

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GOOGLE LLC
Petitioner

v.

JAWBONE INNOVATIONS, LLC
Patent Owner

Case No. IPR2023-01074
U.S. Patent No. 8,321,213

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 8,321,213**

TABLE OF CONTENTS

I.	REQUIREMENTS FOR IPR.....	1
A.	Grounds for Standing.....	1
B.	Challenge and Relief Requested	1
C.	Priority Date.....	2
1.	Dynamic Drinkware Analysis	3
(a)	A method for adaptive processing of a close microphone array in a noise suppression system, comprising:	3
(b)	receiving a primary acoustic signal and a secondary acoustic signal;	3
(c)	performing frequency analysis on the primary and secondary acoustic signals to obtain	4
(d)	generating a forward-facing cardioid pattern and a backward-facing cardioid pattern based on the sub-band signals;	4
(e)	generating a forward-facing cardioid pattern and a backward-facing cardioid pattern based on the sub-band signals;	4
(f)	outputting a noise suppressed signal.	4
II.	BACKGROUND	4
A.	Overview of the '213 Patent.....	4
B.	Prosecution History	6
C.	Level of Ordinary Skill	7
D.	Claim Construction.....	7
III.	GROUND 1: Avendano '880 and Hou (Claims 1-3, 5-9, 12, 13).....	7

A.	Avendano '880 Overview	7
B.	Hou Overview	13
C.	Combination of Avendano '880 and Hou.....	16
D.	Claim 1	31
	[1pre]: An acoustic voice activity detection system comprising:	31
	[1a]: a first virtual microphone comprising a first combination of a first signal and a second signal, wherein the first signal is received from a first physical microphone and the second signal is received from a second physical microphone;.....	31
	[1b]: a filter, wherein the filter is formed by generating a first quantity by applying a calibration to at least one of the first signal and the second signal, generating a second quantity by applying a delay to the first signal, and forming the filter as a ratio of the first quantity to the second quantity	33
	[1c]: a second virtual microphone formed by applying the filter to the first signal to generate a first intermediate signal and summing the first intermediate signal and the second signal	38
	[1d]: wherein acoustic voice activity of a speaker is determined to be present when an energy ratio of energies of the first virtual microphone and the second virtual microphone is greater than a threshold value.	46
E.	Claim 2	48
	[2]: The system of claim 1, wherein the first virtual microphone and the second virtual microphone have approximately similar responses to noise and approximately, dissimilar responses to speech	48
F.	Claim 3	50
	[3]: The system of claim 1, wherein a calibration is applied to the second signal, wherein the calibration compensates a second response of the second physical microphone so that the second response is equivalent to a first response of the first physical	

	microphone	50
G.	Claim 5	51
	[5]: The system of claim 1, wherein the first virtual microphone is formed by applying the filter to the second signal	51
H.	Claim 6	58
	[6]: The system of claim 5, wherein the first virtual microphone is formed by applying the calibration to the second signal	58
I.	Claim 7	59
	[7]: The system of claim 6, wherein the first virtual microphone is formed by applying the delay to the first signal	59
J.	Claim 8	60
	[8]: The system of claim 7, wherein the first virtual microphone is formed by subtracting the second signal from the first signal.....	60
K.	Claim 9	62
	[9]: The system of claim 1, wherein the filter is an adaptive filter	62
L.	Claims 12 and 13	63
	[12]: The system of claim 1, wherein the energy ratio comprises an energy ratio for a frequency band.....	63
	[13]: The system of claim 1, wherein the energy ratio comprises an energy ratio for a frequency subband	63
IV.	GROUND 2: Avendano '880, Hou, And Avendano '252 (Claims 4, 10, 11).....	64
A.	Avendano '252 Overview	64
B.	Combination of Avendano '880, Hou, and Avendano '252	67
C.	Claim 4	70
	[4]: The system of claim 1, wherein the delay is applied to the first	

