

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

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

v.

MAYBELL QUANTUM INDUSTRIES, INC.,
Patent Owner.

Case No. IPR2026-00291
Patent No. 12,313,320

PATENT OWNER'S PRELIMINARY RESPONSE

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STATUTES

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LISTING OF EXHIBITS

Exhibit	Description
2001	U.S. Patent No. 9,699,266
2002	U.S. Patent No. 12,320,557
2003	Letter from A. Olejniczak to R. Pritzker <i>et al.</i> (August 28, 2025)
2004	U.S. Patent App. Pub. No. 2022/0221107
2005	U.S. Patent App. Pub. No. 2023/0008279
2006	Maybell Quantum, “Maybell Quantum Announces \$25M Series A Funding Led by Cerberus,” maybellquantum.com, Mar. 4, 2024. Available: https://www.maybellquantum.com/news/maybell-quantum-announces-25m-series-a-funding-led-by-cerberus . [Accessed: May 18, 2026]
2007	Maybell Quantum, “Maybell Quantum Closes \$40M Series B Led by Addition,” maybellquantum.com, Sept. 3, 2025. Available: https://www.maybellquantum.com/news/maybell-quantum-secures-40-million-series-b . [Accessed: May 18, 2026]
2008	U.S. Patent Publication No. 2021/0076530) (“Hart”)
2009	U.S. Patent No. 6,202,439 (“Mikheev”)

I. INTRODUCTION

The Petition fails to demonstrate any ground of unpatentability with sufficient merit to warrant institution of *inter partes* review. Despite treating the patented invention in a dismissive fashion, the Petition fails to identify a single reference that discloses the claimed dilution refrigerator, and its obviousness arguments are deeply flawed—for example, attempting to borrow key features from **non**-dilution refrigerators that POSAs would not have considered when working on specialized dilution refrigeration technology.

The '320 patent originated from the inventors' recognition that the traditional approach to dilution refrigeration severely limited the ability to scale the technology for quantum computing applications. Quantum computing demands an extremely low temperature environment near absolute zero, and hence requires a corresponding system capable of reaching those low temperatures.

Dilution refrigeration is a highly specialized technique capable of reaching millikelvin temperatures—near absolute zero. Although the basic principles of dilution refrigeration were known before the '320 patent, conventional dilution refrigerators followed an approach that required large amounts of space, expensive supporting infrastructure, and an ultra-high vacuum chamber with a cylindrical shape to minimize surface area and heat transfer and evenly distribute pressure. These cylinders are optimized for manufacturing simplicity and weight.

Traditionally, dilution refrigerators were assembled in a nesting set of cylinders, where the cylindrical geometry was specifically selected to enable one person with mechanical assistance or two people in tandem to lift and align the cylinders, maintaining gaps between the layers and seals on the end caps.

Recognizing that these requirements reduced the scalability of quantum technologies at the cost of manufacturing and mechanical simplicity, the inventors determined that reducing the size and infrastructure requirements of dilution refrigerator assembly could enable quantum computers to scale significantly. This changed the system optimization from the manufacture and assembly of a single system to an architecture optimized for commercial deployment of quantum computing systems. With significant effort and investment, the inventors reimagined how dilution refrigerators are configured, sized, shaped, and serviced. For instance, despite the prior art strongly counseling toward cylindrical dilution refrigerators, the inventors created a new, more modular, design capable of embodying a rectangular form factor. Further, the inventors' novel design facilitates meaningful access to an experimental volume within the vacuum chamber.

The inventors' approach diverged from traditional designs in which access to the coldest part of the refrigerator was impossible once it was assembled, short of disassembly of the entire outer vacuum chamber and inner radiation shielding.

Accessing the coldest region would take considerable time because warming it to room temperature and cooling it down again took many days. As illustrated by the Batey, Garside, and Chow prior art references, the alternative to removal of the entire housing was to insert an experimental sample via a complex mechanism extending through a narrow port in the vacuum chamber while maintaining a vacuum seal. Once the sample was inserted into a probe and a vacuum established, the probe could be inserted into the refrigerator while keeping a vacuum in place. These probes were not configured to provide access to the user of the system because the probe port only allowed the probe to enter the vacuum chamber.

The inventors of the '320 patent recognized that the advent of quantum computers required creative new approaches to dilution refrigerators. Prior to widespread quantum computing and device development, dilution refrigerators were typically used for large, complex device or science testing that required a relatively static experimental load or a less complex materials test using swappable samples, as Batey, Garside, and Chow illustrate. The inventors of the '320 patent recognized that quantum computing devices, in contrast, typically involve complex experiments and samples that also need rapid iteration and change. This combination led to the invention of cold access through an opening in the vacuum chamber to the experiment rather than the arduous sample exchange through movement of nesting cylinders or limited exchange through insertable probes.

For more than half a century, dilution refrigerators shared one basic form: a nested set of cylinders. That convention remained across generations of designs and designers, Petitioners included, despite the access and scaling limitations described above and the competitive market dynamics that existed. Only after the inventors disclosed the claimed design, and Maybell publicly introduced products embodying it, did the field change course. Maybell's competitors, Petitioners among them, began building dilution refrigerators with the very feature the Petition derides as trivial: a substantially planar surface with an opening and a door that lets a user reach the experimental volume—signaling an abrupt, industry-wide shift after decades of stasis.

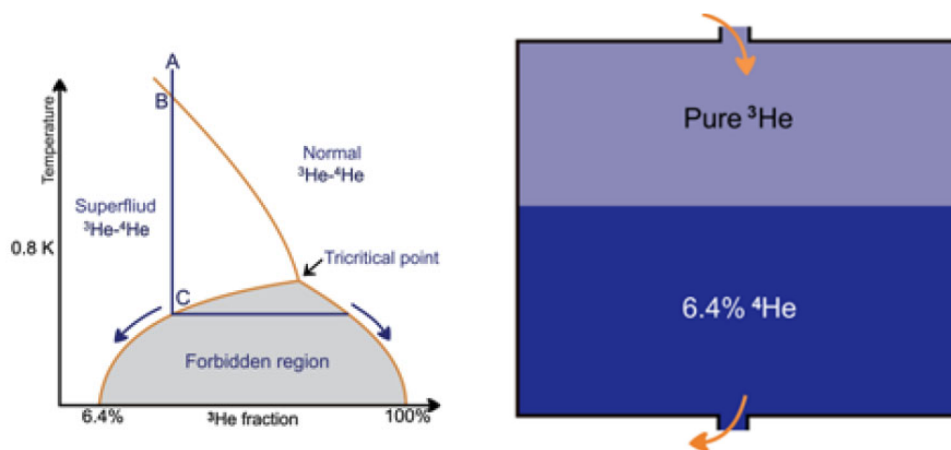
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Maybell separately requested discretionary denial based on, among other things, Petitioners' deliberate delay in filing the Petition to avoid the Office's clearly stated preference for PGR filings, their failure to provide any stipulation regarding overlap with the concurrent litigation, and their attempt to gain an unfair advantage by presenting alternative claim constructions. One additional factor, indeed one that independently warrants denial of institution, is the defective nature of the grounds presented in the Petition.

II. BACKGROUND

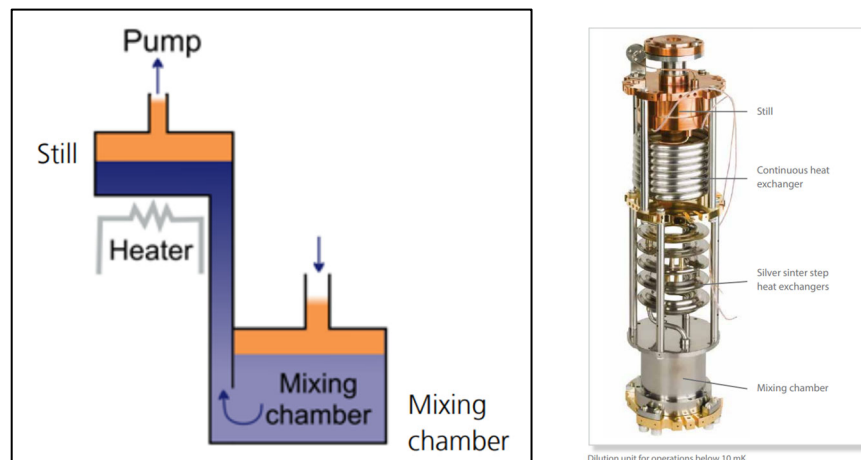
The '320 patent is directed to a novel integrated dilution refrigerator. There is no dispute that dilution refrigerators employ a specialized cooling technique for cooling a sample (*e.g.*, a qubit of a quantum computer) to very near absolute zero (~ 10 millikelvin).

Basics of dilution refrigeration. Dilution refrigeration takes advantage of the differences between helium isotopes (^3He and ^4He). As illustrated by the phase diagram (below left), a mixture of ^3He - ^4He will separate into different phases (^3He poor, *dilute* and ^3He rich, *concentrated*) below a critical temperature (*i.e.*, below 0.87 Kelvin).



EX1003, 7, 9 of 20. The above-right diagram shows phase separation below this critical temperature, where the ^3He -rich “concentrate” phase floats on top of the heavier ^4He -rich (^3He -poor) “dilute” phase. Transfer of ^3He from the concentrate phase into the dilute mixture causes cooling. This is caused by the enthalpy difference as ^3He atoms migrate across the phase boundary.

