UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

LG ELECTRONICS, INC.,

Petitioner,

v.

JAWBONE INNOVATIONS, LLC,

Patent Owner.

Patent No. 11,122,357
Filing Date: August 5, 2013
Issue Date: September 14, 2021

Inventor: Gregory C. Burnett
Title: FORMING VIRTUAL MICROPHONE ARRAYS USING DUAL OMNIDIRECTIONAL MICROPHONE ARRAY (DOMA)

**PATENT OWNER'S PRELIMINARY RESPONSE**

Case No. IPR2023-01134

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# EXHIBIT LIST

| Exhibit No. | Description of Document |
|---|---|
| 2001 | Joint Motion to Terminate Proceedings, *Amazon.com, Inc. v. Jawbone Innovations, LLC*, Case No. IPR2023-00251 (P.T.A.B. July 29, 2023) |
| 2002 | Declaration of Akbar M. Sayeed, Ph.D. |
| 2003 | Curriculum Vitae of Akbar M. Sayeed, Ph.D. |
| 2004 | Excerpts of MICROPHONE ARRAYS: SIGNAL PROCESSING TECHNIQUES AND APPLICATIONS, Ch. 18, Future Directions in Microphone Array Processing (Michael Brandstein & Darren Ward eds., Springer-Verlag 2001) ("Brandstein") |

# I. INTRODUCTION

On June 29, 2023, LG Electronics, Inc. ("LG" or "Petitioner") filed a Petition requesting *inter partes* review of claims 1-20 ("Challenged Claims") of U.S. Patent No. 11,122,357 (the "'357 Patent") (Ex. 1001). Paper 2 ("Petition" or "Pet."). The declaration of Richard M. Stern, Ph.D. (Ex. 1002) accompanied the Petition. On July 12, 2023, the Board issued a Notice of Filing Date Accorded for the Petition and set the time for filing patent owner's preliminary response. Paper 4.

The Board should deny the Petition because the Petition fails to show a reasonable probability of success as to any claim. In particular, the Petition does not show that Brandstein and Gannot render obvious "wherein the first virtual microphone and the second virtual microphone are distinct virtual directional microphones with substantially similar responses to noise," as recited in both independent claims of the '357 Patent. To the contrary, the cited portions of Brandstein contemplate a Griffiths-Jim beamformer in which a top path passes through speech and where "**all other signals are attenuated,**" and a bottom path that suppresses speech and where "**all other signals are passed through**." In other words, the top path nulls out noise, and the bottom path nulls out speech. This sharply contrasts with the '357 Patent invention where the first virtual microphone includes **both** speech and noise, such that a second virtual microphone with a substantially similar noise response may be used to cancel the noise, and is exactly

the type of "conventional array[] and algorithm[], which seek to reduce noise by nulling out noise sources" that the '357 Patent distinguishes.

The Board should further deny the Petition because Petitioner fails to identify any reason or motivation that a POSITA would combine the multiple papers and embodiments within Brandstein on which the Petition relies to underpin its combination and for various limitations.

## II. THE '357 PATENT

The '357 Patent discloses and claims methods for noise suppression in dual omnidirectional microphone arrays. Unlike "conventional arrays and algorithms which seek to reduce noise by nulling out noise sources," the '357 Patent uses omnidirectional microphone arrays "to form two distinct virtual directional microphones which are configured to have very similar noise responses and very dissimilar speech responses." '357 Patent, Abstract. While "conventional multi-microphone systems attempt to increase the [signal-to-noise ratio] of the user's speech by 'steering' the nulls of the system to the strongest noise sources[, t]his approach is limited in the number of noise sources removed by the number of available nulls." *Id.*, 1:58-62. Counterintuitively, in the '357 Patent, "[t]he only null formed by the DOMA is one used to remove the *speech* of the user from [the second virtual microphone]". *Id.* at 5:15-16 (emphasis added). However, the similarity of the '357 Patent's virtual microphones' noise responses allow them to be cancelled

while leaving the speech response intact, "resulting in excellent noise suppression performance and minimal speech removal and distortion." *Id.* at 8:16-18; 10:44-60.