	intermediate signal, wherein the delay is proportional to a time difference between arrival of the speech at the second physical microphone and arrival of the speech at the first physical microphone	70
D.	Claim 10	76
	[10]: The system of claim 1, wherein the filter is adapted to minimize a second virtual microphone output when only speech is being received by the first physical microphone and the second physical microphone	76
E.	Claim 11	79
	[11]: The system of claim 1, wherein coefficients of the filter are generated during a period when only speech is being received by the first physical microphone and the second physical microphone	79
V.	INSTITUTION IS APPROPRIATE HERE	82
A.	Co-Pending Litigation Does Not Warrant Discretionary Denial (<i>Fintiv</i>)	82
	1. Factor 1: Stay	82
	2. Factor 2: Proximity to Trial to FWD	83
	3. Factor 3: Investment in Parallel Proceeding	83
	4. Factor 4: Overlapping Issues	84
	5. Factor 5: The Parties	84
	6. Factor 6: Other Circumstances	84
B.	Google’s Previously Filed IPR Petition Does Not Warrant Discretionary Denial (<i>General Plastic</i>)	85
	1. Factors 1-3: Same Petitioner, Knowledge of Art, Road-Mapping	86
	2. Factors 4 and 5: Length of Time and Explanation	89

3.	Factors 6 and 7: Finite Resources and One-Year Deadline.....	91
C.	DISCRETIONARY DENIAL UNDER §325(D) IS NOT APPROPRIATE.....	92
VI.	MANDATORY NOTICES UNDER 37 C.F.R § 42.8(A)(1)	92
A.	Real Party-In-Interest Under 37 C.F.R. § 42.8(b)(1)	92
B.	Related Matters Under 37 C.F.R. § 42.8(b)(2)	93
C.	Lead And Back-Up Counsel Under 37 C.F.R. § 42.8(b)(3)	95
D.	Service Information.....	96
VII.	Conclusion	96

TABLE OF AUTHORITIES

	Page(s)
Cases:	
<i>Apple Inc. v. Fintiv, Inc.</i> , IPR2020-00019, Paper 11 (P.T.A.B. Mar. 20, 2020).....	85
<i>Apple Inc. v. Jawbone Innovations, LLC</i> , IPR2022-01494, Paper 2 (P.T.A.B. Sept. 2, 2022).....	87
<i>Apple Inc. v. Jawbone Innovations, LLC</i> , IPR2022-01494, Paper 8 (P.T.A.B. Jan. 10, 2023)	88
<i>Apple Inc. v. Uniloc 2017 LLC</i> , IPR2020-00854, Paper 9 (P.T.A.B. Oct. 28, 2020).....	85
<i>Cal. Inst. of Tech. v. Broadcom Ltd.</i> , 25 F.4th 976 (Fed. Cir. 2022)	84
<i>Cisco Sys., Inc. v. Centripetal Networks, Inc.</i> , IPR2022-01151, Paper 12 (P.T.A.B. Jan. 4, 2023)	86, 87
<i>Code200, UAB v. Bright Data Ltd.</i> , IPR2022-00861, Paper 18 (P.T.A.B. Aug. 23, 2022).....	86, 91
<i>Ericsson Inc. v. Uniloc 2017 LLC</i> , IPR2020-00376, Paper 16 (P.T.A.B. May 22, 2020)	91
<i>General Plastic Indus. Co. v. Canon Kabushiki Kaisha</i> , IPR2016-01357, Paper 19 (P.T.A.B. Sept. 6, 2017).....	85, 88, 89, 90
<i>Global Tel*Link Corp. v. HLFIP Holding, Inc.</i> , IPR2021-00444, Paper 14 (P.T.A.B. Jul. 22, 2021).....	83
<i>Google LLC v. Jawbone Innovations, LLC</i> , IPR2022-00888, Paper 6 (P.T.A.B. Sept. 9, 2022).....	87
<i>Google LLC v. Jawbone Innovations, LLC</i> , IPR2022-00630, Paper 10 (P.T.A.B. Sept. 13, 2022).....	84