To remove ^3He atoms from the diluted ^3He - ^4He mixture, a mixing chamber (the coldest part of the dilution refrigerator maintaining a phase boundary) is connected to a still, which distills the ^3He atoms from the dilute ^4He mixture. As ^3He vapor is removed, ^3He moves from the dilute liquid into the still into the vapor above it. The reduction of ^3He in the still liquid produces an osmotic pressure which pulls ^3He atoms from the diluted ^3He - ^4He mixture in the mixing chamber up and out of the fluid circuit. The removed ^3He atoms are then compressed and sent back into the concentrated side of the system. They travel down the dilution fridge until they enter the concentrate phase in the mixing chamber and start the cycle over again.



EX1003, 9, 12 of 20. Vital to dilution refrigerator operation is a mixing chamber at a temperature below 0.87 K so that phase separation of the ^3He - ^4He mixture occurs. These aspects distinguish dilution refrigeration from other cooling techniques.

Challenges of dilution refrigeration. The extreme temperatures of dilution refrigeration present technical challenges, *e.g.*, the need for extremely effective insulation of an experimental volume configured for ultra-low temperature cooling.

The prior art thus emphasized form factors with small volumes, generally achieved via a circular cross-section to make insulation easier. The figures below illustrate a conventional dilution refrigerator. EX2002, 1:23–2:35, Figs. 1, 2.

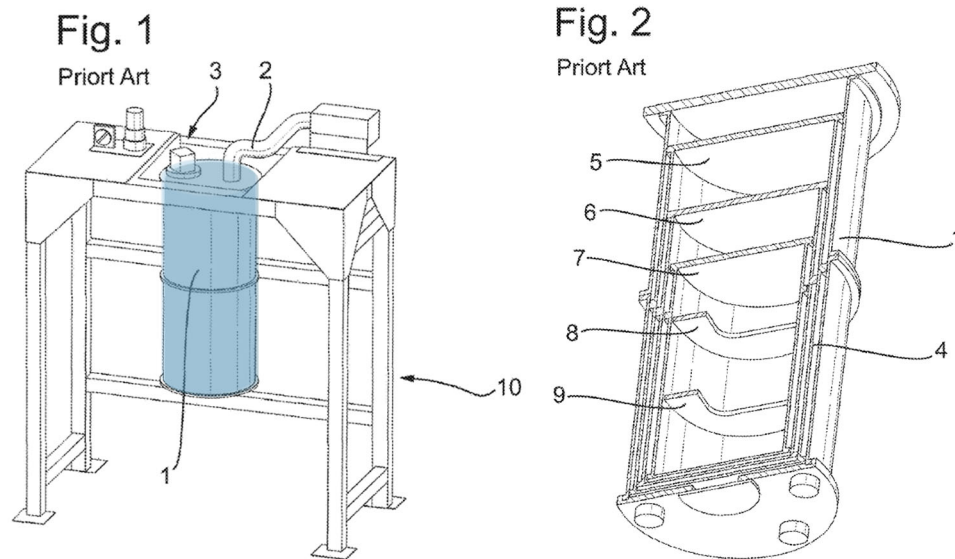


Figure 1 shows a perspective view of a cylindrical outer vacuum chamber 1 supported by a cryostat support frame 10. Figure 2 is a perspective view of a cross-section taken through the outer vacuum chamber 1. The pulse tube refrigerator 3 and dilution unit are not shown in Figure 2. Thermal stages 5–9 are provided in a tiered arrangement, with each stage including a circular plate that is to be cooled to a respective temperature. Each stage is insulated by a cylindrical radiation shield 4, and the shields are arranged as a nested assembly, as is also visible in Figure 2.

Per conventional design principles, dilution refrigerators use cylindrical dewars. EX2001, 5:5–6. Dilution refrigerators must be kept in a vacuum for isolation requirements and therefore the vacuum chamber experiences a high pressure differential between the inside and outside of the vacuum chamber, and the strength of cylinders makes them the preferred geometry for storage of pressurized contents. *Id.*, 5:6–10. The cylindrical shape has been important to legacy dilution refrigerators because the structural integrity of the shape enabled a minimally thick vessel that is lighter for the user to move around. The innovation created by Maybell enabled user access to the cold volumes through the flat surfaces of their thicker pressure vessel. For both vacuum chamber arrangements the components of the dilution refrigerators must fit inside and nesting all the components with the same geometry optimizes the test/experimental volume.

As shown in Figure 2 above, the vacuum chamber 1 and shields 4 have a cylindrical shape, consistent with conventional design principles. EX2002, 1:43–2:10. The dilution unit shown in Figure 2 includes a still stage 7 with a still mounted thereto, an intermediate temperature “cold plate” stage 8, and a mixing chamber stage 9 with a mixing chamber mounted thereto. The stages are connected by a set of heat exchangers, and operational fluid ($^3\text{He}/^4\text{He}$ mixture) is circulated around the dilution unit during cooling.

This complex approach was developed to handle extraordinary cooling and simplify production, but Maybell's inventors recognized that it provides limited access to the coldest experimental region, and the cylindrical shape makes poor use of space due to low packing efficiency.

The '320 patent innovation. The '320 patent inventors recognized that, for quantum computing to be scalable, the industry needs reliable, easy-to-use, and compact dilution refrigerators. EX1001, 4:23–27. The inventors developed dilution refrigerators with access to the experimental volume within the vacuum chamber, easy interaction with other equipment, and increased utilization of available space, as well as distributed cooling systems that can be integrated with a commercial server rack infrastructure for scaling quantum computing. *Id.*, 4:27–36, 16:49–23:2.

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. *Id.*, 12:66–13:2. Because the experimental volume 124 is thermally coupled to the mixing chamber 122, the sample and/or quantum device may be held at or near the mixing chamber temperature. *Id.*, 13:2–5.

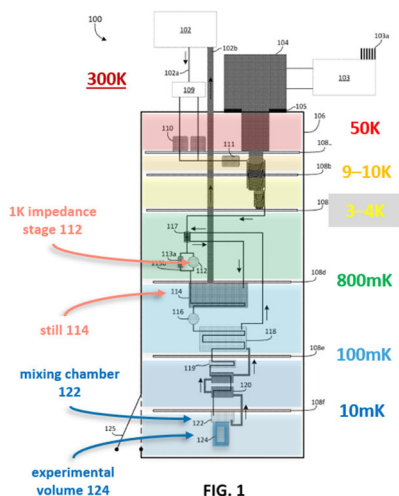


FIG. 1

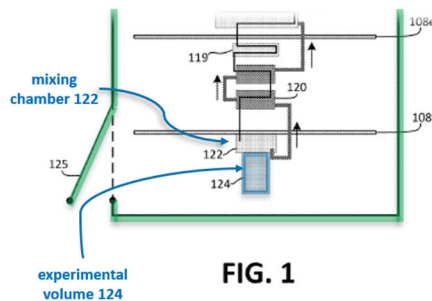


FIG. 1

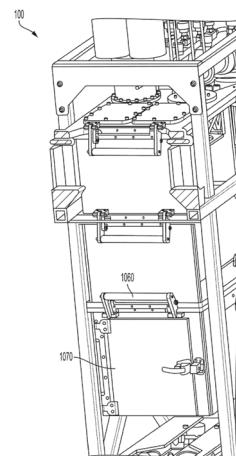


FIG. 10A

EX1001, Figs. 1 (left and middle, annotated) and 10 (right).

The experimental volume 124 may be accessed by a user when dilution refrigerator 100 is not in operation through an opening in the vacuum chamber 106 and door 125. *Id.*, 13:6–9. Door 125 may be a removable panel (*e.g.*, secured with mechanical fasteners) or a hinged door openable using a clamped handle (*e.g.*, as shown in the example of Figure 10A (element 1070) above). *Id.*, 13:9–12.

III. SUMMARY OF THE RELEVANT PROSECUTION HISTORY

While the Petition provides a terse summary of the file history, it ignores important distinctions made with respect to the prior art which are relevant to the grounds presented. *See* Pet., 8–10; *see also* EX1002, ¶¶43–57 (providing more detail but not recognizing its import). Particularly relevant here are the arguments and amendments made to overcome Hart (U.S. Patent Publication No. 2021/0076530) (EX2008) and Mikheev (U.S. Patent No. 6,202,439) (EX2009). This history helps clarify the type of access claimed in the '320 patent.

Mikheev

In a November 7, 2024 Office Action, the Examiner rejected then-pending claims 1 and 2 as purportedly being anticipated Mikheev. EX1004, 111–112.