The '357 Patent discloses a noise suppression apparatus that creates two virtual microphones $V_1$ and $V_2$ based on the signals generated by two omnidirectional microphones.

$$V_1(z) = O_1(z)z^{-\gamma} - \beta O_2(z)$$

$$V_2(z) = O_2(z) - z^{-\gamma}\beta O_1(z)$$

*Id.* at 11:7, 12:20. In these equations, β and γ are defined as follows:

$$\beta = \frac{d_1}{d_2}$$

$$\gamma = \frac{d_2 - d_1}{c} . f_s \text{ (samples)}$$

*Id.* at 11:10-12. "The distances $d_1$ and $d_2$ are the distances from $O_1$ and $O_2$ to the speech source," respectively, and "γ is their difference divided by c, the speed of sound, and multiplied by the sampling frequency $f_s$." *Id.*, 11:19-22.

In the analog frequency domain, the equations for $V_1$ and $V_2$ are written as follows:

$$V_1(f) = e^{-j2\pi f\tau}O_1(f) - \beta O_2(f)$$

$$V_2(f) = -\beta e^{-j2\pi f\tau}O_1(f) + O_2(f)$$

where $z = e^{j2\pi f}$ and $\tau = \frac{d_2 - d_1}{c}$. Ex. 2002, 30.

The ’357 Patent discloses that the apparatus “works very well because the noise (far-field) responses of $V_1$ and $V_2$ are very similar while the speech (near-field) responses are very different.” *Id.* at 17:21-23.

The ’357 Patent discloses polar plots depicting similar noise responses which may be cancelled while leaving dissimilar speech responses intact. For instance, Figures 10 and 12 show the linear responses of virtual microphones $V_2$ and $V_1$, respectively, to noise from a source at 1 meter:

FIG.10

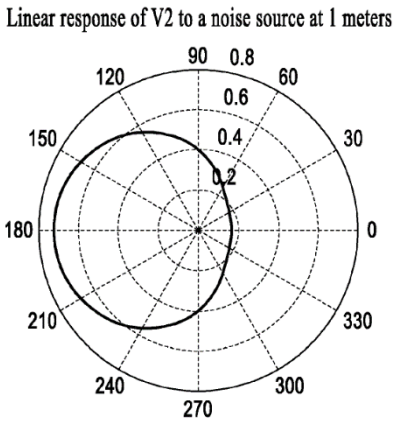
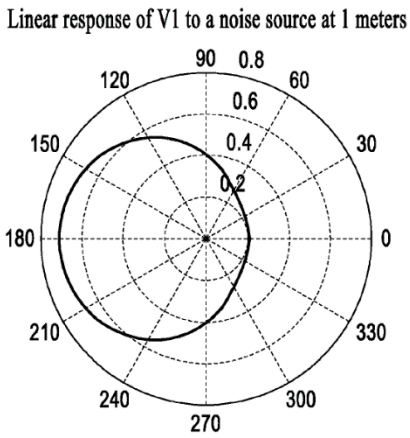



FIG.12




’357 Patent, 11:44-46, 13:44-46, FIGS. 10, 12.

Figures 9 and 11 show the linear responses of virtual microphones $V_2$ and $V_1$, respectively, to speech at a distance of 0.1 meter at an angle of zero degrees:

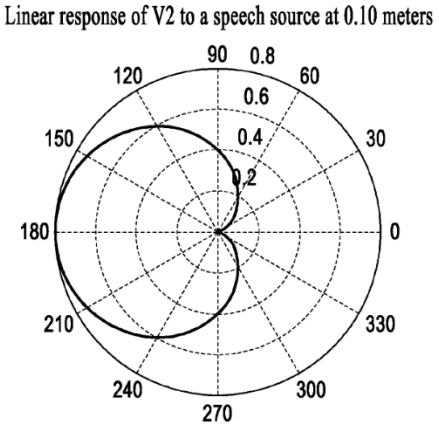



FIG.9

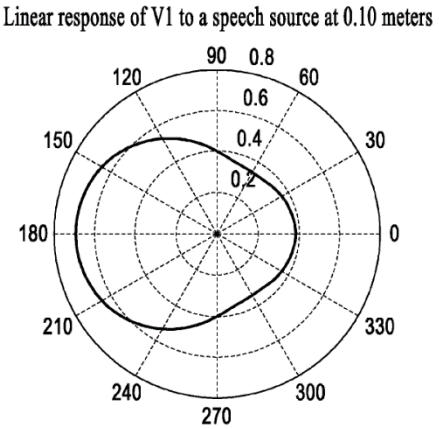



FIG.11

’357 Patent, 11:40-42, 13:39-41, FIGS. 9, 11.

