

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

ANDREA ELECTRONICS CORP.,
Patent Owner.

Case IPR2017-00626
Patent 6,363,345 B1

Before STEPHEN C. SIU, MICHAEL R. ZECHER, and
JEREMY M. PLENZLER, *Administrative Patent Judges*.

PLENZLER, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
Inter Partes Review
35 U.S.C. § 318 and 37 C.F.R. § 42.73

I. INTRODUCTION

We have jurisdiction to hear this *inter partes* review under 35 U.S.C. § 6, and this Final Written Decision is issued pursuant to 35 U.S.C. § 318(a) and 37 C.F.R. § 42.73. For the reasons that follow, we determine that Apple Inc. (“Petitioner”) has shown by a preponderance of the evidence that claims 1–3, 12–25, 38, and 47 of U.S. Patent No. 6,363,345 B1 (Ex. 1001, “the ’345 patent”) are unpatentable, but has failed to establish that claims 4–11 and 39–46 of the ’345 patent are unpatentable.

A. Background

Petitioner filed a Petition to institute an *inter partes* review of claims 1–25 and 38–47 the ’345 patent. Paper 1 (“Pet.”). Andrea Electronics Corp. (“Patent Owner”) filed a Preliminary Response. Paper 6 (“Prelim. Resp.”).

Pursuant to 35 U.S.C. § 314, we instituted trial on all challenged claims, and on all challenges raised in the Petition. See Paper 7 (“Dec. to Inst.”), 12–13. After institution of trial, Patent Owner filed a Patent Owner Response (Paper 11, “PO Resp.”), to which Petitioner filed a Reply (Paper 18, “Pet. Reply”).

An oral argument was held on April 25, 2018. A transcript of the oral argument is included in the record. Paper 25 (“Tr.”).

B. Related Matters

Petitioner and Patent Owner identify a number of proceedings, both in district court and before the Patent Trial and Appeal Board, involving patents related to the ’345 patent, including a district court proceeding specifically directed to the ’345 patent with Petitioner as a party and Case IPR2017-00627, which is directed to the ’345 patent and involves the same

parties as this proceeding. Pet. viii–x; Paper 4, 1. Our final decision in Case IPR2017-00627 issues concurrently herewith.

C. Asserted Grounds of Unpatentability and Evidence of Record

Petitioner contends that the challenged claims are unpatentable under 35 U.S.C. §§ 102 and 103 as set forth in the table below (Pet. 2–3, 17–69).

Reference(s)	Basis	Claims Challenged
Hirsch ¹	§ 102	1–3, 12, 13, 21, 23, and 38
Hirsch and Martin ²	§ 103	4–11, 25, 39–42, and 46
Hirsch and Boll ³	§ 103	13, 14, 17–21, 23, and 47 ⁴
Hirsch, Martin, and Boll	§ 103	43
Hirsch, Boll, and Arslan ⁵	§ 103	15, 16, and 24
Hirsch and Uesugi ⁶	§ 103	22
Hirsch, Martin, and Uesugi	§ 103	44 and 45

Petitioner provides testimony from Bertrand Hochwald, Ph.D. Ex. 1003; Ex. 1023. Patent Owner provides testimony from Scott C. Douglas, Ph.D. Ex. 2002. Petitioner also provides deposition testimony

¹ H.G. Hirsch & C. Ehrlicher, “Noise Estimation Techniques for Robust Speech Recognition,” IEEE 1995 (Ex. 1005, “Hirsch”).

² Ranier Martin, “An Efficient Algorithm to Estimate the Instantaneous SNR of Speech Signals,” Eurospeech 1993 (Ex. 1006, “Martin”).

³ Steven F. Boll, “Suppression of Acoustic Noise in Speech Using Spectral Subtraction,” IEEE 1979 (Ex. 1009, “Boll”).

⁴ Dependent claim 22 is included in this asserted ground of unpatentability in Petitioner’s “Identification of Claims being Challenged (§ 42.104(b))” (Pet. 3) (emphasis omitted), but this claim is not addressed in its substantive analysis (*id.* at 49–52).

⁵ U.S. Patent No. 5,706,395, iss. Jan. 6, 1998 (Ex. 1011, “Arslan”).

⁶ U.S. Patent No. 5,459,683, iss. Oct. 17, 1995 (Ex. 1015, “Uesugi”).

from Dr. Douglas (Ex. 1026) and Patent Owner provides deposition testimony from Dr. Hochwald (Ex. 2005).

D. The '345 Patent

The '345 patent “relates to noise cancellation and reduction and, more specifically, to noise cancellation and reduction using spectral subtraction.” Ex. 1001, 1:19–21. The '345 patent explains that its system receives a noise signal and converts that signal to the frequency domain through a Fast Fourier Transform (FFT). *Id.* at 4:50–5:14. Separate thresholds are set for each frequency bin to determine the location of noise elements for each frequency bin separately. *Id.* at 6:10–13. The '345 patent determines the thresholds by setting two minimum values, which are described as a future minimum and a current minimum. *Id.* at 6:23–41.