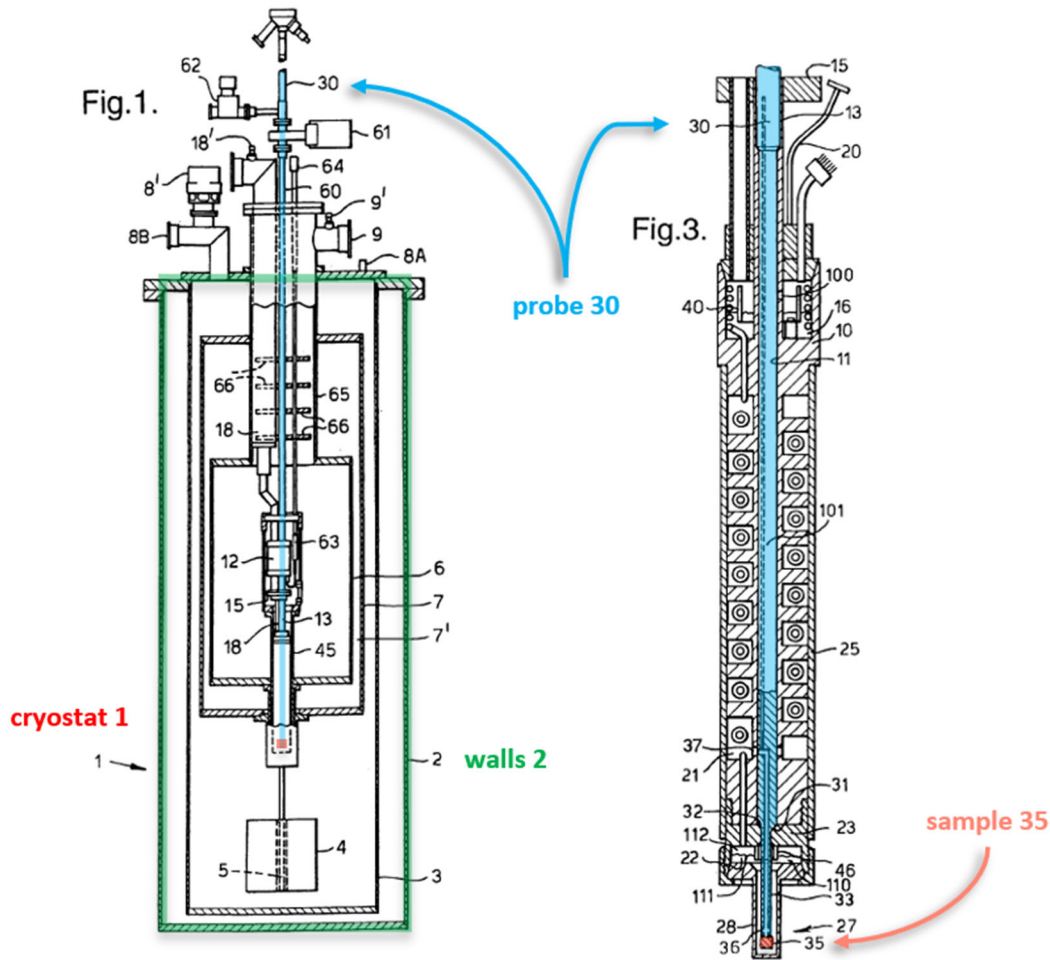
Regarding claim 1, the Examiner stated that:

Mikheev discloses dilution refrigerator comprising:

an outer vacuum chamber (chamber defined by #2 and #3; col. 5, L 14-17) comprising at least one substantially planar surface (see surface of plate comprising #8A); and

an opening in the at least one substantially planar surface configured to provide access to an interior of the outer vacuum chamber (see opening covered by the aforementioned plate; covering the top edge of body #1).

EX1004, 111. Hence, the Examiner considered and relied upon Mikheev’s description of an “access path extending to the mixing chamber” of a dilution refrigerator (EX2009, 2:50–58) and a probe that can be “inserted along the access path to introduce the sample into the mixing chamber,” (*id.*, 4:11–13). Mikheev’s Figures 1 and 3 are annotated below to highlight probe 30 (blue) and sample 35 (orange) as depicted when inserted into extension tail 27.



EX2009, Figs. 1, 3 (annotated)

In response to that Office Action, claim 1 was amended to distinguish the Mikheev reference by reciting:

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.

EX1004, 63 (amendments underlined). Applicant explained, in relevant part, that:

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). See also FIG. 3, in which a probe 30 with sample 35 is disposed in the extension tail 27 (Col. 6, Lines 12-22). The bore 11 is connected to tube 60 via metal tube 13 and 1K pot 12 (Col. 5, Lines 32-40) such that during operation the sample 35 is introduced to the extension tail 27 within the dilution refrigerator by being inserted through tube 60 (see Col. 5, Lines 48-50 of EP 0675330A1, referenced at Col. 7, line 19 of Mikheev). 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.

EX1004, 71–72.

The applicant thus distinguished Mikheev’s approach of inserting a sample into the dilution refrigerator via a probe apparatus, explaining that the claimed “access to an experimental volume” does not include mere insertion of a probe through a small opening in the outer wall of the refrigerator. *See also* EX1004, 78 (examiner interview summary stating that “[a]greement 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”).

This distinction is readily understandable in the context of the '320 patent, which provides for an opening in the outer vacuum chamber that allows a *user* (*i.e.*, not just a probe) to access the experimental volume. EX1001, 13:6–13 (“experimental volume 124 may be *accessed by the user* when the dilution refrigerator 100 is not in operation through an opening in the vacuum chamber 106 and door 125”), 19:21–25 (“door 1070 may provide access through all of the inner radiation shields ... of the dilution refrigerator 100 *to allow a user to access the experimental volume*”), 19:25–30 (“when a user opens the door 1070, the inner radiation shields slide or otherwise move to provide *the user access* with the interior portion of the dilution refrigerator”), 19:56–20:3, 20:13–23.

Hart

The November 7, 2024 Office Action also rejected then pending claims 1, 2 and 4–6 as purportedly being anticipated Hart. EX1004, 110–111. The Examiner contended that Hart discloses a dilution refrigerator and that an outer vacuum chamber is “not discussed by Hart, but inherently present in a dilution refrigerator.” EX1004, 110. In relying primarily on Figure 4 of Hart (reproduced below), the Examiner equated the claimed “opening” to the Hart’s opening covered by cover 425) and the claimed “interior” to Hart’s interior of enclosure 320). EX1004, 111.

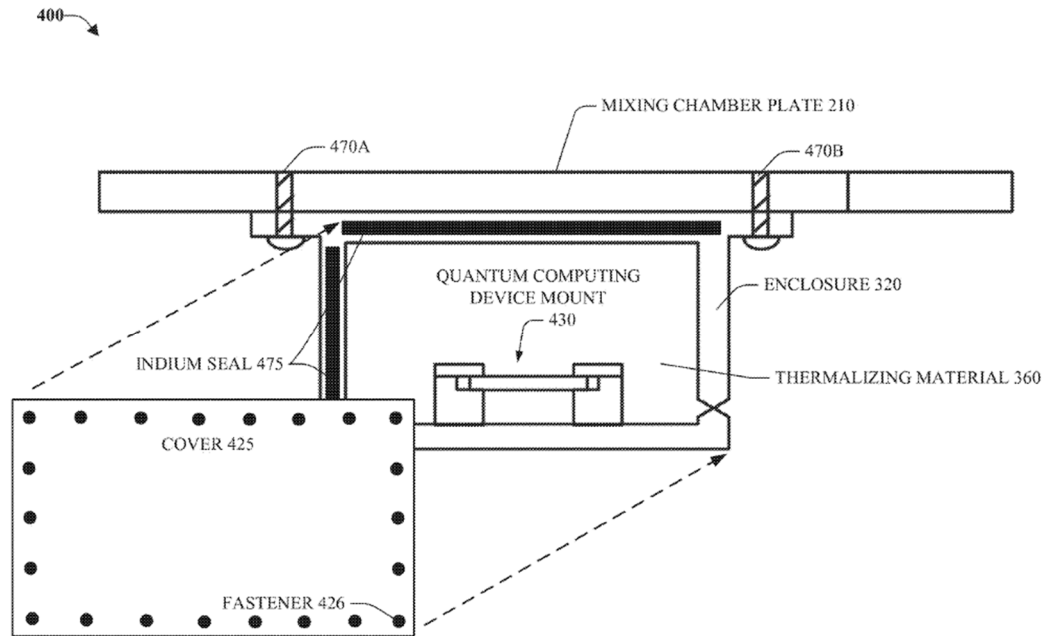


FIG. 4

EX2008 (Hart), Fig. 4.

The claims were amended in response to the Office Action, as discussed above, and Applicant distinguished the Hart reference by explaining that:

[w]hile 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.

EX1004, 70.

IV. LEVEL OF ORDINARY SKILL IN THE ART

Consistent with their attempt to improperly broaden the scope of the '320 patent claims, Petitioners' POSITA (POSA) definition does not require *any* knowledge of dilution refrigeration and thus improperly disregards the '320 patent's specific focus on dilution refrigerators. Specifically, Petitioners contend that a POSA 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*.

Pet., 10; EX1002, ¶¶58–59. The art contains many low-temperature mechanical cryocoolers, such as pulse tube coolers, Stirling coolers, and Gifford-McMahon (GM) coolers—none of which are dilution refrigerators nor capable of reaching millikelvin temperatures like dilution refrigerators. *See* EX1002, ¶62; EX1009, 1:44–56, 5:59–6:2; EX2009 (Mikheev), 1:8–46; EX1001, 1:18–27, 3:52–4:5, 10:53–65, 21:33–46. Mastery of these comparatively simple, higher-temperature cryocoolers would not have equipped equip a POSA to innovate at the millikelvin scale, where practitioners must depend on and are subject to fundamentally different thermal cycles, far more demanding isolation and vacuum requirements, thermal transport governed by Kapitza resistance rather than ordinary conduction

(which is true only below ~100mK), and the unique physics of $^3\text{He}/^4\text{He}$ phase separation governing the design. A POSA knowledgeable only in pulse tube, Stirling, or GM, or other coolers would lack the specialized knowledge the inventors brought to bear. At a minimum, a POSA would have had at least two years of experience designing and/or working with dilution refrigerators, and would have appreciated the unique challenges of designing a dilution refrigerator.