Figure 9 shows a null in the linear response of virtual microphone $V_2$ to speech at zero degrees, “where the speech is typically expected to be located.” *Id.*, 11:42-45. As shown in Figure 10, “[t]he linear response of $V_2$ to noise is devoid of or includes no null, meaning all noise sources are detected.” *Id.*, 11:47-49. This configuration ensures that virtual microphone $V_2$ will detect all of the noise in front of the user so that it can be removed, which is an advantage over “conventional systems that can have difficulty removing noise in the direction of the mouth of the user.” *Id.*, 11:59-60. In addition, “the superior noise suppression made possible using this system more than compensates for the initially poorer SNR,” or signal to noise ratio, of the virtual microphones. *Id.*, 13:11-13.

## III. THE RELEVANT ALLEGED PRIOR ART

### A. Brandstein (Ex. 1003)

Microphone Arrays: Signal Processing Techniques and Applications, (Ex. 1003, “Brandstein”) is a collection of articles discussing topics in microphone

arrays. Ex. 1003 at 5. Brandstein purports to have been published in 2001. *Id.* at 4. As discussed below, *infra* Section VI.B.2, Brandstein is not a single reference, it is a collection of different papers by different authors reproduced as a collection.

Petitioner primarily relies on the paper "Robust Adaptive Beamforming" as reproduced in Brandstein as Chapter 5. *See* Brandstein at 87-99. Petitioner also relies on other papers for certain limitations and teachings for the proposed combination. *See infra* Section VI.B.2

### B. Gannot (Ex. 1004)

Signal Enhancement Using Beamforming and Nonstationarity with Applications to Speech by Sharon Gannot, David Burshtein, and Ehud Weinstein (Ex. 1004, "Gannot") is a paper purportedly published in August 2001. Gannot discusses a "sensor array located in an enclosure, where arbitrary transfer functions (TFs) relate the source signal and the sensors." Ex. 1004 at 1614. Rather than estimating the transfer functions, Gannot provides a method of estimating "the TFs ratios." *Id.*

## IV. CLAIM CONSTRUCTION

For the purposes of this Preliminary Response only, Patent Owner believes that claim construction is not required to resolve any issues.

## V. LEVEL OF ORDINARY SKILL IN THE ART

For the purposes of this Preliminary Response only, Patent Owner utilizes Petitioner's proposed level of skill in the art—"a minimum of a bachelor's degree in computer engineering, computer science, electrical engineering, mechanical engineering, or a similar field, and approximately three years of industry or academic experience in a field related to acoustics, speech recognition, speech detection, or signal processing. Work experience could substitute for formal education, and additional formal education could substitute for work experience" (citation omitted). Pet. at 23-24.

## VI. ARGUMENT

### A. Legal Standard

The question of obviousness is resolved on the basis of underlying factual determinations, including: (1) the scope and content of the prior art, (2) any differences between the claimed subject matter and the prior art, (3) the level of skill in the art, and (4) where in evidence, so called secondary considerations. *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17–18 (1966). A claim is only unpatentable under 35 U.S.C. § 103 if "the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having

ordinary skill in the art to which said subject matter pertains." *KSR Int'l Co. v. Telefex Inc.*, 550 U.S. 398, 406 (2007) (quoting 35 U.S.C. § 103).