<i>Google LLC v. Jawbone Innovations, LLC</i> , IPR2022-00888, Paper 12 (P.T.A.B. Nov. 28, 2022).....	86, 87
<i>Huawei Techs. Co. v. WSOU Invs., LLC</i> , IPR2021-00226, Paper 10 (P.T.A.B. Jun. 10, 2021)	83
<i>Intel Corp. v. VLSI Tech. LLC</i> , IPR2022-00479, Paper 13 (P.T.A.B. Jun. 6, 2022)	86-87
<i>Jawbone Innovations, LLC v. Google LLC</i> , No. 3:23-cv-00466 (N.D. Cal.)	82
<i>Jawbone Innovations, LLC v. Google LLC</i> , No. 6:21-cv-00985 (W.D. Tex.)	82
<i>Samsung Elecs. Am. Inc. v. Snik LLC</i> , IPR2020-01428, Paper 10 (P.T.A.B. Mar. 9, 2021)	83
<i>Sand Revolution II, LLC v. Cont'l Intermodal Grp.-Trucking LLC</i> , IPR2019-01393, Paper 24 (P.T.A.B. Jun. 16, 2020)	84
<i>Well-man, Inc. v. Eastman Chem. Co.</i> , 642 F.3d 1355 (Fed. Cir. 2011)	7
Statutes and Rules:	
35 U.S.C. § 315(c)	88
35 U.S.C. § 316(a)(11).....	91
35 U.S.C. § 325(d)	92
37 C.F.R. § 42.122(b)	88

LIST OF EXHIBITS

Exhibit	Description
EX. 1001	U.S. Patent No. 8,321,213 to Petit et al. (“the ’213 patent”)
EX. 1002	Excerpts from the Prosecution History of the ’213 patent (“the Prosecution History”)
EX. 1003	Declaration of Dr. Thomas Kenny
EX. 1004	<i>Curriculum Vitae</i> of Dr. Thomas Kenny
EX. 1005	U.S. Patent No. 8,194,880 B2 (“Avendano ’880”)
EX. 1006	U.S. Patent No. 8,204,252 B1 (“Avendano ’252”)
EX. 1007	U.S. App. No. 11/699,732 (“Avendano Priority Application”)
EX. 1008	U.S. Patent No. 7,155,019 B2 (“Hou”)
EX. 1009	Declaration of Dr. David V. Anderson
EX. 1010	<i>Curriculum Vitae</i> of Dr. David V. Anderson
EX. 1011	<i>Amazon.com, Inc. v. Jawbone Innovations, LLC</i> , IPR2023-00279, Decision on Institution, Paper 10 (May 24, 2023)
EX. 1012	<i>Jawbone Innovations, LLC v. Google LLC</i> , No. 6:21-cv-00985, ECF 105, Order Transferring Case (W.D. Tex. Feb. 1, 2023)
EX. 1013	<i>Jawbone Innovations, LLC v. Google LLC</i> , 3:23-cv-00466, ECF 137, Order Granting Stay Pending <i>Inter Partes</i> Review (N.D. Cal. Apr. 27, 2023)

LISTING OF CHALLENGED CLAIMS

Claim 1	
[1pre]	An acoustic voice activity detection system comprising:
[1a]	a first virtual microphone comprising a first combination of a first signal and a second signal, wherein the first signal is received from a first physical microphone and the second signal is received from a second physical microphone;
[1b]	a filter, wherein the filter is formed by generating a first quantity by applying a calibration to at least one of the first signal and the second signal, generating a second quantity by applying a delay to the first signal, and forming the filter as a ratio of the first quantity to the second quantity; and
[1c]	a second virtual microphone formed by applying the filter to the first signal to generate a first intermediate signal and summing the first intermediate signal and the second signal,
[1d]	wherein acoustic voice activity of a speaker is determined to be present when an energy ratio of energies of the first virtual microphone and the second virtual microphone is greater than a threshold value.
Claim 2	
[2]	The system of claim 1, wherein the first virtual microphone and the second virtual microphone have approximately similar responses to noise and approximately, dissimilar responses to speech.
Claim 3	
[3]	The system of claim 1, wherein a calibration is applied to the second signal, wherein the calibration compensates a second response of the second physical microphone so that the second response is equivalent to a first response of the first physical microphone.

