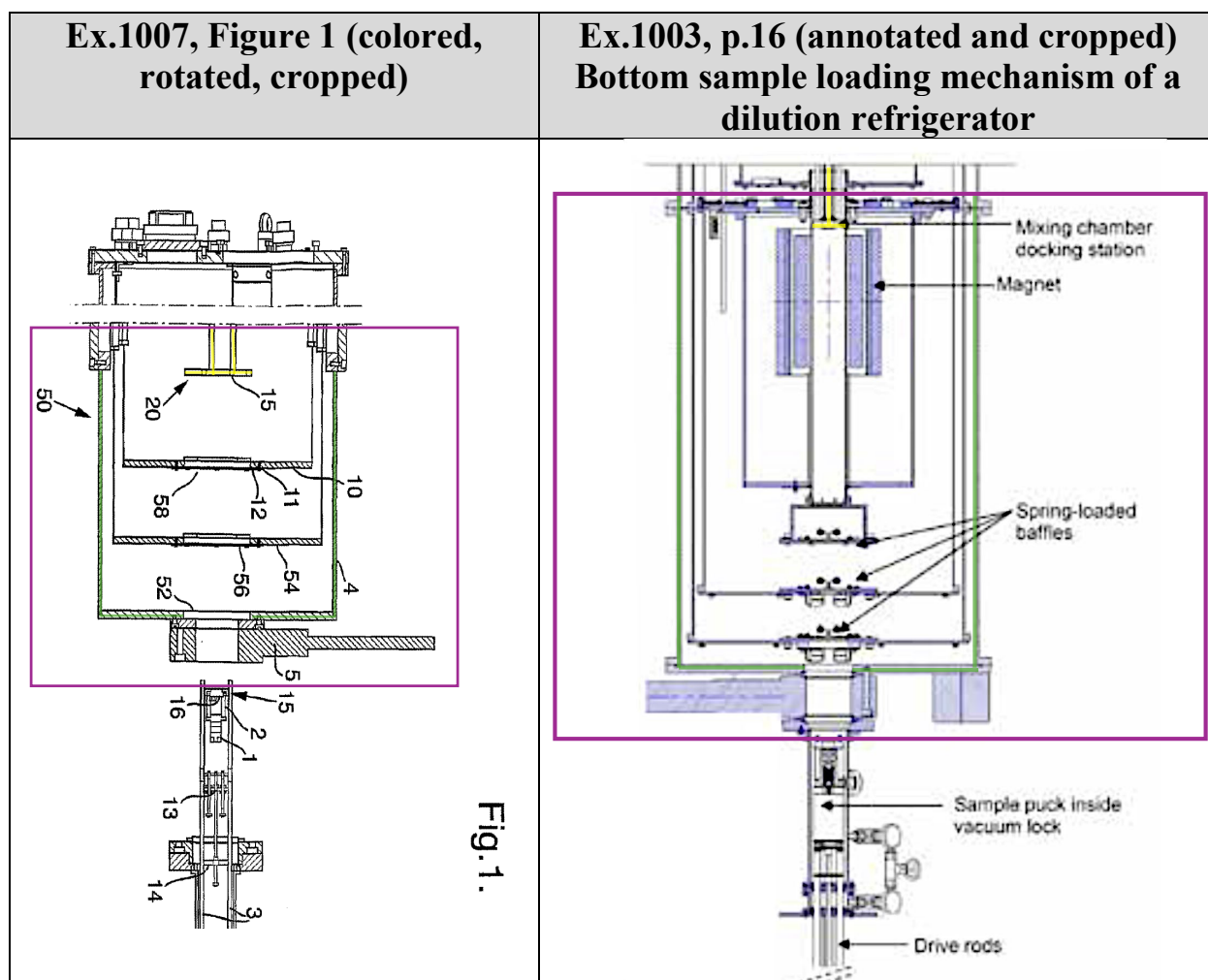
1. 1[pre] – “a dilution refrigerator comprising:”

243. As I discussed above in Section VII.A.1.a, the preamble is not limiting.

244. However, if it were, Garside discloses “a dilution refrigerator.

245. Garside discloses a cryogen free cooling free cooling apparatus, Ex.1007, [0001]. The cryogen free cooling apparatus (also called a “cryostat 50”) includes an “outer vacuum vessel 4” or “vacuum vessel 4.” *Id.*, [0038], Abstract (also called “vacuum chamber 4”). Garside further describes utilizing, within the vacuum chamber of the cryostat 50, a cold body 15 (*e.g.*, a “cold surface coupled to an intermediate stage of a sub 4K cooler, such as a still of **a dilution refrigerator**”) to pre-cool a sample. *Id.*, [0016-17]. Garside also describes the cold body 15 (yellow, below) being “connected to the **mixing chamber** of a **dilution**

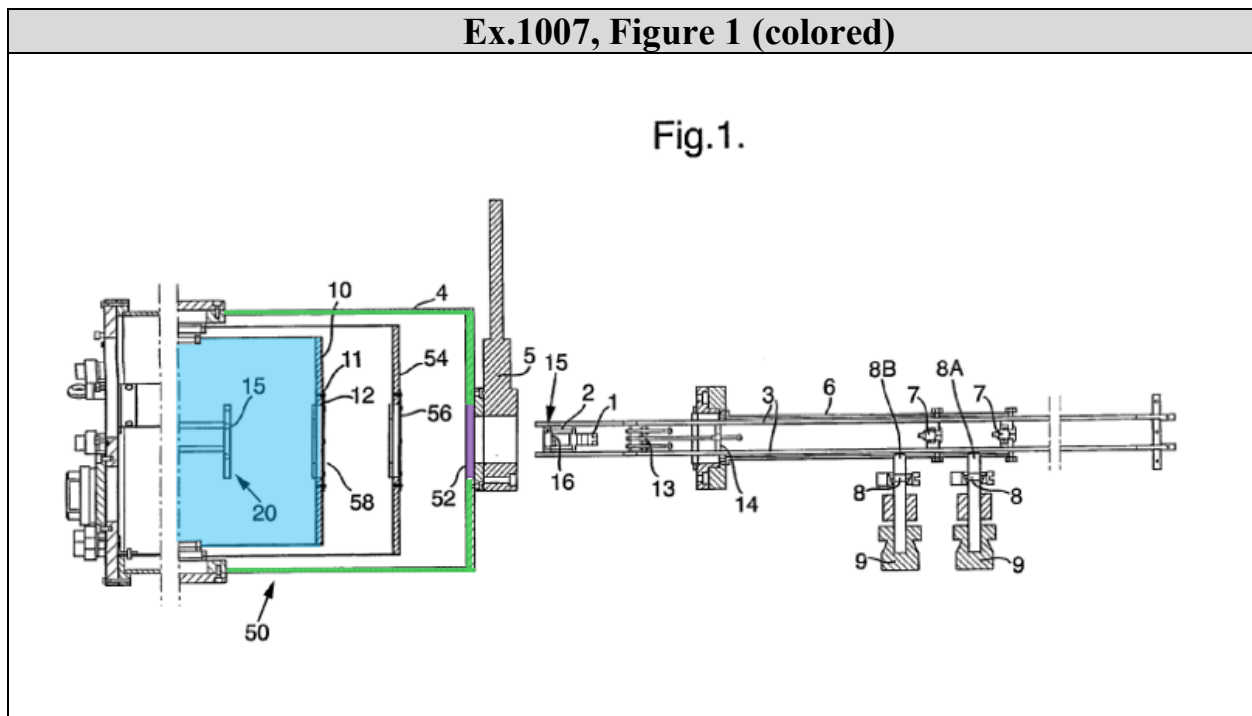
refrigerator.” *Id.*, [0044]. In my opinion, to couple the cold body 15 with the still or the mixing chamber of the dilution refrigerator, the still and mixing chamber of the dilution refrigerator are inherently included in vacuum vessel 4 (green, below). Fig. 1 of Ex.1007 shows a bottom-loading dilution refrigerator (illustrated with 90-degree rotation), similar to a bottom-loading dilution refrigerator shown in Ex.1003.



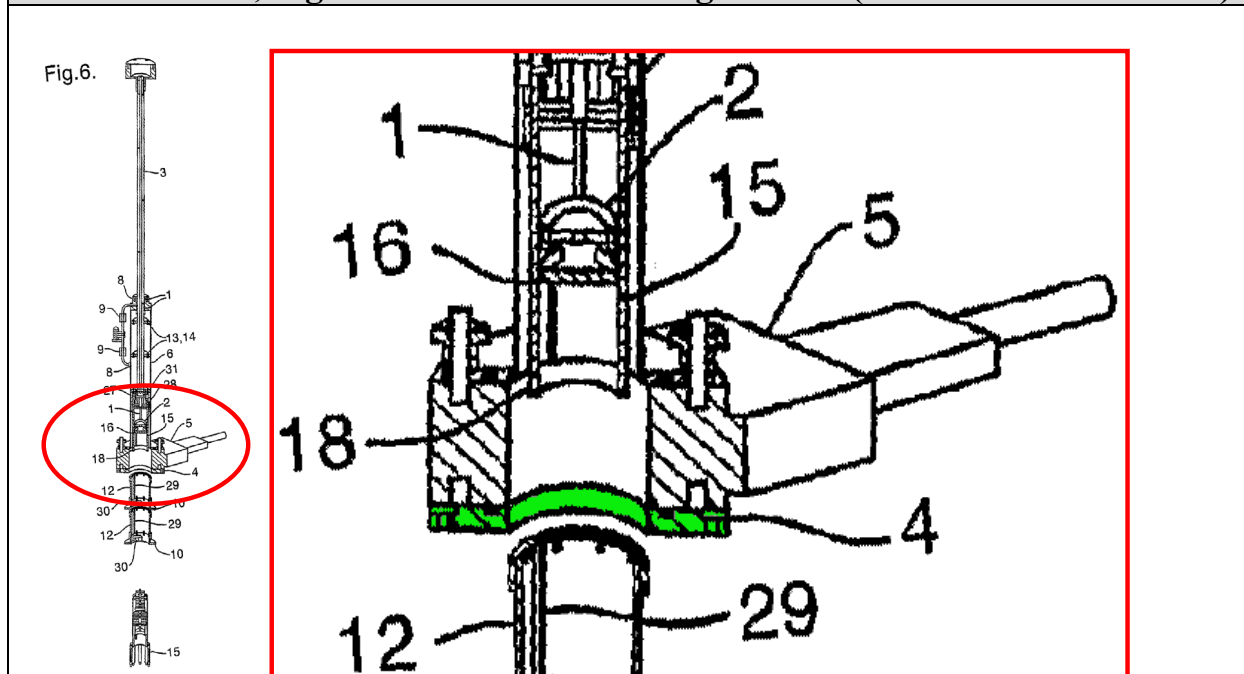
246. In my opinion, cryostat 50 of Garside includes a dilution refrigerator, and Garside discloses “a dilution refrigerator.”