"An invention is not obvious simply because all of the claimed limitations were known in the prior art at the time of the invention. Instead, we ask 'whether there is a reason, suggestion, or motivation in the prior art that would lead one of ordinary skill in the art to combine the references, and that would also suggest a reasonable likelihood of success.'" *Forest Lab'ys, LLC v. Sigmapharm Lab'ys, LLC*, 918 F.3d 928, 934 (Fed. Cir. 2019). "Of course, concluding that the references are within the scope and content of the prior art to be considered for obviousness does not end the inquiry. *Graham* makes clear that the obviousness inquiry requires a determination whether the claimed invention would have been obvious to a skilled artisan." *Apple Inc. v. Samsung Elecs. Co.*, 839 F.3d 1034, 1050 n.14 (Fed. Cir. 2016).

### B. Ground 1: Brandstein and Gannot Do Not Render Obvious Claims 1-20

#### 1. Petitioner's Combination Does Not Disclose or Render Obvious "wherein the first virtual microphone and the second virtual microphone are distinct virtual directional microphones with substantially similar responses to noise and substantially dissimilar responses to speech" as recited in independent Claims 1 and 15.

The Petition argues that Brandstein alone discloses this limitation based on the description related to the Griffiths-Jim beamformer (GJBF) depicted in Figs. 5.1

and 5.2 (Pet at 28-30 (citing Ex. 1003 at 87-90)), a cherry-picked statement related to an evaluation set-up for the paper's proposed modification of a GJBF. (Pet at 29 (citing Ex. 1003 at 101)), and Dr. Stern's conclusory opinions (Pet at 28-30 (citing Ex. 1002, ¶¶ 94-97). Petitioner does not argue that this limitation is inherent or disclosed in view of any reference other than Brandstein.

But, even if the outputs of the GJBF's top and bottom branches are distinct virtual microphones, the petition fails to identify any actual disclosure where their noise responses are substantially similar – there is none. Instead, the petition GJBF-based arguments assume that ***any*** system with a virtual microphone that nulls speech, and another that does not, automatically satisfies the claim. But the ***speech response*** is only half of the limitation. Petitioner fails to show any disclosure wherein virtual microphones have "***substantially similar responses to noise***."

At the outset, the GJBF described in Brandstein has a very different design than the patented invention, because its top path is designed to isolate speech instead of capturing **both** speech and noise (such that the noise may be cancelled using another virtual microphone with a substantially similar noise response). Ex. 2002, ¶ 42. Brandstein clearly states that for the top path "[t]he [fixed beamformer] is designed to form a beam in the look direction so that the target signal is passed [through] ***and all other signals are attenuated***" while for the bottom path "the [blocking matrix] forms a null in the look direction so that the target signal is

suppressed ***and all other signals are passed through***." Ex. 1003 at 88 (emphasis added). In other words, the fixed beamformer (top path) passes speech through (the target signal) **and attenuates noise**, while the blocking matrix (bottom path) suppresses speech **and passes noise through**. These are exactly the type of "conventional arrays and algorithms, which seek to reduce noise by nulling out noise sources" (*i.e.* by attenuating noise in the top path) distinguished by the '357 Patent. '357 Patent at 5:10-11; Ex. 2002, ¶ 42. This is very different than the invention of the '357 Patent, in which the first virtual microphone passes through ***both*** speech and noise, such that another virtual response with a "substantially similar" noise response may be used to cancel noise while preserving speech. A virtual microphone that attenuates noise clearly does not have a "substantially similar" noise response to one that passes noise through.

Indeed, Petitioner ***admits*** that "[t]he two virtual microphones have very different responses to the target signal: the first virtual microphone is designed to form **a beam that captures the target signal**, while the second virtual microphone includes a blocking matrix **designed to block the target signal**." Pet. at 29 (emphasis added). Petitioner does not show any disclosure that the first virtual microphone is ***also*** designed to capture noise, and entirely fails to reconcile this position with the requirement for a substantially similar response to noise in both virtual microphones.

Petitioner's purported support for this limitation amounts to unsupported conclusions that *any* GJBF meets this limitation based on the dissimilarity of speech responses without substantively addressing the requirement for substantially similar noise responses.