At predetermined time intervals (e.g., every 5 seconds), the future minimum value is initialized as the value of the current magnitude of the signal. *Id.* at 6:24–28. Over that time interval, and before the next initialization, the future minimum value of each bin is compared with the current magnitude value of the signal. *Id.* If the current magnitude is smaller than the future minimum, the value of the future minimum is replaced with that current magnitude. *Id.* at 6:28–32.

At the start of each time interval, the current minimum is set as the value of the future minimum that was determined over the previous time interval. *Id.* at 6:34–38. The current minimum then follows the minimum value of the signal for the next time interval by comparing its value with the current magnitude value. *Id.* The current minimum value is used by the spectral subtraction process to remove noise from the signal. *Id.* at 6:38–41.

E. Illustrative Claims

As noted above, Petitioner challenges claims 1–25 and 38–47 of the '345 patent. Claims 1 and 38 are independent, with claims 2–25 and 39–47 depending from either claim 1 or 38. Claim 1 is illustrative, and is reproduced below:

1. An apparatus for canceling noise, comprising:
 - an input for inputting an audio signal which includes a noise signal;
 - a frequency spectrum generator for generating the frequency spectrum of said audio signal thereby generating frequency bins of said audio signal; and
 - a threshold detector for setting a threshold for each frequency bin using a noise estimation process and for detecting for each frequency bin whether the magnitude of the frequency bin is less than the corresponding threshold, thereby detecting the position of noise elements for each frequency bin.

Ex. 1001, 9:35–46.

II. ANALYSIS

A. Claim Construction

“[W]e need only construe terms ‘that are in controversy, and only to the extent necessary to resolve the controversy.’” *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017) (quoting *Vivid Techs., Inc. v. Am. Sci. & Eng’g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)). We construe the claims using the broadest reasonable construction in light of the '345 patent Specification. See 37 C.F.R. § 42.100(b). Applying that standard, we interpret the claim terms of the '345 patent according to their ordinary and customary meaning in the context of the patent’s written description. See *In re Translogic Tech., Inc.*,

504 F.3d 1249, 1257 (Fed. Cir. 2007). An inventor is entitled to be his or her own lexicographer of patent claim terms by providing a definition of the term in the specification with reasonable clarity, deliberateness, and precision. *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994). In the absence of such a definition, however, limitations are not to be read from the specification into the claims. *In re Van Geuns*, 988 F.2d 1181, 1184 (Fed. Cir. 1993).

For purposes of this decision, we determine that no term requires express construction to resolve the controversies between the parties identified below.

B. Challenges

1. Hirsch

Petitioner challenges claims 1–3, 12, 13, 21, 23, and 38 as anticipated by Hirsch under 35 U.S.C. § 102. Pet. 22–31. “In [its] Response, Patent Owner does not address the anticipation grounds with respect to the Hirsch reference.” PO Resp. 12. Based on our review of the record before us, we are persuaded that Petitioner has established by a preponderance of the evidence that claims 1–3, 12, 13, 21, 23, and 38 are anticipated by Hirsch.

Claim 1, for example, is directed to “[a]n apparatus for canceling noise.” Claim 1 requires an apparatus that receives an audio signal (“an input for inputting an audio signal”), converts that audio signal to the frequency domain to provide frequency bins (“a frequency spectrum generator for generating the frequency spectrum of said audio signal”), and determines that the various frequency bins of that signal are noise if their magnitudes are below corresponding thresholds (“a threshold detector for setting a threshold for each frequency bin . . . and for detecting . . . whether

the magnitude of the frequency bin is less than the corresponding threshold, thereby detecting the position of noise elements for each frequency bin”). Claim 38 is similar to claim 1, but is directed to a “method” rather than an “apparatus,” and additionally recites “subtracting said noise elements . . . from said audio signal.” We adopt Petitioner’s un rebutted arguments and evidence related to how Hirsch properly accounts for each and every element of claims 1 and 38. *See* Pet. 18–31.

Hirsch is directed to “techniques . . . to estimate the noise spectra or the noise characteristics for noisy speech signals” that “can be combined with a nonlinear spectral subtraction scheme.” Ex. 1005, 153. Hirsch discusses use of “FFT based spectral analysis” (*id.* at 154), for example, which Petitioner cites as corresponding to the “generating the frequency spectrum of said audio signal thereby generating frequency bins of said audio signal” recited in claim 1 (Pet. 27). Hirsch discusses use of an “adaptive threshold” for each frequency bin to distinguish between speech and noise (Ex. 1005, 153), which Petitioner cites as corresponding to the “setting a threshold for each frequency bin using a noise estimation process” recited in claim 1 (Pet. 27). Hirsch describes comparing spectral components to their corresponding thresholds to determine if speech is present (Ex. 1005, 153), which Petitioner cites as corresponding to the “detecting for each frequency bin whether the magnitude of the frequency bin is less than the corresponding threshold, thereby detecting the position of noise elements for each frequency bin” recited in claim 1 (Pet. 27–28). Based on the record before us, we are persuaded that Hirsch discloses each and every element of claim 1.