2. 1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”

247. As shown in Figure 1 below, Garside's cryostat 50 includes an "outer vacuum vessel 4" that is "closed except for a port 52 covered by a large diameter gate valve 5." Ex.1007, [0038]. Garside also discloses a "vacuum chamber wall" of the vacuum chamber. *Id.*, [0006]. In my opinion, the outer vacuum vessel 4 (green) of Garside corresponds to the outer vacuum chamber of the '320 Patent, and the vacuum chamber wall of Garside corresponds to an outer housing of the outer vacuum chamber.



Ex.1007, Figure 6 and Partial Enlarged View (colored and annotated)



248. Figure 6 of Garside, a cutaway view of the sample loading apparatus, shows that the outer housing (the vacuum chamber wall (green)) of the vacuum vessel 4 has at least one planar surface (e.g., top and bottom surfaces of the vacuum chamber wall).³

³ I note that although Figures 1 through 5 in Garside illustrate a first embodiment of a sample loading apparatus while Figures 6 and 7 illustrate a second embodiment of a sample loading apparatus, both the first and second embodiments of the sample loading apparatus work with the same cryostat 50 with vacuum chamber 4 and gate valve 5 seen in Figure 1. Ex.1007, [0047] (“A second embodiment of the current invention is shown in FIG. 6. ... The sample is loaded

249. In my opinion, Garside discloses an outer vacuum chamber 4 comprising an outer housing (*e.g.*, vacuum chamber wall) having at least one substantially planar surface (*e.g.*, top and bottom surfaces of the vacuum chamber wall).

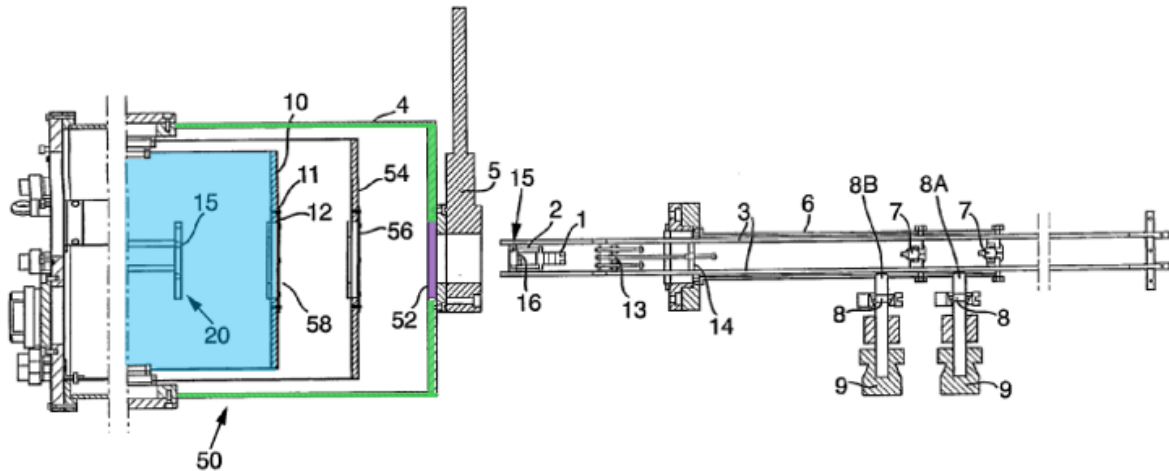
3. **1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”**

250. In my opinion, Garside discloses this limitation because outer vacuum vessel 4 includes “a port 52” (also called “aperture 52”), which provides access to the interior of outer vacuum vessel 4. Ex.1007, [0038]. As shown in Figures 1 and 6 of Garside, the port/aperture 52 (purple) is located in a planar surface of the vacuum chamber wall.

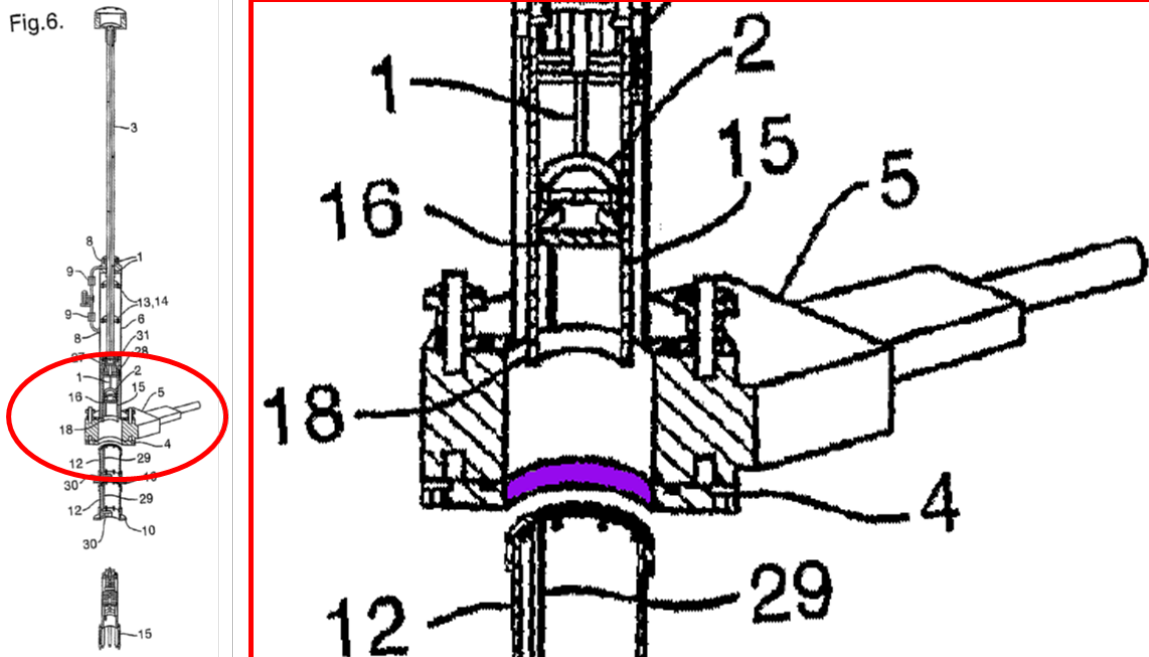
into the carrier and entered through the gate valve 5 as per the first embodiment.”).

Ex.1007, Figure 1 (colored)

Fig.1.



Ex.1007, Figure 6 and Partial Enlarged View (annotated)



251. Garside also discloses that gate valve 5 can be opened. *Id.*, [0042].

Garside discloses that once gate valve 5 is opened, the sample carrier can move through opened aperture 52 into working region 20 within outer vacuum vessel 4. See Ex.1007, ¶ [0008] (“In accordance with a second aspect of the present invention, a method of loading a sample into the working region of cryogen free cooling apparatus according to the first aspect of the invention comprises:...*opening the aperture of the vacuum chamber*...to insert the sample holding device *through the opened aperture* so that the sample holding device is thermally coupled to a cold body...”).

252. In my opinion, working region 20 is an “experimental volume” because it is “disposed within an interior of the outer vacuum chamber,” as required by the claims. Ex.1007, [0038] (“*Within the vacuum vessel 4* is located a first radiation shield 54...and within the first radiation shield 54 is located a second radiation shield 10...The radiation shields 10,54 surround a **working region 20**...”). In addition, in my opinion, experiments may be conducted in the working region 20 when a sample held by the sample holding device is thermally coupled to the cold body in the working region 20.

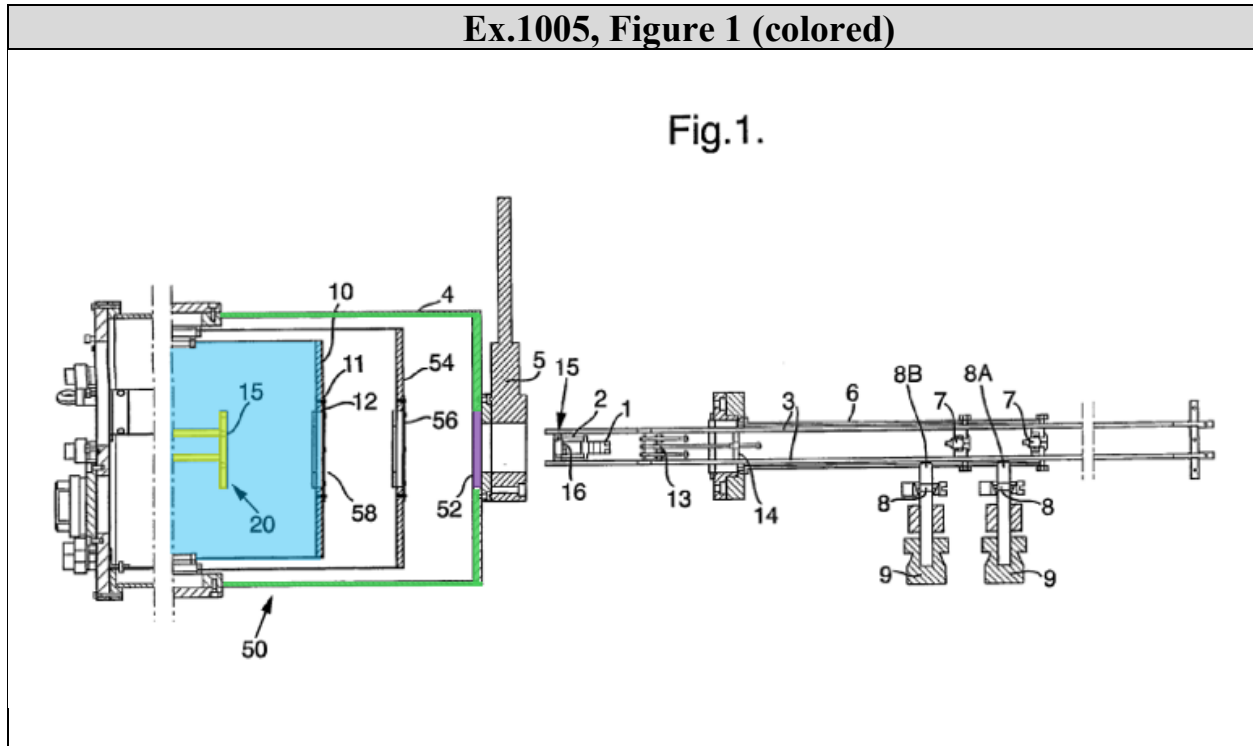
253. In my opinion, Garside therefore discloses an opening in the at least one substantially planar surface (e.g., aperture 52) configured to provide access to an experimental volume (e.g., working region 20) within an interior of the outer vacuum chamber (e.g., outer vacuum vessel 4).