First, Petitioner argues that "[t]he two virtual microphones also have similar responses to noise so that in the final subtraction output the noise cancels out," citing to Dr. Stern's declaration ¶ 95. Pet. at 29. At the outset, Dr. Stern's opinions on this point are not entitled to any weight since they are conclusory and merely parrot the petition. *Compare id. with* Pet. at 29. This argument amounts to an unsupported assumption that ***all*** systems in which noise is ultimately cancelled necessarily have virtual microphones with similar noise responses. Ex. 2002, ¶ 43. It also completely ignores Brandstein's explanation that it uses a "multiple input canceller" ("MC") which "generate[s] replicas of components correlated with the interferences" that are "subtracted from a delayed output signal [] of the fixed beamformer" based on which "the target signal is enhanced and undesirable signals such as ambient noise and interferences are suppressed." Ex. 1003 at 88-89. In other words, **instead of** using virtual microphones with substantially similar noise responses, Brandstein's GJBF attempts to isolate speech in the top path as much as possible, then uses the MC to subtract only those noise components of the bottom path that are "correlated with the interferences." *Id.*; *see also* Ex. 2002, ¶ 43. Petitioner's speculation cannot stand

in the face of Brandstein's teachings that it does **not** use substantially similar noise responses to cancel noise as Petitioner assumes, and its expert cannot cure that deficiency.

Second, Petitioner argues that "[t]he different responses to the target signal and similar responses to noise are evident from Figure 5.2, which shows the directivity pattern for the final output of an example Griffiths-Jim beamformer:

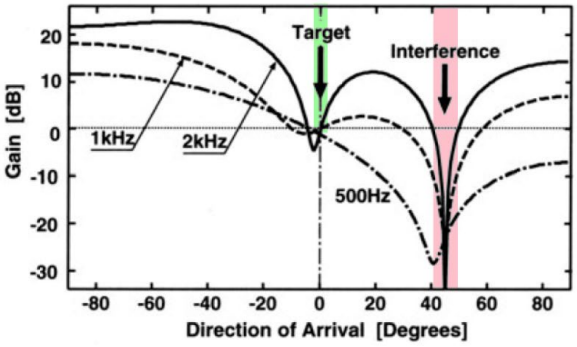



**Fig. 5.2.** Example directivity pattern of the Griffiths-Jim beamformer.

Pet. at 29-30. Petitioner further argues that "[t]he deep null reflects that subtracting the two virtual microphones' outputs cancels the interference, which confirms that the virtual microphones' responses to the interference are similar." But this figure does not support Petitioner's assertion. At the outset, Figure 5.2 shows the ***overall*** directivity of an exemplary GJBF at three different frequencies (*i.e.* the combination of both the top and bottom path), not the directivity of either virtual microphone. That directivity merely has an area of significantly reduced gain in the direction of an interference (*i.e.* a noise source). Ex. 2002, ¶ 44. This reflects the overall result of the system in attenuating noise; it discloses nothing about the comparative

responses to noise of the top or bottom path within that system (which are not even depicted in the figure). *Id.* In any case, contrary to Petitioner's speculation, Brandstein contemplates this result based on subtracting elements of noise (generated by a multiple input canceller by taking "replicas of components correlated with the interferences") from an FBF signal that already has as little noise as possible, **not** based on any "substantially similar" noise response. *Id.*

Moreover, while speculating about the noise responses based on the overall output, Petitioner conspicuously omits contradictory disclosure in Figure 5.3 immediately following the cited portion. Unlike Figure 5.2, Figure 5.3 actually does depict the directivity of the fixed beamformer (top path) and blocking matrix (bottom path) in relation to a target signal (*i.e.* speech). A POSITA would plainly understand that their noise responses (highlighted in green) are **not** substantially similar.

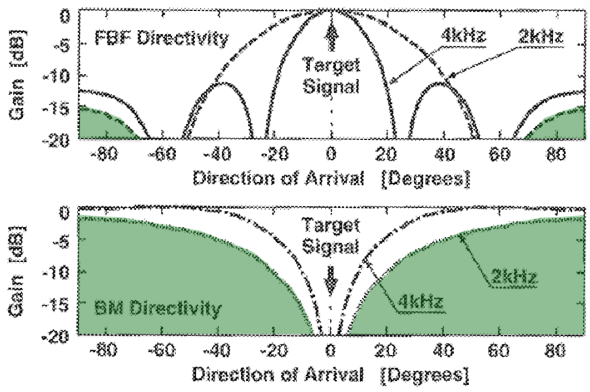



**Fig. 5.3.** Directivity pattern of a fixed beamformer (FBF) and a blocking matrix (BM).

Ex. 2002, ¶ 45; 1003 at 90. As Brandstein's chapter 5 does not disclose any equations with which to determine the responses of its top and bottom branches, Fig.