We also are persuaded that Hirsch discloses each and every element of claim 38 for the reasons discussed above in connection with claim 1, as well as the “subtracting said noise elements . . . from said audio signal” additionally recited in claim 38. With respect to the recited “subtracting,” Petitioner cites Hirsch’s discussion of spectral subtraction. Pet. 25–26 (citing Ex. 1005, 153–155). As Petitioner notes, “[t]he spectral subtraction technique shown in Hirsch subtracts the noise estimate from each sub-band or ‘bin’ and sets any negative values to zero” (*id.* (citing Ex. 1005, 153)), which “is the same technique used in the ’345 patent” (*id.* (citing Ex. 1001, 6:58–61, 7:16–27)).

Claims 2, 3, 12, 13, 21, and 23 depend from claim 1, and Petitioner cites to relevant portions of Hirsch as disclosing the additional limitations of those claims. See Pet. 28–31. We are persuaded by Petitioner’s un rebutted arguments and evidence related to how Hirsch properly accounts for each and every element of these dependent claims, which we adopt for purposes of this decision. Specifically, we find that Hirsch discloses the additional limitations recited in those claims based on the citations to Hirsch therein and the supporting expert testimony. See *id.*

Based on our review of the record before us, the preponderance of the evidence supports Petitioner’s contentions that claims 1–3, 12, 13, 21, 23, and 38 are anticipated by Hirsch.

2. Hirsch and Martin

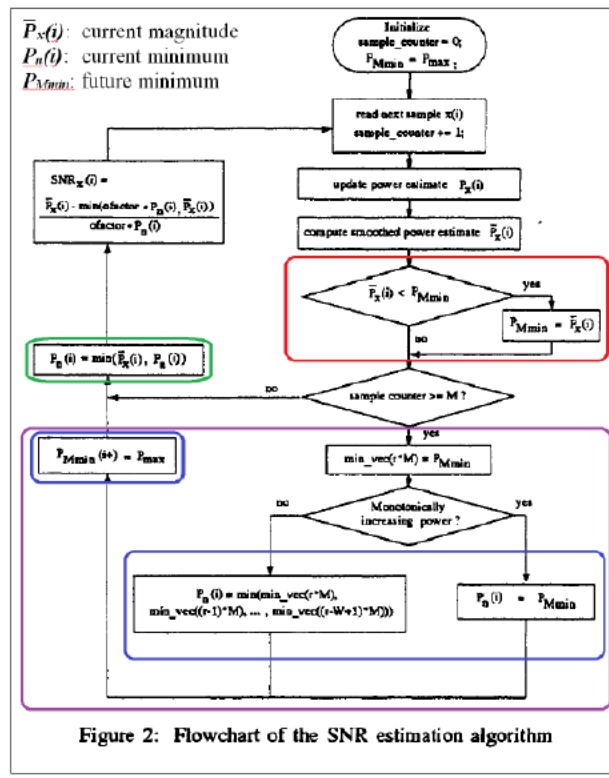
Petitioner challenges claims 4–11, 25, 39–42, and 46 as unpatentable over Hirsch and Martin under 35 U.S.C. § 103. Pet. 38–49. Patent Owner responds that “Petitioner fails to demonstrate by a preponderance of the evidence that claims 4–11 and 39–42 are unpatentable as alleged,” but does

not address specifically Petitioner's contentions regarding claim 25 or claim 46. PO Resp. 13. Based on our review of the record before us, Petitioner has established that claim 25 is unpatentable over Hirsch and Martin, but has failed to establish by a preponderance of the evidence that claims 4–11, 39–42, and 46 are unpatentable over Hirsch and Martin.

a. Claims 4–11, 39–42, and 46

Claim 4 depends from claim 1, and claims 5–11 ultimately depend from claim 4. Claim 39 depends from claim 38, and claims 40–42 and 46 ultimately depend from claim 39. Claims 4 and 39 each recite that “the threshold for each frequency bin [is set] in accordance with a current minimum value of the magnitude of the corresponding frequency bin” and “said current minimum value [is] derived in accordance with a future minimum value of the magnitude of the corresponding frequency bin.” With respect to claims 4 and 39, Petitioner acknowledges that “Hirsch does not expressly disclose . . . maintaining the noise threshold for each frequency bin using ‘current minimum’ and ‘future minimum’ values,” but contends that these features are “obvious variations of Hirsch in view of the guidance in Martin.” Pet. 31–32 (emphases omitted).

