

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of: Markus Priske
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MAINTENANCE COSTS

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**CORRECTED PETITION FOR *INTER PARTES* REVIEW OF UNITED
STATES PATENT NO. 10,471,380 B2 PURSUANT TO 35 U.S.C. §§ 311–319,
37 C.F.R. § 42**

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EXHIBITS

AP-1001	U.S. Patent No. 10,471,380 to Priske (“the ’380 patent”)
AP-1002	Prosecution History of the ’380 Patent (“the Prosecution History”)
AP-1003	Declaration of Dr. Richard W. Baker
AP-1004	<i>Curriculum Vitae</i> of Dr. Richard W. Baker
AP-1005	November 29, 2022 Complaint in <i>Evonik Operations GmbH et al. v. Air Products and Chemicals, Inc. et al.</i> , C.A. No. 1:22-cv-01543-UNA (D. Del.)
AP-1006	U.S. Patent No. 8,999,038
AP-1007	Scholz, Marco et al., <i>Structural optimization of membrane-based biogas upgrading processes</i> , J. Membr. Sci., 474 (Available online 28 September 2014), 1-10 (“Scholz”)
AP-1008	Japanese Patent Application No. JP2009-242773 (“Tsuchida”)
AP-1009	Qi, Runhong et al., <i>Membrane system design for multicomponent gas mixtures via mixed-integer nonlinear programming</i> , Comput. Chem. Eng., 24 (2000) (“Qi”)
AP-1010	Datta, Anjan K., <i>Optimization of membrane unit for removing carbon dioxide from natural gas</i> , J. Membr. Sci., 283 (2006), 291-300 (“Datta”)
AP-1011	Machine translation of Japanese Patent Application No. JP2009-242773
AP-1012	Zhang, Yuan et al., <i>Current status and development of membranes for CO₂/CH₄ separation: A review</i> , Int. J. Greenhouse Gas Control, 12 (2013), 84-107 (“Zhang”)

AP-1013	Baker, Richard W., <i>Membrane Technology and Application</i> (3d Ed. 2012)
AP-1014	U.S. Patent No. 7,968,758
AP-1015	Baker, Richard W. et al., <i>Permeability, permeance, and selectivity: A preferred way of reporting pervaporation performance data</i> , J. Membr. Sci., 348 (2010), 346-352
AP-1016	Alshehri, Ali et al., <i>Membrane Systems Engineering for Post-combustion Carbon Capture</i> , Energy Procedia, 37 (2013), 976-985.
AP-1017	CAS Registry for Polymers 9046-51-9 and 134119-41-8
AP-1018-1028	RESERVED
AP-1029	February 23, 2023 Waiver of the Service of Summons in <i>Evonik Operations GmbH et al. v. Air Products and Chemicals, Inc. et al.</i> , C.A. No. 1:22-cv-01543-MN (D. Del.)
AP-1030	July 18, 2023 Scheduling Order in <i>Evonik Operations GmbH et al. v. Air Products and Chemicals, Inc. et al.</i> , C.A. No. 1:22-cv-01543-JPM (D. Del.)
AP-1031	February 21, 2024 docket sheet for <i>Evonik Operations GmbH et al. v. Air Products and Chemicals, Inc. et al.</i> , C.A. No. 1:22-cv-01543-JPM (D. Del.)
AP-1032	2023 Comparison of Districts Trial Statistics
AP-1033	<i>Memorandum: Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation</i> (June 21, 2022).
AP-1034	Declaration of June Munford
AP-1035	Declaration of Nathaniel E. Frank-White

- AP-1036 Declaration of Luaine Bandounas
- AP-1037 Scholz, Marco et al., *Structural Optimization of membrane-based biogas upgrading processes*, J. Membr. Sci.
<http://dx.doi.org/10.1016/j.memsci.2014.08.032>, Authors
Accepted Manuscript (from Dr. Richard Baker)
- AP-1038 U.S. Patent App. Pub. No. 2013/0098242 (“Ungerank”)

LISTING OF CHALLENGED CLAIMS

Claim	Identifier	Claim Language
1	[1pre]	A method for separating gases from a crude gas stream comprising at least two components wherein in an apparatus comprising a feed stream separation stage, a retentate separation stage and a permeate separation stage, each stage being a membrane separation stage with gas separation membranes,
	[1a]	a feed stream is separated in the feed stream separation stage into a first permeate stream and a first retentate stream,
	[1b]	the first retentate stream is separated in the retentate separation stage into a second permeate stream and a second retentate stream,
	[1c]	the first permeate stream is separated in the permeate separation stage into a third retentate stream and a third permeate stream,
	[1d]	the second retentate stream is removed as a first product,
	[1e]	the third permeate stream is removed as a second product,
	[1f]	and the second permeate stream and the third retentate stream are combined with the crude gas stream to give the feed stream,
	[1f.i]	and wherein the combined gas volume of the second permeate stream and the third retentate stream is from 60 to 100% of the volume of the crude gas stream,
	[1f.ii]	the total capacity of the gas separation membranes in the retentate separation stage is higher than the total capacity of the gas separation membranes in the feed stream separation stage, the total capacity being measured for nitrogen Grade 4.8 under standard conditions as defined in the description,
	[1f.iii]	and the quotient of the pressure ratio over the permeate separation stage to the pressure ratio over the feed stream separation stage is in a range of from 0.5 to 8.

2	[2]	The method of claim 1, wherein the apparatus comprises a compressor arranged up-stream of the feed stream separation stage.
3	[3]	The method of claim 1, wherein the apparatus comprises at least one vacuum device arranged in at least one permeate stream of the feed stream separation stage, the retentate separation stage and/or the permeate separation stage.
4	[4]	The method of claim 1, wherein the first permeate stream is not subjected to a recompression.
5	[5]	The method of claim 1, wherein the ratio of the total capacity of the gas separation membranes in the retentate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 1.05 to 10.
6	[6]	The method of claim 5, wherein the ratio of the total capacity of the gas separation membranes in the retentate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 1.5 to 6.
7	[7]	The method of claim 1, wherein the ratio of the total capacity of the gas separation membranes in the permeate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 0.5 to 3.
8	[8]	The method of claim 7, wherein the ratio of the total capacity of the gas separation membranes in the permeate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 0.8 to 1.
9	[9]	The method of claim 1, wherein the combined gas volume recycled with the second permeate stream and the third retentate stream is from 65 to 85% of the volume of the crude gas stream.
10	[10]	The method of claim 1, wherein the quotient of the pressure ratio over the permeate separation stage to the pressure ratio over the feed stream separation stage is in a range of from 1 to 3.

11	[11]	The method of claim 1, wherein the gas separation membranes in the feed stream separation stage have a pure gas selectivity for CO ₂ /CH ₄ of at least 10.
12	[12]	The method of claim 11, wherein the gas separation membranes in the feed stream separation stage have a pure gas selectivity for CO ₂ /CH ₄ of from 20 to 100.
13	[13]	The method of claim 1, wherein the gas separation membranes comprise a separation-active layer of a material selected from the group consisting of...polyimides.
14	[14]	The method of claim 13, wherein the gas separation membranes comprise a separation-active layer of a polyimide consisting of monomer units A and B
15	[15]	The method of claim 13, wherein the gas separation membranes comprise a separation-active layer of a polyimide selected from the group of polyimides with CAS number 9046-51-9 and polyimides with CAS number 134119-41-8.
16	[16]	The method of claim 2, wherein the second permeate stream and the third retentate stream are combined with the crude gas stream on the suction side of the compressor.
17	[17]	The method of claim 2, wherein the compressor is a multistage compressor and the second permeate stream, the third retentate stream, or both are introduced into the compressor between two compression stages.
18	[18]	The method of claim 1, wherein the gas separation membranes are hollow fiber membranes.
19	[19]	The method of claim 1, wherein the retentate pressure of the feed stream separation stage and of the retentate separation stage are adjusted with a pressure reducing valve in the second retentate stream to a value of from 1 to 100 bar.
20	[20]	The method of claim 19, wherein the retentate pressure of the feed stream separation stage and of the retentate separation stage are adjusted to a value of from 10 to 70 bar.
21	[21]	The method of claim 1, wherein the pressure on the permeate side of the feed stream separation stage is

		adjusted with a pressure reducing valve on the retentate side of the permeate separation stage to a value of from 1 to 30 bar.
22	[22]	The method of claim 19, wherein the pressure on the permeate side of the feed stream separation stage is adjusted to a value of from 2 to 10 bar.
23	[23]	The method of claim 1, wherein the crude gas stream is selected from the group consisting of biogas, natural gas, air, a gas mixture comprising carbon dioxide and methane, a gas mixture comprising hydrogen and methane, a gas mixture comprising carbon monoxide and methane, a gas mixture comprising helium and methane, a gas mixture comprising helium and nitrogen, a gas mixture comprising hydrogen and carbon monoxide, a gas mixture comprising a permanent gas having a boiling point of less than 110 Kelvin at 1 atm and a non permanent gas having a boiling point above or equal to 110 Kelvin at 1 atm, a gas mixture comprising carbon dioxide and a hydrocarbon, and a gas mixture comprising nitrogen and a hydrocarbon.

I. INTRODUCTION

Air Products and Chemicals Inc. (“Petitioner”) petitions for *Inter Partes* Review (“IPR”) under 35 U.S.C. §§311-319 and 37 C.F.R. §42 of claims 1-23 (“Challenged Claims”) of U.S. Patent No. 10,471,380 (“’380 patent”).

The ’380 patent claims a method for separating the gases in mixtures of gases using a series of permeable membranes. In doing so, it purports to solve a “new problem” in areas where “energy is very cheap” by using lower-selectivity, lower-cost membranes to minimize “investment and maintenance costs.” AP-1001, 1:45-51. But this need already existed and such systems were well-known in the prior art.

As shown in Ground 1, patent owner Evonik’s own prior art patent (Ungerank) disclosed an *identical* system configuration as the ’380 patent’s “new” system. Moreover, Ungerank expressly disclosed all but one claim limitation ([1.f.ii]) in the ’380 patent’s sole independent claim—a limitation pertaining to two membranes’ “capacity” ratio. “Capacity” is a convoluted term used in the ’380 patent to describe a simple concept. In reality, capacity is simply a function of a membrane’s surface area, and in many cases, the “capacity” ratio of two membranes is simply their surface area ratio. In fact, when “capacity” is explained and unraveled, it becomes abundantly clear that the prior art, namely, Scholz, taught skilled artisans to use surface areas ratios that necessarily meet the capacity

ratio limitation. In other words, this is a textbook *KSR* case.

Furthermore, as explained in Ground 2, Scholz itself discloses very similar systems to the '380 patent's Figure 1, and teaches or suggests all of the limitations of independent claim 1 and many of its dependent claims. Here again, Scholz, like Ungerank, shows that there was nothing new or nonobvious regarding the '380 patent. For at least these reasons, compelling evidence herein demonstrates at least a reasonable likelihood that Petitioner will prevail on at least one Challenged Claim.

II. REQUIREMENTS FOR IPR UNDER 37 C.F.R. §42.104

A. Grounds for Standing

Petitioner certifies that the '380 patent is available for IPR. Petitioner has not filed any civil litigation challenging the '380 patent's validity. Litigation has been filed accusing Petitioner of infringing the '380 patent—*Evonik Operations GmbH et al. v. Air Products and Chemicals, Inc. et al.*, C.A. No. 1:22-cv-01543-JPM (D. Del.)—where the original complaint was served on February 23, 2023. AP-1005. Petitioner is not barred or estopped from requesting this review.

B. Challenge, Relief Requested and Prior Art

Petitioner requests cancellation of the Challenged Claims on these Grounds:

	Claims	
Ground 1	1-5, 7, 9, 11-23	Obvious (§103) over Ungerank and Scholz
Ground 2	1-13, 16-17, 21, 23	Obvious (§103) over Scholz

U.S. application 15/540,709 that issued as the '380 patent claims priority to December 29, 2014 (the "Critical Date"). AP-1001, 1. Petitioner takes no position on whether the '380 patent is entitled to this priority date but has applied references that pre-date the Critical Date.

The portions of U.S. Patent No. 8,999,038 (AP-1006), cited by column and line numbers herein and in AP-1003, are prior art under §102(a)(1), as they were published on April 25, 2013 in U.S. Patent App. Pub. No. 2013/0098242 (AP-1038) ("Ungerank"). The publication's specification and figures are identical to the patent. *Compare* AP-1006 to AP-1038. Ungerank issued under §151, names another inventor than the '380 patent's named inventor, and was filed May 26, 2011, effectively before the earliest effective filing date of the '380 patent. AP-1006, 1.

Scholz is prior art under §102(a)(1). Scholz was published in the *Journal of Membrane Science* in January 2015, but as shown on its cover, was available online in late September 2014. This is corroborated by the Bandounas Declaration (AP-1036), the Frank-White Declaration (AP-1035), and the Munford Declaration (AP-1034), all showing that Scholz was available by at least October 2014 on the www.sciencedirect.com website, which at that time was a well-known online repository of scientific articles, searchable by interested parties using reasonable diligence, among other ways, by titles and key words. AP-1034, ¶¶4-34; *Weber*

Inc. v. Provisur Techs. Inc., C.A. No. 2022-1751, ___ F. 4th ___, 2024 WL 481266, *4 (Fed. Cir. Feb. 8, 2024) (where “a publication’s purpose is dialogue with the intended audience, that purpose indicates public accessibility.”) (internal quotation omitted). This is further corroborated by Petitioner’s expert, Dr. Richard Baker, a preeminent leader in the field of membrane technology, (*see* AP-1004; AP-1003, ¶¶1-25), who was on the Editorial Board of the *Journal of Membrane Science* at the time of Scholz’s publication and who personally had a copy of the accepted article dated September 2014, (AP-1003, ¶¶246-254).

C. Claim Construction Under 37 C.F.R. §42.104(b)(3)

No formal claim constructions are presently necessary since “claim terms need only be construed to the extent necessary to resolve the controversy.”

Wellman, Inc. v. Eastman Chem. Co., 642 F.3d 1355, 1361 (Fed. Cir. 2011); AP-1003, ¶¶30-34.