B. Claim 2

254. Claim 2 depends from claim 1, which Garside discloses for the reasons I discussed above in Section X.A., which I incorporate herein. Claim 2 recites: “The dilution refrigerator of claim 1, further comprising a sample stage housed within the experimental volume, wherein the opening is configured to provide access to the sample stage through the outer vacuum chamber.”

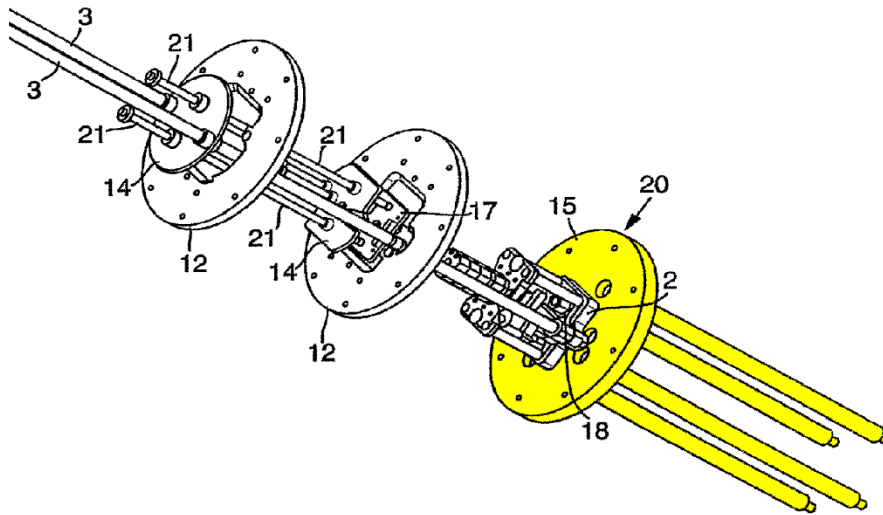
255. As I discussed with respect to limitation 1[b], aperture 52 shown in Figure 1 of Garside allows a sample carrier to “move through the gate valve” to the first pre-cool position *within* outer vacuum vessel 4. Ex.1007, [0042]. In my opinion, Garside discloses all of the limitations of claim 2 by disclosing that the sample carrier can be pushed through outer vacuum vessel “to their final position” where it can be connected to “*cold body 15* which could by way of example be connected to the mixing chamber of a dilution refrigerator or a sample plate of a cryostat.” *Compare id.* at [0044] *with* Ex.1001 at 12:66-13:2 (“In some embodiments, an experimental volume 124 (*e.g., a sample stage* or plate) may be thermally coupled to the mixing chamber 122 and configured to support a sample and/or quantum device.”). Garside also refers to cold body 15 as cold *mounting* body 15 interchangeably and discloses that it is located in working region 20. *See* Ex.1007, [0038], Figs. 1&3. Garside further provides that the sample moves from room temperature to the cold mounting body. Ex.1007, [0005].

256. In my opinion, the cold body 15 (yellow) and/or sample plate is a “sample stage” “housed within the experimental volume,” within the vacuum vessel 4, as required by claim 2.



Ex.1007, Figure 3 (cropped and colored, showing “the sample holding device connected to a cold plate in the cryostat”)

Fig.3.



257. In my opinion, Garside discloses “[t]he dilution refrigerator of claim 1 [e.g., cryostat 50], further comprising a sample stage [e.g., cold body 15/cold mounting body 15] housed within the experimental volume [e.g., working region 20], wherein the opening [e.g., aperture 52] is configured to provide access to the sample stage through the outer vacuum chamber [e.g., outer vacuum vessel 4].”

C. Claim 3

258. Claim 3 depends from claim 2, which Garside discloses for the reasons I discussed above in Section X.B., which I incorporate herein. Claim 3 recites: “The dilution refrigerator of claim 2, further comprising one or more radiation shields housed within the outer vacuum chamber, and wherein portions of the one or more radiation shields proximate the sample stage are slidable and/or

removable to provide access to the sample stage.”

259. Garside discloses that within vacuum vessel 4 of cryostat 50, there is a first radiation shield 54 (orange) with an aperture 56 (pink) and a second radiation shield 10 (orange) with an aperture 58 (pink). Ex.1007, [0038]. In my opinion, a POSITA viewing Figure 1 would recognize radiation shield 10 (with aperture 58) is proximate to the sample stage (*e.g.*, cold body 15).

260. The radiation shield 54 includes a plate 12 covering the aperture 56, as seen in Figures 1 and 5. *Id.*, [0041], Figs. 1, 5. Similarly, another plate 12 of shield 10 covers the aperture 58. *Id.* In my opinion, a POSITA would understand, based on Figures 1 and 5 and the corresponding description in Garside, that a portion of radiation shield 10, such as the plate 12, is removable from the remainder of the shield 10 because it is bolted to the remainder of the shield 10 and that the removal of the plate 12 would provide access to cold body 15.

261. I also note that this is consistent with the use of the term “removable” in the ’320 Patent (“a removable panel (*e.g.*, secured with mechanical fasteners)”). Ex.1001, 13:9-11.

Ex.1007, Figures 1 and 5 (cropped, colored and annotated)

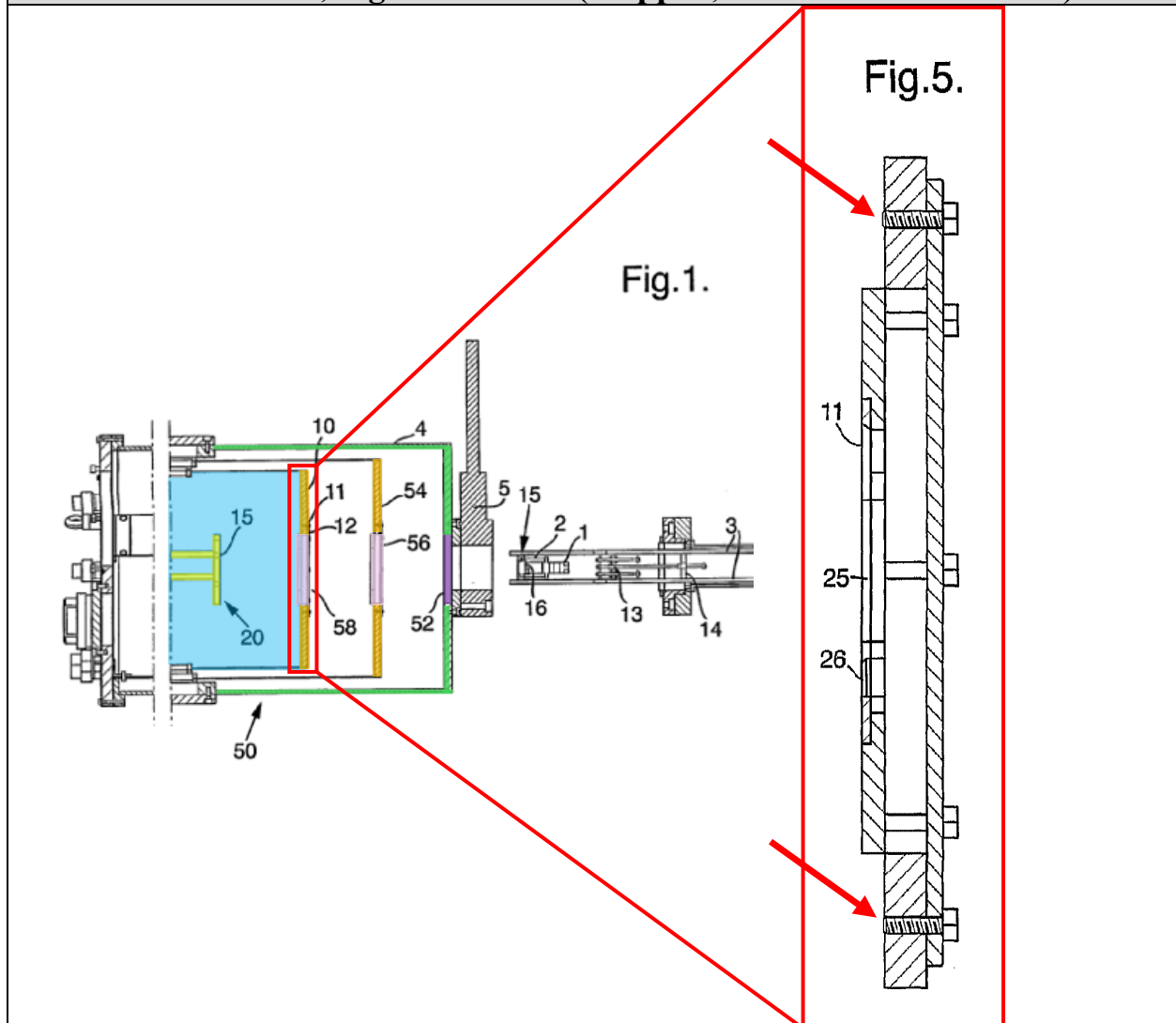
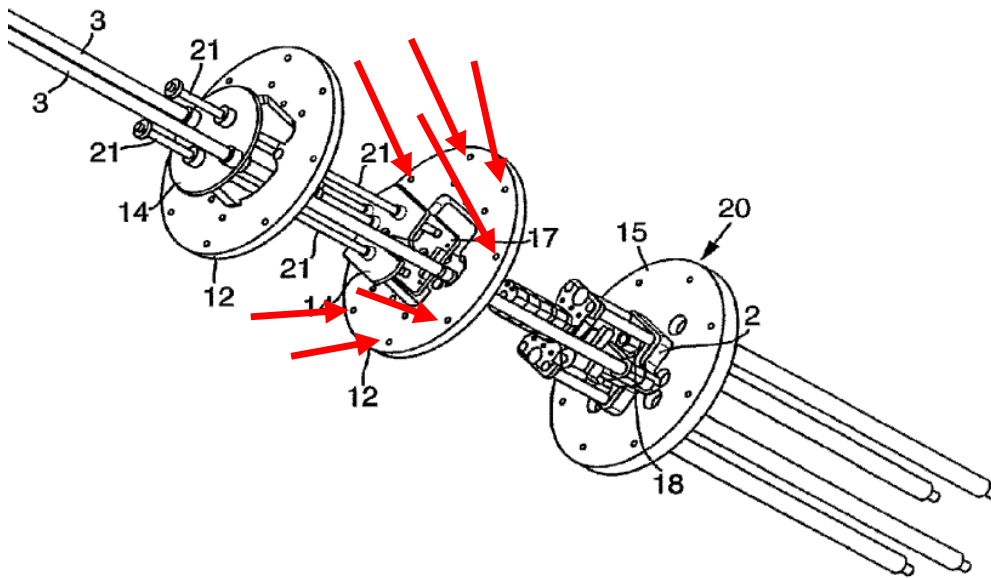


Fig.3.