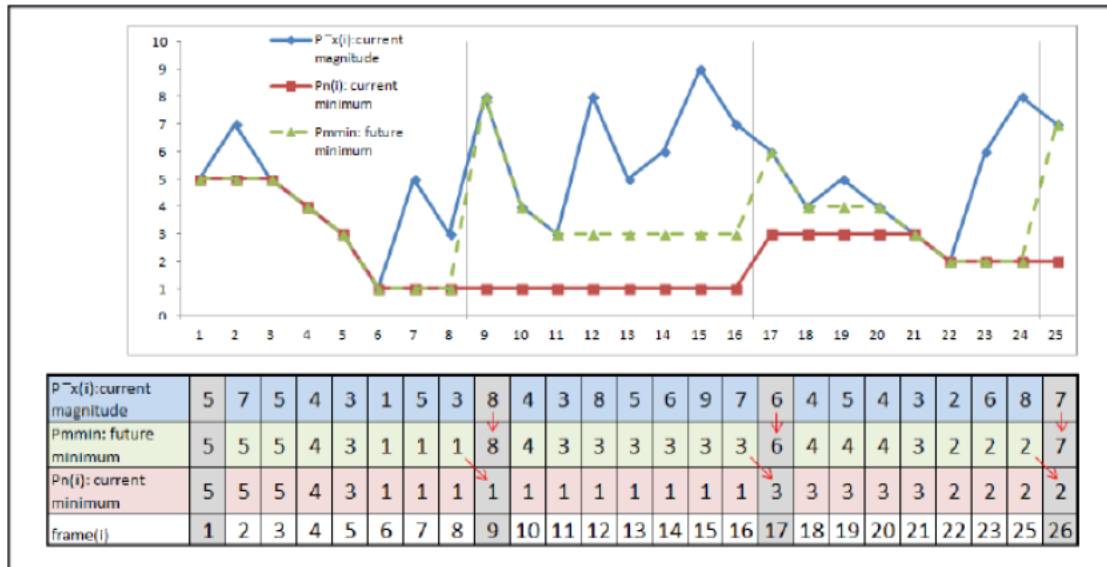
Martin is directed to “estimat[ing] the instantaneous signal-to-noise ratio of speech signals” (Ex. 1006, 1093), and is specifically referenced in Hirsch as a known way to estimate noise characteristics in a past speech segment (Ex. 1005, 153). Petitioner provides an annotated version of Martin's Figure 2 (Pet. 39), reproduced below.



This annotated version of Martin’s Figure 2 is a flow chart illustrating a signal-to-noise ratio estimation algorithm (Ex. 1006, 1094), and Petitioner’s annotations include colored boxes around certain portions of the flow chart for purposes of discussion. Petitioner cites Martin’s noise floor estimate $P_n(i)$ as corresponding to the “current minimum value” and Martin’s minimum observed noise level during a period P_{Mmin} as corresponding to the “future minimum value” recited in claims 4 and 39. Pet. 41–42. Petitioner explains that, “[d]uring each period of M samples, Martin’s algorithm tracks the observed power level of the signal and stores the minimum value as P_{Mmin} (red box),” and “[a]t the end of the period (purple box), the algorithm sets the estimated noise floor $P_n(i)$ to the minimum observed power value (right-hand side blue box).” Pet. 39 (citing Ex. 1006, 1094). The Petition relies on a specific scenario where “ $W=1$ (the number of sub-windows)” in its contentions regarding the teachings of Martin. Pet. 40.

Dr. Hochwald provides an example illustrating the algorithm of Martin based on the scenario with $W = 1$, which is reproduced below.

Ex. 1003 ¶¶ 137–140.



The figure reproduced above is a graphical illustration of the determination of current magnitude, future minimum, and current minimum with Martin’s Figure 2 algorithm. Dr. Hochwald explains that, “[i]n response to [the current magnitude] data stream, Martin’s algorithm would derive the values for the estimated noise power, $P_n(i)$, and the minimum observed noise power, P_{Mmin} , that are listed in the figure above,” with “[t]he arrows in the chart above show[ing] how values change when the window of M samples ends.” Ex. 1003 ¶ 137.

Petitioner contends that, “[w]hile Martin shows its algorithm operating on signal power, it teaches that the algorithm can be adapted to work with spectral subtraction techniques that operate on the magnitude of a signal.” Pet. 40 (citing Ex. 1006, 1096). Petitioner further contends that “a person of ordinary skill in the art would have understood that Martin’s

algorithm also could be used to track the magnitude of the noise signal instead of its power.” *Id.* at 34 (emphases omitted) (citing Ex. 1003 ¶ 123). Dr. Hochwald testifies that “[t]he power of an audio signal is its magnitude squared” and “a person of ordinary skill can readily move between the two.” Ex. 1003 ¶ 123.

Petitioner contends, for example, that a person skilled in the art would have combined the teachings of Martin with those of Hirsch “because Hirsch not only cites to Martin, but identifies relevant benefits it provides in spectral subtraction schemes.” Pet. 34 (citing Ex. 1005, 156; Ex. 1006, 1096; Ex. 1003 ¶¶ 128, 129). Petitioner reasons that it would have been obvious to modify Hirsch’s teachings “to incorporate Martin’s technique for estimating the noise floor of a signal within Hirsch’s adaptive threshold calculation to improve operation of Hirsch’s system in non-stationary noise settings.” *Id.* at 35 (citing Ex. 1003 ¶¶ 129–32).