V. CLAIM CONSTRUCTION

A. The Term “dilution refrigerator” Cannot Be Disregarded

The Title, Abstract, Background, Summary, drawings, and every disclosed embodiment of the '320 patent are directed to novel dilution refrigerators. The problems that the inventions solved specifically relate to dilution refrigerators. The prior art references overcome during prosecution and the arguments made by the Applicant likewise involved dilution refrigerators. And the only mention of other cryogenic devices in the '320 patent is as auxiliary components to a dilution refrigerator for pre-cooling. Yet Petitioners contend that the preambular recitation of a “dilution refrigerator” should not be given any weight. Pet., 14–15.

Petitioners' argument contradicts the '320 patent and invites legal error.

“A claim's preamble may limit the claim when the claim drafter uses the preamble to define the subject matter of the claim.” *C.W. Zumbiel Co. v. Kappos*, 702 F.3d 1371, 1385 (Fed. Cir. 2012). It has long been established that a preamble

is limiting when it is “necessary to give life, meaning and vitality” to the claim based on the facts of the case at hand in view of the claim as a whole. *Kropa v. Robie*, 187 F.2d 150, 152 (1951); *Corning Glass Works v. Sumitomo Elec. U.S.A., Inc.*, 868 F.2d 1251, 1257 (Fed. Cir. 1989) (a preamble’s weight must be determined “on review of the entirety of the patent to gain an understanding of what the inventors actually invented and intended to encompass by the claim.”).

For example, the preamble is limiting when it recites structure highlighted as important in the patent specification. *Proveris Sci. Corp. v. Innovasystems, Inc.*, 739 F.3d 1367, 1372–73 (Fed. Cir. 2014); *Deere & Co. v. Bush Hog, LLC*, 703 F.3d 1349, 1358 (Fed. Cir. 2012) (preamble limiting where the specification referred to it as the “present invention”); *Poly-Am., LP v. GSE Lining Tech., Inc.*, 383 F.3d 1303, 1310 (Fed. Cir. 2004) (preamble limiting where it described a “fundamental characteristic of the claimed invention”); *Corning*, 868 F.2d at 1257 (preamble “optical waveguide” did not encompass any optical fiber because “the inventors were working on the particular problem of an effective optical communication system not on general improvements in conventional optical fibers”). “Additionally, when limitations in the body of the claim rely upon and derive antecedent basis from the preamble, then the preamble may act as a necessary component of the claimed invention.” *Proveris*, 739 F.3d at 1372.

Here, the “dilution refrigerator” in claims 1, 17, and 18 is necessary to understand the subject matter encompassed by the claims, which otherwise generally recite an “outer vacuum chamber” including “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.” EX1001, 24:27–36. Unlike non-limiting preamble terms, “dilution refrigerator” does not merely state a name or a use for the claimed vacuum chamber. Rather, the term describes a “fundamental characteristic of the claimed invention” that informs persons of ordinary skill in the art of the fundamental technology covered by the claims. *Poly-Am.*, 383 F.3d at 1310. For example, as described by the ’320 patent specification, “[d]ilution refrigerators are cryogenic devices that rely on the heat of mixing of the ³He and ⁴He isotopes to provide cooling down to temperatures between approximately 2 mK and 1 K.” EX1001, 1:18–21; *see also id.*, 1:52–2:5. That the claims are specifically drawn to a “dilution refrigerator,” rather than other or broader cooling technologies, breathes life and meaning into the claims, including the “outer vacuum chamber” limitation—given the ultra-high vacuum needed for dilution refrigerator operation. EX1008, 141–142 of 174 (acknowledging that diffusion through a gasket of a cryostat may not permit it to reach ultra-high vacuum levels needed for a dilution refrigerator mixing chamber).

Similarly, the “experimental volume” in a dilution refrigerator is cooled by the coldest part of the dilution refrigerator to millikelvin temperatures.

The specification further demonstrates that the preamble phrase “dilution refrigerator” is limiting. The title of the patent, the background, the summary of the invention, and every drawing describe or relate specifically to dilution refrigerators. *Poly-Am.*, 383 F.3d at 1310. The specification repeatedly refers to “dilution refrigerators” as the invention. *See, e.g.*, EX1001, 4:23–36 (“the inventors have developed dilution refrigerators...”), 5:8–11, 7:47–61, 8:6–62, 11:27–38, 16:50–17:2; 21:33–22:19. The specification explains that the inventions address concerns specific to dilution refrigerators, not cryogenic devices generally. For instance, the specification explains that the quantum technology industry needs reliable, easy-to-use, easy-to-maintain, and compact dilution refrigerators and there is a need for reducing the size and infrastructure requirements of dilution refrigerators. *See, e.g.*, EX1001, 4:23–36, 16:50–17:2. In sum, the specification underscores the importance of “dilution refrigerator” as a fundamental limitation of the claimed invention.

The bodies of the claims also support this conclusion. Although Petitioners aver that “the body of claim 1 ... never refers back to the preamble” (Pet., 14), they ignore that other claims do. The bodies of claims 4, 8, and 17 all rely on the preamble for antecedent basis. EX1001, 24:44–50 (referring to “***the*** dilution refrigerator”), 24:60–64 (same), 26:3–6 (same). The courts have consistently held a preamble limiting when it serves as antecedent basis for a term appearing in the body of a claim. *In re Fought*, 941 F.3d 1175, 1178 (Fed. Cir. 2019).

The ’320 patent’s prosecution history further confirms that the preamble is limiting. For instance, the Applicant distinguished features of the invention from the prior art by explaining:

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.***

EX1004, 73 (emphasis added). In emphasizing the highly specialized features of the outer vacuum chamber of a dilution refrigerator, the patentee was relying on the fact that dilution refrigerators utilize the heat of mixing of the ³He and ⁴He isotopes to provide cooling, as noted above, and thus require a suitable vacuum chamber commensurate with the demanding nature of dilution refrigeration.

In re Cruciferous Sprout Litig., 301 F.3d 1343, 1347 (Fed. Cir. 2002) (“Clear reliance on the preamble during prosecution to distinguish the claimed invention from the prior art may indicate that the preamble is a claim limitation...”).¹

In summary, “dilution refrigerator” as recited in the preambles of the challenged claims plainly defines the subject matter of those claims, and not merely one “intended use” of a vacuum chamber among many.

VI. ARGUMENT

The Petition presents five “Grounds” and various alternative theories challenging individual claims of the ’320 patent, yet each attack fails to demonstrate a likelihood of success on the merits as discussed in detail below.

Petitioners attack the claims as follows:

¹ Petitioners argue that a single sentence by the patentee during prosecution, noting that hinged doors were not well-known “within the specialized technical area of cryogenic vacuum devices,” suggests the patentee contemplated cryogenic devices more generally. Pet., 15; EX1004, 73. That sentence, however, immediately followed the patentee’s detailed explanation quoted above. In context, it only reinforces the patentee’s emphasis on dilution refrigeration.

Ground	Claims	Basis	Reference(s)
1	1-5, 17-19	§103	Batey, Dain
2	1-4	§103	Batey, PWS
3	1-6, 8, 17-19	§103	Chow, Dain
4	1-3, 5-6, 8	§§102,103	Garside
5	1-3, 5, 17-19	§§102,103	Wikus

A. Ground 1 Fails to Establish a Reasonable Likelihood of Success on the Merits

1. The Batey-Dain Combination Fails Because It Lacks a Proper Rationale to Combine Batey With a Non-Dilution Refrigerator such as Dain

Ground 1 of the Petition attempts to combine the teaching of Batey and the teachings of Dain without demonstrating that a POSA concerned with dilution refrigeration would have looked to the teachings of Dain—which discloses neither a dilution refrigerator nor any technology applicable to dilution refrigeration.

Batey describes a cryostat and dilution refrigerator with a specialized top-loading system designed to introduce a sample into the interior of the cryostat while maintaining the vacuum within the outer vacuum vessel. EX1009, 7:3–8:27. Batey’s system allows for the “warm” loading of the sample and pre-cooling the sample carrier (target apparatus) once *in situ*. EX1009, 2:41–59. Batey recognizes that the changing of samples can be a lengthy process because of the considerable time needed to warm up/cool down the system to/from room temperature. EX1009, 1:21–43; *see also* EX1008, 23 of 174 (explaining that a dilution refrigerator may take three to four days to cool from room temperature to millikelvin temperatures).

For this reason, sample transfer mechanisms were designed to exchange samples without the need to warm up the entire system. EX1009, 1:37–56.

In short, Batey describes a system that *maintains* a vacuum seal and *avoids* the need to open the vacuum chamber to access an experiment within the chamber and the subsequent multi-day warmup and cooldown of the coldest part of the dilution refrigerator. As discussed above, Batey’s approach was consistent with the conventional approaches to dilution refrigeration at the relevant time.

Dain, in contrast to Batey, has nothing to do with dilution refrigeration nor do its teachings reasonably address any problems associated with dilution refrigeration. Dain does not mention dilution refrigeration, nor does the Petition allege that Dain discloses a dilution refrigerator. Dain merely describes a storage freezer for tissue samples. EX1010, ¶¶0002–0008. In contrast, and as discussed above, dilution refrigerators are highly specialized, well-recognized technology. Petitioners admit that a “dilution refrigerator” refers to “a cryostat that provides cooling based on spontaneous phase separation of ^3He and ^4He ... [w]hen a mixture of ^3He and ^4He is *cooled below ~0.87 K.*” Pet., 3 (emphasis added) (citing EX1002, ¶¶61–62; EX1003, 7 of 20); *see also* EX1001, 1:52–65 (“[D]ilution refrigerators rely on the heat of mixing of ^3He and ^4He isotopes ... *[w]hen cooled below approximately 870 mK....*”) (emphasis added); EX2009 (U.S. Patent No. 6,202,439) (“Mikheev”), 1:8–61.