262. In my opinion, Garside discloses “[t]he dilution refrigerator of claim 2 [e.g., cryostat 50], further comprising one or more radiation shields [e.g., radiation shields 10 and 54] housed within the outer vacuum chamber [e.g., outer vacuum vessel 4], and wherein portions [e.g., aperture 58] of the one or more radiation shields proximate the sample stage [e.g., cold body 15] are slidable and/or removable [e.g., spring hinge arrangement 26] to provide access to the sample stage.”

D. Claim 5

263. Claim 5 depends from claim 1, which Garside discloses for the reasons I discussed above in Section X.A., which I incorporate herein. Claim 5

recites: “The dilution refrigerator of claim 1, wherein the opening comprises a hermetic opening.”

264. Garside discloses gate valve 5 is located adjacent to aperture 52 of outer vacuum vessel 4. Ex.1007, [0042]. Garside teaches that gate valve 5 can be opened or closed. *Id.* In addition, the fact that “a vacuum can be established on both sides of the gate valve 5” indicates that gate valve 5 must consist of a hermetic opening in order to maintain the vacuum on both sides of the valve. *Id.* Thus, in my opinion, aperture 52 of Garside coupled with the gate valve 5 corresponds to a hermetic opening.

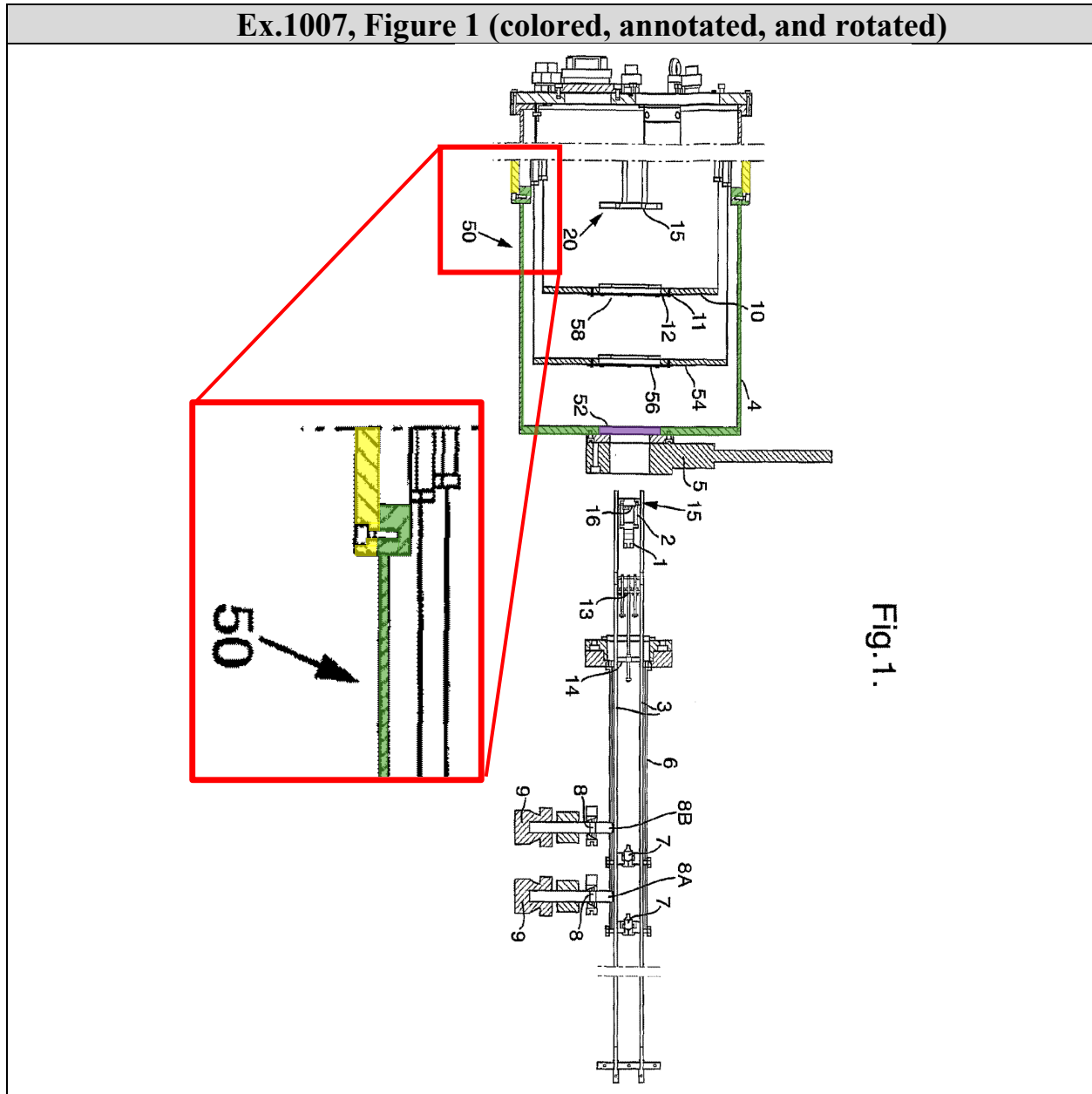
265. In my opinion, Garside discloses “[t]he dilution refrigerator of claim 1, wherein the opening [*e.g.*, gate valve 5] comprises a hermetic opening.”

E. Claim 6

266. Claim 6 depends from claim 1, which Garside discloses for the reasons I discussed above in Section X.A., which I incorporate herein. Claim 6 recites: “The dilution refrigerator of claim 1, wherein the outer vacuum chamber comprises: a first section; and a second section suspended from the first section.”

267. Figure 1 of Garside (annotated below) discloses that vacuum vessel 4 has a first section (yellow) and a second section (green) connected to the first section with a bolt. A POSITA would understand that Garside discloses a bottom-loading cryostat, which in use, the cryostat is oriented as shown in the annotated

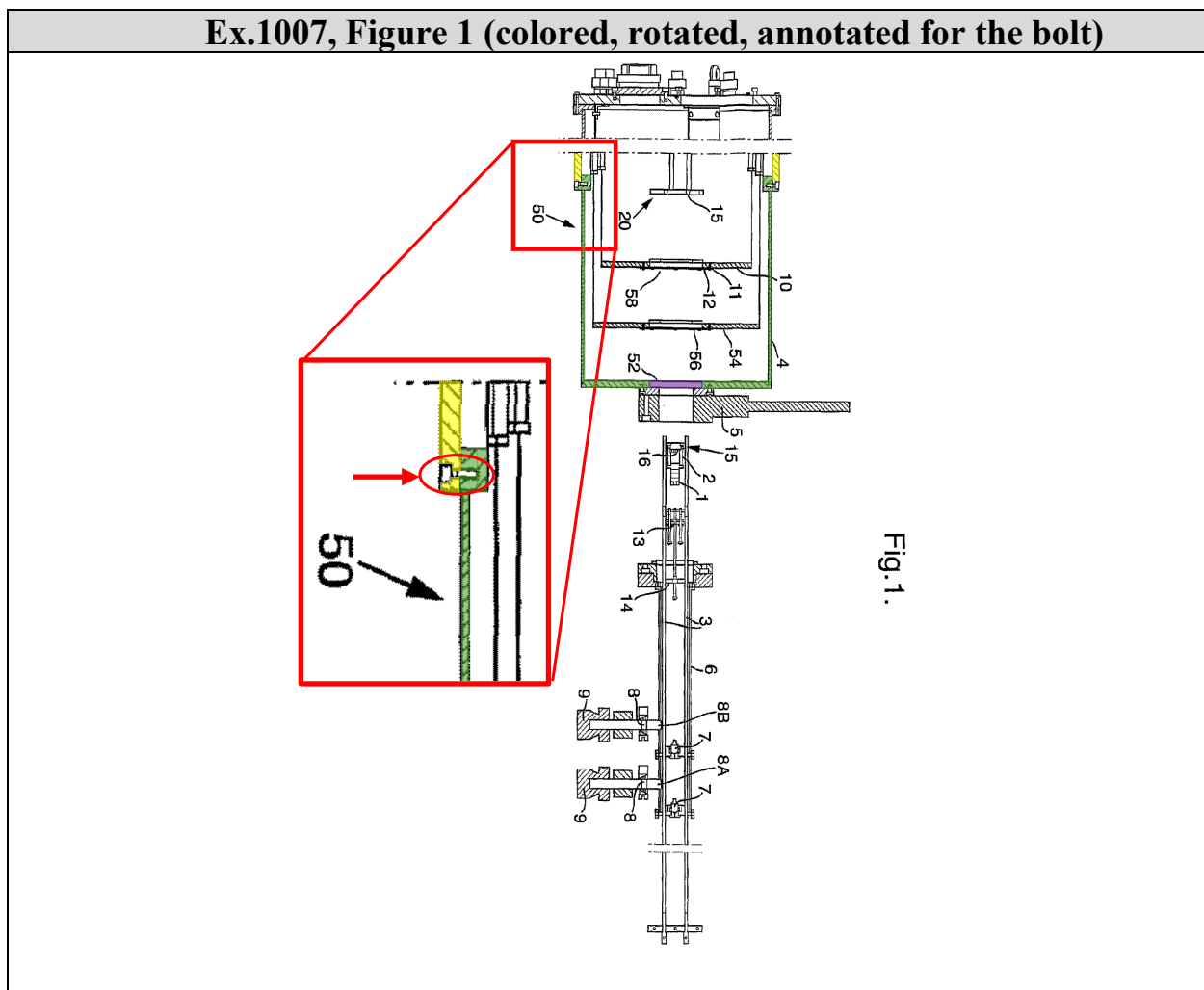
figure below where the second section (green) is suspended from the first section (yellow).