Patent Owner responds that “[Petitioner] and its expert, Dr. Hochwald, analyze the combination of Martin and Hirsch where $W = 1$, *i.e.*, where subwindows are eliminated in an apparent attempt to overcome the deficiencies of Martin.” PO Resp. 44 (underlining omitted). Patent Owner explains that “[a] key aspect of Martin’s algorithm is its ability to distinguish between slowly varying and rapidly varying noise levels – a distinction made by the monotonic decision block” and, “[a]s explained by Dr. Douglas, one of ordinary skill in the art would not have eliminated subwindows from the Martin system, because it would be directly contrary to Martin’s disclosure and it would thwart the ability of the algorithm to track rapidly varying noise power.” *Id.* (underlining omitted) (citing Ex. 1006, 194;

Ex. 2002 ¶¶ 94–95). Based on the record developed during trial, Patent Owner’s contentions are persuasive.

Initially, we agree with Petitioner that one skilled in the art would have considered Martin’s teachings, generally, when reviewing the teachings of Hirsch, as Martin is specifically referenced in Hirsch itself. Nevertheless, we are not persuaded that one skilled in the art would have modified Hirsch’s system based on the teachings of Martin in the particular manner proposed by Petitioner.

Consistent with Patent Owner’s contentions noted above, Martin describes determining “[t]he noise power estimate is based on the minimum of signal power within a window of L samples” and “[f]or reasons of computational complexity and delay the data window of length L is decomposed into W windows of length M such that $M * W = L$,” and provides an example where $W=4$. Ex. 1006, 1094. Martin distinguishes between “slowly varying noise power” and “rapidly varying noise power” to determine its noise power estimate, with a determination of whether the minimum power in successive sub-windows is monotonically increasing central to its estimation. *Id.* “If the minimum power of the last W windows with M samples each is monotonically increasing we decide on rapid noise power variation” and “the noise power estimate equals the power minimum of the last M samples $P_n(i) = P_{Mmin}(i = r * M)$.” *Id.* “In case of non monotonic power the noise power estimate is set to the minimum of the length L window.” *Id.*

Regardless of whether the noise power calculation is that for “slowly varying noise power” or “rapidly varying noise power,” Martin requires that first a determination is made as to whether or not “the minimum power of

the last W windows with M samples each is monotonically increasing.” *Id.* (emphasis added). To the extent there can be any dispute on this issue, the testimony from Dr. Douglas supports the understanding that at least two subwindows are required to determine which noise power calculation to use. *See* Ex. 2002 ¶¶ 95, 96.

In its Reply, Petitioner contends that, “[i]n this configuration [where $W = 1$], any purported distinction between windows and sub-windows in Martin vanishes and [Patent Owner]’s argument is irrelevant,” acknowledging that the proposed modification eliminates Martin’s sub-windows. Pet. Reply 5. Petitioner further contends that Patent Owner “incorrectly argues that the use of sub-windows is central to Martin’s algorithm” and “[n]othing in Martin suggests that the use of sub-windows is required.” *Id.* at 7 (citing Ex. 1023 ¶¶ 6–8). We disagree with Petitioner, and credit the testimony of Dr. Douglas over that of Dr. Hochwald with respect to Martin’s use of sub-windows because, as discussed below, Dr. Hochwald’s testimony is not consistent with the disclosure of Martin, while the testimony of Dr. Douglas is consistent with that disclosure. *See, e.g.*, Ex. 1023 ¶¶ 6–9 (asserting that Martin does not expressly *require* sub-windows); Ex. 2002 ¶¶ 94–96 (discussing Martin’s use of at least two sub-windows for monotonic determination).

As noted above, Martin’s algorithm requires a determination of whether or not “the minimum power of the last W windows with M samples each is monotonically increasing.” Ex. 1006, 1094. We are not persuaded by Petitioner’s argument that one skilled in the art would have found it obvious to modify Hirsch’s system based on a scenario from Martin where $W = 1$ because such a scenario is counter to the entire purpose of Martin.

Even Petitioner's Declarant, Dr. Hochwald, acknowledges that a single data point (i.e., $W = 1$) cannot be used to determine whether something is monotonically increasing. See Ex. 2005 69:10–17 (explaining that you need at least two data points to make such a determination, meaning $W \geq 2$). Petitioner fails to provide persuasive reasoning as to why one skilled in the art would have modified Hirsch's teachings in a manner that is contrary to the express disclosure of Martin.

Petitioner attempts to cure these deficiencies in its Reply, contending that, “[e]ven where Martin's algorithm is configured to use multiple sub-windows, it still teaches the claimed ‘*future minimum*.’” Pet. Reply 8. We do not consider this new argument, as it is a new theory of unpatentability presented for the first time in the Petitioner's Reply. See *Dell Inc. v. Acceleron, LLC*, 818 F.3d 1293, 1301 (Fed Cir. 2016) (“A patent owner . . . is undoubtedly entitled to notice of and a fair opportunity to meet the grounds of [unpatentability].”) (quoting *Belden Inc. v. Berk-Tek LLC*, 805 F.3d 1064, 1080 (Fed. Cir. 2015)).