Dain’s system indisputably fails to achieve low enough temperatures for dilution refrigeration. Dain’s system has an aspirational operating temperature of -150°C (or 123 K)—approximately *four orders of magnitude greater* than the operational temperature for a dilution refrigerator. EX1010, ¶0008. While the Petition asserts that the applied references are from the field of “cryogenic vacuum devices and systems” (Pet., 10), as discussed above in the Claim Construction section, the ’320 patent does not broadly encompass all cryogenic vacuum devices and systems. Rather, the claims and specification of the ’320 patent are specific to dilution refrigerators. And Petitioners fail to explain how Dain’s teachings would reasonably suggest solutions with respect to the highly specialized area dilution refrigeration and the teachings of Batey specifically.

Petitioners appear to concede that the problems addressed by the ’320 patent are specific to dilution refrigeration. Pet., 10. Although their expert claims Dain “addresses similar unmet needs in the art that the ’320 patent identifies, such as storage systems “be[ing] able to reach *the required low temperature*” (EX1002, ¶77), that claim is conclusory and over-generalized. As discussed above, dilution refrigerators operate in the millikelvin range, well outside even Dain’s most aspirational range. Petitioners offer nothing to suggest a POSA would disregard the technical challenges of achieving near absolute zero temperatures and find any value or applicability in Dain’s teachings when designing a dilution refrigerator.

Further, neither Petitioners nor Dain provide any indication that Dain's vacuum region/insulation assembly is relevant to a dilution refrigerator vacuum chamber. For instance, Dain states that its vacuum region is evacuated to approximately 0.2 millitorr. EX1010, ¶0007. Petitioners fail to explain how this would have any applicability to the claimed vacuum chamber for a dilution refrigerator, which requires ultra-high vacuum levels. *See* EX1008, 142 of 174.

Petitioners thus have not shown that a POSA would have considered its teachings as applicable to dilution refrigeration. Considering that Batey's teachings specifically present an approach to transferring a sample to avoid opening the vacuum chamber and that Dain does not offer any alternative applicable to dilution refrigeration, Petitioners' purported reasons to combine are improperly based on hindsight.

2. The Batey-Dain Combination Fails to Provide the Claimed Access

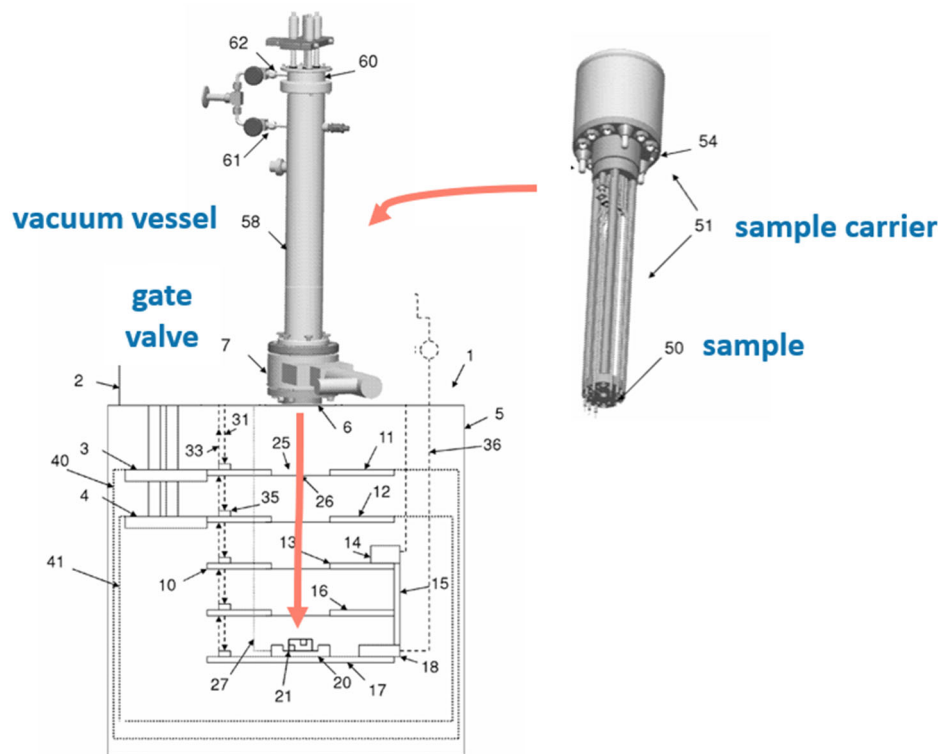
Each independent claim of the '320 patent requires "an opening in the at least one substantially planar surface of the outer housing configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber." EX1001, 24:30–33, 25:25–26:2, 26:10–12. As made clear by the '320 patent specification and the patent's prosecution history, the access required is access by the user of the dilution refrigerator to the coldest stage of the dilution refrigerator where the experimental volume is located. EX1001, 13:6–13

(“the experimental volume 124 may be *accessed by the user* when the dilution refrigerator 100 is not in operation through an opening in the vacuum chamber 106 and door 125”), 19:21–25 (“the door 1070 may provide access through all of the inner radiation shields ... of the dilution refrigerator 100 *to allow a user to access the experimental volume*”), 19:25–30 (“when a user opens the door 1070, the inner radiation shields slide or otherwise move to provide *the user access* with the interior portion of the dilution refrigerator”), 19:56–20:3, 20:13–23; *see also* Prosecution History Section above. This approach ran entirely counter to conventional thinking at the time, and to the approach taken by Batey and others focused on complex sample transfer mechanisms—which maintained a vacuum seal and provided no access to a user.

Petitioners argue that Batey discloses limitation 1[b] because Batey describes a central port 6 in its vessel as an “access opening” which allows “an experimental ‘probe’ to pass into the interior of the cryostat 1.” Pet., 20. Yet Petitioners tellingly omit that Batey’s probe access is “whilst *maintaining the vacuum within the vacuum vessel 5*.” EX1009, 7:7–11 (emphasis added). In support, Petitioners point to an annotated Figure 1 from Batey, which merely shows a cryostat with a port shown as a purple line. Pet., 21. From this Petitioners conclude that Batey discloses an opening in a cryostat, and therefore, claim limitation 1[b] is met. *Id.* With their oversimplified analysis of limitation 1[b],

Petitioners then argue that a POSA would modify Batey in view of Dain to arrive at a rectangular shape with the port from Batey. *Id.*

However, Batey's probe port provides access only to a sample carrier (probe)—not to a user of the system. Batey describes that a cryostat 1 is fitted with a gate valve 7 in port 6 and describes inserting a probe (*e.g.*, sample carrier 51) through gate valve 7 once a vacuum seal has been established. EX1009, 7:3–11. Batey does not describe using gate valve 7 of port 6 to provide access without using the probe. On the contrary, Batey describes that a probe is to be used with said gate valve 7 to “maintain[] the vacuum within the vacuum vessel 5.” EX1009, 7:9–11. Batey states that, in order to load the sample carrier 51 into cryostat 1, a “vacuum vessel 58 is [] attached to the gate valve 7 and air is pumped out of the vacuum vessel 58” and that “the system is ready for the gate valve to be opened” only “[w]hen a similar vacuum is established on both sides of the gate valve 7.” EX1009, 9:51–54.



EX1009, Figs. 1, 2, 5 (combined and annotated). Hence, at no point is the experimental volume accessible to a user of the system.

Thus, Batey describes accessing its cryostat only using a probe much as in Mikheev, which was distinguished during prosecution. As discussed in the Prosecution History section above, probe insertion does not allow a user to access the experimental volume and thus is not the claimed access. The Applicant explained that “the experimental volume of Mikheev, depicted in Figures 2 and 3 as extension tail 27, is accessible only through bore 11 ‘which defines a probe access path,’” but does not satisfy the claims. EX1004, 71–72 (citing EX2009 (Mikheev), 5:34). The Petition ignores this critical distinction.

The Petition also fails to explain how Batey's port is like any example in the '320 patent, which describes the "opening" as, for example, a hatch mechanism, *i.e.*, a door or a hermetic seal, that can be opened to provide the user the ability to reach into the dilution refrigerator. EX1001, 13:6–13, 19:13–33, 20:50–51 (describing access by door). A probe feedthrough, like that disclosed in Batey, does not provide an opening capable of user access. Hence, Batey's port 6 does not meet limitation 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." EX1004, 71.

Petitioners' disregard for challenges unique to dilution refrigeration further infects their obviousness analysis. For example, Petitioners allege that Batey's cylinder-shaped outer vacuum vessel 5 of Batey would have been replaced with Dain's rectangular chamber as a matter of "simple substitution." Pet., 19. Yet Dain discloses neither a dilution refrigerator nor an outer vacuum chamber.

3. Claims 17–18: The Petition Fails to Explain How Dain's Door Would Provide the Claimed Access

The Petition's approach to claim 17 is self-contradictory. The Petition begins by stating that limitation 17[b] is satisfied "for the same reasons as described above with respect to limitation 1[b]." Pet., 31. In other words, the Petition begins by relying on Batey's probe for the claimed access, which is incorrect for the reasons explained above.

Immediately thereafter, however, the Petition argues that Dain's access door would help meet limitation 17[b]. Pet., 31–32. The argument is non-sensical, though, because the Petition relies on the Batey device, changing only its outer form factor to be rectangular per Dain. Pet., 19 (discussing limitation 1[b]: “The combination would involve the simple substitution of the cylinder-shaped outer vessel 5 of Batey with a rectangular chamber as described in Dain.”); *id.*, 31 (for claim 17, the combination is “as described above with respect to limitation 1[b]”).

