UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
90/011,112	07/26/2010	6616909	086353-0059	6455

29171 7590 12/02/2016
BATTELLE MEMORIAL INSTITUTE
ATTN: IP LEGAL SERVICES, K1-53
P.O. BOX 999
RICHLAND, WA 99352

EXAMINER
TORRES VELAZQUEZ, NORCA LIZ

ART UNIT	PAPER NUMBER
3991	

MAIL DATE	DELIVERY MODE
12/02/2016	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRAIL AND APPEALS BOARD

Ex parte BATTELLE MEMORIAL INSTITUTE,
Patent Owner and Appellant

Appeal 2015-005944
Reexamination control 90/011,112
Patent 6,616,909 B1
Technology Center 3900

Before RICHARD M. LEBOVITZ, JEFFREY N. FREDMAN, and
RAE LYNN P. GUEST, *Administrative Patent Judges*.

GUEST, *Administrative Patent Judge*.

DECISION ON REQUEST FOR REHEARING

Battelle Memorial Institute (hereinafter "Patent Owner"), the real party in interest[1] of Patent 6,616,909 B1 (hereinafter the "'909 patent"), requests rehearing in response to the Board's Decision of November 25, 2015 ("Decision") affirming the Examiner's decision to reject claims 19, 55, and 64–72 under 35 U.S.C.

---

[1] *See* Appellant's Appeal Brief filed November 14, 2011 (hereinafter "App. Br.") at 1.

§ 103(a) as unpatentable over Tonkovich[2] in view of Schubert[3] alone and further in view of Yarrington.[4] Patent Owner's Request for Rehearing 1, filed January 25, 2016 ("Request").

Requests for rehearing must comply with 37 C.F.R. § 41.52(a)(1) which specifies in pertinent parts that "[t]he request for rehearing must state with particularity the points believed to have been misapprehended or overlooked by the Board."

In their Request, Patent Owner states the following points were misapprehended or overlooked in the Decision.

1. The Board erred in finding that "volumetric heat transfer rate is an inherent property of a particular reactor design" and that optimization inherently would have resulted in the claimed level of volumetric heat flux. Request 2–5 and 7.
2. The Board erred in its optimization analysis because the volumetric heat flux was not recognized to be a result-effective-variable. Request 6–7.
3. The Board overlooked the reasons, discussed in the Tonkovich Declaration, paragraphs 7–12, why there would not have been an

[2] A.L. Tonkovich et al., "The Catalytic Partial Oxidation of Methane in a Microchannel Chemical Reactor," Process Miniaturization: 2nd International Conference on Microreaction Technology, Topical Conference Preprints, AICHE Spring Meeting, New Orleans, March 9–12 1998, pp. 45–53.
[3] K. Schubert et al., "Realization and Testing of Microstructure Reactors, Micro Heat Exchangers and Micromixers for Industrial Applications in Chemical Engineering," Process Miniaturization: 2nd International Conference on Microreaction Technology, Topical Conference Preprints, AICHE Spring Meeting, New Orleans, March 9–12 1998, pp. 88–95.
[4] U.S. Patent 5,023,276, issued June 11, 1991, to Robert M. Yarrington et al.

expectation of success in combining the water heat exchanger of Schubert with the reactor design of Tonkovich. Request 5 and 7–9.

4. The board misapprehended the adiabatic nature of the individual channels of the monolith described in Yarrington. Request 9–11 and 18.
5. The Board overlooked the facts that Yarrington teaches the use of a monolithic catalyst in an autothermal reformer, operating differently than that plate reactor of Tonkovich, in combination with a hydrocarbon synthesis reactor. Request 10–12.
6. The Board misapprehended what the skilled artisan would have understood regarding the monolithic catalyst of Yarrington. Request 13 and 16–17.
7. The Board misapprehended that Yarrington's adiabatic monolith would have led away from the idea of combining a monolith with a process requiring exceptionally high levels of heat transfer. Request 14–16.