For at least these reasons, Petitioner has failed to establish by a preponderance of the evidence that claims 4–11, 39–42, and 46 are unpatentable over the combined teachings of Hirsch and Martin.

b. Claim 25

Claim 25 depends from claim 1, and additionally recites “an adaptive array comprising a plurality of microphones for receiving said audio signal.” Petitioner cites Martin's microphone arrays that include adaptive processing of microphone signals as teaching this feature. Pet. 48 (citing Ex. 1006, 1096). Petitioner reasons that “[i]t would have been obvious to add these conventional adaptive microphone arrays to Hirsch's speech processing

systems.” *Id.* (citing Ex. 1003 ¶¶ 125–32). Petitioner explains that “[a] skilled person would have recognized such arrays to have been one of a small number of conventional design choices for capturing a signal, and could have integrated this conventional component into Hirsch’s system with only routine effort.” *Id.* at 38 (citing Ex. 1003 ¶ 145). Petitioner reasons that “a skilled person would have considered Hirsch together with Martin because Hirsch not only cites to Martin, but identifies relevant benefits it provides,” and “[a] skilled person also would have recognized that techniques such as those shown in both Hirsch and Martin are routinely combined.” *Id.* at 34–35. Patent Owner provides no evidence or argument to rebut Petitioner’s contentions and evidence in connection with claim 25.⁷

Based on the record before, Petitioner’s unrebutted arguments and evidence establish by a preponderance of the evidence that it would have been obvious to modify Hirsch’s system to include “a plurality of microphones for receiving said audio signal,” as taught by Martin. Accordingly, Petitioner has established by a preponderance of the evidence that claim 25 is unpatentable over the combined teachings of Hirsch and Martin.

3. Hirsch and Boll

Petitioner challenges claims 13, 14, 17–21, 23, and 47 as unpatentable over the combined teachings of Hirsch and Boll under 35 U.S.C. § 103. Pet. 49–59. Claim 13 depends from claim 1, and further recites “a subtractor

⁷ Patent Owner provides arguments that address, generally, Petitioner’s proposed combination of Martin’s teachings with those of Hirsch, but does not address specifically any issues in connection with claim 25. See *generally* PO Resp. 33–43. Patent Owner’s general arguments are directed to Martin’s algorithm rather than its use of multiple microphones.

for subtracting said noise elements estimated at said positions determined by said threshold detector from said audio signal to derive said audio signal substantially without said noise.” Claims 14 and 17–20 each ultimately depend from claim 13. Claim 21 depends from claim 1, and further recites “an estimator for estimating a magnitude of each frequency bin.” Claim 23 depends from claim 21. Claim 47 depends from claim 38 and recites limitations similar to those in claim 13. Petitioner cites Boll as teaching the additional features recited in those claims, and contends that one skilled in the art would have found it obvious to apply those teachings in Hirsch’s system. Pet. 49–59. Patent Owner does not dispute that Boll teaches the additional features recited in those claims, but responds that Petitioner has failed to provide a reason why one skilled in the art would have included those particular features in Hirsch’s system. PO Resp. 52–54.

We are persuaded by Petitioner’s contentions regarding how Boll teaches the features in claims 13, 14, 17–21, 23, and 47, and find that the portions of Boll cited in the Petition as corresponding to those features teach the additional limitations found in claims 13, 14, 17–21, 23, and 47. We also are persuaded by Petitioner’s reasons why one of ordinary skill in the art would have combined Boll’s teachings with those of Hirsch. For example, Petitioner reasons that “a skilled person would have considered Hirsch in conjunction with Boll” because “Hirsch is focused on a particular improvement to the noise estimation process used in spectral subtraction, and logically does not provide details of the other aspects of the spectral subtraction process,” and “[a] skilled person . . . would have known that certain operations are ordinarily performed to carry out spectral subtraction, and would have looked to a reference like Boll for details in doing so.” Pet.

51 (underlining omitted) (citing Ex. 1003 ¶ 147; Ex. 1005, 153, Abstract; Ex. 1009, 114). More specifically, Petitioner reasons that one skilled in the art would have found it obvious to use Boll's well-known spectral subtraction features, such as filter multiplication, in Hirsch's spectral subtraction process, as well as Boll's other teachings including smoothing signal value inputs and residual noise reduction techniques. *Id.* at 51–52 (citing Ex. 1003 ¶¶ 149, 150, 154, 156, 157).

Patent Owner responds, generally, that Petitioner has failed to provide sufficient explanation as to why one skilled in the art would have made the particular modifications to Hirsch that it proposes. PO Resp. 52–54. Patent Owner does not rebut Petitioner's contentions with respect to the teachings of Hirsch or Boll relied on in Petitioner's reasoning for combining the teachings of those references or the supporting testimony from Dr. Hochwald. We credit the testimony of Petitioner's declarant, Dr. Hochwald, in connection with these challenges, as that testimony is unrebutted by any testimony from Patent Owner. *See* Ex. 1003 ¶¶ 147, 149, 150, 154, 156, 157. Indeed, Patent Owner provides no testimony from its declarant or deposition testimony from Petitioner's declarant in response to these challenges. We are persuaded by Petitioner's rationale and supporting evidence, which we adopt for purposes of this decision.