268. In my opinion, Garside discloses “[t]he dilution refrigerator of claim 1 [e.g., cryostat 50], wherein the outer vacuum chamber comprises a first section [green]; and a second section [yellow] suspended from the first section.”

F. Claim 8

269. Claim 8 depends from claim 6, which Garside discloses for the same reasons I discussed above in Section X.E, which I incorporate herein. Claim 8 recites: “The dilution refrigerator of claim 6, wherein the first and/or second section of the outer vacuum chamber are configured to be at least partially removed from the dilution refrigerator to provide access to an interior of the outer vacuum chamber.”



270. As I discussed above with respect to claim 6, Figure 1 of Garside

(annotated above) discloses a first section (yellow) with a second section (green) bolted to the first section. A POSITA would understand the bolted structure shown in Figure 1 would allow the second section to be removed from the first section. I note that this is consistent with the use of the term “removable” in the ’320 Patent (“a removable panel (e.g., secured with mechanical fasteners)”). Ex.1001, 13:9-11. A POSITA would also understand that removing the green section would also provide access to the interior of the outer vacuum chamber.

271. Furthermore, in my opinion, even if Garside did not explicitly disclose the bolt, a POSITA would understand that the first section (yellow) with the second section (green) can be coupled with removable mechanical fasteners, such as bolts, for maintenance of components located inside, such as cold body 15.

272. In my opinion, Garside discloses “[t]he dilution refrigerator of claim 6 [e.g., cryostat 50], wherein the first and/or second section [green] of the outer vacuum chamber are configured to be at least partially removed [through a bolted structure] from the dilution refrigerator to provide access to an interior of the outer vacuum chamber.”

XI. GROUND 5: WIKUS ANTICIPATES OR RENDERS OBVIOUS CLAIMS 1-3, 5, AND 17-19

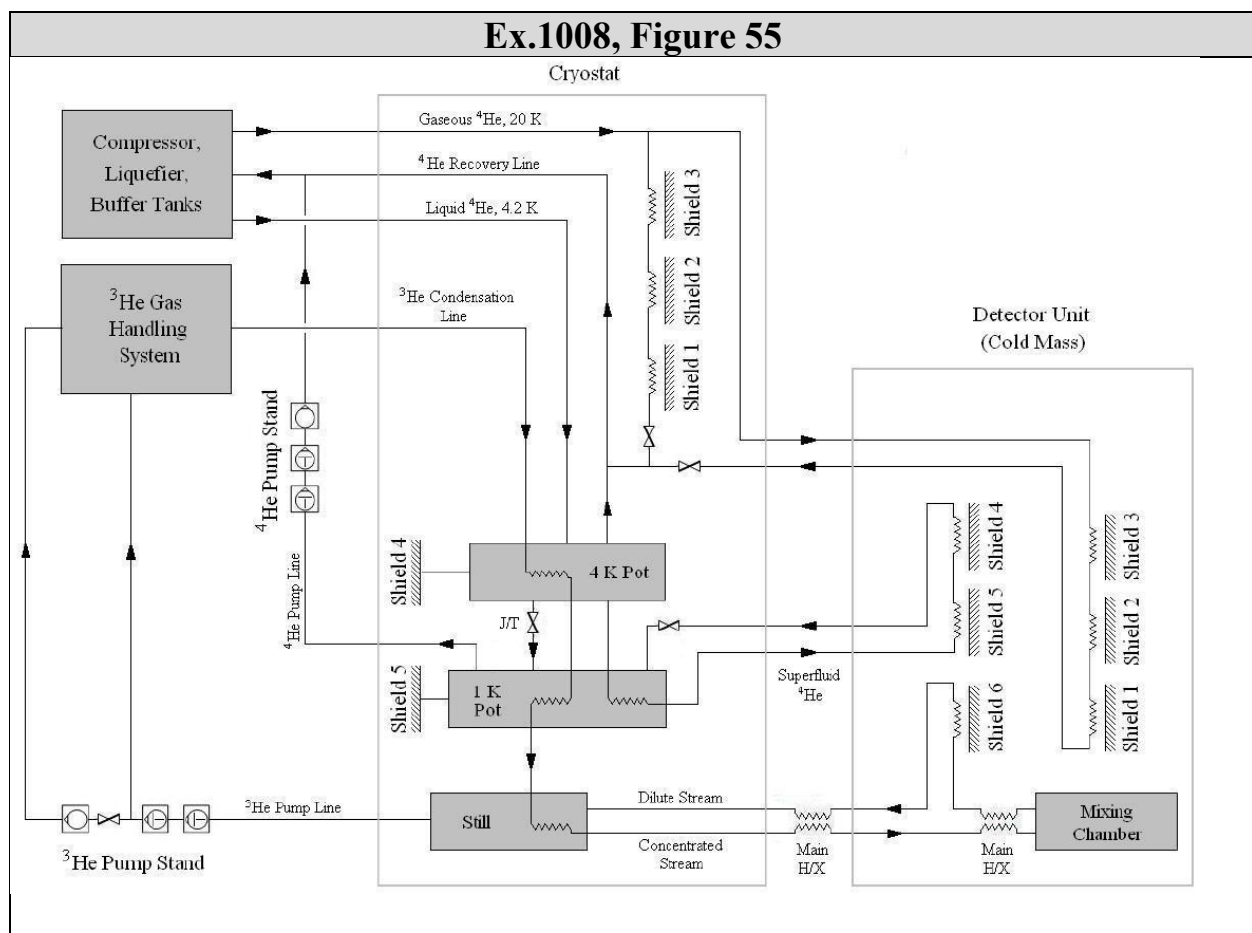
A. Claim 1

1. 1[pre] – “a dilution refrigerator comprising:”

273. As I discussed above in Section VII.A.1, I understand the preamble is

not limiting.

274. However, if the preamble is limiting, Wikus discloses “a dilution refrigerator.” See Ex.1008, p.117 (“A Dilution Refrigerator for a Multi-Ton Cold Mass”), p.127 (“Dilution Refrigerator Design Parameters”). Figure 55 of Wikus also depicts a design for the European Underground Rare Event Calorimetric Array (“EURECA”) cooling system, in which the “**dilution refrigerator**” is “partly housed by the cryostat” and the “mixing chamber” of the dilution refrigerator is “accommodated in the detector unit.” Ex.1008, pp.128-29.



275. A POSITA would understand the EURECA cooling system to be a

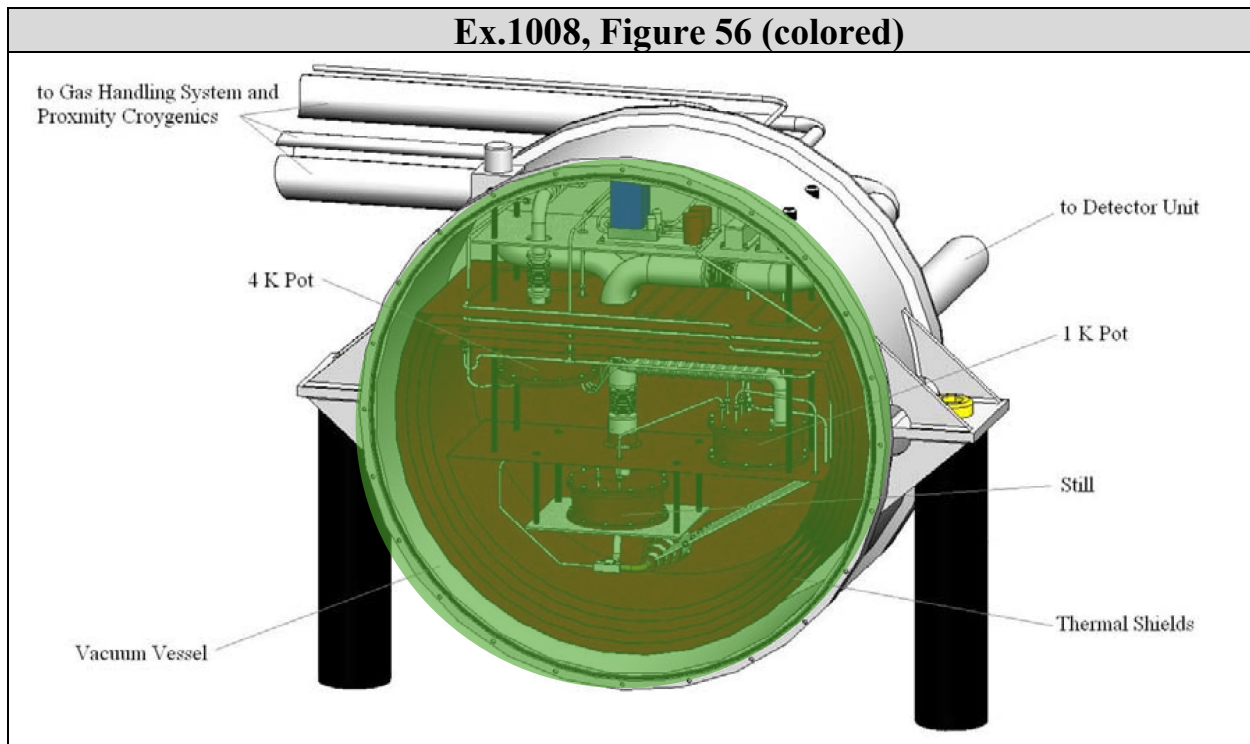
dilution refrigerator system.

276. In my opinion, Wikus discloses “a dilution refrigerator.”

2. **1[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface”**

277. As shown in Figure 56, Wikus’s EURECA dilution refrigerator system includes a “vacuum vessel.” Ex.1008 at 130.

278. In my opinion, Wikus thus discloses a vacuum chamber (e.g., the vacuum vessel).



279. Wikus further describes that “[t]he cryostat vacuum vessel consists of a **stainless steel ring**, which is sealed by a domed bulkhead on its rear side. On its front side, a door allows for access to the subsystems installed inside.” Ex.1008, p.130. In my opinion, Wikus discloses an outer housing of the outer vacuum

chamber.