Characterization of volumetric heat flux as an inherent property of the reactor design

Patent Owner is correct that there was an error in the full paragraph on page 12 of the Decision. In fact, throughout the Decision "volumetric heat transfer rate," should have been referring to "volumetric heat flux," which is the value ("W[atts] of heat per cc of total reactor volume") of steady-state heat transfer recited in all the claims. *See also* Decision 7 ("claimed heat transfer rate" should read "claimed volumetric heat flux"), 12–13 ("inherent volumetric heat transfer rate" should read "inherent volumetric heat flux" and "optimized volumetric heat transfer rate" should read "optimized volumetric heat flux"). The Decision describes the '909 patent's definition of volumetric heat flux, as follows:

> FF2. The ’909 patent defines volumetric heat flux as the amount of heat transferred (in watts) divided by “the sum of the volume of the reaction chamber(s) and heat exchanger chambers(s) including the volume of chamber walls.” ’909 patent, col. 3, ll. 40–42. The ’909 patent states that “[r]eactors and methods of the present invention can be characterized by various properties that they exhibit. Heat flux is a particular important characteristic in the present invention.” ’909 patent, col. 11, ll. 44–45. According to the ’909 patent, the volumetric heat flux of a particular reactor is calculated by first determining the amount of conversion and estimating the necessary energy to reach such conversion, and dividing that conversion by the reactor volume. *See* ’909, col. 16, l. 23 to col. 17, l. 37 (“A microchannel isooctane steam reformer was built, with a total volume of roughly 30 cubic centimeters . . . . The reactor was able to reach isooctane conversions ranging from 86.5% to 95%, thus requiring roughly 300 W of thermal energy . . . . The volumetric heat flux of the reactor was roughly 10W/cc . . . . Under these conditions, nearly 500 W of thermal energy were required to convert roughly 75% of the inlet isooctane stream set at 5.04 mL/min. This device demonstrated a volumetric heat flux greater than 16 W/cc [500 W/30 cc = 16.667 W/cc].”).

Decision 7–8.

While a “volumetric heat transfer rate” may depend on particular reactor conditions, as argued by Patent Owner in its request (*see* Request 2–5), that finding is irrelevant where the claims are directed to volumetric heat flux and is silent as to any particular reactor conditions. Based on the definition and example in the ’909 patent, volumetric heat flux is the amount of heat transferred for any given reaction divided by the volume of all reactor and heat exchange chambers including the volume of the chamber walls. Decision FF2. The amount of heat transferred is the total amount of heat transferred for any given reaction and not a function of amount over time and not the rate of heat transfer. Rather, the amount of heat transferred is back calculated from the overall conversion measured for any given

reaction. Decision FF2. We note that the claims are silent as to any particular reaction conditions and thus encompass any reaction conditions for any thermal catalytic chemical conversion reaction, including the reaction described by Tonkovich and as routinely optimized using the techniques taught by Tonkovich and Schubert.

Accordingly, the full paragraph on page 12 of the Decision, should be rewritten as follows, with underlining showing text added and brackets showing text deleted from the Decision:

> Volumetric heat flux in Watts per cubic centimeter, as defined by the ’909 patent, [transfer rate] is an inherent property of a particular reactor design for any given reaction. FF2. Accordingly, arriving at an optimal volumetric heat [transfer] flux would be inherent in the optimization of reactor/heat exchanger designs in accordance with the teachings of Tonkovich and Schubert for the reactions described in Tonkovich.

We also note a similar error in the last sentence of the paragraph spanning pages 12–13 of the Decision, which should be rewritten as follows, with underlining showing text added and brackets showing text deleted from the Decision (footnote 5 has been omitted in our reproduction but is to be retained from the original decision):

> With respect to the specific [heat transfer values] volumetric heat flux values recited in the claims, the Examiner’s reasoning that the choice of a specific [heat transfer rate] volumetric heat flux value would be routine optimization to “maintain the reactor catalyst within a desired temperature range and reduce the formation of undesirable by-products” (Final 8; see also RAN 5–6) is supported by a preponderance of the evidence as discussed above.

While the change in terminology corrects any confusion on the record, we do not find any error in the reasoning of the Decision, which is properly based on the findings of fact as stated therein, as discussed in further detail below.