Claim 4	
[4]	The system of claim 1, wherein the delay is applied to the first intermediate signal, wherein the delay is proportional to a time difference between arrival of the speech at the second physical microphone and arrival of the speech at the first physical microphone.
Claim 5	
[5]	The system of claim 1, wherein the first virtual microphone is formed by applying the filter to the second signal.
Claim 6	
[6]	The system of claim 5, wherein the first virtual microphone is formed by applying the calibration to the second signal.
Claim 7	
[7]	The system of claim 6, wherein the first virtual microphone is formed by applying the delay to the first signal.
Claim 8	
[8]	The system of claim 7, wherein the first virtual microphone is formed by subtracting the second signal from the first signal.
Claim 9	
[9]	The system of claim 1, wherein the filter is an adaptive filter.
Claim 10	
[10]	The system of claim 1, wherein the filter is adapted to minimize a second virtual microphone output when only speech is being received by the first physical microphone and the second physical microphone.
Claim 11	
[11]	The system of claim 1, wherein coefficients of the filter are

	generated during a period when only speech is being received by the first physical microphone and the second physical microphone.
Claim 12	
[12]	The system of claim 1, wherein the energy ratio comprises an energy ratio for a frequency band.
Claim 13	
[13]	The system of claim 1, wherein the energy ratio comprises an energy ratio for a frequency subband.

Petitioner Google LLC (“Petitioner”) requests an *inter partes* review (“IPR”) of claims 1-13 (the “Challenged Claims”) of U.S. Patent No. 8,321,213 (“the ’213 Patent”). This petition is substantively the same as the petition in IPR2023-00279 (which is instituted) and is concurrently filed with a motion requesting joinder with that proceeding.

I. REQUIREMENTS FOR IPR

A. Grounds for Standing

Petitioner certifies that the ’213 patent is available for IPR. This petition is accompanied by a motion for joinder. Pursuant to 37 C.F.R. 42.122(b), Petitioner is not barred or estopped from requesting this review.

B. Challenge and Relief Requested

Petitioner requests IPR on the following grounds.

Ground	Claims	§103 Basis
1	1-3, 5-9, 12, 13	Avendano ’880, Hou
2	4, 10, 11	Avendano ’880, Avendano ’252, Hou

C. Priority Date

The '213 patent was filed 10/26/2009 as a continuation-in-part of applications filed 05/25/2007 and 06/13/2008, and claims priority to a provisional application filed 10/24/2008.

The Challenged Claims are not entitled to the 05/25/2007 and 06/13/2008 dates because neither application discloses: (i) “a filter, wherein the filter is formed by generating a first quantity by applying a calibration to at least one of the first signal and the second signal, generating a second quantity by applying a delay to the first signal, and forming the filter as a ratio of the first quantity to the second quantity,” and (ii) “wherein acoustic voice activity of a speaker is determined to be present when an energy ratio of energies of the first virtual microphone and the second virtual microphone is greater than a threshold value.” Thus, the earliest possible priority date is 10/24/2008 (“Critical Date”).

Each reference qualifies as prior art:

Reference	Date	Section
Avendano '880	01/29/2007 (filed)	§102(e)
Avendano '252	03/31/2008 (filed) 01/29/2007 (filed, priority application)	§102(e)

Hou	03/14/2001 (filed)	§102(e)
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Avendano '252 qualifies as prior art because its filing date (03/31/2008) and the filing date of U.S. App. No. 11/699,732 (“Avendano Priority Application”) (01/29/2007), from which Avendano '252 claims priority, predate the Critical Date.¹

1. Dynamic Drinkware Analysis

Avendano '252 claims priority to the Avendano Priority Application. EX. 1006, 1:8-23. The Avendano Priority Application is incorporated in its entirety in Avendano '252. *Id.* Avendano '252 is entitled to the 01/29/2007 filing date because the Avendano Priority Application includes the relevant prior art disclosure and supports at least one of Avendano '252's claims (claim 1), as shown below.

(a) A method for adaptive processing of a close microphone array in a noise suppression system, comprising:

EX. 1007, [0008], [0021], [0062]-[0070], FIGS. 7-8; EX. 1003, ¶85.

(b) receiving a primary acoustic signal and a secondary acoustic signal;

EX. 1007, [0009], [0022]-[0024], [0027], [0029], [0062], FIGS. 1a-1b, 2-5, 7; EX. 1003, ¶85.

¹ The Avendano Priority Application issued as U.S. Pat. No. 8,194,880 (*i.e.*, Avendano '880).

(c) performing frequency analysis on the primary and secondary acoustic signals to obtain

EX. 1007, [0010]-[0011], [0029]-[0037], [0053]-[0060], [0063]-[0064], FIGS. 3-5, 7; EX. 1003, ¶85.