280. In my opinion, Wikus discloses an outer housing of the outer vacuum chamber.

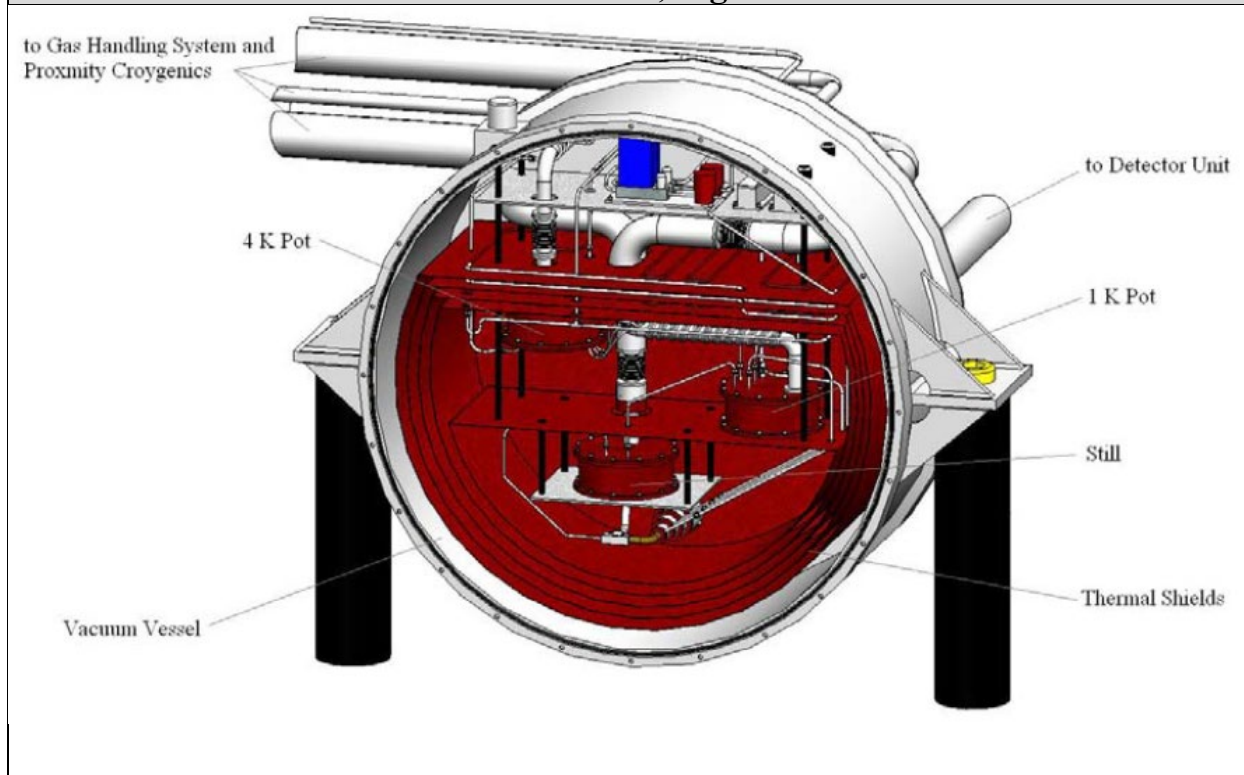
281. Figure 56 of Wikus also illustrates that the front side of the cylindrical housing made of the stainless steel ring has a planar surface (green).

282. In my opinion, Wikus therefore discloses an outer housing having planar surfaces.

3. **1[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”**

283. In my opinion, Wikus discloses this limitation because Figure 56 depicts an opening in the planar front surface of the cylindrical vacuum vessel to provide access to the enclosed three-dimensional space (containing the 4K pot, 1K pot, and still) within an interior of the vacuum vessel. The EURECA dilution refrigerator system of Wikus includes components “in a single vacuum space of cylindrical shape such that all parts can be maintained through the front hatch without performing any disassembly work.” Ex.1008, p.130.

Ex.1008, Figure 56

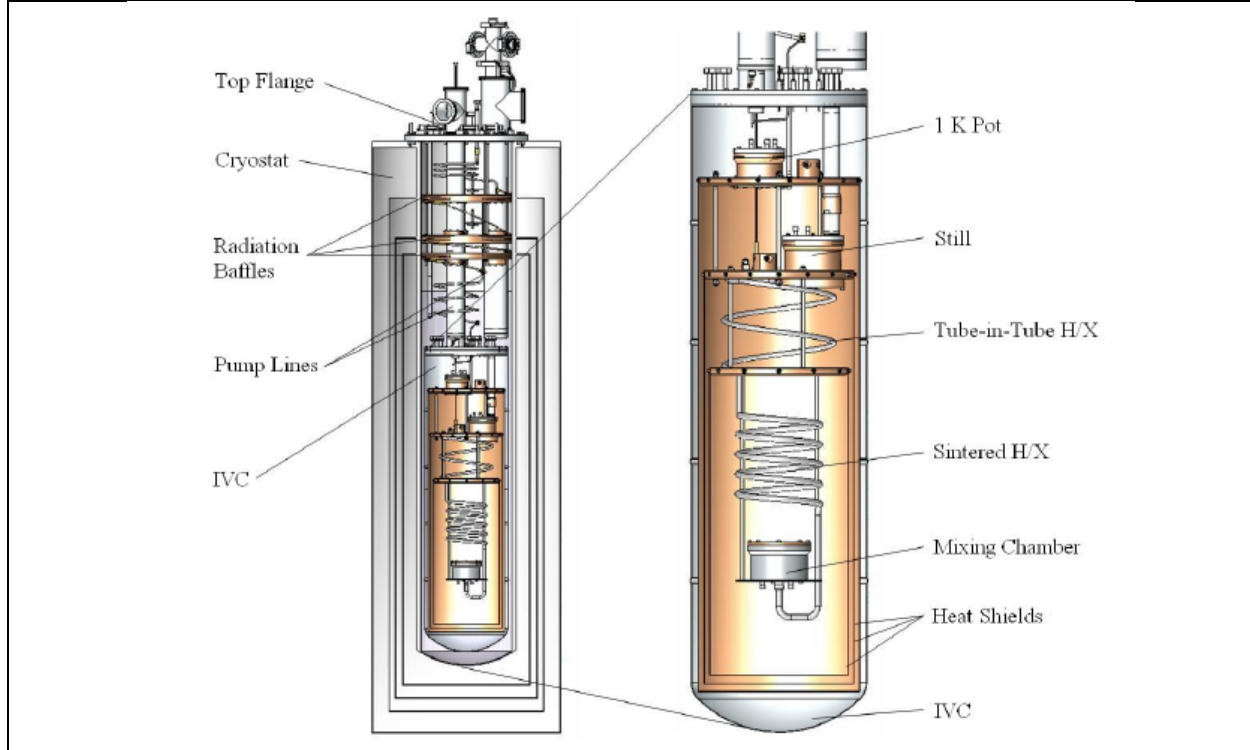


284. In my opinion, any of the 4K pot, 1K pot, and still can be used for an experiment. This is consistent with Ex.1013, which describes “experimental stations” located below cooling plates at respective temperatures of 4K and 1K.

285. In my opinion, Wikus discloses “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber.”

286. Alternatively, if the term “experimental volume” were to require a mixing chamber within the vacuum chamber, Wikus also illustrates a traditional dilution refrigerator in which both the still and the mixing chamber are located within a same vacuum chamber. Ex.1008, Fig.4.

Ex.1008, Figure 4



287. In my opinion, it would have been obvious for a POSITA to modify the design of the EURECA cooling system and place the mixing chamber within the same vacuum chamber like the traditional dilution refrigerator, which would yield predictable results. Although placement of the mixing chamber in the same vacuum chamber with an elastomer gasket could make it more difficult to achieve ultra-high vacuum levels, ultra-high vacuum levels are not needed for operation of dilution refrigerators. This is consistent with Ex.1014, which describes the use of a room temperature o-ring seal in dilution refrigerators.

288. In my opinion, with this modification, the opening in the planar front surface of the cylindrical vacuum vessel provides access to the “volume” where the

mixing chamber is located.

289. In my opinion, Wikus anticipates or renders obvious claim 1.

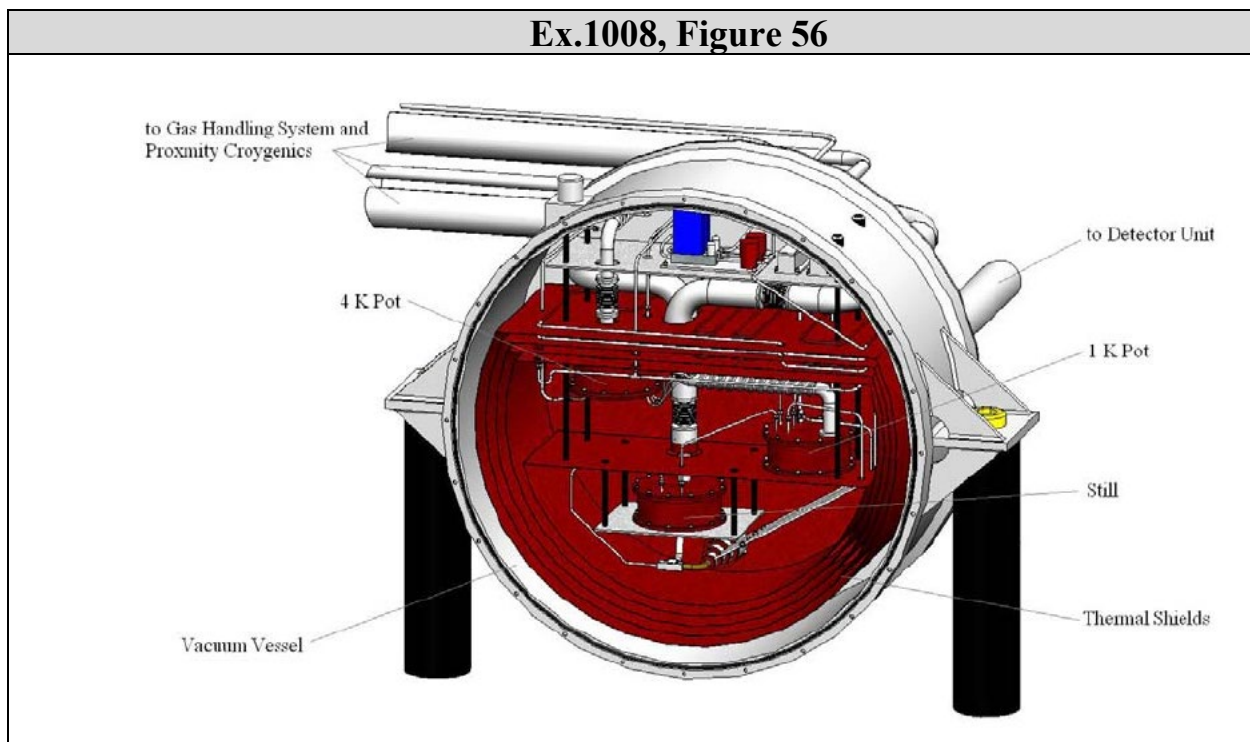
B. Claim 2

290. Claim 2 depends from claim 1, which Wikus discloses for the reasons I discussed above in Section XI.A., which I incorporate herein. Claim 2 recites: “The dilution refrigerator of claim 1, further comprising a sample stage housed within the experimental volume, wherein the opening is configured to provide access to the sample stage through the outer vacuum chamber.”