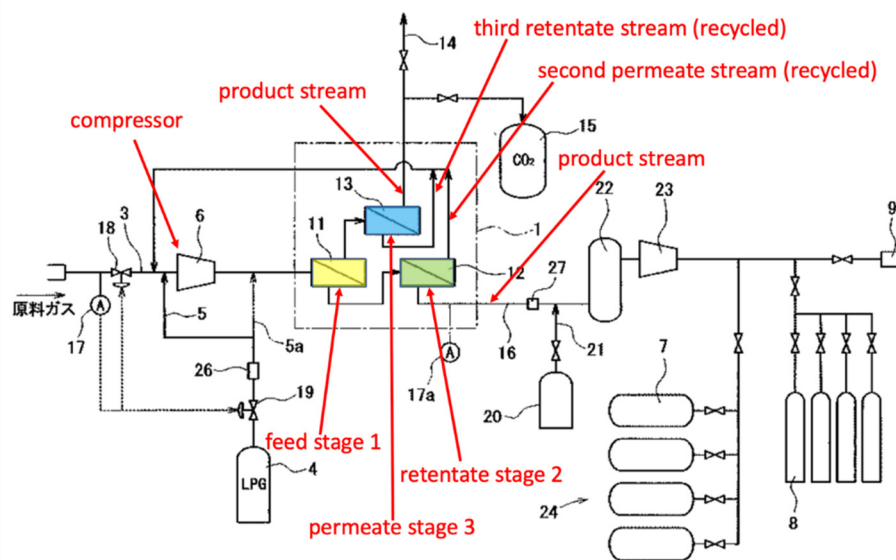
III. SUMMARY OF THE TECHNOLOGY AND ’380 PATENT

A. Technology Overview

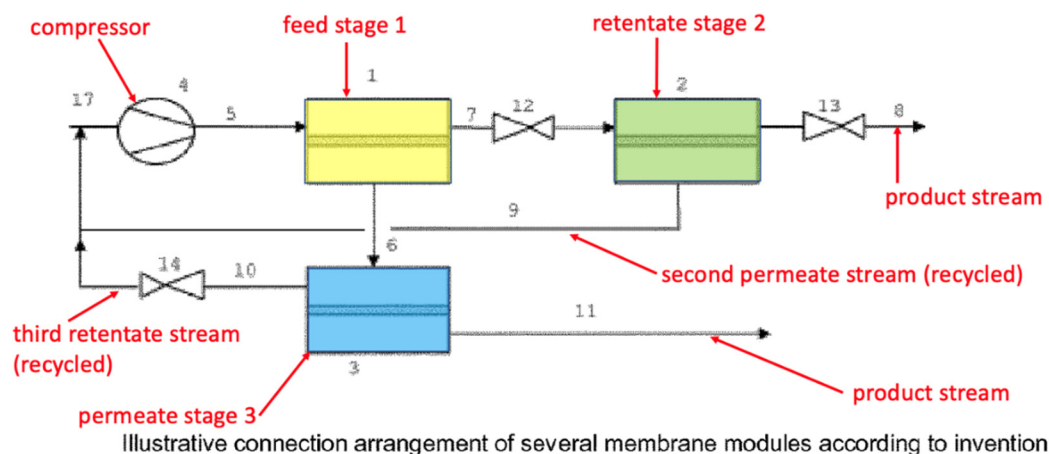
Mixtures of two or more gases, e.g., methane and carbon dioxide, are frequently generated in municipal waste disposal and other fields. AP-1003, ¶¶61-78. These mixtures can be separated into their individual components using membrane separation systems, where the gas mixture is exposed, under pressure, to polymer membranes that allow one gas to pass through the membrane more readily than another. *Id.*, ¶62. Membranes cannot separate gases entirely or

perfectly, but by using a series of membranes, the final product streams may be relatively pure. *Id.*, ¶¶63-64. The gas that passes through a membrane is called “permeate” and the gas that does not pass through a membrane is called “retentate.” *Id.*, ¶¶65-66.

The '380 patent pertains to three-stage membrane-separation systems. But years before the Critical Date, three-stage membrane-separation systems were well-known, and skilled artisans were routinely optimizing them. *Id.*, ¶¶67-78. For example, in 2009, Tsuchida disclosed a three-stage system that has a nearly identical configuration to the '380 patent's Figure 1:



Tsuchida



'380 patent, Figure 1

AP-1003, ¶68; AP-1008, 13 (annotated); AP-1011, 24; AP-1001, Figure 1 (annotated).

Similarly, the 2000 Qi publication, titled “*Membrane system design for multicomponent gas mixtures via mixed-integer nonlinear programming*,” disclosed an “optimal design strategy for membrane networks separating multicomponent gas mixtures” and applied that strategy for three-stage systems for separating mixtures containing CH₄ and CO₂:

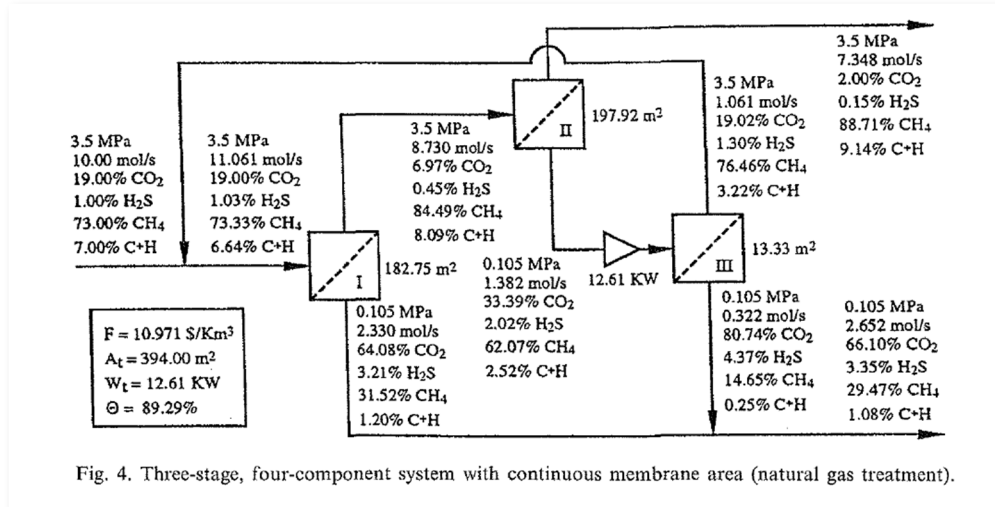


Fig. 4. Three-stage, four-component system with continuous membrane area (natural gas treatment).

AP-1009, Abstract, 2725; *see also* Figure 5. Also, the 2006 Datta paper, titled “*Optimization of membrane unit for removing carbon dioxide from natural gas,*” discussed “optimization of...membrane unit[s] having up to three stages[.]” AP-1010, Abstract.

B. The '380 Patent

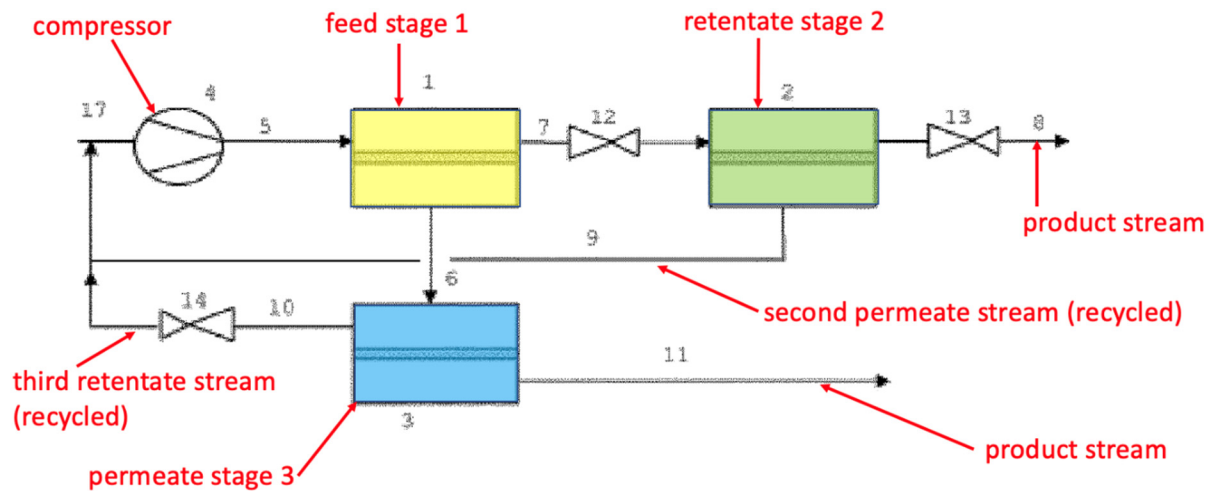
As of the Critical Date, skilled artisans characterized membranes by their selectivity. AP-1007, Abstract; AP-1013, 328; AP-1015, 347; AP-1003, ¶¶79-103. The '380 patent characterizes “selectivity” as “how well [a]...membrane can separate a gas mixture[.]” AP-1001, 3:26-30; *see also* AP-1013, 328.

Lower-selectivity membranes are almost always less expensive than higher-selectivity membranes because lower-selectivity membranes have much less surface area, and thus require less polymer to manufacture. AP-1003, ¶¶79-81. However, in three-stage systems, lower-selectivity membranes usually result in more gas needing to be compressed. Compressing gases requires energy, which is

often expensive. *Id.*, ¶81. Thus, higher-selectivity membranes can be cost-effective from an energy standpoint.

The '380 patent identifies an allegedly “new problem,” that “some gas separation plants are operated at sites where energy is very cheap” and “the focus...lies on investment and maintenance costs rather than on an energy saving.” AP-1001, 1:45-51; AP-1003, ¶¶56-60. Purportedly, the '380 patent solves this “problem” by using lower-cost, lower-selectivity membranes—i.e., systems that are “advantageous in terms of...the costs for expendable materials like the membranes” which “should be as low as possible.” AP-1001, 1:60-63; *see also* AP-1003, ¶¶82-84.

In Figure 1, the '380 patent depicts the “invention”:



Illustrative connection arrangement of several membrane modules according to invention

AP-1001, Figure 1 (annotated), 29:35-36. The three stages are the feed separation stage (1) (yellow), retentate separation stage (2) (green), and permeate separation

stage (3) (blue). *Id.*, 4:54-58. Each stage contains a membrane or membranes for separating the gases. *Id.*, 29:65-67, 7:4-32.

The mixture of gases is introduced via a “crude” stream (17). *Id.*, 3:46-51, 7:43-46, 29:62. Stream 8, one of the two product streams, is called the “second retentate” stream; and stream 11, the second product stream, is called the “third permeate” stream. *Id.*, 4:18-28; AP-1003, ¶¶85. Stream 9 (second permeate stream) and stream 10 (third retentate stream) are recycled and combined with the “crude” stream (17), which together make up the “feed” stream (5). AP-1001, 4:1-14; AP-1003, ¶¶85-86.

The feed stream (5) is pressurized by a compressor (4). As gas passes through a membrane, its pressure drops. The pressure difference across the membranes (the retentate pressure minus the permeate pressure) drives the permeate through the membrane. AP-1001, 3:18-22, 3:33-45; AP-1003, ¶¶85-86.

Claim 1 of the '380 patent is the only independent claim and has three limitations in addition to a three-stage configuration: (1) “recycle,” (2) “capacity” and (3) “pressure-ratio quotient” limitations:

1. recycle – the combined volume of the recycle streams (9) and (10) must be “from 60 to 100% of the volume” of the incoming crude stream (17). AP-1001, 30:44-46; AP-1003, ¶¶86-90.
2. capacity – the capacity in the retentate stage (2) must be higher than the

capacity in the feed stage (1). AP-1001, 30:47-52. That is, the capacity ratio of the retentate stage to the feed stream stage must be greater than 1. AP-1003, ¶¶86, 91-94.

Capacity is not a term used in this industry; rather, membrane surface area is used. The '380 patent describes “capacity” as “the product of the membrane surface and the permeance of the membrane” at certain conditions. AP-1001, 2:53-57. The patent also explains that if “membranes of identical materials are operated in different separation stages and if the operating temperature is identical, their permeance is identical” and “[a]s [a] consequence, the ratio of membrane capacities...correlates to the ratio of the membrane surfaces.” *Id.*, 3:1-5. In other words, if membranes used in different stages have the same permeance, the stages’ capacity ratio is equal to the ratio of the membranes’ areas. AP-1003, ¶¶86, 91-94. Membrane area is therefore a proxy for “capacity.”

3. pressure-ratio quotient – the quotient of the stage (3) pressure ratio to the stage (1) pressure ratio must be between 0.5 and 8. AP-1001, 30:53-55. The pressure ratio for a stage is the retentate gas pressure divided by the permeate gas pressure. *Id.*, 5:54-57; AP-1003, ¶¶86, 95-101.

C. Prosecution History

The application for the '380 patent was the national stage of PCT application EP2015/080925, filed December 22, 2015. AP-1002, 1-2.

In the first Office Action, all pending claims were rejected. *Id.*, 481-490. Most were rejected as anticipated by, or in the alternative as obvious over, Baker (U.S. 6,565,626). *Id.*, 483, 486.

Several dependent claims were rejected as obvious over Baker in view of the Application for Ungerank (US 2013/0098242). *Id.*, 486. The Ungerank Application was cited for its disclosure of vacuum pumps, polyimide membranes, and other features recited in dependent claims, for which the Examiner found Baker's disclosure lacking. *Id.*, 486-488.

In response, applicants amended the only independent claim (16), changing the required recycle volume from "60 to 200%" to "60 to 100%." *Id.*, 502. The applicants then argued that the Ungerank Application "explicitly teaches to operate...with **a total recycle volume of less than 60 %** and therefore apparently teaches away from using a total recycle volume as claimed." *Id.*, 510 (emphasis in original). Ungerank Application's Comparative Example 1 and its 86.7% recycle volume were never mentioned. *Id.*

The Examiner "agree[d] with Applicants that the prior art made of record fails to teach or fairly suggest" a recycle volume "between 60% and 100%," and the '380 patent then issued. *Id.*, 521, 545.

Scholz was never of record during prosecution.

D. Level of Ordinary Skill in the Art

A person having ordinary skill in the art (“POSITA”) for the subject matter of the ’380 patent at the Critical Date would have had a Master of Science degree in physical chemistry, chemistry, chemical engineering, or a related field, and at least three years of work experience in membrane gas-separation systems, including but not limited to biogas membrane separations. AP-1003, ¶¶56-60.

IV. THE CHALLENGED CLAIMS ARE UNPATENTABLE

The Challenged Claims are unpatentable by a preponderance of the evidence, as explained below in Grounds 1 and 2 and AP-1003. AP-1003, ¶¶51-55, 104-245; *see also* 26-29, 35-50.

A. Ungerank

Like the ’380 patent, Ungerank states it is assigned to Evonik Fibres GmbH, but the ’380 patent does not claim priority to Ungerank and has a different specification. *Compare generally* AP-1006, *with* AP-1001.