(d) generating a forward-facing cardioid pattern and a backward-facing cardioid pattern based on the sub-band signals;

EX. 1007, [0010]-[0011], [0029]-[0037], [0053]-[0061], [0063]-[0064], FIGS. 3-7; EX. 1003, ¶85.

(e) generating a forward-facing cardioid pattern and a backward-facing cardioid pattern based on the sub-band signals;

EX. 1007, [0010]-[0011], [0029]-[0037], [0053]-[0061], [0063]-[0064], FIGS. 3-7; EX. 1003, ¶85.

(f) outputting a noise suppressed signal.

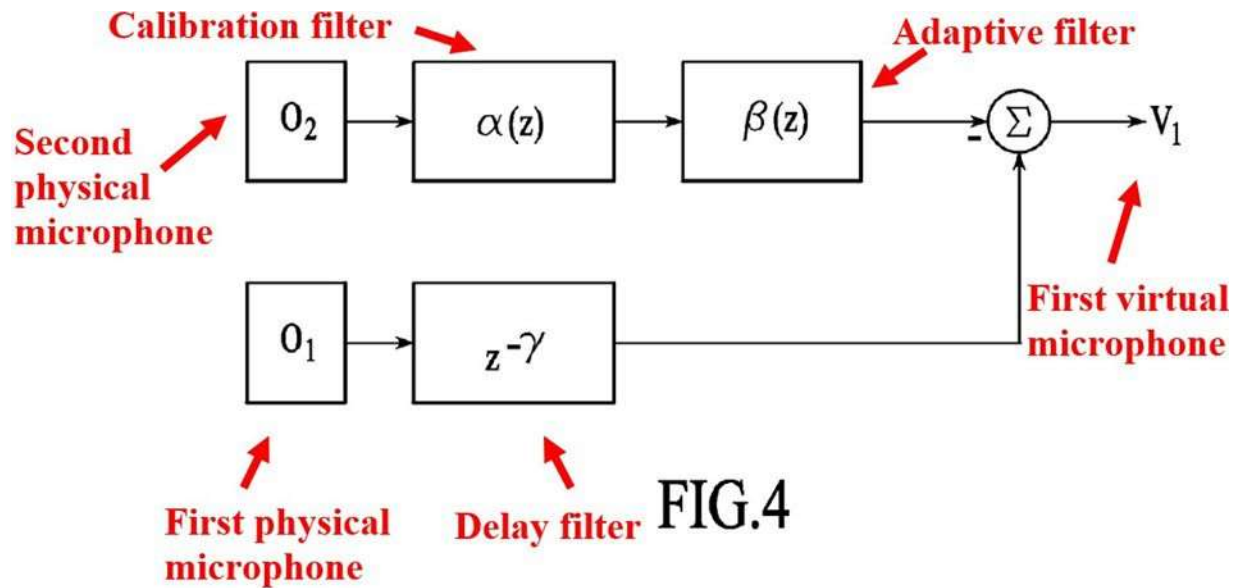
EX. 1007, [0011], [0038]-[0052], [0065]-[0071], FIGS. 3-5, 7, 8; EX. 1003, ¶85.

II. BACKGROUND

A. Overview of the '213 Patent

The '213 patent “relates to noise suppression systems, devices, and methods for use in acoustic applications.” EX. 1001, 1:16-18; EX. 1003, ¶¶42-49. A first virtual microphone (V_1) is generated by (i) applying a delay filter ($z^{-\gamma}$) to a signal

from a first physical microphone (O_1), (ii) applying a calibration filter ($\alpha(z)$) and an adaptive filter ($\beta(z)$) to a signal from a second physical microphone (O_2), and (iii) combining the filtered signals. EX. 1001, 5:20-6:19, FIG. 4.



EX. 1001, FIG. 4²

A second virtual microphone (V_2) is generated by (i) applying an adaptive filter ($\beta(z)$) and a delay filter ($z^{-\gamma}$) to the signal from a first physical microphone (O_1), (ii) applying a calibration filter ($\alpha(z)$) to the signal from a second physical microphone (O_2), and (iii) combining the filtered signals. *Id.*, 5:20-6:19, FIG. 3.

² Red annotations added throughout.