291. As I discussed with respect to limitation 1[b], the EURECA dilution refrigerator system has a front opening that provides access to the interior of the vacuum vessel. Ex.1008 at 130. In my opinion, a POSITA would understand the “sample stage,” which I discussed above, is a platform which may be configured to support a sample. I understand Wikus to disclose that the EURECA dilution refrigerator system has at least three stages: the 4 K stage, the 1 K stage, and the still in the vacuum chamber. Ex.1008 at 128 (referring to both the “4 K stage” and “1 K stage”), 132 (“4 Kelvin Subsystem,” “1 Kelvin Subsystem,” “Still Subsystem”). As explained above, in my opinion, experiments can be performed with any of the 4K stage and 1K stage. This is consistent with Ex.1013, which describes “experimental stations” located below cooling plates at respective temperatures of 4K and 1K.

292. In my opinion, a POSITA would also understand that each of the “stages” is a region configured to support a sample, and they function as sample stages. Ex.1008, p.130. In addition, the stages are accessible through the front opening “without performing any disassembly work.” *Id.* In my opinion, a POSITA would further understand that the 4K and 1K stages are housed within an experimental volume within the vacuum vessel as required by claim 2.

293. In my opinion, Wikus discloses “[t]he dilution refrigerator of claim 1 [e.g., EURECA dilution refrigerator], further comprising a sample stage [e.g., 4K, 1 K, and still stages] housed within the experimental volume, wherein the opening is configured to provide access to the sample stage through the outer vacuum chamber [e.g., vacuum vessel].



C. Claim 3

294. Claim 3 depends from claim 2, which Wikus discloses for the reasons I discussed above in Section XI.B, which I incorporate herein. Claim 3 recites: “The dilution refrigerator of claim 2, further comprising one or more radiation shields housed within the outer vacuum chamber, and wherein portions of the one or more radiation shields proximate the sample stage are slidable and/or removable to provide access to the sample stage.”

295. Wikus discloses that the vacuum vessel of the EURECA dilution refrigerator system has three thermal shields inside the vessel. Ex.1008 at 128 (“The three outermost thermal shields of the cryostat and the detector unit are cooled by a continuous flow of gaseous ^4He .”); 130 (“The vacuum vessel and the thermal shields are shown in Figure 57.”), 140 (“Three copper shields are accommodated *inside* the vacuum vessel of the cryostat.”), Figs. 56, 57. In my opinion, these thermal shields operate in the same manner as the radiation shields of the ’320 Patent, by reducing radiant heat transfer. A POSITA would understand and recognize the thermal shields within the EURECA dilution refrigerator’s vacuum vessel to be the “radiation shields” required by claim 3.

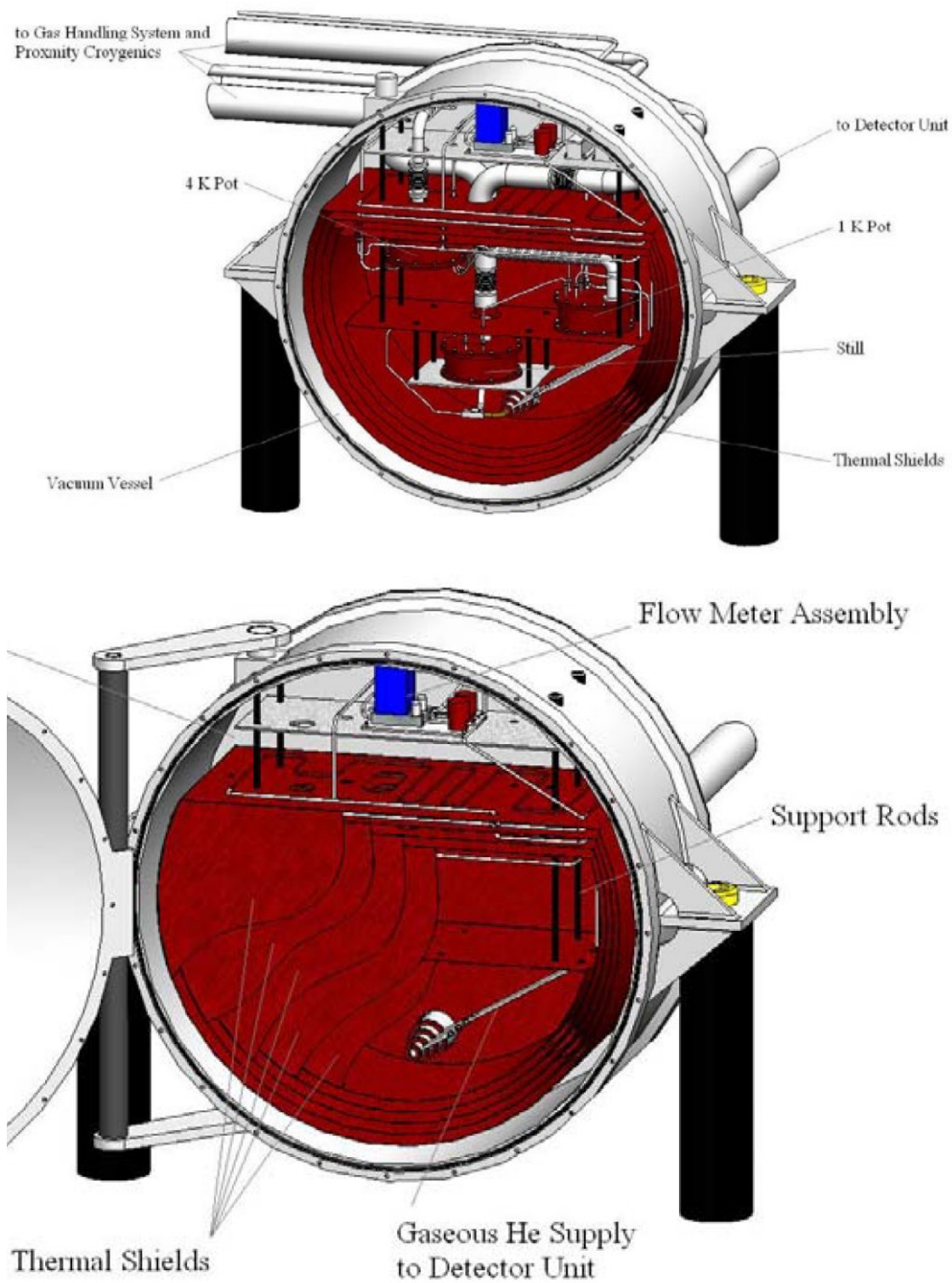
296. Wikus also teaches that the “lids of the thermal shields” can be “removed.” Ex.1008, at 130 (“Figure 56: The EURECA cryostat, which – for clarity – is depicted with the vacuum tight front cover and the lids of the thermal

shields removed.”). As seen in Figure 56, showing the lids of the thermal shields removed, the 4K stage, 1 K stage, and still are visible and accessible. *See id.* at Fig. 56.

297. In my opinion, a POSITA would recognize and understand that the lids of the thermal shields are slidable and/or removable such that it would provide access to the 4K stage, 1 K stage, and still.

298. In my opinion, Wikus discloses “[t]he dilution refrigerator of claim 2 (*e.g.*, EURECA dilution refrigerator), further comprising one or more radiation shields (*e.g.*, thermal shields) housed within the outer vacuum chamber (*e.g.*, vacuum vessel), and wherein portions of the one or more radiation shields (*e.g.*, thermal shield lids) proximate the sample stage are slidable and/or removable to provide access to the sample stage (*e.g.*, 4K stage, 1 K stage, or still).”