5.3 is the ***only*** disclosure of those responses outside the above-cited discussion that noise in the FBF (top branch) is attenuated compared to the BM (bottom branch). Ex. 2002, ¶ 45. It is telling that Petitioner chose to ignore this figure in favor of one which does not even depict the directivities of its alleged "virtual microphones" at all.

The Petition fails to show any disclosure of "wherein the first virtual microphone and the second virtual microphone are distinct virtual directional microphones with substantially similar responses to noise," as required by every independent claim, and should therefore be denied.

#### 2. Petitioner Does Not Identify Any Motivation to Combine Embodiments and References Within Brandstein

Brandstein (Ex. 1003) is not a single reference. It is a collection of different papers by different authors, each reproduced as a chapter in Brandstein. Each paper is a separate reference, and contains separate embodiments, for which the Petitioner bears the burden of showing a reason or motivation to combine. *See Application of Arkley*, 455 F.2d. 586, 587-88 (C.C.P.A. 1972); *see also Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1371 (Fed. Cir. 2008) ("Thus, it is not enough that the prior art reference . . . includes multiple, distinct teachings that the artisan might somehow combine to achieve the claimed invention."). The Petition relies on at least two different papers within Brandstein, each of which pertains to distinct

embodiments. But the petition entirely fails to articulate (or even assert) any reason or motivation for a POSITA to combine those distinct references and embodiments within those references. The petition therefore fails as a threshold matter and must be denied on this basis.

The Petition relies on at least two different articles within the Brandstein collection: "Superdirective Microphone Arrays," by Bitzer and Simmer, collected as Chapter 2; and "Robust Adaptive Beamforming," by Hoshuyama and Sugiyama, collected as Chapter 5; s*ee e.g.* Pet. at 7 (citing to Ex. 1003 at 87 regarding "Robust Adaptive Beamforming" by Hoshuyama and Sugiyama); Pet. at 14 (citing to Ex. 1003 at 25 regarding "Superdirective Microphone Arrays," by Bitzer and Simmer).[1]

Petitioner's proposed combination is based on, among other things, its assertion that "[d]elaying signals based on geometry to adjust for differences in arrival times was well known," and its assumption that a POSITA would incorporate a "near-field design" in a GSC. *See* Pet. at 14-15 ("When the source of the target signal is close enough to the array, instead of treating the signal's wavefront as a

[1] The Petition further relies on "Robust Localization in Reverberant Rooms," by DiBiase et al, collected as Chapter 8; and "Acoustic Echo Cancellation for Beamforming Microphone Arrays," by Walter L. Kellermann, collected as Chapter 13 for dependent claims. *See* Pet. at 39 (citing to Ex. 1003 at 159 regarding "Robust Localization in Reverberant Rooms" by DiBiase et al.); Pet. at 48 (citing to Ex. 1003 at 290 regarding "Acoustic Echo Cancellation for Beamforming Microphone Arrays" by Walter L. Kellermann).

plane, it may be useful to account for the spherical geometry of the wavefront— *i.e.*, to use a *near-field* design. [] Near-field designs were well known before the '357 Patent…"); *see also* Pet. at 18-20 (arguing that the '357 Patent implementation of virtual microphones reflects "the standard near-field design"). But while the Petition primarily relies on "Robust Adaptive Beamforming" by Hoshuyama and Sugiyama, it does not contend that article discloses the near-field design incorporated in its proposed combination. *Id.*; *see also* Pet. at 28-30. Instead, the Petition relies on the "Superdirective Microphone Arrays," article by Bitzer and Simmer for the proposition that embodiments of *other* embodiments within Brandstein could be implemented with a near-field design. Pet. at 14 (citing Ex. 1003, 25). But the Petition does not even assert that a POSITA would have any reason or motivation to modify any embodiment within "Robust Adaptive Beamforming" based on the alleged "standard near-field design" discussed in "Superdirective Microphone Arrays." At most, the Petition argues that near-field designs were "well known before the '357 Patent." Pet. at 14. Even if true, that would not be a sufficient basis for a POSITA to implement any particular embodiment described in "Robust Adaptive Beamforming" with a near-field design for receiving speech. *Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1073 (Fed. Cir. 2015) ("[O]bviousness concerns whether a skilled artisan not only *could have made* but *would have been motivated to make* the combinations or modifications of prior art to arrive at the claimed