Ungerank’s Figure 11 is exactly the same as Figure 1 in the ’380 patent; and both figures are labeled “[i]llustrative connection arrangement of several membrane modules according to invention”:

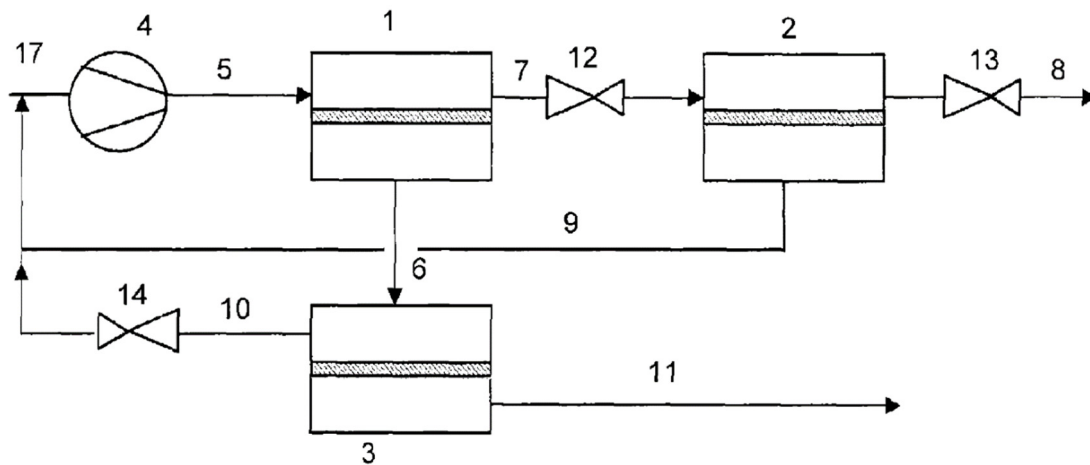


Fig. 11: Illustrative connection arrangement of several membrane modules according to invention

AP-1006, Figure 11; AP-1001, Figure 1; AP-1003, ¶¶104-105.

Unlike the '380 patent, however, Ungerank claims systems with highly-selective (higher-cost) membranes. AP-1006, claims; AP-1003, ¶¶104, 106-111. Highly-selective membranes reduce the amount of gas that is recycled (streams 9 and 10 in Figure 11 above), to the inlet of the compressor (4), which reduces the amount of compression needed, which in turn reduces energy costs. AP-1003, ¶106. As Ungerank explains, its “gas separation membrane modules have a mixed gas selectivity...especially preferably of at least 45 to 80”; and “[m]embranes of higher selectivity have the advantage that the separation becomes more effective and less” gas “has to be recycled” making it “necessary to compress less gas twice, which entails economic advantages in the operation of the plant.” AP-1006, 9:9-20. Similarly, Ungerank explains “the inventive operation can be conducted in a

much more economically viable manner with more selective membranes, and the necessary...energy required can be reduced.” *Id.*, 9:31-34.

Ungerank includes four Examples of the Figure 11 “connection arrangement” with “highly selective” membranes. *Id.*, 11:1-9, 11:53-66, 12:44-58, 13:43-57; AP-1003, ¶107. Ungerank also includes a Comparative Example 1 as a baseline that has the same Figure 11 “connection arrangement.” AP-1006, 10:17-24. However, in Comparative Example 1, the membranes have a lower “selectivity for carbon dioxide over methane,” of 20. *Id.*, 10:66-67; AP-1003, ¶108.

As required by the recycle limitation of claim 1 of the ’380 patent, in Ungerank’s Comparative Example 1, the “sum of recycled gas streams (9) and (10) is...86.7%” (AP-1006, 10:62-64) and as explained below, Comparative Example 1 also meets claim 1’s pressure-ratio quotient limitation. And while not required by the ’380 patent’s claims, in Comparative Example 1, “[p]ure product streams are obtained,” with 98.5% methane and 99.0% carbon dioxide, respectively. AP-1006, 10:27-28, 10:40-42, 10:56-59; AP-1003, ¶¶109-110.

In sum, Ungerank’s Comparative Example 1 discloses all the limitations of the ’380 patent’s claim 1 except the capacity limitation. As explained above, capacity is a function of membrane area, and Ungerank’s Comparative Example 1 does not describe the membranes’ areas. AP-1003, ¶111.

Regarding Evonik’s argument during prosecution that Ungerank taught

away because it “explicitly teaches to operate” with a recycle volume less than 60% (AP-1002, 510), that argument was incorrect and misleading. While Ungerank teaches using higher-selectivity membranes to reduce recycle volume, so that the “energy required can be reduced,” (AP-1006, 9:31-34), it discloses a Comparative Example that meets the ’380 patent’s objective of using lower-cost, lower-selectivity membranes in systems that “operate[] at sites where energy is very cheap,” where “the focus” is not on “energy saving,” and “the costs for expendable materials like the membranes should be as low as possible” (AP-1001, 1:45-63). Evonik misdirected the Examiner by staying silent on Ungerank’s Comparative Example 1, which has lower-selectivity membranes and an 86.7% recycle volume, and disclosed all but one of the limitations of independent claim 1.

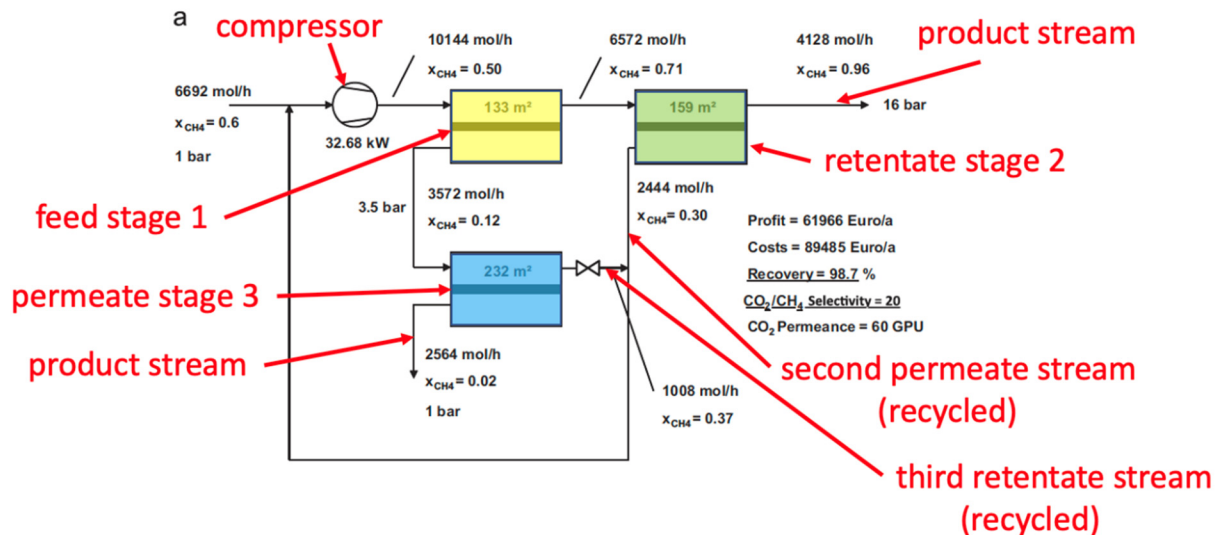
B. Scholz

Scholz’s title is *Structural optimization of membrane-based biogas upgrading processes*. AP-1007, 1. Scholz cites Qi and the PCT publication of Ungerank, and like Qi, addresses optimization of membrane gas separation systems. *Id.*, 9-10; AP-1003, ¶112.

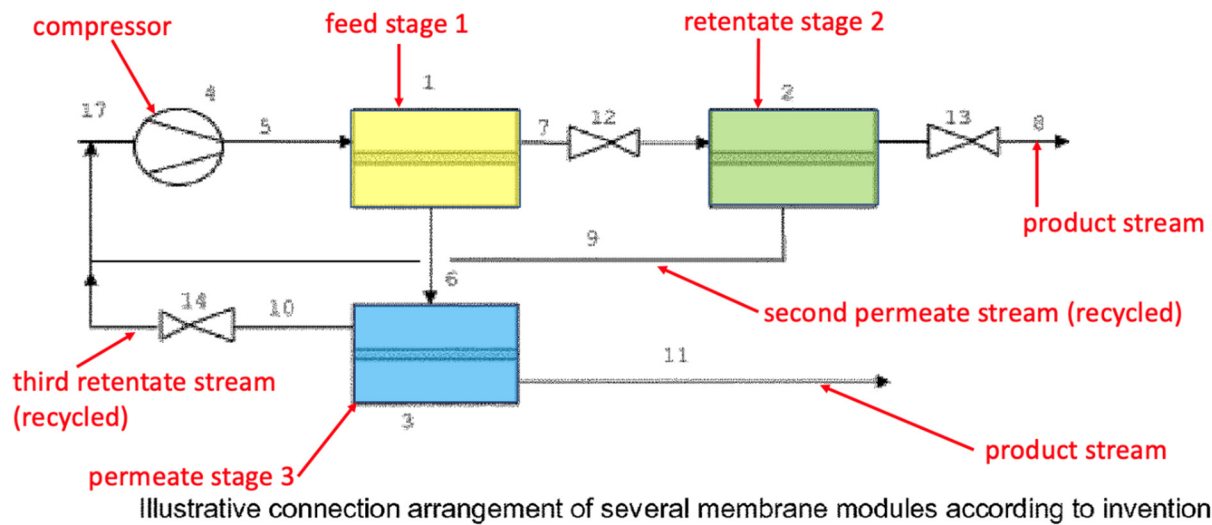
Scholz explains that it applied “a structural optimization approach to biogas upgrading processes” to “determine[] the most profitable process layout[.]” AP-1007, Abstract. Scholz further explains that it “determine[d] the most profitable

process configuration by taking both, operational cost, mainly caused by electrical energy consumption, and investment costs for the compression equipment and the membrane modules into account.” *Id.*, 4. Similarly to Ungerank, Scholz explains that lower-selectivity membranes “increase the amount of the retained gas species which permeates through the membrane resulting in increased compression duty.” *Id.*; AP-1003, ¶¶113-114.

Scholz explains that “two commercial membrane materials” were compared, one “with a CO₂/CH₄ selectivity of 60” and a second “with a selectivity of 20.” AP-1007, 5. Scholz explains that for both membranes, a “three stage membrane process using a single compressor is identified to be the best process configuration.” *Id.*, 5-6; AP-1003, ¶115. Figure 7 shows the optimized results for the lower-selectivity membranes in two scenarios, (a) and (b). The system configuration is very similar to the configuration in the ’380 patent’s Figure 1:



Scholz Figure 7(a)



'380 Patent Figure 1

AP-1007, Figure 7(a) (annotated); AP-1001, Figure 1 (annotated); AP-1003, ¶116. In both systems, a compressor compresses the gas introduced to a first “feed” stage (yellow). AP-1003, ¶117. The retentate of the first stage is fed to a second “retentate” separation stage (green), and the permeate of the first stage is fed to a third “permeate” separation stage (blue). *Id.* The retentate of the second stage and the permeate of the third stage are the product streams. *Id.* The permeate of the second stage and the retentate of the third stage are recycled and combined with the “crude” stream upstream of the compressor. *Id.*

Scholz explains that its optimization “method determine[d] the most profitable process layout including membrane areas[.]” AP-1007, Abstract; AP-1003, ¶118. As explained below, in systems like in Scholz’s Figure 7, the

membranes' areas are proportional to their capacities.

C. Ground 1 – Claims 1-5, 7, 9, 11-23 are obvious over Ungerank in view of Scholz

As described above and addressed further below, Ungerank's Comparative Example 1 discloses every limitation in claim 1 except for element [1f.ii]. AP-1003, ¶¶119-195. Element [1f.ii] requires that the capacity of the membranes in the retentate separation stage be higher than the capacity of the membranes in the feed stream separation stage. In other words, the capacity *ratio* must be greater than 1. *Id.*, ¶119.

The '380 patent describes "capacity" as "the product of the membrane surface and the permeance of the membrane" at certain standard conditions. AP-1001, 2:54-47. As the '380 patent explains (*id.*, 3:1-5), in certain circumstances (like in Scholz's Figure 7(a) and (b) systems¹), capacity ratios are proportional to membrane area ratios.

Scholz's Figure 7 three-stage systems use lower-selectivity membranes that meet the capacity ratio limitation [1f.ii] by virtue of the simple fact that the membrane areas in their retentate stream separation stages are larger than the

¹ Scholz's Figure 7(a) and (b) systems have the same three-stage configuration but are optimized for different product purities. AP-1007, Figure 7.

membrane areas in their feed stream separation stages. As Scholz explains, the membrane areas (and thus their ratios) in Figure 7 are optimized. AP-1007, Abstract, 6.

Because Ungerank's Comparative Example 1 does not provide details on the membranes' areas (or their ratios), a POSITA would have found it obvious to combine Ungerank's teachings on three-stage systems with lower-selectivity membranes with Scholz's teachings in Figure 7 on optimized surface area ratios (proportional to the capacity ratios). AP-1003, ¶¶119-142. In doing so, a POSITA would have arrived at the Challenged Claims. *Id.*

1. Motivation to Combine

Energy and membrane costs are two of the most significant costs in building and operating membrane-separation systems, and a POSITA would have understood before the Critical Date there are tradeoffs between the two. *See, e.g.*, AP-1013, 346; AP-1003, ¶¶120-127. Ungerank explained that “[m]embranes of higher selectivity have the advantage that the separation becomes more effective and less” gas “has to be recycled” making it “necessary to compress less gas twice, which entails economic advantages in the operation of the plant”; and that “with more selective membranes...the necessary...energy required can be reduced.” AP-1006, 9:14-20, 9:31-34. Scholz similarly explained that “low selectivities increase the amount of the retained gas species which permeates through the membrane

resulting in increased compression duty.” AP-1007, 4; AP-1003, ¶¶121-122.

Scholz also explained, however, that “[f]or high selectivity [membranes], permeance drops which increases the required membrane area remarkably,” resulting in “higher investment costs and membrane replacement costs [that] reduce the profitability[.]” AP-1007, 4.

In other words, a POSITA would have understood the cost tradeoffs between lower-selectivity and higher-selectivity membranes: higher-selectivity membranes are more expensive than low-selectivity membranes, but higher-selectivity membranes result in lower recycle volumes, requiring less compression, which requires less energy, which can be costly. AP-1003, ¶¶122-123.

The ’380 patent premises the need for systems with lower-selectivity, lower-cost membranes as a solution to a supposed “new problem” that occurred, which is “some gas separation plants are operated at sites where energy is very cheap” and “the focus...lies on investment and maintenance costs rather than on an energy saving.” AP-1001, 1:45-51; AP-1003, ¶124.