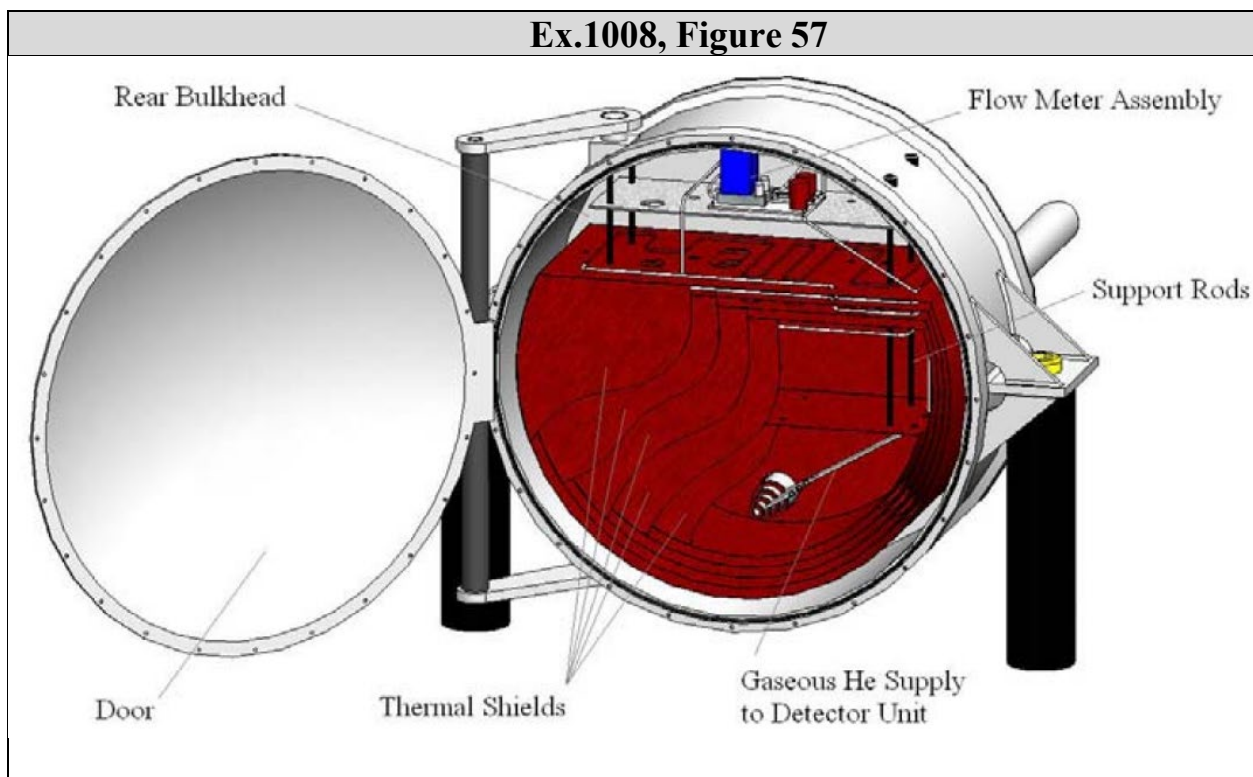
Ex.1008, Figures 56 (top, without lids) and 57 (bottom, with lids)



D. Claim 5

299. Claim 5 depends from claim 1, which Wikus discloses for the reasons I discussed above in Section XI.A, which I incorporate herein. Claim 5 recites: “The dilution refrigerator of claim 1, wherein the opening comprises a hermetic opening.”

300. Figure 57 of Wikus depicts a door attached to the front opening.



301. Wikus discloses that the door is “leak tight[]” by way of an elastomer gasket. Ex.1008 at 131. As explained above, as described in Ex.1014, it is a common practice to use a room temperature o-ring seal in dilution refrigerators. A POSITA would understand Wikus’ disclosure of a door with “leak tightness” that is “ensured by an elastomer gasket” corresponds with a hermetic opening.

302. In my opinion, Wikus discloses “[t]he dilution refrigerator of claim 1 [e.g., EURECA dilution refrigerator], wherein the opening comprises a hermetic opening [e.g., vacuum vessel door with an elastomer gasket].”

E. Claim 17

1. 17[pre] – “a dilution refrigerator comprising:”

303. In my opinion, Wikus discloses the preamble of claim 17 for the same reasons I described above with respect to 1[pre].

2. 17[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”

In my opinion, Wikus discloses limitation 17[a] for the same reasons I described above with respect to limitation 1[a].

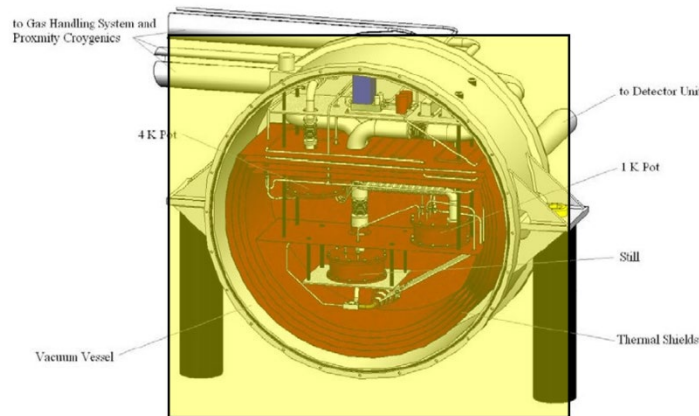
3. 17[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber, wherein:”

304. In my opinion, Wikus discloses limitation 17[b] for the same reasons I described above with respect to limitation 1[b].

4. 17[c] “the at least one substantially planar surface of the outer housing comprises a first surface disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator.”

305. In my opinion, Wikus discloses limitation 17[c], because the entire front surface (yellow) of the vacuum vessel is disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator.

Ex.1008, Figure 56 (annotated to show perpendicular plane)



306. In my opinion, Wikus discloses “the at least one substantially planar surface of the outer housing comprises a first surface disposed within a plane perpendicular to a plane of a floor supporting the dilution refrigerator.”

F. Claim 18

1. 18[pre] – “a dilution refrigerator comprising:”

307. In my opinion, Wikus discloses the preamble of claim 18 for the same reasons I described above with respect to claim 1.

2. 18[a] – “an outer vacuum chamber comprising an outer housing having at least one substantially planar surface;”

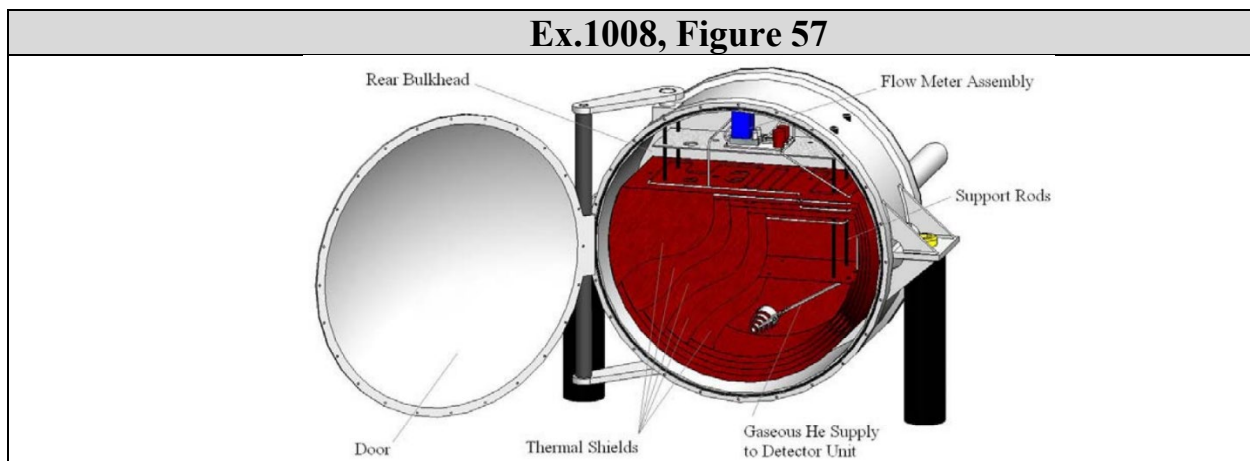
308. In my opinion, Wikus discloses limitation 18[a] for the same reasons I described above with respect to limitation 1[a].

3. **18[b] – “an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber,”**

309. In my opinion, Wikus discloses limitation 18[b] for the same reasons I described above with respect to limitation 1[b].

4. **18[c] “wherein the opening comprises a hinged door.”**

310. Figure 57 of Wikus depicts a hinged door attached to the front opening of the vacuum vessel. In my opinion, Wikus discloses “the opening comprises a hinged door.”



311. I note that, during prosecution, in response to an official notice, the Patentee argued:

Applicant further traverses the Office Action's official notice that "going from a door closed by fasteners to a door closed by hinge[s] would have been obvious to an ordinary skill[ed] artisan" (p. 7). ... The outer vacuum chamber for a dry dilution

refrigerator is a specialized device designed to maintain an internal pressure several orders of magnitude below typical atmospheric pressure. Proper sealing of the outer vacuum chamber is needed to maintain the low internal pressure within the vacuum chamber, to prevent atomic and molecular contaminants from entering the vacuum chamber, and to prevent valuable purified ^3He or ^4He from leaking out of the vacuum chamber. It cannot be said that the use of hinged doors rather than fasteners is beyond dispute or "capable of instant and unquestionable demonstration as being well-known" within the specialized technical area of cryogenic vacuum devices.

Ex.1004, p. 73 (Applicant Response dated February 7, 2025).

312. However, Wikus discloses the use of a hinged door as a closure for a vacuum chamber of a dilution refrigerator system. Furthermore, as I explained with respect to claim 5 in Section XI.D, Wikus discloses the hermetic opening. In my opinion, there is nothing special about maintaining an internal pressure at a level relevant to dilution refrigerators in a vacuum chamber with a hinged door.

G. Claim 19

313. Claim 19 depends from claim 18, which Wikus discloses for the same reasons I discussed above. Claim 19 recites "the dilution refrigerator of claim 18,

further comprising one or more radiation shields housed within the outer vacuum chamber, and wherein portions of the one or more radiation shields proximate the hinged door are slidable and/or removable to provide access to the interior of the outer vacuum chamber.”

314. In my opinion, Wikus discloses all of the features of claim 19 for the same reasons I discussed above with respect to claim 3. As can be seen in Figure 56 of Wikus, the lids to the thermal shields proximate to the vacuum vessel door of the EURECA dilution refrigerator are removable. Ex.1008, Fig. 56. Removing the lids provides access to the interior (e.g., still) of the outer vacuum chamber. *Id.*

315. In my opinion, Wikus discloses “the dilution refrigerator of claim 18 [e.g., EURECA dilution refrigerator], further comprising one or more radiation shields [e.g., thermal shields] housed within the outer vacuum chamber [e.g., vacuum vessel], and wherein portions [e.g., lids] of the one or more radiation shields proximate the hinged door [e.g., door] are slidable and/or removable to provide access to the interior of the outer vacuum chamber.”

XII. SUMMARY OF OPINIONS

316. For the reasons explained above, it is my opinion that the preponderance of the evidence shows that each of claims 1-6, 8, and 17-19 is anticipated by or obvious over the prior art discussed herein.

317. I reserve the right to analyze any evidence or arguments that Maybell

may offer in support of the patentability of any claim of the '320 Patent, and to further clarify and explain my opinions in light of any such evidence or arguments. I also reserve the right to further clarify and explain my opinions in light of any Order issued by the Board in this *Inter Partes* Review, including but not limited to any Order on claim construction.

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

Date: 16/03/2026

Respectfully submitted,

Andrew Casey