The petition offers no explanation of how providing Dain's door in the outer vessel would provide access to Batey's experimental volume given Batey's radiation shields 40 and 41, which are critical for insulation of an ultra-cold dilution refrigerator. Fig. 1 of Batey shows apertures 25 contained in certain stages of its cryostat 1. EX1009, 8:4–5. However, in the Batey-Dain combination, apertures 25 would not “provide access to an experimental volume” for the same reason Batey's gate valve 7 does not “provide access” (*see* Section VI(A)(2)). Indeed, Batey only describes the apertures 25 as being used with a probe (Batey's sample carrier 51). Batey describes that each aperture 25 includes a baffle 26 that “is biased to a closed position, for example using a spring, such that the baffle 26 covers the aperture 25,” EX1009, 8:19–22, and that the baffles 26 are opened in conjunction with insertion of the sample carrier 51, e.g., when “the sample carrier 51 is pushed down progressively through the apertures 25,” EX1009, 12:7–11.

Finally, because claim 18 recites a “hinged door,” the Petition is forced to rely on Dain in a fashion identical to the Petition’s alternative argument just discussed with respect to claim 17. Once again, because the Petition fails to explain how providing Dain’s door would provide access to Batey’s experimental volume, limitation 18[b] is plainly missing.

B. Ground 2 Fails to Establish a Reasonable Likelihood of Success on the Merits

1. The Petition Offers No Explanation Why, in the Batey-PWS Combination, POSAs Would Use PWS’s Square Footprint Without PWS’s Unique Architecture

Ground 2 of the Petition, which addresses only claims 1–4, is based on the argument that a POSA would “modify outer vacuum vessel 5 of Batey to have the rectangular form as taught in PWS” and this “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.” Pet., 39.

PWS describes cryostats having “side-by-side arrangements” of “experimental stations.” EX1013, 7. Figures 2A and 2B show top-down views of cryostat having a “rectangular cross-sectional shape and the individual experimental stations 4-1 to 4-5 arranged next to each other in a plane are nested in an L-shape.” EX1013, 7. Figures 5 and 6 show side views of a cryostat. EX1013, 8, 10. PWS describes that its special side-by-side arrangement is selected to provide a “low height of the cryostat.” EX1013, 10.

In alleging that the combination of Batey and PWS involves only a simple substitution, the Petition ignores the teachings of PWS as a whole. Contrary to the argument in the Petition, a POSA would modify Batey's system to have PWS's rectangular form only if the POSA were also modifying the system to adopt PWS's special horizontal configuration.

As noted above, PWS describes that its rectangular cross-sectional shape enables its experimental stations to be arranged nested in an L-shape, to reduce the height of the cryostat. Thus, when considering the teachings of PWS as a whole, a POSA would only modify Batey's system to have such shape if the POSA were also to adopt the internal layout of PWS's system. In that case, however, there would be no access to the experimental volume, which is presumably why the Petition does not even attempt to justify such a combination.

2. Batey's Port and Probe Do Not Provide the Claimed Access

Ground 2 argues that limitation 1[b]'s "access to an experimental volume" is satisfied for the same reasons discussed in Ground 1. Pet., 39. Limitation 1[b] is thus missing from the combination for the same reasons described in Section VI.A.2 above since Batey's probe is exactly what the Applicant distinguished during prosecution, and thus does not provide the claimed access.

C. Ground 3 Fails to Establish a Reasonable Likelihood of Success on the Merits

1. The Chow-Dain Combination Fails Because Dain, a Non-Dilution Refrigerator, Is Not Even Analogous Art

As explained above in Section VI.A.1, Dain does not describe a dilution refrigerator and would not be considered by POSAs aiming to improve on a dilution refrigerator design. The combination of Chow with Dain thus fails for the same threshold reasons as the Batey-Dain combination. *Supra* § VI.A.1.

2. The Chow-Dain Combination Fails to Provide the Claimed Access

Ground 3 also fails because, similar to other combinations argued in the Petition, the “access” limitations are plainly absent.

Ground 3 is based primarily on Chow, except that the Petition argues it would have been obvious to adopt the rectangular external shape of Dain. But Chow, the only dilution refrigerator reference in the combination, only describes a feedthrough port, which is limited to facilitating insertion of a loading mechanism 520, or “a probe that is communicatively coupled with a sample mounting surface via a vacuum.” EX1011, ¶¶0003, 0032. In attacking claim 1, the Petition fails to explain how a restrictive feedthrough port designed for probe insertion provides the access claimed in limitation 1[b], particularly given that such a structure was specifically distinguished during prosecution as discussed earlier. Pet., 49.

With respect to limitations 17[b] and 18[b] of independent claims 17 and 18, the Petition attempts to suggest that Dain's hinged door is relevant, similar to the argument in Ground 1 addressed in Section VI.A.3 above. Once again, though, the argument is non-sensical because the Petition's combination expressly relies on Chow's feedthrough port, changing only Chow's outer form factor to be rectangular as in Dain. Pet., 50 (discussion of limitation 1[b]: Chow's "cylindrical outer vacuum vessel 900 modified to have the rectangular shape described in Dain would also have the feedthrough port 240 on a planar front surface"); *id.*, 61 ("The combination of Chow and Dain teaches limitation 17[b] for the same reasons as described above with respect to limitation 1[b]"), 64 ("The combination of Chow and Dain teaches limitation 18[b] for the same reasons as described above with respect to limitation 17[b]."). Chow's feedthrough port and probe fail to provide the claimed access for the reasons described above; indeed, they are exactly what was distinguished during prosecution.

D. Ground 4 Fails to Establish a Reasonable Likelihood of Success

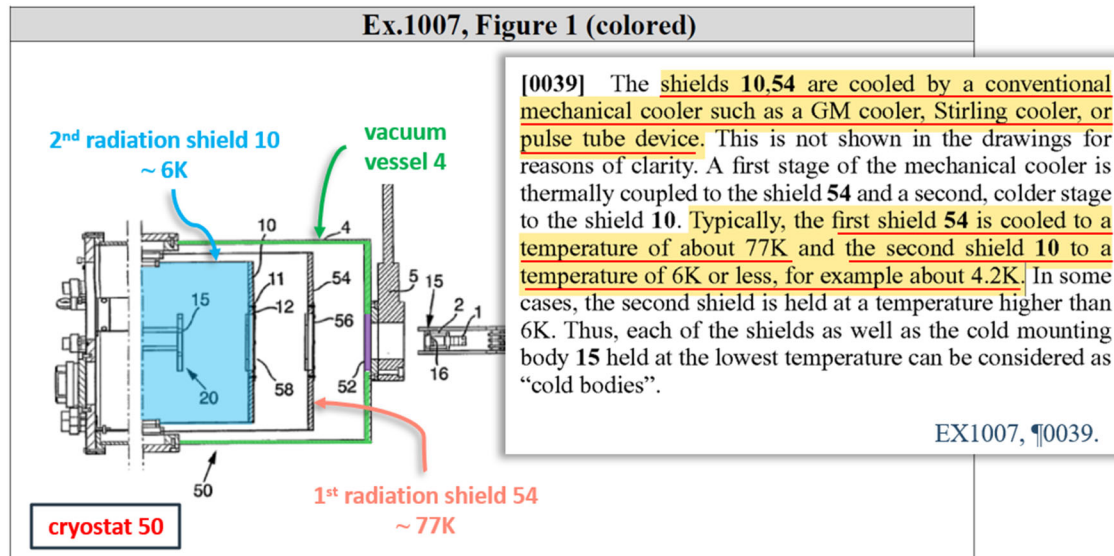
Although the Petition listed Ground 4 as both based on 35 U.S.C. § 102 and § 103, it does not provide the requisite obviousness analysis for claim 1 and for this reason its obviousness ground fails. For the reason discussed below, its anticipation ground, which is based on inherency, likewise fails.

1. Garside Is Not a Dilution Refrigerator

“To establish inherency, the extrinsic evidence ‘must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill.’” *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999). “Inherency, however, may not be established by probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient.” *Id.*

Petitioners and Petitioners’ expert, Dr. Casey, allege that “[t]o 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.” Pet., 66 (emphasis added); EX1002, ¶245 (citing EX1007, ¶44). The only evidence offered as alleged support for Dr. Casey’s opinion is the purported visual similarity between Garside’s Figure 1 and a schematic illustration of a bottom-loading dilution refrigerator. Pet., 66–67; EX1002, ¶¶245–246. Neither Petitioners nor Dr. Casey provide any substantive explanation regarding this inherency theory, let alone how unspecified visual similarities could support their conclusion. Moreover, Dr. Casey’s assertion appears to be no more than mere speculation that one could possibly arrange still and mixing chamber of a dilution refrigerator within Garside’s vacuum vessel—which is not adequate to show inherency.

Notably, Petitioners' expert differentiates the category of "cryostats" from dilution refrigerators. EX1002, ¶¶61–62 ("A dilution refrigerator is *a specific realization of a cryostat* that typically can reach a temperature of 10 mK."); *see also id.*, ¶¶29, 65. He also differentiates dilution refrigerators from mechanical cryocoolers, such as the Gifford-McMahon (GM) coolers or pulse tube (PT) coolers (EX1002, ¶29, ¶¶62–63)², as does the '320 patent (EX1001, 10:53–65, 21:33–35 (explaining that dilution refrigerators often use a less powerful PT or GM cryocooler to pre-cool the ³He/⁴He mixture gas below 5 K)). Indeed, the distinction between dilution refrigerators and PT or GM cryocoolers is well-recognized in the record. EX1009, 1:44–56, 5:59–6:2, 6:61–7:65, 15:1–22.