There is no dispute that Hirsch teaches using spectral subtraction and, itself, states that it “can be combined with well-known spectral subtraction techniques” or that Boll is a well-known paper in the area of spectral subtraction. Ex. 1005, 156; *see also* Pet. 30 (contending that Hirsch discloses the features of claim 13, which Patent Owner does not dispute). Indeed, both Dr. Hochwald and Dr. Douglas provide testimony to that effect.

Ex. 1003 ¶¶ 147, 149, 150, 154, 156, 157; Ex. 1030, 17:1–8; 195:11–196:7, 197:20–198:10. For example, Patent Owner’s declarant, Dr. Douglas, explains that Boll “is a foundational reference . . . on the general set of techniques associated with spectral subtraction.” Ex. 1030, 195:21–196:1. We are persuaded that selecting various ones of a finite number of known techniques for implementing spectral subtraction in Hirsch’s system, such as Boll’s filter multiplication, smoothing techniques, or residual noise reduction techniques, would have been obvious based on the unrebutted evidence before us.

Accordingly, Petitioner has established by a preponderance of the evidence that claims 13, 14, 17–21, 23, and 47 are unpatentable over the combined teachings of Hirsch and Boll.

4. Hirsch, Martin, and Boll

Claim 43 depends from claim 40, which depends from claim 39. Petitioner’s contentions regarding claim 43 do not cure the deficiencies in either Hirsch or Martin with respect to the challenge to claim 39 identified above. See Pet. 59–60. Accordingly, Petitioner has failed to establish by a preponderance of the evidence that claim 43 is unpatentable over the combined teachings of Hirsch, Martin, and Boll.

5. Hirsch, Boll, and Arslan

Claim 15 depends from claim 13, claim 16 depends from claim 15, and claim 24 depends from claim 23. Those claims define additional features of the particular spectral subtraction techniques recited in the claims from which they depend, such as specifying the type of filter function for the spectral subtraction (claims 15 and 16) and the smoothing process (claim 24). Petitioner cites Arslan as teaching the additional features in claims 15

and 16, as well as smoothing over neighboring frequencies in connection with claim 24, which we find persuasive, and adopt for purposes of this decision. Pet. 62–66. Patent Owner does not dispute those contentions. Rather, similar to the response to Petitioner’s challenge based on the combination of Hirsch and Boll, discussed above, Patent Owner responds, generally, that Petitioner “fails to establish that a skilled artisan would have been motivated to combine Hirsch and Boll,” but even if it had, Petitioner “makes no showing as to why a skilled artisan would have been motivated to further modify these references in view of Arslan.” PO Resp. 56 (underlining omitted). We disagree with Patent Owner’s characterization of Petitioner’s contentions, which we find persuasive as explained below. Further, we credit the testimony of Petitioner’s declarant in support of these challenges, as that testimony is unrebutted by any testimony from Patent Owner. See Ex. 1003 ¶¶ 177, 178, 183–185. Again, Patent Owner provides no testimony from its declarant or deposition testimony from Petitioner’s declarant in response to these challenges.

With respect to claims 15 and 16, Petitioner contends that one skilled in the art would have further considered Arslan in combination with Hirsch and Boll because Arslan specifically describes improvements to Boll’s system, including use of a Wiener filter. Pet. 60–62 (citing, *e.g.*, Ex. 1011, 2:66–3:5, 7:29–31). Petitioner also provides testimony from Dr. Hochwald to support its rationale. See Ex. 1003 ¶¶ 177, 178 (explaining that, in addition to Boll, one skilled in the art “would have looked to other references that describe spectral subtraction based techniques” like “Arslan, which explains that it is intended to describe improvements to the conventional spectral subtraction technique that is taught by Boll”). Dr.

Douglas also acknowledges that a Wiener filter was a known way to design a filter. Ex. 1030, 71:8–20.

We are persuaded that one skilled in the art would have combined Boll’s teachings with those of Hirsch for the reasons discussed above relative to claim 13. We are also persuaded that selecting a specific filter technique, such as that taught by Arslan, from a finite number of known techniques for implementing spectral subtraction in the combination of Hirsch and Boll would have been obvious based on the unrebutted evidence before us.