But the need for systems with lower-selectivity, lower-cost membranes already existed before and was not new at the Critical Date. AP-1003, ¶¶125-128. For instance, such systems were utilized on offshore platform applications, where smaller membranes were needed because of weight concerns and low-cost energy was readily available (e.g., as otherwise flared hydrocarbon gases). *Id.*, ¶125; AP-

1013, 360-63. Thus, the “invention” in the ‘380 patent was simply an “identified, predictable solution[]” and a POSITA would have had “good reason to pursue” this “known option[] within his or her technical grasp.” *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 421 (2007).

Furthermore, in the years before the Critical Date, lower-cost, lower-selectivity membranes were used routinely. Indeed, Zhang explained in 2012 that membranes that “suffer from...either low permeability or low selectivity,” nonetheless “dominate[]” “due to their low cost[.]” AP-1012, 88; *see also id.*, Abstract; AP-1013, 360; AP-1003, ¶129.

As Zhang alluded to, in 2014 and since, initial investment costs for membrane-separation systems were relatively expensive; and were incurred before the system operated (and thus provided income), and before it was certain the system would function as intended once operational. AP-1003, ¶126. In contrast, operating costs are paid over time and may be covered or deferred with income from the systems. *Id.*, ¶127. For these reasons, some operators have sought to minimize their initial investment costs, leading to the use of lower-cost, lower-selectivity membranes. *Id.*, ¶128. The demand for and importance of such systems is further shown by the fact that in 2014, Scholz optimized and discussed systems with both higher-selectivity and lower-selectivity membranes. *Id.*, ¶129; AP-1007, Figures 5 and 7.

Moreover, the demand for lower-selectivity membranes was not inconsistent with Ungerank's teachings. AP-1003, ¶130. Ungerank taught using higher-selectivity membranes to minimize operating costs (AP-1006, 3:10-13, 9:9-14), but with necessarily increased initial investment costs for higher-selectivity membranes. That is, Ungerank shows that skilled artisans understood the tradeoffs between selectivity and costs involved when choosing membranes. AP-1003, ¶130. Ultimately, Ungerank taught using high-selectivity membranes to address a different issue than the supposed "new problem" addressed in the '380 patent.

In designing a system with lower-cost, lower-selectivity membranes, a POSITA would have looked to Ungerank's Comparative Example 1, initially because it employs relatively low-selectivity membranes and achieves relatively "[p]ure product streams[.]" AP-1006, 10:19-67, 10:64-66; *see also id.*, 10:40-42, 10:56-59; AP-1003, ¶131. Further, the system in Comparative Example 1 is three-stage with a single compressor (AP-1006, 10:24-67) and Scholz explained that for "commercial membranes a three stage gas permeation process is the most profitable process which operates with only a single compressor." AP-1007, Abstract. This is further reason a POSITA designing a system with lower-selectivity membranes would have looked to Ungerank's Comparative Example 1. AP-1003, ¶¶131-132.

Ungerank's Comparative Example 1 provides detailed information on the

gases' compositions and flowrates in the system's streams, the recycle volume, the pressures (and thus the pressure ratios); and it specifies the type of membranes used having "a moderate mixed gas selectivity for carbon dioxide over methane of 20." AP-1006, 10:24-67. These details would have further steered a POSITA to Ungerank's Comparative Example 1 because they are the details a POSITA would need to design a three-stage system with a single compressor. AP-1003, ¶133. At least for the reasons discussed above, a POSITA would have been motivated and found it obvious to implement Ungerank's Comparative Example 1 in designing systems with lower-selectivity, lower-cost membranes.

A POSITA also would have been motivated to look for guidance on membrane surface areas (and more particularly their ratios) in three-stage, one-compressor systems with relatively low-selectivity membranes. AP-1003, ¶¶130-134. A POSITA would have looked to Scholz because Scholz discusses optimizations of such low-selectivity membrane systems, namely in Figure 7. AP-1007, Abstract, 6, Figure 7; AP-1003, ¶¶134-135. As explained above, the system configuration in Scholz's Figure 7 is similar to Figure 11 of Ungerank, and Scholz cites the PCT publication of Ungerank, which would have further motivated a POSITA to combine them. AP-1007, 10 (Reference 14).

Indeed, Scholz specifically states that its "systematic method determines the

most profitable process layout *including membrane areas*,”² and Figure 7 provides those details. *Id.*, Abstract, 2, 6, Figure 7; AP-1003, ¶135. This disclosure relating to optimal membrane area ratios would have steered a POSITA towards Scholz and been further reason for a POSITA to combine Scholz’s teachings with Ungerank’s Comparative Example 1. AP-1003, ¶¶134-136.

2. Reasonable Expectation of Success

A POSITA would have had a reasonable expectation of success in combining the teachings of Ungerank and Scholz on three-stage systems with relatively low-selectivity membranes. AP-1003, ¶¶137-142. Both Ungerank’s Comparative Example 1 and Scholz’s Figure 7 provide detailed information on the systems’ gas compositions, flowrates, membranes, etc. These details would have provided a POSITA with necessary inputs for designing a system, which could then be optimized. *Id.*, ¶138. The detailed system information in Ungerank and Scholz would have provided a POSITA confidence that a design based on these teachings would work. *Id.*

Additionally, both Ungerank and Scholz teach that their systems work to separate methane (CH₄) and carbon dioxide (CO₂). In Ungerank’s Comparative Example 1, the “crude gas mixture” is 50% methane and 50% carbon dioxide (AP-1006, 10:27-29); and Scholz, titled *Structural optimization of membrane-based*

² Emphasis added unless otherwise noted.

biogas upgrading processes, discusses throughout systems for “separating CO₂ and CH₄” (*see* AP-1007, Abstract, Figure 7). Both systems also disclose a gas selectivity for CO₂/CH₄ of 20. *See* AP-1006, 10:66-67; AP-1007, Figure 7; AP-1003, ¶140. These similarities between Ungerank’s Comparative Example 1 and Scholz’s Figure 7 would have given a POSITA additional confidence that combining the two references’ teachings would work. AP-1003, ¶140.

Further, Qi discussed optimizing three-stage systems in 2009, years before the Critical Date, as did Datta and others. *Id.*, ¶141; AP-1009, 2723-24, Figures 4 and 5; AP-1010, Abstract, 292. And Scholz discussed Qi and other earlier optimization publications. AP-1007, 1-2. Moreover, Scholz expressly explained that its “process model can easily be adapted to other gas separation problems...to determine the most profitable process configurations.” *Id.*, 2. The prior history of optimizations by the Critical Date and Scholz’s explanation that its process model was adaptable would have given a POSITA confidence that Scholz’s optimizations were reasonably robust and reliable and applying Scholz’s teachings to Ungerank’s Comparative Example 1 would result in a predictable and successful combination. AP-1003, ¶¶137-142.

3. Analysis

Claim 1

[1pre] *A method for separating gases from a crude gas stream comprising at least two components wherein in an apparatus comprising a feed stream separation*

stage, a retentate separation stage and a permeate separation stage, each stage being a membrane separation stage with gas separation membranes.

To the extent the preamble has patentable weight, Ungerank discloses the method and structures.

In Ungerank's Comparative Example 1 ("CE1"), the Figure 11 "connection arrangement was used" to separate "a crude gas mixture of 50% methane and 50% carbon dioxide"; and there is a "feed stream separation stage (1)," "retentate separation stage (2)" and a "permeate separation stage (3)." AP-1006, 10:24-53. Ungerank explains that each of the "three membrane separation stages" "consists of one or more physical gas separation modules, which are connected in parallel and/or in series within one stage" and "[t]he membranes are preferably used in the form of hollow fiber membranes...assembled into modules." *Id.*, 4:57-61, 9:1-4. Ungerank's CE1 teaches and/or suggests this limitation. AP-1003, ¶¶143-145.

[1a] a feed stream is separated in the feed stream separation stage into a first permeate stream and a first retentate stream,

In Ungerank's CE1, "a crude gas mixture...together with recycled...streams (9) and (10)...is applied to the feed stream separation stage (1). The retentate of the feed stream separation stage (1) is...passed via the first retentate stream (7) to...separation stage (2)" and the "permeate of the feed stream separation stage (1)...is passed via the first permeate stream (6)" into "separation stage (3)." AP-

1006, 10:27-53. This disclosure, along with Figure 11, in Ungerank teaches and/or suggests this limitation. AP-1003, ¶146.

[1b] the first retentate stream is separated in the retentate separation stage into a second permeate stream and a second retentate stream.

In Ungerank's CE1, the "retentate of the feed stream separation stage (1) is...passed...to...separation stage (2)... The retentate of the retentate separation stage (2) has a content of 98.5% methane... The permeate of retentate separation stage (2) has a" flow rate "of 0.743 m³/h." AP-1006, 10:33-48, Fig. 11. Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶147.

[1c] the first permeate stream is separated in the permeate separation stage into a third retentate stream and a third permeate stream.

In Ungerank's CE1, the "permeate of the feed stream separation stage (1)...is passed" into "the permeate separation stage (3)... This gives a third permeate stream (11)" and a "third retentate stream (10) from the permeate separation stage (3)[.]" AP-1006, 10:49-62, Fig. 11. Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶148.

[1d] the second retentate stream is removed as a first product.

In Ungerank's CE1, "a crude gas mixture of 50% methane and 50% carbon dioxide" was separated. AP-1006, 10:27-32. The "retentate of the retentate separation stage (2) has a content of 98.5% methane" (*id.*, 10:40-42) and Ungerank explains that "[p]ure **product streams** are obtained" (*id.*, 10:64-66). Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶149.

[1e] the third permeate stream is removed as a second product,

In Ungerank's CE1, "a crude gas mixture of 50% methane and 50% carbon dioxide" was separated. AP-1006, 10:27-32. The "third permeate stream (11)" has "a composition of 99.0% carbon dioxide" (*id.*, 10:56-59) and Ungerank explains that "[p]ure **product streams** are obtained (*id.*, 10:64-66). Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶150.

[1f] and the second permeate stream and the third retentate stream are combined with the crude gas stream to give the feed stream,

Ungerank's CE1 explains that "a crude gas mixture of 50% methane and 50% carbon dioxide...is introduced into a mixing chamber...together with recycled gas composed of gas streams (9) and (10)" (AP-1006, 10:27-32); the "permeate of retentate separation stage (2)...is recycled via the second permeate stream (9) into the mixing chamber" (*id.*, 10:43-48); and the "third retentate stream (10) from the permeate separation stage (3) is...recycled into the mixing chamber" (*id.*, 10:59-62). Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶151.

[1f.i] and wherein the combined gas volume of the second permeate stream and the third retentate stream is from 60 to 100% of the volume of the crude gas stream,

In Ungerank's CE1, the volumetric flowrate of the crude gas is 1.78 m³/h (AP-1006, 10:27-32), and the "sum of recycled gas streams (9) and (10) is therefore 1.544 m³/h or 86.7% based on the amount of gas to be separated supplied [i.e., the crude gas stream]" (*id.*, 10:62-64). Ungerank's disclosure of a combined

gas volume of the second permeate stream (9) and the third retentate stream (10) of 86.7% of the volume of the crude gas stream is within the claimed range of 60 to 100%. Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶152.

[1f.ii] the total capacity of the gas separation membranes in the retentate separation stage is higher than the total capacity of the gas separation membranes in the feed stream separation stage, the total capacity being measured for nitrogen Grade 4.8 under standard conditions as defined in the description,

As discussed above (IV.C.1, *supra*), Ungerank's CE1 does not disclose the membranes' surface areas (or their ratios), which is information needed to design a three-stage separation system. A POSITA would have been motivated to integrate Scholz's disclosure in Figure 7 regarding "optimized" surface areas (and thus, as explained below, membrane capacity ratios) into Ungerank's three-stage systems using lower-selectivity membranes. AP-1003, ¶¶153-154. As explained above, Scholz's Figure 7 systems were similar in many respects to Ungerank's CE1.

Scholz's disclosure of optimal surface areas (and thus their ratios) is significant because when membranes used in two stages have identical permeance, "the ratio of membrane capacities...correlates to the ratio of the membrane surfaces." AP-1001, 3:1-5. Thus, in certain situations—like in Scholz' Figure 7 systems—capacity is proportional to membrane area, and consequently, capacity ratios are proportional to area ratios. AP-1003, ¶155.

Scholz explains that the membranes in its Figure 7 have "the characteristics of a cellulose acetate membrane" and Figure 7 explains that it shows the "[o]ptimal

process design and process conditions for gas permeation membranes with a CO₂/CH₄ selectivity of 20 and a CO₂ permeance of 60 GPU.” AP-1007, 6, Figure 7 (caption). A POSITA would have understood from this that all the membranes in Scholz’s Figure 7 are the same material and have identical selectivity and permeance. AP-1003, ¶156. From this, a POSITA would have understood that the permeances of the membranes in the Figure 7 systems measured at any given set of conditions, including the claimed conditions, would be identical. *Id.*, ¶157; AP-1001, 2:53-57.

As the ’380 patent further explains, a “consequence” of having identical permeance is that “the ratio of membrane capacities used in two separation stages correlates to the ratio of the membrane surfaces.” AP-1001, 3:1-5; AP-1003, ¶158. Thus, in Scholz’s Figure 7 systems, the ratio of membrane capacities “measured for nitrogen Grade 4.8 under standard conditions as defined in the description,” is proportional to the ratio of the membrane surface areas. AP-1003, ¶158.

In system (a) in Scholz’s Figure 7, the surface areas of the retentate and feed stages are 159 m² and 133 m², respectively; and in system (b), 382 m² and 57 m², respectively. AP-1007, Figure 7; AP-1003, ¶160. Because the surface areas of the retentate stages are greater than the surface areas of the feed stages, and because for these systems, surface area is proportional to capacity, both systems meet this limitation. AP-1003, ¶¶159-160.

Additionally, it would have also been obvious to a POSITA to measure “total capacity” “for nitrogen Grade 4.8 under standard conditions as defined in the description.” As the ’380 patent explains, capacity is the product of permeance and surface area, and measuring capacity therefore requires measuring permeance at those conditions. AP-1001, 14:55-15:23; AP-1003, ¶159, n.1. It would have been obvious to a POSITA to measure permeances at standard conditions, and the specific standard condition in this limitation would have been an obvious design choice. AP-1003, ¶¶154-159. For example, Dr. Baker’s 2010 paper discusses using membrane permeance at standard temperature and pressure to describe permeation through gas separation membranes. AP-1015, 352.

For at least the reasons provided above, the Ungerank-Scholz combination teaches and/or suggests this limitation and would have rendered it obvious to a POSITA. AP-1003, ¶¶153-161.

[1f.iii] and the quotient of the pressure ratio over the permeate separation stage to the pressure ratio over the feed stream separation stage is in a range of from 0.5 to 8.