Adapted from EX1002, ¶247; EX1007, ¶0039.

² Citing <https://qd-uki.co.uk/what-are-the-differences-between-pulse-tube-and-gifford-mcmahon-cryocoolers/>

Contrary to Dr. Casey's inherency theory, connection of sample carrier 20 to a dilution refrigerator's mixing chamber does not require the mixing chamber to be in vacuum vessel 4. Garside describes only "connection" between sample carrier 2 and cold body 15, which does not require the components of a dilution refrigerator.

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. FIG. 3 shows the sample carrier 2 *contacting* the cold plate 15. The screw threads 18 are engaged in mating screw threads (not shown) on the cold plate 15. During the *thermal connection* between the sample carrier 2 and the cold body [15], a number of optional push fit electrical and optional optical connections can be made between the sample carrier 2 and the cold body 15.

EX1007, ¶0044. There is nothing in this passage to suggest that a dilution refrigerator must be inside of the vacuum vessel, which Petitioners rely on for all other claim limitations.

Petitioners' position is also contrary to the evidence presented in Ground 5. As discussed below, Wikus presents a dilution refrigerator where the mixing chamber is located remotely from the cryostat. Pet., 82–83; EX1002, ¶274 (Petitioners' expert stating that the dilution refrigerator is part housed by the cryostat and the mixing chamber is accommodated in a separate detector unit).

Petitioners further argue that one *could* relocate the mixing chamber of Wikus. Pet., 86–87. With respect to Ground 4, Petitioners cannot credibly argue that the mixing chamber must inherently be within the same vacuum vessel and at the same time argue it was possible to relocate the mixing chamber to another vacuum vessel.

Accordingly, Garside plainly fails to anticipate claim 1.

2. Garside’s Port and Probe Do Not Provide the Claimed Access

Like the other prior art references used in the Petition (discussed above) Garside describes a gate valve that provides only for insertion of a probe. As with Chow and Batey, Petitioners fail to explain how a feedthrough port for the use of a probe provides access by an opening in a dry dilution refrigerator’s outer wall needed to meet limitation 1[b].

The Petition argues, without merit, that Garside discloses limitation 1[b] because of a port (“port 52” or “aperture 52”) which leads to the interior of the outer vacuum vessel 4. Pet., 70. Petitioner points to annotated Figures 1 and 6 from Garside, noting that the gate valve covering Garside’s aperture 52 can be opened. Pet. 70–71.

Figure 1 of Garside shows a cryostat 50 with a gate valve 5 having a port 52. EX1007, Fig. 1. Figure 1 also shows the probe assemblies 3. *Id.* Garside does not describe using gate valve 5 to provide access without using the probe assemblies 3.

Instead, like Batey, Garside describes that “the gate valve 5, the gate valve is opened” only when “the vacuum vessel 6 is then attached to the gate valve 5 and air is pumped out of the vacuum vessel 6.” *Id.*, ¶0042. Garside describes accessing its cryostat only using probe assemblies 3 and gate valve 5, which is not access provided by an “opening in the at least one substantially planar surface of the outer housing,” as claimed. *Id.*

Once more, Petitioners rely on a probe port to satisfy limitation 1[b]. And for the same reasons already mentioned, that is not the opening claimed in the ’320 patent, as Applicant explained, and the Examiner accepted, during prosecution. Garside’s gate valve 5 with port 52 thus does not satisfy “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,” as required by 1[b].

For this additional reason, Garside does not anticipate claim 1.

E. Ground 5 Fails to Establish a Reasonable Likelihood of Success on the Merits Because Wikus fails to teach “an opening ... configured to provide access to an experimental volume disposed within an interior of the outer vacuum chamber” as Claimed

Wikus describes a refrigeration system tailored for a multi-ton cold mass experiment known as the European Underground Rare Event Calorimetric Array (EURECA). EX1008, 5, 128–155 of 174. The experiment was designed for dark matter research and designed to operate in remote underground laboratories. *Id.*

As illustrated below, Wikus envisioned the refrigeration subsystem spatially separate from the detector subsystem suspended in radiopure water with a thickness of several meters. EX1008, 132–133 of 174, Fig. 54. This is done because dark matter searches are low background experiments that need to be thoroughly shielded. EX1008, 132 of 174.

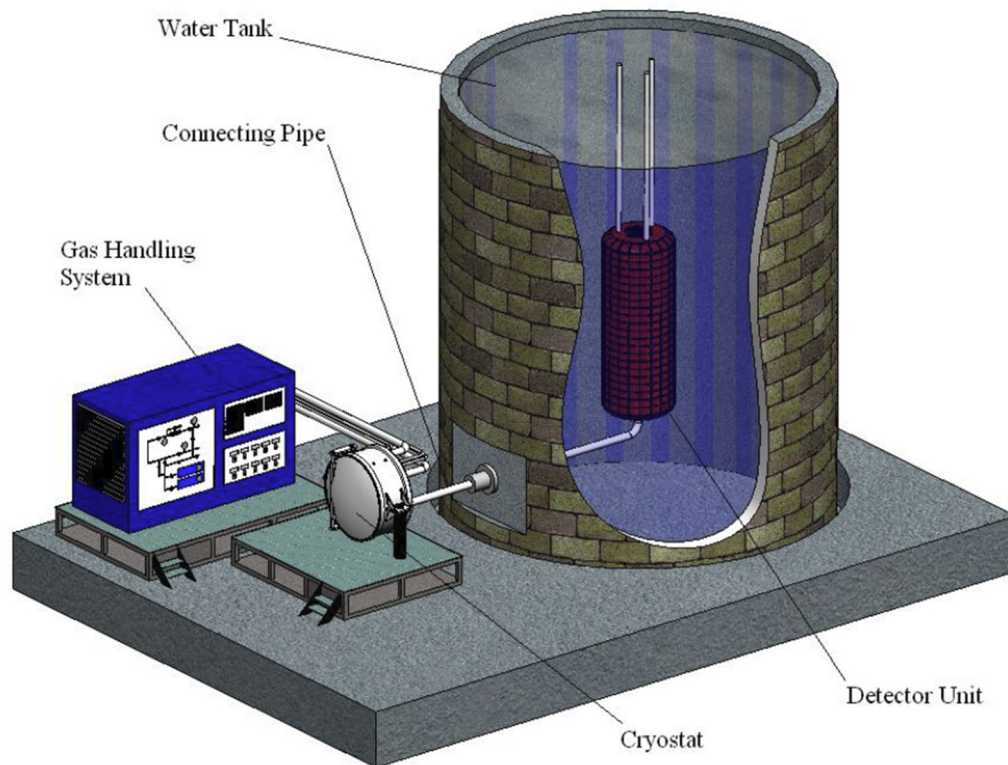
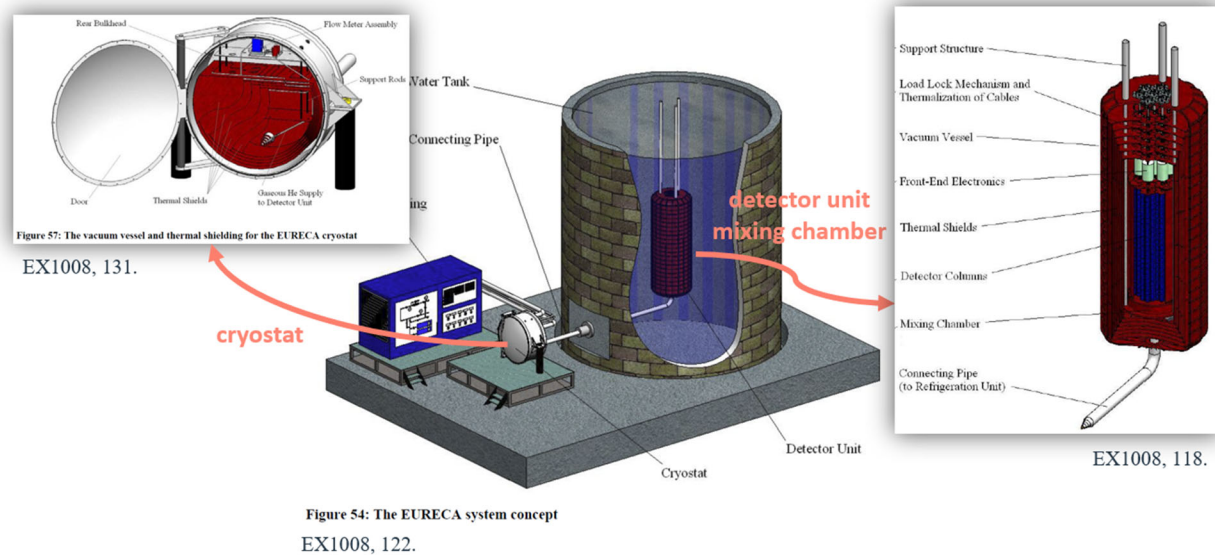


Figure 54: The EURECA system concept

EX1008, 133 of 174.

Unlike a conventional dilution refrigerator, the mixing chamber is accommodated in a detector unit. EX1008, 129, 132, 139, 148–149 of 174, Figs. 53–55. The mixing chamber is in direct contact with the detector elements and connected to the cryostat via a main heat exchanger located in a connecting pipe.