invention.") The Petition therefore fails as a threshold matter to identify a reason or motivation to combine for its proposed combination.

The Petition further omits articles within Brandstein that challenge its uncritical combination of bits and pieces throughout the collection. "Future Directions in Microphone Array Processing," by Dirk Van Compernolle, collected as chapter 18 discusses these problems at length: "[a]fter 20 years of active research, however, we cannot claim that microphone array processing has had the success many of us hoped for, and many will wonder when the great breakthrough in microphone array processing will finally come, ***if ever***. . . . However, too often the same problems that were considered too hard ten or twenty years ago are still set apart for 'future research.' Admitted weaknesses to proposed solutions are similar to the ones that we have been struggling with for a long time. Generally speaking, we may say that many proposed solutions add to our understanding but lack robustness in order to make a bright future for themselves." Ex. 2004 at 389. Von Compernolle goes on to explain that "[i]t is especially difficult to come up with tractable mathematical models for this complex environment. The result of this complex situation is that a lot of research effort has gone into and continues to go into the search for optimal beamforming strategies that rely on extra assumptions and constraints. Sadly enough, this all too often leads to solutions that lack robustness when evaluated in a variety of real-life situations . . . we should admit to

ourselves that robustness has been, and still is today, one of the main issues." *Id.* at 390.

Given the Petition's failure to assert any reason or motivation to combine the references and embodiments within Brandstein on which it relies for its combination, and particularly in view of discussion in other articles challenging any such combination, the Petition fails as a threshold matter and must be denied.

### C. Ground 2: Brandstein, Gannot, and Griffiths-Jim Do Not Render Any Claims Obvious

Ground 2 is directed to dependent claims 4, 13, 14, 18, and 19, and utilizes Petitioner's Ground 1 arguments for the independent claims on which those claims rely. Pet. at 66-68. As discussed above, Petitioner has failed to show that Claims 1 or 15 are obvious under Ground 1. Petitioner's Ground 2 arguments do not remedy this deficiency. Accordingly, the Petition does not present a reasonable likelihood of prevailing with respect to any claim as to Ground 2.

### D. Ground 3: Brandstein, Gannot, and McCowan Do Not Render Any Claims Obvious

Ground 3 is directed to dependent claims 4, 5, 6, 13, 14, 18, and 19, and utilizes Petitioner's Ground 1 arguments for the independent claims on which those claims rely. Pet. at 66. As discussed above, Petitioner has failed to show that Claims 1 or 15 are obvious under Ground 1. Petitioner's Ground 3 arguments do not remedy

this deficiency. Accordingly, the Petition does not present a reasonable likelihood of prevailing with respect to any claim as to Ground 3.

## VII. CONCLUSION

As discussed above, Petitioner's combination fails to disclose or render obvious a key limitation of each claim of the '357 Patent, and therefore, does not anticipate or render obvious any claims. The Board should, therefore, deny the Petition.

Respectfully submitted,

Dated: October 12, 2023 By: */ Peter Lambrianakos /*

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**CERTIFICATE OF WORD COUNT**

The undersigned hereby certifies that the portions of the above-captioned PATENT OWNER'S PRELIMINARY RESPONSE specified in 37 C.F.R. § 42.24 has 3,817 words in compliance with the 14,000 word limit set forth in 37 C.F.R. § 42.24. This word count was prepared using Microsoft Word for Office 365.

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**CERTIFICATE OF SERVICE**

A copy of the foregoing Patent Owner's Preliminary Response and Exhibits 2002 through 2004 have been served on Petitioner's counsel of record as follows:

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