The volumetric heat flux would have been obvious over Tonkovich and Schubert based on routine optimizations of the principles of Schubert applied to the reaction described in Tonkovich

Patent Owner argues that the objective described in Tonkovich, namely short residence times, which can only be achieved by providing rapid quenching, can be achieved without increasing volumetric heat flux. Request 5. In particular, Patent Owner points out that the goals can be met with a "relatively large" total volume, "such that the volume over which volumetric heat flux is calculated is large (and, hence, the heat transferred divided by the volume is relatively small)." *Id.*

Patent Owner's argument is not supported by the teachings of Tonkovich and Schubert, and does not show any fact overlooked or misapprehended. Neither Tonkovich nor Schubert teach increasing heat removal with volumes that are "relatively large," and thus, Patent Owner's arguments do not fairly address the rejection made by the Examiner. To the contrary, Tonkovich teaches removing heat production quickly via a "highly efficient embedded microchannel heat exchanger[]," and not a large volume heat exchanger. *See* Decision FF4. Likewise, Schubert is directed to microchannel heat exchangers for use in catalyzed reactions and to optimizing such heat exchangers. Decision FF12 and FF13.

Moreover, Tonkovich teaches that as the residence time is reduced, the yield increases (and reduces the presence of side reactions). *See* Tonkovich, ¶ spanning 45–46; Decision 10, last full ¶. Tonkovich also teaches that millisecond reaction

times are possible "because of the rapid thermal quenching that results from integrated microchemical heat exchangers." *Id.* 46, first full ¶. Thus, to the extent that increasing the volume would have facilitated rapid quenching and short residence times, as argued by Patent Owner, yield, or conversion, also would have increased based on the teachings of Tonkovich.[5] Thus, addressing a "relatively large" volume increase, without addressing the described increase in yield and, thus, the increase in total heat transferred by the improvement in rapid quenching, is not persuasive.

Patent Owner argues that the volumetric heat flux is not expressly identified in the art as a result effective variable and thus the Examiner has not shown that this property can be optimized. Request 6–7. Patent Owner also argues that our determination is contrary to law which requires that the property is "necessarily present." *Id.* at 7.

We are not persuaded that our Decision overlook or misapprehended any area of law in applying the prior art to the claims of the '909 patent. While the prior art may be silent as to volumetric heat flux, the prior art expressly states optimizing the two factors that are used to calculate volumetric heat flux. For example, Tonkovich teaches an optimized yield, from which an optimum heat transfer is back calculated. Decision 10. Likewise, both Tonkovich and Schubert teach optimizing reactor designs of embedded microchannel heat exchangers for

[5] We note that the calculations of volumetric heat flux of the example reactor and reaction described in Tonkovich is based on a yield of only about 50% (Tonkovich 51, first full ¶), while Tonkovich expressly teaches that yields as high as 90% can be achieved. Tonkovich, ¶ spanning 45–46. Thus, substantially higher yields, and thus higher total heat transfer are to be expected with the optimization described in Tonkovich and Schubert. *See e.g.*, Tonkovich 50, next to last ¶ (expressly stating that the configuration was "non-optimized").

optimal heat exchange. Decision 10–13. The overall volume would be calculated from an optimal reactor design. Thus, the evidence supports a finding that volumetric heat flux is a result effective variable, which is routinely optimized by optimizing rapid thermal quenching and, thus, residence times (i.e., optimal yield) and doing so by optimizing reactor design (i.e., total volume), as taught by the prior art. *Id*. "The mere fact that multiple result-effective variables were combined does not necessarily render their combination beyond the capability of a person having ordinary skill in the art." *In re Applied Materials, Inc*., 692 F.3d 1289, 1298 (Fed. Cir. 2012).

"[D]iscovery of an optimum value of a result effective variable in a known process is ordinarily within the skill of the art." *In re Boesch*, 617 F.2d 272, 276 (C.C.P.A. 1980); *see also In re Luck*, 476 F.2d 650, 652–53 (C.C.P.A. 1973) (use of routine testing to identify optimum amounts of silane to be employed in a lamp coating, without establishing a critical upper limit or demonstrating any unexpected result, lies within the ambit of the ordinary skill in the art); *In re Esterhoy*, 440 F.2d 1386, 1389 (C.C.P.A. 1971) ("One skilled in the art would thus manifestly operate the Switzer et al. process under conditions most desirable for maximum and efficient concentration of the acid. The conditions recited in the claims appear to us to be only optimum and easily ascertained by routine experimentation."); *In re Swain*, 156 F.2d 246, 247–48 (C.C.P.A. 1946) ("In the absence of a proper showing of an unexpected and superior result over the disclosure of the prior art, no invention is involved in a result obtained by experimentation.").