Ungerank’s CE1 explains that a “reducing valve (13) on the retentate side of the retentate separation stage (2) is set to 18.2 bara and thus determines the driving force through the membrane of membrane separation stages (1) and (2).” AP-1006, 10:36-39. Also, the “pressure drop over the membrane of stage (1) does not extend to ambient pressure, but is limited to 4.2 bara by a reducing valve (14)[.]”

Id., 10:53-56. Thus, the pressure on the retentate side of the feed stage is 18.2 bara and the pressure on the permeate side of the feed stage (and thus in the retentate side of the permeate stage) is 4.2 bara, meaning the pressure ratio over the feed stream separation stage is 4.33 (18.2 bara/4.2 bara). AP-1003, ¶¶162-163.

In Ungerank CE1, a POSITA would have understood that the pressure on the permeate side of the permeate separation stage is 1 bara, because (unlike stream 8, with pressure-reducing valve 13), there is no pressure-reducing valve in stream 11, the third permeate stream. *Id.*, ¶164. Without a pressure reducing valve, a POSITA would understand that the stream pressure would be atmospheric pressure, ~ 1 bara. *Id.*, ¶165. Thus, the pressure ratio over the permeate separation stage is 4.2 (4.2 bara/1 bara), and the quotient of the pressure ratio over the permeate separation stage to the pressure ratio over the feed stream separation stage is thus $4.2/4.33 = 0.97$. *Id.*, ¶166. A POSITA would thus have understood this limitation was taught and/or suggested by Ungerank. *Id.*, ¶¶162-166.

Claim 2 – The method of claim 1, wherein the apparatus comprises a compressor arranged up-stream of the feed stream separation stage.

In Ungerank's CE1, Figure 11 shows a compressor arranged up-stream of the feed stream separation stage and Ungerank explains that the "gas which has been compressed...is applied to the feed stream separation stage (1)." AP-1006, 4:59-60, 10:32-33. Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶167.

Claim 3 – *The method of claim 1, wherein the apparatus comprises at least one vacuum device arranged in at least one permeate stream of the feed stream separation stage, the retentate separation stage and/or the permeate separation stage.*

In Ungerank's CE1, in the "inventive apparatus...for example, FIG.

11...The partial pressure differential can be generated...by...vacuum pump(s)...in the second permeate stream (9) on the permeate side of the retentate separation stage (2) and/or in the third permeate stream (11) on the permeate side permeate separation stage (3)." AP-1006, 4:57-5:4, 10:24. Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶168.

Claim 4 – *The method of claim 1, wherein the first permeate stream is not subjected to a recompression.*

In Ungerank's Figure 11 and CE1, there is no recompression in the first permeate stream (6). AP-1006, Figure 11, 10:24-67. Ungerank discloses that Figure 11 is an example of the "inventive apparatus" (*id.*, 4:57-5:4) and that its invention overcomes a "disadvantage of the...prior art is that...there are no processes which do not need a recompression unit" (*id.*, 2:59-3:3). Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶169.

Claim 5 – *The method of claim 1, wherein the ratio of the total capacity of the gas separation membranes in the retentate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 1.05 to 10.*

See [1f.ii], *supra*, explaining that (i) for Scholz's Figure 7 systems, the

capacities are proportional to the membrane areas; (ii) in system (a) in Figure 7, the surface areas of the retentate and feed stages are 159 m^2 and 133 m^2 respectively (the ratio thus being $1.2 (159 \text{ m}^2/133 \text{ m}^2)$); and (iii) in system (b), the surface areas of the retentate and feed stages are 382 m^2 and 57 m^2 respectively (the ratio thus being $6.7 (382 \text{ m}^2/57 \text{ m}^2)$). AP-1007, Figure 7; AP-1003, ¶170. Both ratios are from 1.05 to 10 and thus a POSITA would have thus understood Scholz teaches this limitation and renders it obvious in combination with Ungerank. AP-1003, ¶¶170-171.

Claim 7 – The method of claim 1, wherein the ratio of the total capacity of the gas separation membranes in the permeate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 0.5 to 3.

See [1f.ii], *supra*, explaining that for the systems in Scholz's Figure 7, the capacities are proportional to the membrane areas. In Figure 7's system (a), the surface areas of the permeate and feed stages are 232 m^2 and 133 m^2 respectively, (the ratio thus being $1.7 (232 \text{ m}^2/133 \text{ m}^2)$). A POSITA would have thus understood Scholz teaches this limitation and renders it obvious in combination with Ungerank. AP-1003, ¶172.

Claim 9 – The method of claim 1, wherein the combined gas volume recycled with the second permeate stream and the third retentate stream is from 65 to 85% of the volume of the crude gas stream.

See [1f.i], *supra*, explaining that the recycle volume in Ungerank's CE1 is 86.7%. AP-1006, 10:62-64; AP-1003, ¶173. A POSITA would have found this to render the claimed range obvious because 86.7% is 2% higher than 85%, and a POSITA would have expected that varying the recycle volume by 2% would not have a significant effect on a system's performance. AP-1003, ¶174; *Titanium Metals Corp. of Am. v. Banner*, 778 F.2d 775, 783 (Fed. Cir. 1985) (finding prior art value "so close" to claimed range "that prima facie one skilled in the art would have expected them to have the same properties.").

Moreover, at the Critical Date and before, a POSITA would have used simulation software such as Aspen and ChemCad to optimize systems. AP-1003, ¶175. Doing so would have allowed a POSITA to test recycle volumes across various ranges. *Id.* A POSITA would have been motivated to use simulation software to test recycle volumes in the claimed range because of Ungerank's disclosure of a recycle volume that was very close to the upper end of the claimed range, and based on the benefits of lowering the recycle volume as explained in Ungerank and Scholz. *Id.* In the combination, a POSITA would thus have found the claimed range obvious based on Ungerank's disclosure of an 86.7% recycle volume. *Id.*, ¶¶173-176.

Claim 11 – The method of claim 1, wherein the gas separation membranes in the feed stream separation stage have a pure gas selectivity for CO₂/CH₄ of at least 10.

In Ungerank's CE1, the membranes "exhibit...mixed gas selectivity for carbon dioxide over methane of 20." AP-1006, 10:66-67. A POSITA would have known that for the conventional membranes in Ungerank CE1, their pure-gas selectivity is higher than their mixed gas selectivity for CO₂/CH₄. AP-1003, ¶103. A POSITA therefore would have understood that Ungerank teaches and/or suggests this limitation. AP-1003, ¶177.

Claim 12 – The method of claim 11, wherein the gas separation membranes in the feed stream separation stage have a pure gas selectivity for CO₂/CH₄ of from 20 to 100.

See [11], *supra*. In Ungerank's CE1, the membranes have a mixed-gas selectivity for CO₂/CH₄ of 20, and thus a pure-gas selectivity for CO₂/CH₄ of at least 20. AP-1006, 10:66-67; AP-1003, ¶178. A POSITA would have known that although a membrane's pure-gas selectivity is higher than its mixed-gas selectivity, the pure-gas selectivity for the membranes in Ungerank's CE1 would not be more than 500% higher than the mixed-gas selectivity and thus the pure-gas selectivity would be less than 100. AP-1003, ¶178; *see also* AP-1013, 334-335. A POSITA therefore would have understood that Ungerank teaches and/or suggests this limitation. AP-1003, ¶178.

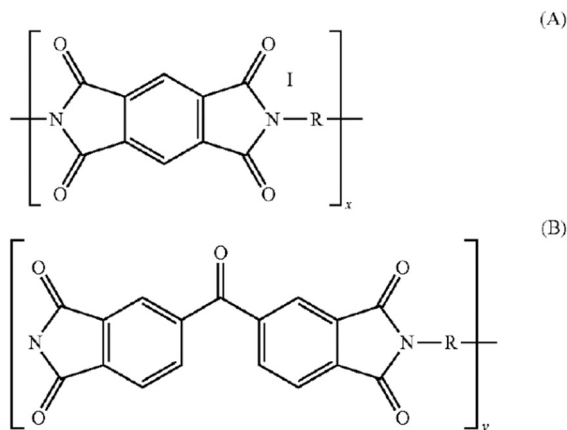
Claim 13 – The method of claim 1, wherein the gas separation membranes comprise a separation-active layer of a material selected from the group consisting of...polyimides.

In Ungerank's CE1, "[e]ach stage consisted of a hollow fiber membrane

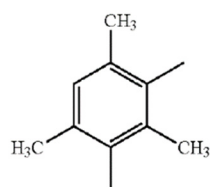
module consisting of hollow polyimide fibers[.]” AP-1006, 10:25-26. Thus,

Ungerank teaches and/or suggests this limitation. AP-1003, ¶179.

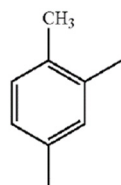
Claim 14 – The method of claim 13, wherein the gas separation membranes comprise a separation-active layer of a polyimide consisting of monomer units A and B.



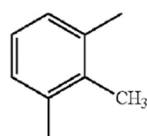
with $0 \leq x \leq 0.5$ and $1 \geq y \geq 0.5$, wherein each R is an identical or different radical selected from the group consisting of radicals L1, L2, L3 and L4



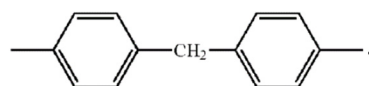
(L1)



(L2)

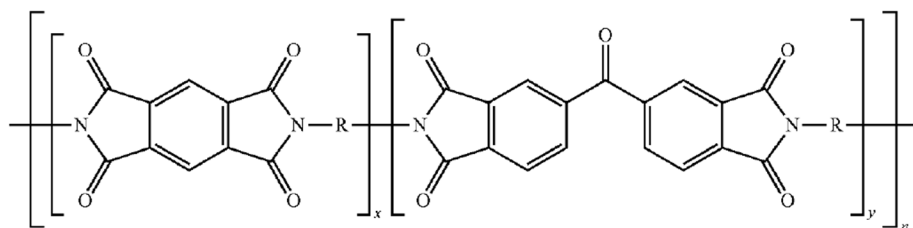


(L3)

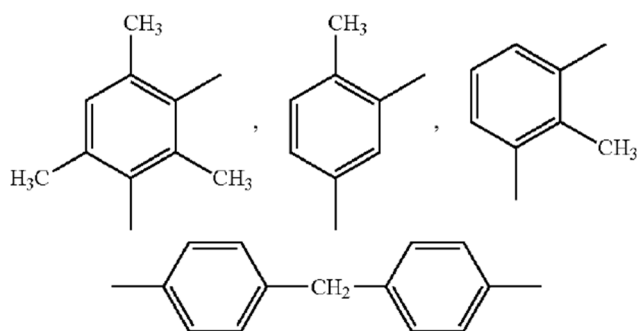


(L4)

Ungerank's CE1 has the Figure 11 "connection arrangement." AP-1006, 10:24. Ungerank explains that Figure 11 is an example of the "inventive apparatus," and that in the "inventive apparatus," "[p]articularly preferred membranes comprise, as materials for the separation-active layer or as a material for the complete membrane, a polyimide of the general formula:



R is selected from the group consisting of



x,y: mol fraction where $0 < x < 0.5$ and $1 > y > 0.5$.

Id., 4:57-58, 8:17-57. This “general formula” is nearly identical to, albeit slightly narrower than the formula in claim 14 (the slight difference being in the “x” and “y” ranges). AP-1003, ¶¶180-181. A POSITA would have thus understood that Ungerank, in the formula and the description above, teaches this limitation or at least renders it obvious. *Id.*, ¶¶180-182.

Claim 15 - The method of claim 13, wherein the gas separation membranes comprise a separation-active layer of a polyimide selected from the group of polyimides with CAS number 9046-51-9 and polyimides with CAS number 134119-41-8.

As explained in detail by Dr. Baker, Ungerank’s “general formula” discussed, *supra*, for claim 14 includes the polyimide with CAS number 134119-41-8. AP-1003, ¶¶183-187. A POSITA would have therefore understood the “general formula” and the language from Ungerank in the claim 14 analysis above to teach this limitation or at least render it obvious. *Id.*, ¶¶183-188.

Claim 16 – *The method of claim 2, wherein the second permeate stream and the third retentate stream are combined with the crude gas stream on the suction side of the compressor.*

In Ungerank's CE1, the Figure 11 "connection arrangement was used." AP-1006, 10:24. Figure 11 shows that the second permeate stream (9) and the third retentate stream (10) are combined with the crude gas stream (17) on the suction side of the compressor (4). *Id.*, Figure 11, 10:27-62. Thus, Ungerank teaches and/or suggests this limitation in the combination. AP-1003, ¶189.

Claim 17 – *The method of claim 2, wherein the compressor is a multistage compressor and the second permeate stream, the third retentate stream, or both are introduced into the compressor between two compression stages.*

In Ungerank's CE1, the Figure 11 "connection arrangement was used." AP-1006, 10:24. Ungerank discloses that the compressor (4) in Figure 11 can be a "[o]ne-stage or multistage compressor" and that in "FIG. 11" if "a multistage compressor is used, it is preferable that the second permeate stream (9)" and "the third retentate stream (10)" are "introduced into the compressor between two compression stages." *Id.*, 6:40-46, 7:8-13, 15:11. Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶190.

Claim 18 – *The method of claim 1, wherein the gas separation membranes are hollow fiber membranes.*

In Ungerank's CE1, "[e]ach stage consisted of a hollow fiber membrane module consisting of hollow polyimide fibers[.]" AP-1006, 10:25-26. Ungerank explains that in the Figure 11 "connection arrangement" used in Comparative

Example 1, each stage “consists of one or more physical...modules...connected in parallel and/or in series within one stage.” *Id.*, 10:24, 4:58-61; *see also id.*, 9:1-3.

Thus, Ungerank teaches and/or suggests this limitation. AP-1003, ¶191.

Claim 19 – The method of claim 1, wherein the retentate pressure of the feed stream separation stage and of the retentate separation stage are adjusted with a pressure reducing valve in the second retentate stream to a value of from 1 to 100 bar.

Ungerank’s CE1 explains that a “reducing valve (13) on the retentate side of the retentate separation stage (2) is set to 18.2 bara and thus determines the driving force through the membrane of...stages (1) [feed stream separation stage] and (2) [retentate separation stage].” AP-1006, 10:37-40; *id.*, 10:24, Figure 11. A POSITA would have understood this to mean the retentate pressure of the feed stage and the separation stage are adjusted to 18.2 bara with a pressure reducing valve in the second retentate stream, and thus Ungerank’s CE1 teaches and/or suggests the limitation in claim 19³. AP-1003, ¶192.

Claim 20 – The method of claim 19, wherein the retentate pressure of the feed stream separation stage and of the retentate separation stage are adjusted to a value of from 10 to 70 bar.