As for claim 24, Petitioner cites Boll as teaching “that the magnitude of the signal should be smoothed over time by taking the average of signal magnitude over adjacent frames in the signal,” and Arslan as teaching “the technique of smoothing over neighboring frequencies.” Pet. 65 (citing Ex. 1009, 114, 116; Ex. 1011, 6:25–26, 8:13–29; 8:34–38). Petitioner provides testimony from Dr. Hochwald, explaining that “[t]o a person knowledgeable in the arts, when given a sequence of samples arriving in time and asked to compute a running average, it was very common at the time to use either simple moving averages, as done by Boll, or exponential moving averages.” Ex. 1003 ¶ 184. Petitioner reasons that “[t]he skilled person would have recognized that it would have been advantageous to combine Arslan’s frequency smoothing technique with Boll’s time smoothing technique to allow for ‘averaging over as many spectral magnitude sets as possible,’ as taught by Boll.” Pet. 65–66 (Ex. 1003 ¶¶ 183–85). Petitioner further reasons that one skilled in the art “also would have found it obvious to incorporate the magnitude averaging processes suggested by Boll and Arslan into Hirsch’s noise reduction scheme” because

“[t]hat person would have recognized the well known benefits of ‘averaging over as many spectral magnitude sets as possible,’ as Boll explains.” *Id.* at 66 (citing Ex. 1009, 116). Dr. Hochwald’s testimony and the disclosure of Boll and Arslan support Petitioner’s reasoning in this regard. *See* Ex. 1003 ¶¶ 183–85; Ex. 1009, 114, 116; Ex. 1011, 6:25–26, 8:13–29; 8:34–38.

As noted above with respect to claims 15 and 16, again, we are persuaded that one skilled in the art would have combined Boll’s teachings with those of Hirsch for the reasons discussed above relative to claim 13. Further, there is no dispute that Boll teaches that spectral subtraction techniques can be improved by averaging over as many magnitude sets as possible or “that it would have been advantageous to combine Arslan’s frequency smoothing technique with Boll’s time smoothing technique to allow for ‘averaging over as many spectral magnitude sets as possible, as taught by Boll,” as Petitioner contends. *Id.* at 65–66.

Accordingly, Petitioner has established by a preponderance of the evidence that claims 15, 16, and 24 are unpatentable over the combined teachings of Hirsch, Boll, and Arslan.

6. Hirsch and Uesugi

Claim 22 depends from claim 21, which depends from claim 1, and additionally recites “wherein said estimator estimates said magnitude of each frequency bin as a function of the maximum and the minimum values of the complex element of said frequency bins for a number n of the frequency bins.” Petitioner cites Uesugi’s approximation method as teaching this additional feature. *Pet.* 66–67 (citing Ex. 1015, 1:14–22, 1:28–29, 4:26–42, 5:18–24). Petitioner provides evidence and persuasive explanation, which is largely un rebutted, in support of its contentions. Specifically, Petitioner

explains that Uesugi discloses a method to approximate magnitude to eliminate the need for a square root operation. *Id.* Petitioner reasons that the skilled person would have understood that performance of Hirsch's system, which requires two square operations and a square root operation, would be improved by approximating the magnitude of each frequency bin to eliminate the square root operation. *Id.* at 67 (citing Ex. 1003 ¶¶ 169–71; Ex. 1005, 153). Petitioner explains that “[t]o implement this feature, the skilled person would have looked to standard digital signal processing techniques, including those taught by Uesugi, which is a standard engineering practice.” *Id.* (underlining omitted) (citing Ex. 1003 ¶¶ 186, 187).

Patent Owner responds that Petitioner's “expert fails to provide any basis for his conclusion that the use of Uesugi's approximation method will ‘significantly reduce’ the computational requirements of the stated square root calculation.” PO Resp. 60. Notably, Patent Owner does not dispute Dr. Hochwald's testimony, which is, in fact, supported by the disclosure of Uesugi. *See, e.g.*, Ex. 1015, 1:14–22, 1:28–29, 4:26–42, 5:18–24 (discussing approximations as a way to reduce complications of the calculation). Although Dr. Hochwald does not cite to additional evidence to reach the conclusion that approximating a square root operation using addition and multiplication significantly reduces computational requirements, we nevertheless are persuaded by his testimony, particularly in the absence of any testimony to the contrary from Patent Owner. Further, consistent with the disclosure of Uesugi, as noted above, the whole point of an approximation is to reduce computational requirements. It is a trade-off between computational resources and accuracy. Thus, we also are

unpersuaded by Patent Owner's contentions regarding the reduction in accuracy that would result from using such an approximation in Hirsch's system.

Accordingly, Petitioner has established by a preponderance of the evidence that claim 22 is unpatentable over the combined teachings of Hirsch and Uesugi.

7. Hirsch, Martin, and Uesugi

Claim 44 depends from claim 40, which depends from claim 39, and claim 45 depends from claim 44. Petitioner's contentions regarding claims 44 and 45 do not cure the deficiencies in either Hirsch or Martin with respect to the challenge to claim 39 identified above. *See* Pet. 68–69. Accordingly, Petitioner has failed to establish by a preponderance of the evidence that claims 44 and 45 are unpatentable over the combined teachings of Hirsch, Martin, and Uesugi.

C. ORDER

For the reasons given, it is

ORDERED that Petitioner has demonstrated that claims 1–3, 12–25, 38, and 47 of the '345 patent are unpatentable;

FURTHER ORDERED that Petitioner has not demonstrated that claims 4–11 and 39–46 of the '345 patent are unpatentable; and

FURTHER ORDERED that parties to the proceeding seeking judicial review of this Final Written Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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