It is true that a routine variable change may cause an unexpected effect. However, this is the kind of situation that requires Patent Owner to show

secondary considerations such as unexpected results or criticality to overcome the prima facie case. *See In re Huang*, 100 F.3d 135, 139 (Fed. Cir. 1996) ("This court and its predecessors have long held, however, that even though applicant's modification results in great improvement and utility over the prior art, it may still not be patentable if the modification was within the capabilities of one skilled in the art, unless the claimed ranges "produce a new and unexpected result which is different in kind and not merely in degree from the results of the prior art."); (*quoting In re Aller*, 220 F.2d 454, 456 (C.C.P.A. 1955) and *citing In re Woodruff*, 919 F.2d 1575, 1578 (Fed. Cir. 1990)).

Patent Owner present no persuasive argument that the volumetric heat flux recited in the claims is more would have been achieved through routine optimization. Similarly, as stated in the Decision (Decision 13 and 15), Patent Owner has not shown that the recited volumetric heat flux is critical to the operation of the invention or produces any unexpected results.

Tonkovich Declaration Evidence

Patent Owner argues that the Decision does not address the reasons supported by the Tonkovich Declaration as to why the combination of Tonkovich and Schubert do not provide a reasonable basis for success. Request 7–9. However, the Decision fully considered the Tonkovich declaration and found it not persuasive for the reasons stated on pages 13–15 of the Decision.

Additionally, Dr. Tonkovich's Declaration addresses catalytic packing, pressure drop through a catalyst, temperature, reactants (e.g., methane), etc., which are specific reaction conditions that are not recited in the claims. Thus, Patent Owner's arguments with respect to specific reactions conditions are not persuasive.

See Request 8; PO App. Br. 9. Moreover, Tonkovich describes reaction conditions and reactor design in a non-optimized form and expressly teaches that these reaction conditions and the reactor design are routinely varied by the ordinary artisan for optimal yield. *See, e.g.*, Decision FF6 and FF7.

Accordingly, for the reasons discussed above and in the Decision, the Examiner did not err in rejecting claims 19, 55, and 64–70 under 35 U.S.C. § 103(a) as unpatentable over Tonkovich in view of Schubert.

The use of a monolithic catalyst in an autothermal reformer of Yarrington that operates differently than that plate reactor of Tonkovich

Patent Owner argues that the Board misapprehended the teachings in Yarrington of an autothermal reformer in determining that Yarrington teaches the use of a monolithic catalyst in "any suitable type of hydrocarbon synthesis" and that the autothermal reformer of Yarrington operates similarly to that of the reactor in Tonkovich. Request 11 and 13–18.

Indeed, the reasoning set forth on pages 21–22 of the Decision misapprehended the teachings of Yarrington in several respects. Accordingly, we are persuaded of error in the Decision's ultimate determination that the skilled artisan would have had an expectation of success in using a monolithic catalyst, as taught in Yarrington, in the rapid quenching reactor design taught by Tonkovich.

Tonkovich describes a highly exothermic partial oxidation reaction for the generation of CO_2 and hydrogen. Decision FF3; Tonkovich, ¶ spanning 45–46. The highly exothermic partial oxidation reaction of Tonkovich requires very rapid removal of heat from the reaction so as to create near isothermal conditions and to avoid "hot spots, thermal runaway and possible explosions." Decision FF4 and FF5; Tonkovich, 46, second full ¶.

Yarrington teaches this same partial oxidation reaction, but as a very small part of an overall hydrocarbon fuel (specifically gasoline, diesel, and liquid petroleum gas) synthesis reaction using the CO_2 and hydrogen generated. Yarrington, col. 4, ll. 26–35; Fig. 2. Unlike Tonkovich, Yarrington takes advantage of the exothermic heat generation of the partial oxidation reaction and couples it with a very highly endothermic steam reforming reaction, which is an alternative process for the generation of CO_2 and hydrogen from hydrocarbons. *Id.*, col. 4, ll. 45–56. Yarrington describes the use of monolithic catalysts for both the exothermic and endothermic reactions, for the benefits of "low pressure drop and high volumetric rate through-put of a monolithic body platinum group metal catalyst [which] provides a reduced size and volume of catalyst," "operations at relatively very low O_2 to C ratios without carbon deposition fouling the catalyst and [enabling] efficient conversion of methane," "more geometric surface area exposed to the reactant gas than does a bed of coated beads," and "lower catalytic metal loading." Yarrington, col. 5, ll. 5–26; Decision FF21. Yarrington also teaches that at the time of the invention, catalytic partial oxidation using a platinum group catalyzed monolith was known in the art for use in autothermal reformers of the type described in Yarrington. Decision FF18; Yarrington, col. 2, ll. 35–54 and col. 5, ll. 28–35 ("Such monolithic carrier members are often referred to as 'honeycomb' type carriers and *are well known in the art*.") (emphasis added).