See [19], *supra*. Because 18.2 bara in Ungerank’s CE1 falls within the

³ Claims 19 to 22 are unclear because they do not specify bara (absolute) or barg (gauge). As explained further by Dr. Baker, Ungerank’s CE1 teaches the claimed limitations regardless. AP-1003, ¶192, n.2.

claimed range, Ungerank's CE1 discloses the limitation in claim 20. AP-1003, ¶192.

Claim 21 – *The method of claim 1, wherein the pressure on the permeate side of the feed stream separation stage is adjusted with a pressure reducing valve on the retentate side of the permeate separation stage to a value of from 1 to 30 bar.*

Ungerank's CE1 explains that the “pressure drop over the membrane of stage (1) [feed stream separation stage (1)]...is limited to 4.2 bara by a reducing valve (14) on the retentate side of the permeate separation stage (3).” AP-1006, 10:53-56; *id.*, 10:24, Figure 11. A POSITA would have understood this to mean the pressure on the permeate side of the feed stream separation stage is adjusted to 4.2 bara by the pressure reducing valve and that Ungerank thus teaches and/or suggests this limitation. AP-1003, ¶193.

Claim 22 – *The method of claim 19, wherein the pressure on the permeate side of the feed stream separation stage is adjusted to a value of from 2 to 10 bar.*

See [19] and [21], *supra* – For the reasons explained, *supra*, for claim 21, the relevant pressure is 4.2 bara and thus a POSITA would have understood that Ungerank teaches and/or suggests this limitation. AP-1003, ¶194.

Claim 23 – *The method of claim 1, wherein the crude gas stream is selected from the group consisting of biogas...a gas mixture comprising carbon dioxide and methane...*

In Ungerank CE1, there is “a crude gas mixture of 50% methane and 50% carbon dioxide, which corresponds approximately to a gas mixture of biogas.”

AP-1006, 10:27-32. A POSITA would have understood that Ungerank teaches and/or suggests this limitation. AP-1003, ¶195.

D. Ground 2 – Claims 1-13, 16-17, 21, 23 are obvious over Scholz

The claims challenged in Ground 2 would have been rendered obvious by Scholz. Even without relying on Ungerank, Scholz itself not only discloses very similar systems to the '380 patent's Figure 1, it also teaches or suggests all of the claimed methods of independent claim 1 and a majority of its dependent claims, as explained below.

1. Analysis

Claim 1

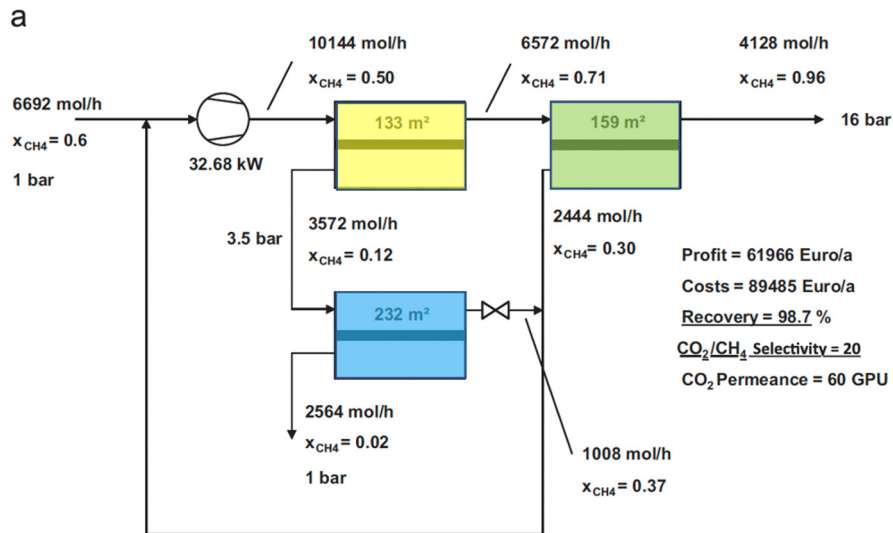
[1pre] A method for separating gases from a crude gas stream comprising at least two components, wherein in an apparatus comprising a feed stream separation stage, a retentate separation stage and a permeate separation stage, each stage being a membrane separation stage with gas separation membranes,

To the extent the preamble has patentable weight, Scholz discloses the claimed method and structures.

Scholz discloses systems that use “[g]as permeation membranes” that “are well known for separating CO₂ and CH₄.” AP-1007, Abstract. In Figures 5 and 7, Scholz depicts such systems, separating inlet (crude) streams containing CO₂ and CH₄. *Id.*, 5-7; AP-1003, ¶196.

The apparatuses in Scholz's Figure 7 comprise a feed stream separation stage (annotated in yellow below), a retentate separation stage (green) and a

permeate separation stage (blue):



Scholz's Figure 7(a) (annotated)

AP-1007, 7; AP-1003, ¶196. Scholz explains that in Figure 7, the “process layout does not change compared to” the systems in Figure 5. AP-1007, 6; AP-1003, ¶197. Scholz explains that Figure 5 (and thus also Figure 7) shows a “three stage membrane process.” AP-1007, 5. Scholz further discusses using multiple “25 m²” membrane “module[s]” in various stages in the Figure 7 systems. *Id.*, 6. A POSITA would have understood this to teach and/or suggest the method and structures in the preamble. AP-1003, ¶¶196-197.

[1a] a feed stream is separated in the feed stream separation stage into a first permeate stream and a first retentate stream,

Scholz explains that in Figure 5 (and thus in Figure 7), the “raw gas is...fed to the first membrane stage [the “feed stream separation stage” annotated in yellow

above in Figure 7],” the “retentate of the first stage is fed to a second stage,” and the “third stage polishes the permeate of the first stage[.]” AP-1007, 5-6. Thus, Scholz’s Figure 7 teaches and/or suggests this limitation. AP-1003, ¶198.

[1b] the first retentate stream is separated in the retentate separation stage into a second permeate stream and a second retentate stream,

Scholz explains that in Figure 5 (and thus in Figure 7), the “retentate of the first stage [annotated in yellow above in Figure 7] is fed to a second stage [the “retentate separation stage” annotated in green] in which the final product purity is obtained” and the “permeate of the second stage is recycled[.]” AP-1007, 5-6.

Thus, Scholz’s Figure 7 teaches and/or suggests this limitation. AP-1003, ¶199.

[1c] the first permeate stream is separated in the permeate separation stage into a third retentate stream and a third permeate stream,

Scholz explains that in Figure 5 (and thus in Figure 7), the “third stage [the “permeate separation stage” annotated in blue in Figure 7 above] polishes the permeate of the first stage[.]” AP-1007, 5-6. A POSITA would have understood the “third stage polishes the permeate of the first stage” to mean further removing the desired retentate from the stage 1 permeate—i.e., separating the first permeate stream in a permeate separation stage into a third retentate stream and a third permeate stream. AP-1003, ¶200. A POSITA would have thus understood this, along with Scholz’s Figure 7, to teach and/or suggest this limitation. *Id.*

[1d] the second retentate stream is removed as a first product,

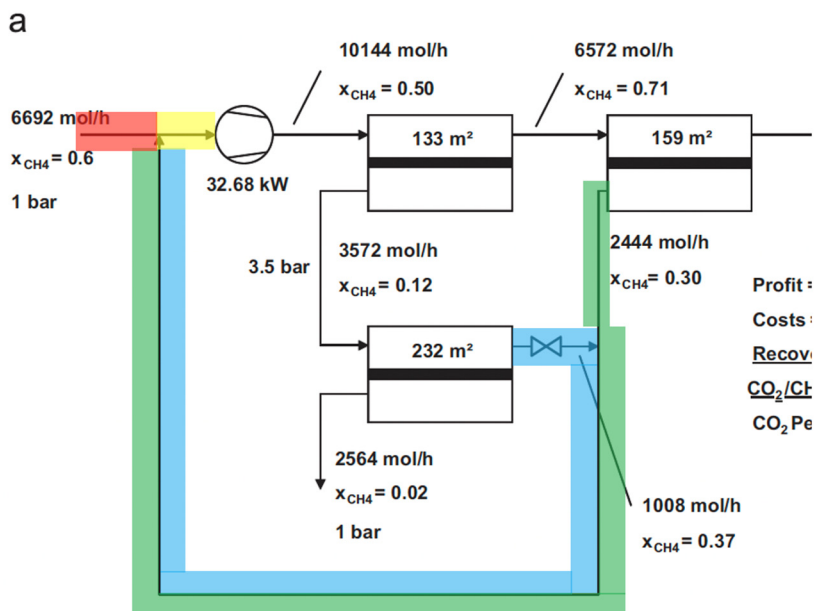
Scholz's Abstract explains that it is a paper on membrane systems for "separating CO₂ and CH₄." AP-1007, Abstract. Scholz explains that in Figure 5 (and thus in Figure 7), the "retentate of the first stage is fed to a second stage in which the *final product* purity is obtained" (AP-1007, 5). Figure 7 shows the second retentate streams have 0.96 mol fraction of CH₄. *Id.*, 7. Further, Figure 7 does not show any additional processing of the second retentate stream. *Id.*; AP-1003, ¶201. Thus, Scholz teaches and/or suggests this limitation. AP-1003, ¶201.

[1e] the third permeate stream is removed as a second product,

Scholz pertains to membrane systems for "separating CO₂ and CH₄." AP-1007, Abstract. Scholz explains that in Figure 5 (and thus in Figure 7) that the "third stage polishes the permeate of the first stage[.]" AP-1007, 5-6. Figure 7 shows the third permeate streams have 0.02 and 0.008 mol fraction of CH₄. *Id.*, 7; *see also id.*, 6. A POSITA would have understood this to mean that the third permeate streams are predominantly CO₂. AP-1003, ¶202. Further, Figure 7 does not show any additional processing of the third permeate streams. *Id.*, ¶202. A POSITA would have understood that Scholz teaches and/or suggests this limitation. *Id.*, ¶202.

[1f] and the second permeate stream and the third retentate stream are combined with the crude gas stream to give the feed stream,

Scholz explains that in Figure 5 (and thus in Figure 7), the “permeate of the second stage is recycled and mixed with the raw gas stream...and the retentate of the third stage is also recycled.” AP-1007, 5-6. As shown below, in Figure 7, the second permeate stream (annotated in green) and the third retentate stream (blue) are combined with the crude gas stream (red) to give the feed stream (yellow):



Thus, Scholz teaches and/or suggests this limitation. AP-1003, ¶¶203-04.

[1f.i] and wherein the combined gas volume of the second permeate stream and the third retentate stream is from 60 to 100% of the volume of the crude gas stream,

Scholz’s disclosure, including its teaching relating to Figure 7, and the POSITA’s knowledge prior to the Critical Date would have rendered obvious limitation [1f.i]. AP-1003, ¶¶205-210.

In *Titanium Metals*, the Federal Circuit held that prior art rendered a claim obvious where the prior art “disclosed single points, not ranges, and the claimed amount fell within the two single amounts disclosed by the prior art.” *In re Patel*, 566 F. App’x 1005, 1009-10 (Fed. Cir. 2014) (nonprecedential) (discussing *Titanium Metals*, 778 F.2d at 781-83); Fed. Cir. R 32.1(c)-(d); *Bos. Sci. Scimed, Inc. v. Cordis Corp.*, 554 F.3d 982, 991 (Fed. Cir. 2009) (“Combining two embodiments disclosed adjacent to each other in” a prior art reference “does not require a leap of inventiveness.”).

In Scholz’s Figure 7 (a) system “the combined gas volume of the second permeate stream and the third retentate stream” as a percentage “of the volume of the crude gas stream” (i.e. “recycle percentage” or “recycle volume”) is 51%. AP-1007, 7. In the Figure 7(b) system, the recycle percentage is 135%. *Id.*; AP-1003, ¶205. The claimed “60 to 100%” range falls within the two single recycle percentages (51% and 135%) disclosed in Scholz, and thus would have been *prima facie* obvious. AP-1003, ¶¶205-210.

Furthermore, even outside the *Titanium Metals* fact pattern, a POSITA would have had other reasons to vary the recycle percentages to achieve a recycle percentage within the claimed range with a reasonable expectation of success. First, a POSITA would have understood that varying the recycle percentage in the Figure 7 system affects, among other things, product recovery and operating costs.

Id., ¶206. For example, Scholz explains that in the Figure 7 (b) system, the CH₄ recovery is higher than in system (a), but the “high[er] recovery can only be obtained on cost of an increased recycle flow rate.” AP-1007, 6. In addition, Ungerank expressly teaches a recycle percentage of 86.7% and explains that having “less permeate...recycled” “entails economic advantages in the operation of the plant.” AP-1007, 6; AP-1006, 10:62-64, 9:14-20. A POSITA also would have understood that varying the recycle percentage within and around the range between the Figure 7 systems (a) and (b) would have a predictable effect on product recovery and operating costs, as for example, the language above from Scholz and Ungerank describes. AP-1003, ¶206.

Moreover, a POSITA would have been motivated to use simulation software to test recycle volumes in the claimed 60-100% range because a POSITA would try to optimize systems using the data in Scholz, in the first instance by choosing values close to the middle of the disclosed range—i.e., 91% (51-135%/2), which is in the claimed range. *Id.*, ¶¶207-208; *see also* [9] in Ground 1, *supra*, discussing Aspen and ChemCad.

Additionally, or alternatively, a POSITA would have understood that a third permeate stream having very high purity CO₂ (e.g., X_{CH₄} = 0.008) as in system (b) in Scholz’s Figure 7 would be unnecessary in most applications. *Id.*, ¶209. Instead, a POSITA would have sought a lower recycle percentage to lower energy costs (as

described in Scholz, for example), and, thus, would have been motivated to use a lower recycle percentage than in system (b), further leading a POSITA towards the claimed range of 60-100% recycle percentage. *Id.*

A POSITA would have had a reasonable expectation of success in optimizing systems using the data in Scholz for three-stage systems with low-selectivity membranes based on the known prior art. AP-1003, ¶¶137-142, 206-208. For example, as previously discussed (IV.C.2, *supra*), Scholz's Figure 7 provides sufficient detail that would have provided a POSITA with necessary inputs for designing and optimizing a system. *Id.* Additionally, Ungerank CE1 expressly teaches using a recycle percentage of 86.7% in its exemplary lower-selectivity membrane system, and Qi and other earlier optimization publications would have given a POSITA confidence that the optimizations in Scholz were reasonably robust and reliable. *See* AP-1009, Abstract, 2725, Figure 5; AP-1010, Abstract. Accordingly, a POSITA would have had confidence that a design based on Scholz's examples as well as designs that had parameters (e.g., recycle percentages) ranging between Schulz's examples would have worked with a reasonable expectation of success. AP-1003, ¶¶137-142, 206-208. A POSITA would have therefore found the recycle percentage range in Scholz's Figure 7 (51%-135%) teaches and/or suggests the 60-100% claimed range. *Id.*, ¶¶205-210.