Id. Hence, both the coldest part of the refrigerator (*i.e.*, the mixing chamber) and the experiment cooled by the refrigerator are physically separate from the cryostat.



In Ground 5, Petitioners argue that the Wikus dissertation (1) anticipates or (2) alone renders obvious claims 1–3, 5, and 17–19. Pet., 82–97. Each theory is deficient on its face.

Petitioners’ anticipation theory depends on its assertion that *any* part of the interior of the cryostat *could* be used for an experiment and therefore *could* qualify as the claimed “experimental volume.” Pet., 86 (“Any of the 4K pot, 1K pot, and still can be used for an experiment.”) In making that assertion, Petitioners implicitly acknowledge that Wikus does not in fact disclose that the cryostat opening is configured to provide access to an experimental volume. Indeed, as discussed above, the dark matter experiment of Wikus is conducted by the detector unit which is not located within the cryostat but rather in a water tank separated

from the cryostat. Yet anticipation of a claim would require that Wikus disclose all of the claim limitations “arranged or combined in the same way as in the claim.”

Net MoneyIN, Inc. v. VeriSign, Inc., 545 F.3d 1359, 1369–70 (Fed. Cir. 2008).

Hence, despite its anticipation arguments, Petitioners appear to concede that Wikus fails to teach the cryostat opening is configured to provide access to an experimental volume in the context of the ’320 patent.

Petitioners described the novelty of the ’320 patent as lying “in its dilution refrigerator having a vacuum chamber with an outer housing having ‘an opening’ in ‘at least one substantially planar surface’ to ‘provide access’ to an ‘experimental volume disposed within an interior of the outer vacuum chamber.’” Pet., 2 (citing EX1001, 1:31–35). Yet Petitioners appear to fundamentally misunderstand the claimed “access” feature. According to Petitioners, “[t]his is nothing more than a dilution refrigerator with a planar wall instead of a cylindrical shape.” Pet., 2. The claims, however, do not merely recite a planar wall.

As illustrated below in Figure 1 from the ’320 patent, 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. Because experimental volume 124 is thermally coupled to the mixing chamber 122, the sample and/or quantum device may be held at or near the mixing chamber temperature. EX1001, 12:66–13:5; *see also* 1:36–40, 4:23–36, 19:7–13, 24:35–38.

Given that claim terms are interpreted in light of the specification, POSAs would not have construed “*experimental volume*” so broadly as to include *any* volume within dilution refrigerator.

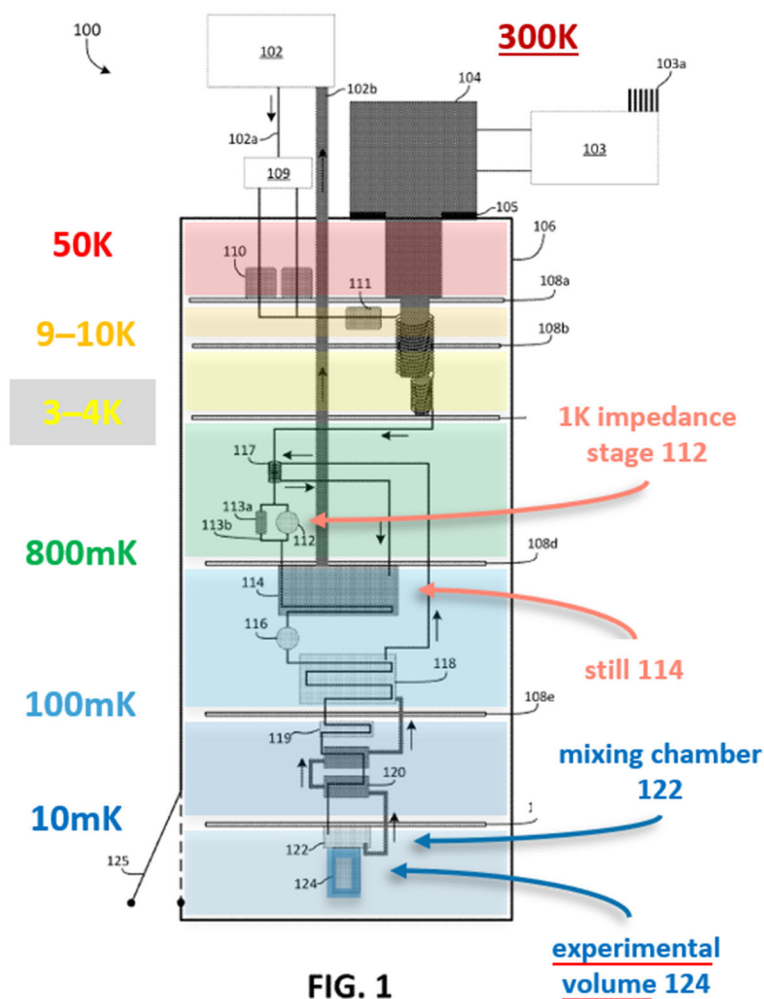


FIG. 1

EX1001, Fig. 1 (annotated).

Petitioners’ obviousness theory is equally problematic. Petitioners argue that, if the term “experimental volume” were to require a mixing chamber within the vacuum chamber, it would have been obvious to locate the mixing chamber inside the cryostat, presumably instead of inside the detector unit. Pet. 86–87.

The only rationale Petitioner offer for this modification is that dilution refrigerators traditionally included a still and mixing chamber within the same vacuum chamber. *Id.* But this type of hindsight-based reasoning has long been criticized by the Federal Circuit. Petitioners only offer conclusory references to a belief that one of ordinary skill in the art *could* modify Wikus's cryostat, not that they *would* have been motivated to do so. *InTouch Techs., Inc. v. VGO Commc'ns, Inc.*, 751 F.3d 1327, 1352 (Fed. Cir. 2014).

Petitioners also fail to address how the modification proposed (*i.e.*, moving the mixing chamber into the cryostat) would result in access to an experimental volume where the detector unit resides outside the cryostat. Nor do they address the effect of such a modification on the EURECA detector unit—particularly when the mixing chamber was designed to provide the necessary cooling power for the detector modules, which rest on the mixing chamber (*i.e.*, the coldest part of the dilution refrigerator). EX1008, 135 of 174.

Petitioners also disregard the fact that Wikus suggests that the door seal to the cryostat is not suitable for reaching the ultra-high vacuum level necessary for the mixing chamber and heat exchanger. Wikus for instance states:

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. *As the very low temperature parts (i.e. the mixing chamber and the heat exchanger) of the dilution refrigerator are accommodated in a different vacuum space*, this is not deemed problematic, though.

EX1008, 142 of 174 (emphasis added). The proposed modification to accommodate the mixing chamber *within* the vacuum vessel of the cryostat would—according to Wikus—be “problematic.” Hence, any suggestion to accommodate the mixing chamber within the vacuum vessel does not come from Wikus but only from impermissible hindsight.

To address this clear flaw in their reasoning, Petitioners argue that use of a room temperature o-ring seal was known. Pet., 87 (citing Ex.1002, ¶287 and Ex.1014). But existence of an o-ring to seal a pre-cooling system does not provide the requisite motivation for the proposed modification. Nor does it address the problem identified by Wikus because the o-ring does not seal an opening between the outer vacuum chamber and an experimental volume as claimed. *See* Ex.1014, 728–729.

Thus, contrary to Petitioners’ obviousness assertion, Wikus deliberately deviated from the very arrangement proposed by modifying a dilution refrigerator for cooling for a dark matter detector including locating the mixing chamber separate from a vacuum vessel. There is no suggestion that a POSITA would simply disregard the very reasons why the mixing chamber was located with the detector unit in the first place. *See DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1326 (Fed. Cir. 2009) (“An inference of nonobviousness is especially strong where the prior art’s teachings undermine the very reason being proffered as to why a person of ordinary skill would have combined the known elements.”); *Trivascular, Inc. v. Samuels*, 812 F.3d 1056, 1068 (Fed. Cir. 2016) (finding of no motivation to combine where the “proposed substitution would destroy the basic objective of the [feature in the prior art]”); *In re Gordon*, 733 F.2d 900, 902 (Fed. Cir. 1984) (finding modification nonobvious where modified reference would have been rendered inoperable for intended purpose). The additional fact that Wikus also suggests that the vacuum vessel would not be suitable for achieving ultra-high vacuum need for the mixing chamber and also undermines the modification Petitioners propose. Petitioners’ conclusory assertions to the contrary are not sufficient.

VII. CONCLUSION

The Petition for *inter partes* review should be denied. The Petition ignored the prosecution of the '320 patent. It would be a waste of the Office's resources to address such a Petition, and the Office should exercise discretion to deny it. In addition, the Petitioner fails to establish that the references teach all the elements of the claims or would have been modified or combined to teach all the elements of the claims.

Respectfully submitted,

Date: June 22, 2026

/Michael N. Rader/

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CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24, the undersigned certifies that the foregoing **PATENT OWNER'S PRELIMINARY RESPONSE** contains 9,494 words excluding; a table of contents, a table of authorities, Mandatory Notices under § 42.8, a certificate of service or word count, or appendix of exhibits or claim listing. Patent Owner has relied on the word count feature of the word processing system used to create this paper in making this certification.

Date: June 22, 2026

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CERTIFICATE OF SERVICE UNDER 37 C.F.R. § 42.6 (e)(4)

I certify that on June 22, 2026, a copy of the foregoing document, including any exhibits filed therewith, is being served via electronic mail, as previously consented to by Petitioner, upon the following:

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