Yarrington is relied upon by the Examiner for the limited purpose of showing that it was known in the art at the time of the invention to use a monolithic catalyst, as opposed to a packed bed catalyst, in partial oxidation reactions for the benefits described in Yarrington. Final Office Action 9 and 11-12. Yarrington is not being relied upon for the particular structure of the

autothermal reformer. *Id.* As noted in the Decision, "[t]he skilled artisan would have considered the benefits of using a monolithic catalyst instead of a coated bead and packed powder catalysts, as recited in Yarrington (FF21), to improve the reactor throughput over the packed powder catalyst taught by Tonkovich." Decision 21.

However, we agree with Patent Owner that the Board Decision misapprehended that the particular reactor design of Yarrington uses the monolith catalyst adiabatically, i.e., without heat loss. Request 10. Although Yarrington teaches that, in the autothermal reformer, the monolithic catalyst is surrounded by "thermal insulating material 5 to reduce heat losses" and to "provide essentially a fixed bed, adiabatic reactor" (Decision FF24), there is no suggestion in the teaching of Yarrington that the monolithic catalyst would function the same, even in the same reaction, in a reactor design where optimal heat loss is a primary objective, as taught by Tonkovich. Even if the metal monolith carriers are described in Yarrington as having better heat transfer than ceramic carriers, the metal monolithic catalysts are less preferred in the reactor structure of Yarrington, because Yarrington's reactor design has the opposite objective of Tonkovich's reactor. Decision FF23.

Additionally, we agree with Patent Owner that Tonkovich's proposed improvement of a "robust catalyst with engineered microstructures" is insufficient evidence that the skilled artisan would have considered the use of the monolithic catalyst taught by Yarrington for Tonkovich's reactor, when Yarrington teaches the opposite objective regarding heat transfer to that of Tonkovich. *See* Decision 22.

The Examiner states that "the reactor vessel disclosed in Example 2 [of Yarrington] is a preferred embodiment and that other configurations would be

encompassed by the reference." Final Action 12. Upon further review, we agree with Patent Owner (Request 11–12) that the autothermal reformer reactor is the only reactor described in Yarrington, and Yarrington does not suggest the suitability of a monolithic catalyst for partial oxidation reactions that are not in conjunction with a steam reforming reaction in an autothermal reformer.

In Response to Patent Owner's arguments, the Examiner further states that "'individual gas flow passages' are not the same as a reaction chamber and heat exchangers." Ans. 8. Yet, the Examiner's statement does not explain sufficiently why the skilled artisan would have used a catalyst designed for adiabatic conditions in a different type of reactor designed for rapid thermal quenching. We agree that the claimed invention can only be reached through hindsight modification of Tonkovich with the monolithic catalyst of Yarrington. *In re Rouffet*, 149 F.3d 1350, 1358 (Fed. Cir. 1998) ("hindsight" is inferred when the specific understanding or principal within the knowledge of one of ordinary skill in the art leading to the modification of the prior art in order to arrive at appellant's claimed invention has not been explained).

Accordingly, upon review and for the reasons discussed above, we reverse the Examiner's rejection of claims 71 and 72 under 35 U.S.C. § 103(a) as unpatentable over Tonkovich in view of Schubert and Yarrington.

The Request for Rehearing has been considered and is granted to the extent that we find that it would not have been obvious to combine the monolithic catalyst of Yarrington with the reactor of Tonkovich. The Request for Rehearing is otherwise denied. Accordingly, the Request for Rehearing is granted-in-part.

Requests for extensions of time are governed by 37 C.F.R. § 1.550(c). See 37 C.F.R. §41.52(b).

GRANTED-IN-PART

FOR PATENT OWNER:

BATTELLE MEMORIAL INSTITUTE
Attn: IP Legal Services, K1-53
P.O. Box 999
Richland, WA 99352

FOR THIRD-PARTY REQUESTER:

MCDERMOTT WILL & EMERY LLP
600 13th Street N.W.
Washington, DC 20005-3096