[1f.ii] the total capacity of the gas separation membranes in the retentate separation stage is higher than the total capacity of the gas separation membranes in the feed stream separation stage, the total capacity being measured for nitrogen Grade 4.8 under standard conditions as defined in the description,

See [1f.ii] in Ground 1, *supra*. AP-1003, ¶211.

[1f.iii] and the quotient of the pressure ratio over the permeate separation stage to the pressure ratio over the feed stream separation stage is in a range of from 0.5 to 8.

In Scholz's Figure 7 (a) system, "the quotient of the pressure ratio over the permeate separation stage to the pressure ratio over the feed stream separation stage" ("3/1 pressure ratio quotient") is 0.77. AP-1003, ¶212. Therefore, Scholz teaches and/or suggests this limitation. *Id.*

See also [1fi], *supra*, discussing *Titanium Metals*. The 3/1 pressure ratio quotient is 0.42 in Figure 7's system (b); and thus the range encompassed by systems (a) and (b) (0.42-0.77) overlaps the 0.5-8 claimed range. *Id.*, ¶213; AP-1007, 7.

A POSITA would have also understood that in systems like Figure 7, varying pressure ratios (and thus 3/1 pressure ratio quotients) affects cost in predictable ways. AP-1003, ¶214. As further explained by Dr. Baker, because of the 3/1 pressure ratio quotients' impact on membrane costs, a POSITA would have been motivated to avoid extreme 3/1 pressure ratio quotients. *Id.*, ¶215.

See also [9] in Ground 1, *supra*, discussing Aspen and ChemCad. A POSITA would have been motivated to use simulation software to test 3/1 pressure

ratio quotients in the range encompassed by systems (a) and (b) in Scholz's Figure 7, and particularly near the middle of that range ($0.59 = (0.42+0.77)/2$)), which is within the claimed range. *Id.*, ¶216.

Thus, a POSITA would have found that the 3/1 pressure ratio quotient range in Scholz's Figure 7 (0.42-0.77) teaches and/or suggests the claimed range of 0.5-8. *Id.*, ¶¶212-217.

Claim 2 – *The method of claim 1, wherein the apparatus comprises a compressor arranged up-stream of the feed stream separation stage.*

Scholz explains that in Figure 5 (and thus in 7), “a single compressor is” used (AP-1007, 5) and in Figure 7, there is a single compressor shown up-stream of the feed stage. *Id.*, 7; AP-1003, ¶218. Thus, Scholz teaches and/or suggests this limitation. AP-1003, ¶218.

Claim 3 – *The method of claim 1, wherein the apparatus comprises at least one vacuum device arranged in at least one permeate stream of the feed stream separation stage, the retentate separation stage and/or the permeate separation stage.*

Scholz discloses that “a vacuum pump” can be used “to generate the driving force for permeation.” AP-1007, 6. A POSITA would have understood generating a “driving force for permeation” to mean a vacuum pump in a permeate stream, and thus would have understood this description in Scholz to teach this limitation. AP-1003, ¶219.

Claim 4 – *The method of claim 1, wherein the first permeate stream is not subjected to a recompression.*

Scholz explains that in Figure 5 (and thus in Figure 7), “a single compressor is” used and in Figure 7 the compressor is in the feed line, not in the first permeate stream. AP-1007, 5, 7; AP-1003, ¶220. Thus, Scholz teaches and/or suggests this limitation. AP-1003, ¶220.

Claim 5 – *The method of claim 1, wherein the ratio of the total capacity of the gas separation membranes in the retentate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 1.05 to 10.*

See [5] in Ground 1, *supra*. AP-1003, ¶221.

Claim 6 – *The method of claim 5, wherein the ratio of the total capacity of the gas separation membranes in the retentate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 1.5 to 6.*

See [1fi] and [9] in Ground 1, *supra*, discussing *Titanium Metals*; see also [5], *supra*.

In Scholz’s Figure 7 (a) system the “ratio of the total capacity of the gas separation membranes in the retentate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage” (“2/1 capacity ratio”) is 1.2, and 6.7 in system (b). AP-1003, ¶222, AP-1007, 7. The range encompassed by systems (a) and (b) (1.2-6.7) overlaps and is close to the 1.5-6 claimed range. AP-1003, ¶222.

A POSITA would have understood that in Scholz's Figure 7 systems, where capacity is proportional to surface area (*see* 1[fii] in Ground 1, *supra*), varying the areas in stages 1 and 2 (and thus the 2/1 capacity ratio) affects costs. *Id.*, ¶223. For example, Scholz explained that "increas[ing] the required membrane area" results in "higher investment costs and membrane replacement costs, reduc[ing] the profitability." AP-1007, 4, 7; AP-1003, ¶223. A POSITA would have understood that varying the surface area ratios of stages 1 and 2 (and thus the 2/1 capacity ratio) within and around the disclosed range has a predictable effect on cost—i.e., the more total surface area, the higher the cost. AP-1003, ¶223.

See also [9] in Ground 1, *supra*, discussing Aspen and ChemCad. A POSITA would have been motivated to use simulation software to test the areas in stages 1 and 2 such that they were within the claimed 2/1 capacity ratio because the area ratios (and thus the 2/1 capacity ratios) in the range encompassed by Scholz's Figure 7 systems (a) and (b) overlaps the claimed range, and a POSITA would have been motivated by Scholz's optimizations to test values within the range encompassed by Scholz's Figure 7 systems (a) and (b), and particularly near the middle of that range ($3.9 = (1.2 + 6.7)/2$), which is within the claimed range. *Id.*, ¶224.

Thus, a POSITA would have found that the 2/1 capacity ratio range in Scholz's Figure 7 teaches and/or suggests the claimed range. *Id.*, ¶¶222-225.

Claim 7 – The method of claim 1, wherein the ratio of the total capacity of the gas separation membranes in the permeate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 0.5 to 3.

See [7] in Ground 1, *supra*, explaining that in Scholz Figure 7 system (a), “the ratio of the total capacity of the gas separation membranes in the permeate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage” (“3/1 capacity ratio”) is 1.7. AP-1003, ¶226. Thus, a POSITA would have understood the Figure 7 system (a) teaches and/or suggests this limitation. *Id.*, ¶¶226.

See also [1fi], *supra*, discussing *Titanium Metals*. In Scholz’s Figure 7 system (b), the 3/1 capacity ratio is 22.8, and thus the range encompassed by the values in systems (a) and (b) (1.7-22.8) overlaps the 0.5-3 claimed range. *Id.*, ¶227.

As explained for claim 6, a POSITA would have understood that in Scholz’s Figure 7 systems, capacity is proportional to surface area, and varying surface areas (and thus surface area ratios and capacity ratios) affects costs. A POSITA would have understood that varying the surface area ratios of stages 1 and 3 (and thus the 3/1 capacity ratio) within and around the disclosed range has a predictable effect on cost—i.e., the more total surface area, the higher the cost. *Id.*, ¶228.

See also [9] in Ground 1, *supra*, discussing Aspen and ChemCad. A POSITA would have been motivated to use simulation software to test the areas in

stages 1 and 3 such that they were within the claimed 3/1 capacity ratio because the area ratios (and thus the 3/1 capacity ratios) in the range encompassed by Scholz's Figure 7 overlaps the claimed range, and a POSITA would have been motivated by Scholz's optimizations to test values within the disclosed range. *Id.*, ¶229.

Thus, a POSITA would have found that the 3/1 capacity ratio range in Scholz's Figure 7 teaches and/or suggests the claimed range. *Id.*, ¶¶226-230.

Claim 8 – The method of claim 7, wherein the ratio of the total capacity of the gas separation membranes in the permeate separation stage to the total capacity of the gas separation membranes in the feed stream separation stage is in a range of from 0.8 to 1.

See [7], *supra*, explaining Scholz's Figure 7 discloses a range for the 3/1 capacity ratio of 1.7-22.8. That range does not overlap the 0.8-1 claimed range, but the low-end of the Scholz range is near the high-end of the claimed range. AP-1003, ¶231.

See also [9] in Ground 1, *supra*, discussing Aspen and ChemCad. A POSITA would have been motivated to use simulation software to test surface area ratios (and thus 3/1 capacity ratios) across various ranges, including the claimed range, which a POSITA would have been motivated to do by Scholz's disclosure of surface area ratios that result in 3/1 capacity ratios near the claimed range. *Id.*, ¶231. Doing so would have allowed a POSITA to predict how varying the 3/1 capacity ratio in the disclosed and claimed ranges would affect system performance.

A POSITA would thus have found the claimed range obvious. *Id.*, ¶231.

Claim 9 – The method of claim 1, wherein the combined gas volume recycled with the second permeate stream and the third retentate stream is from 65 to 85% of the volume of the crude gas stream.

See [1.f.i], *supra*. Scholz's Figure 7 discloses a range of 51-135% for the recycle percentage, which encompasses the 65-85% claimed range. AP-1003, ¶232. For the reasons explained for [1.f.i], a POSITA would have found that the recycle percentage range in Scholz's Figure 7 teaches and/or suggests the 65-85% claimed range or at least renders it obvious. *Id.*, ¶¶232-235.

Claim 10 – The method of claim 1, wherein the quotient of the pressure ratio over the permeate separation stage to the pressure ratio over the feed stream separation stage is in a range of from 1 to 3.

See [1.f.iii], *supra*. Scholz's Figure 7 discloses a range for the 3/1 pressure ratio quotient of 0.42-0.77, which does not overlap with the 1-3 claimed range, but the high-end of the Scholz range is close to the low-end of the claimed range. AP-1003, ¶¶212-213, 236-237.

See also [9] in Ground 1, *supra*, discussing Aspen and ChemCad. A POSITA would have been motivated to use simulation software to test 3/1 pressure ratio quotient across various ranges, including the claimed range, which a POSITA would have been motivated to do by Scholz's disclosure of pressure ratios that result in 3/1 pressure ratio quotient near the claimed range. *Id.*, ¶237. Doing so

would have allowed a POSITA to predict how varying 3/1 pressure ratio quotients in the disclosed and claimed ranges would affect system performance.

A POSITA would thus have found the claimed range obvious. *Id.*, ¶¶236-237.

Claim 11 – The method of claim 1, wherein the gas separation membranes in the feed stream separation stage have a pure gas selectivity for CO₂/CH₄ of at least 10.

Scholz discloses that the membranes in its Figure 7 systems have “a CO₂/CH₄ selectivity of 20.” AP-1007, Figure 7. Scholz does not specify if this selectivity is mixed gas or pure gas. AP-1003, ¶238. If mixed gas selectivity, however, a POSITA would have understood that the pure gas selectivity would be higher than the mixed gas selectivity, and thus higher than 20. AP-1003, ¶¶103, 238. A POSITA thus would have understood Scholz to teach and/or suggest this limitation. *Id.*, ¶238.

Claim 12 – The method of claim 11, wherein the gas separation membranes in the feed stream separation stage have a pure gas selectivity for CO₂/CH₄ of from 20 to 100.

See [11], *supra*. Further, if the “selectivity of 20,” in Scholz is mixed-gas selectivity, a POSITA would have understood that the pure-gas selectivity would be higher, but nonetheless not 500% higher—i.e., it would be less than 100. AP-1003, ¶239. Thus, a POSITA would understand that Scholz teaches and/or suggests this limitation or at least renders it obvious. *Id.*

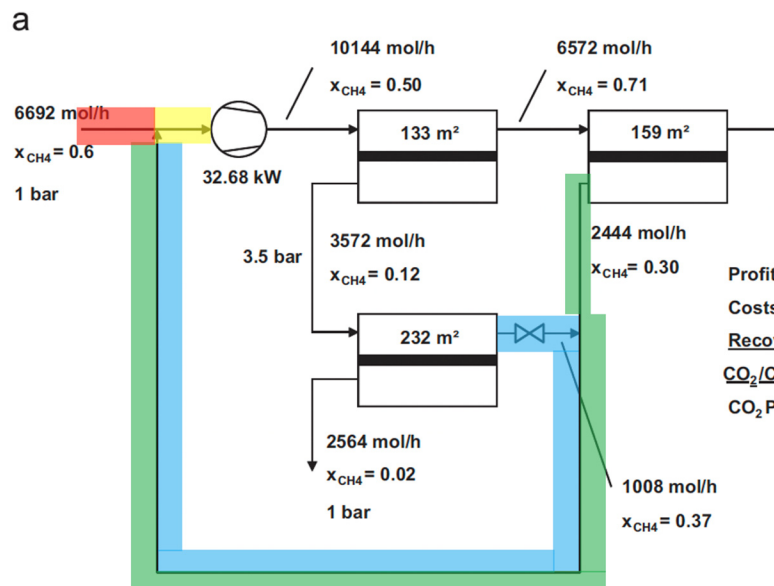
Claim 13 – The method of claim 1, wherein the gas separation membranes comprise a separation-active layer of a material selected from the group consisting of...cellulose acetate...

Scholz discloses that “a membrane reflecting the characteristics of a cellulose acetate membrane...are depicted in Fig. 7.” AP-1007, 5-6, Figure 7.

Thus, Scholz teaches and/or suggests this limitation. AP-1003, ¶240.

Claim 16 – The method of claim 2, wherein the second permeate stream and the third retentate stream are combined with the crude gas stream on the suction side of the compressor.

See [2], *supra*. As shown in Scholz’s Figure 7, the second permeate stream (in green below) and third retentate stream (blue), are combined with the crude stream (red) on the suction side of the compressor. AP-1007, Figure 7; AP-1003, ¶241. Thus, Scholz teaches and/or suggests this limitation. AP-1003, ¶241.

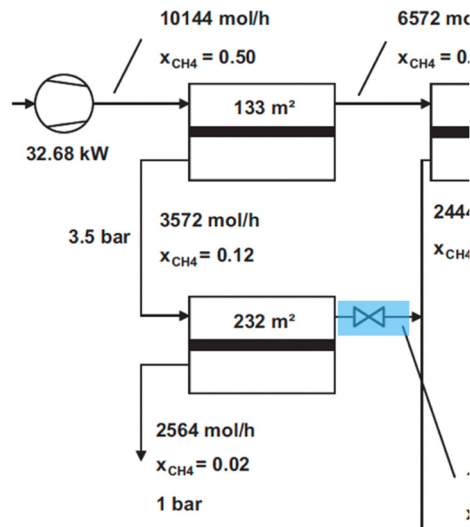


Claim 17 – The method of claim 2, wherein the compressor is a multistage compressor and the second permeate stream, the third retentate stream, or both are introduced into the compressor between two compression stages.

See [2], *supra*. Scholz discloses that “the application of a multistage compressor would further reduce the energy demand for the gas permeation processes.” AP-1007, 6. A POSITA would have understood this to mean that the recycled stream(s) would be introduced between two compression stages, as that is how multistage compressors reduce energy demand. AP-1003, ¶242. By introducing such streams between two compression stages, the recycle stream(s) pressure is not reduced all the way down to the inlet stream pressure, and accordingly the recycle stream(s) do not need to be recompressed as much. *Id.* A POSITA would have thus understood Scholz to teach and/or disclose this limitation. *Id.*

Claim 21 – The method of claim 1, wherein the pressure on the permeate side of the feed stream separation stage is adjusted with a pressure reducing valve on the retentate side of the permeate separation stage to a value of from 1 to 30 bar.

In Scholz’s Figure 7, there is a pressure reducing valve on the retentate outlet of the third permeate stage (annotated blue below), and the pressure on the permeate side of the feed stage is 3.5 bar in system (a), and 2.6 bar in system (b):



AP-1007, Figure 7; AP-1003, ¶¶243-244. Scholz further discloses that in Figure 5 (and thus in 7), “[t]he pressure valve on the retentate outlet of the third stage controls the feed pressure in the third stage [i.e., the pressure on the permeate side of the feed stage].” AP-1007, 6. A POSITA would have thus understood Scholz teaches and/or suggests this limitation. AP-1003, ¶244.

Claim 23 – *The method of claim 1, wherein the crude gas stream is selected from the group consisting of...carbon dioxide and methane...*

Scholz explains that in Figure 5 (and thus in 7), the “raw gas is compressed...and fed to the first membrane stage. The first stage performs a bulk separation of CO₂ and CH₄,” and Figure 7 further shows systems separating a CO₂ and CH₄ crude gas stream. *Id.*, 5, Figure 7; AP-1003, ¶245. Thus, Scholz teaches and/or suggests this limitation. AP-1003, ¶245.

V. DISCRETION SHOULD NOT PRECLUDE INSTITUTION

A. The Board should not exercise discretion under 35 U.S.C. §314(a)

The factors in the Board's precedential *Fintiv* decision favor institution.

Apple Inc. v. Fintiv, Inc., IPR2020-00019, Paper 11, 5-6 (PTAB Mar. 20, 2020) (precedential).

1. Factor 1: Institution's impact on a stay

The '380 patent's validity is at issue in one pending district court litigation which is in an exceptionally early stage. Evonik filed its original complaint in November 2022 but did not serve it until February 2023. AP-1005; AP-1029. Petitioner then filed a motion to dismiss and Evonik then filed an amended Complaint. AP-1031, 4-7. Petitioner then filed a second motion to dismiss, for which oral argument was held on January 5, 2024. *Id.*, 7.

The Court has entered a scheduling order, (AP-1030), but all the dates in the schedule are timed from Petitioner's answer, (*id.*, 2-3). Because the Court has not ruled on the motion to dismiss, Petitioner has not responded to the amended Complaint. Therefore, no contentions have been served, nor has any discovery been initiated or conducted.

Institution would enable the Board to resolve the validity of the '380 patent, one of two patents asserted in the litigation, and a finding of invalidity would advance judicial efficiency by obviating the need for the Court to conduct a trial on that patent. Even a finding that only certain Challenged Claims are invalid would

narrow the litigation issues. Accordingly, if institution occurs, Petitioner intends to approach Patent Owner to negotiate a potential stay of the litigation, at least for the '380 patent.

Thus, stay of the litigation pending the Board's final written decision ("FWD") is either neutral or weighs in favor of institution. *Snap, Inc. v. SRK Tech. LLC*, IPR2020-00820, Paper 15, 8-9, 19 (PTAB Oct. 21, 2020) (precedential).

2. Factor 2: No trial date is set

As explained above, the dates in the scheduling order are triggered from Petitioner's answer, which has not been filed. Moreover, the dates in the present scheduling order conclude with the deadlines for claim construction briefing. AP-1030, 2-3. There are no dates on the schedule for a *Markman* hearing, expert discovery, summary judgment briefing, or trial. *Id.* Those dates need to be set in a subsequent scheduling order. Additionally, as noted above, the case has already seen significant delays due to the motions to dismiss. The remoteness of the trial favors institution.

Trial statistics further support institution in this case. The median time-to-trial in Delaware is 37.8 months from filing. AP-1032, 3. Therefore, even if this case were on a typical schedule for Delaware cases (as explained above, it is not—e.g., Petitioner has not answered more than fourteen months after the case was filed), the anticipated trial date would be in December 2025, after a Final Written

Decision would likely issue by late-summer 2025.

3. Factor 3: Petitioners' investment in IPR outweighs the parties' minimal investment in litigation to date

The litigation is in an exceptionally early stage, such that very little has been invested in substantive aspects of the litigation to date. No infringement or invalidity contentions have been served, claim construction has not begun, and trial has not been set. Additionally, under the current scheduling order, once Petitioner answers (if the case is not dismissed), claim construction briefing will not be complete until over 7.5 months later. AP-1030, 2-3. Therefore, any *Markman* hearing will not be scheduled until well after the Board issues an institution decision. These facts weigh strongly in favor of institution. *See Fintiv*, Paper 11, 9-10 (“If, at the time of the institution decision, the district court has not issued orders related to the patent at issue...this fact weighs against exercising discretion to deny institution”); *Snap*, Paper 15, 11.

4. Factor 4: No overlap between issues raised in the Petition and the parallel proceeding

Petitioner asks the Board to consider the unique challenges raised in the Petition. *See Fintiv*, Paper 11, 12-13. If the Board institutes, Petitioner will not pursue district court invalidity challenges raised in this Petition, thereby eliminating any risk of duplicated effort between the Court and the PTAB. *See, e.g., CoolIT Sys., Inc. v. Asetek Danmark A/S*, IPR2021-01196, Paper 10, 14

(PTAB Dec. 28, 2021) (finding similar stipulation weighed against discretionary denial). This lack of overlapping issues weighs in favor of institution.

5. Factor 5: Same parties

With respect to Factor 5, Petitioner is one of two defendants in the co-pending litigation. This factor is neutral. *See, e.g., Samsung Elecs. Co., Ltd. v. DoDots Licensing Sols. LLC*, IPR2023-0756, Paper 9, 17 (PTAB Oct. 11, 2023).

6. Factor 6: Other circumstances supporting institution

Factor 6 strongly favors institution. The strength of the merits outweighs any potential inefficiencies, regardless of whether the litigation timing is relevant (it is not, as explained in Factors 1-5). *Fintiv*, Paper 11, 14-15 (noting “if the merits of a ground raised in the petition seem particularly strong...institution...may serve...overall system efficiency and integrity”).

With Factors 2, 3, 4, and 6 favoring institution, and Factors 1 and 5 likely being neutral, discretion should not be exercised to deny institution (and thus the Board should consider the merits of the Petition). *Snap*, Paper 15, 19 (declining to deny institution based on a “holistic” balancing of “all of the *Fintiv* factors”).

Even so, USPTO Guidance requires that “where the PTAB determines that the information presented at the institution stage presents a compelling unpatentability challenge, that determination alone demonstrates that the PTAB should not discretionarily deny institution under *Fintiv*.” AP-1033, 4-5.

Specifically, the PTAB should not discretionarily deny institution if “the Petition presents challenges ‘in which the evidence, if unrebutted in trial, would plainly lead to a conclusion that one or more claims are unpatentable[.]’” *CommScope Techs. LLC v. Dali Wireless, Inc.*, IPR2022-01242, Paper 23, 3 (PTAB Feb. 27, 2023) (precedential) (quoting AP-1033, 4); *see also* AP-1033, 3-5, 9. The merits of this Petition are compelling. As it demonstrates, evidence including the applied references and Dr. Baker’s corroborating testimony, if unrebutted in trial, would plainly lead to a conclusion that one or more claims are unpatentable.

For all of the reasons discussed herein, Petitioner therefore respectfully requests that the Board institute an IPR.

B. The Board should not exercise discretion under 35 U.S.C. §325(d)

The Board should not deny institution under 35 U.S.C. §325(d) because the two-part framework set forth in *Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH* is not satisfied. IPR2019-01469, Paper 6 (PTAB, Feb. 13, 2020).

The first prong of *Advanced Bionics* asks whether the art or arguments presented in the Petition are the same or substantially the same as those previously presented to the Office. *Id.*, 7-8. Here, Ungerank was cited among other references on an Information Disclosure Statement submitted before the first office action. AP-1002, 134. The Examiner subsequently relied on portions of the

publication of the Ungerank application as a secondary reference in combination with primary reference Baker to reject dependent claims. *Id.*, 486-488.

Specifically, Ungerank was cited for its disclosure of vacuum pumps, polyimide membranes, multistage compressors and pressure reducing valves that were recited in pending dependent claims. *Id.* Applicants overcame this rejection by arguing that Ungerank “explicitly teaches to operate...with **a total recycle volume of less than 60 %** and therefore apparently teaches away from using a total recycle volume as claimed.” *Id.*, 510 (emphasis in original). Critically, neither the Examiner nor the applicant ever cited Ungerank’s “Comparative Example 1.” Comparative Example 1 had a significantly higher recycle volume—**86.7%**—falling within the pending (and ultimately issued) claims. Additionally, the disclosure in Comparative Example 1 of Ungerank was not cumulative to Baker, which disclosed a recycle volume greater than 100%, falling outside the claims. *See id.*, 510.

Likewise, Scholz is not substantially the same art and does not present the same arguments as presented in prosecution. Scholz was not before the Examiner, was never cited during prosecution, and discloses key teachings that were not discussed by the Examiner during prosecution, such as guidance regarding the selection of the optimal membrane surface area ratios (i.e., capacity ratios) in three-stage systems with low-selectivity membranes. AP-1007, Abstract, 5-7.

For these reasons, the first prong of the *Advanced Bionics* test is not met, and the Board's analysis should end here. But even if the Board considers the second prong, it likewise is not met. The second prong of *Advanced Bionics* asks "whether the petitioner has demonstrated that the Office erred in a manner material to the patentability of challenged claims." Paper 6, 8. *Becton, Dickinson* factors (c), (e), and (f) inform this inquiry. *Id.*, 10-11. Thus, the Board inquires "(c) the extent to which the asserted art was evaluated during examination, including whether the prior art was the basis for rejection...(e) whether petitioner has pointed out sufficiently how the examiner erred in its evaluation of the asserted prior art; and (f) the extent to which additional evidence and facts presented in the petition warrant reconsideration of the prior art or arguments." *Id.*, 9, n.10.

Factor (c) is discussed *supra*. Regarding factors (e) and (f), the Petition highlights that the Examiner made a material error by overlooking Comparative Example 1 in the evaluation of Ungerank and explains that Comparative Example 1 meets the claims' recycle volume limitation, even after the claims were amended during prosecution to narrow that limitation, allegedly to distinguish Ungerank on that basis. AP-1002, 510. Indeed, in the Notice of Allowance, the Examiner stated that "the prior art made of record fails to teach or fairly suggest" a recycle volume "between 60% and 100%." *Id.*, 521. Therefore, the Examiner overlooked and did not consider Comparative Example 1, and in doing so, materially erred by allowing

the claims.

The Board should therefore not exercise discretion under §325(d).

VI. CONCLUSION

As explained, the Challenged Claims are unpatentable. Petitioner authorizes charging of fees to Deposit Account 06-1050.

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

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

Air Products and Chemicals, Inc. is the real party-in-interest.

B. Related Matters Under 37 C.F.R. §42.8(b)(2)

The '380 is the subject of *Evonik Operations GmbH et al v. Air Products and Chemicals, Inc. et al.*, 1-22-cv-01543 (DDE) (i.e. the pending litigation discussed above in Sections II.A and V.A). *See also* AP-1005. Petitioner is not aware of any other judicial or administrative matter that would affect, or be affected by, a decision in this matter.

C. Lead And Back-Up Counsel Under 37 C.F.R. §42.8(b)(3)

Petitioner provides the following counsel designation.

Lead Counsel	Backup counsel
Grace Kim, Reg. No. 71,977 Fish & Richardson P.C. 60 South Sixth Street Suite 3200 Minneapolis, MN 55402 Tel: 202-783-5070 Fax: 877-769-7945 Email: IPR55766-0003IP1@fr.com	Gwilym J. Attwell, Reg. No. 45,449 Josh Griswold, Reg. No. 46,310 Fish & Richardson P.C. 60 South Sixth Street Suite 3200 Minneapolis, MN 55402 Tel: 202-783-5070 Fax: 877-769-7945 Email: IPR55766-0003IP1@fr.com

D. Service Information

Please address all correspondence and service to the address listed above.

Petitioner consents to electronic service by email at IPR55766-0003IP1@fr.com.

Respectfully submitted,

Dated 5/1/2024

/Grace J. Kim/
Grace Kim, Reg. No. 71,977
Gwilym J. Attwell, Reg. No. 45,449
Josh Griswold, Reg. No. 46,310
Fish & Richardson P.C.
60 South Sixth Street
Suite 3200
Minneapolis, MN 55402
T: 202-783-5070
F: 877-769-7945

(Control Number IPR2024-00611) *Counsel for Petitioner*

CERTIFICATION UNDER 37 CFR § 42.24

Under the provisions of 37 CFR § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Petition for *Inter Partes* Review totals 13,999 words, which is less than the 14,000 allowed under 37 CFR § 42.24.

Dated 5/1/2024

/Grace J. Kim/

Grace Kim, Reg. No. 71,977
Gwilym J. Attwell, Reg. No. 45,449
Josh Griswold, Reg. No. 46,310
Fish & Richardson P.C.
60 South Sixth Street
Suite 3200
Minneapolis, MN 55402
T: 202-783-5070
F: 877-769-7945

Counsel for Petitioner

CERTIFICATE OF SERVICE

Pursuant to 37 CFR §§ 42.6(e)(4)(i) *et seq.* and 42.105(b), the undersigned certifies that on May 1, 2024, a complete and entire copy of the Corrected Petition for Inter Partes Review and Exhibit 1038 were provided via email to the Patent Owner by serving the correspondence addresses of record as follows:

Philip Y. Braginsky
Nels T. Lippert
Rachel J. Lin
Tarter, Krinsky & Drogin LLP
1350 Broadway
New York, NY 10018
Tel.: (212) 216-8065
Fax: (212) 216-8001

Email: pbraginsky@tarterkrinsky.com
manageddocket@docket.tarterkrinsky.com
nlippert@tarterkrinsky.com
rlin@tarterkrinsky.com

/Anastasia Renard/

Anastasia Renard
Fish & Richardson P.C.
60 South Sixth Street, Suite 3200
Minneapolis, MN 55402
renard@fr.com