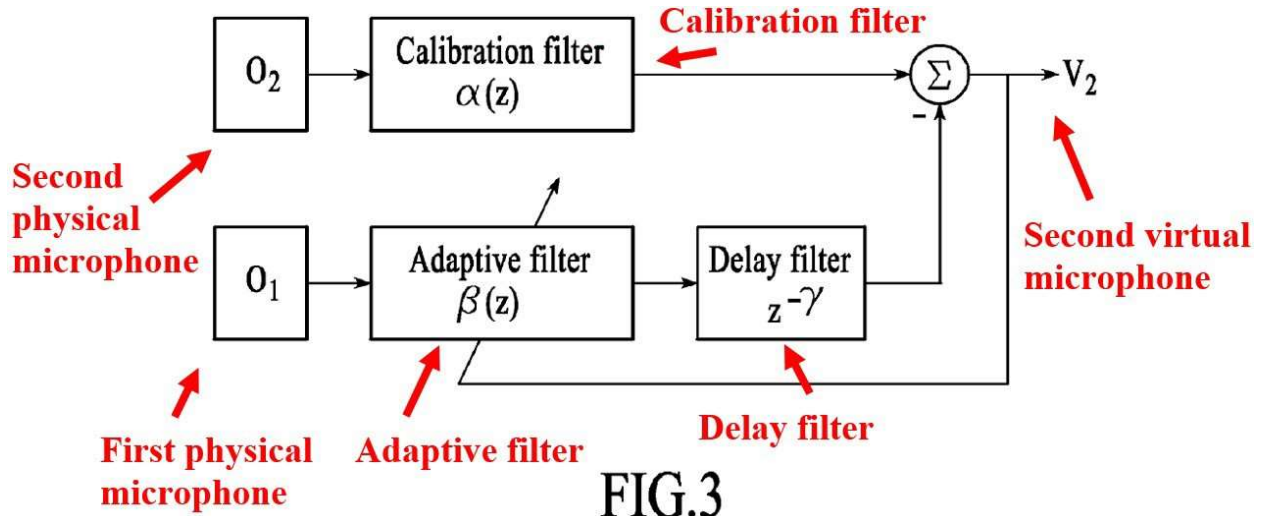


FIG.3

EX. 1001, FIG. 3

The ratio of energies of the first and second virtual microphones is used “to determine when speech is occurring.” *Id.*, 6:20-10:8, FIGS. 5-11. A ratio that is greater than a threshold is indicative of voice activity, whereas a ratio that is less than the threshold is indicative of an absence of voice activity. *Id.*, 6:47-51, 7:5-7, FIGS. 5-11; EX. 1003, ¶¶42-49.

B. Prosecution History

The claims were allowed after the filing of a terminal disclaimer over U.S. App. No. 12/606,140. EX. 1002, 195-196, 218-219, 227-234. None of Avendano ’880, the Avendano Priority Application, Hou, or Avendano ’252 was cited during prosecution of the ’213 patent. EX. 1003, ¶50.

C. Level of Ordinary Skill

A person of ordinary skill in the art (“POSITA”) would have at least a bachelor of science in electrical engineering, computer engineering, computer science, mechanical engineering, or a related discipline, with at least two years of relevant experience in a field related to acoustics, speech recognition, speech detection, or signal processing. EX. 1003, ¶¶22-23. Additional education or industry experience may compensate for a deficit in the other. *Id.*

D. Claim Construction

No formal claim constructions are necessary because “claim terms need only be construed to the extent necessary to resolve the controversy.” *Well-man, Inc. v. Eastman Chem. Co.*, 642 F.3d 1355, 1361 (Fed. Cir. 2011).³

III. GROUND 1: Avendano ’880 and Hou (Claims 1-3, 5-9, 12, 13)

A. Avendano ’880 Overview

Avendano ’880 determines “inter-microphone level differences (ILD) ... based on energy level differences of a pair of omni-directional microphones,” and uses ILD “to attenuate noise and enhance speech.” EX. 1005, 2:5-9; EX. 1003, ¶¶51-67.

³ Petitioner is neither conceding that each claim satisfies all statutory requirements, such as §§101 and 112, nor waiving any arguments concerning claim scope or grounds that can only be raised in district court.

Avendano '880 discloses “audio device 104” having “primary microphone 106” and “secondary microphone 108,” which may be “omni-directional microphone[s].” EX. 1005, 3:27-35; FIGS. 1a-1b; EX. 1003, ¶52.

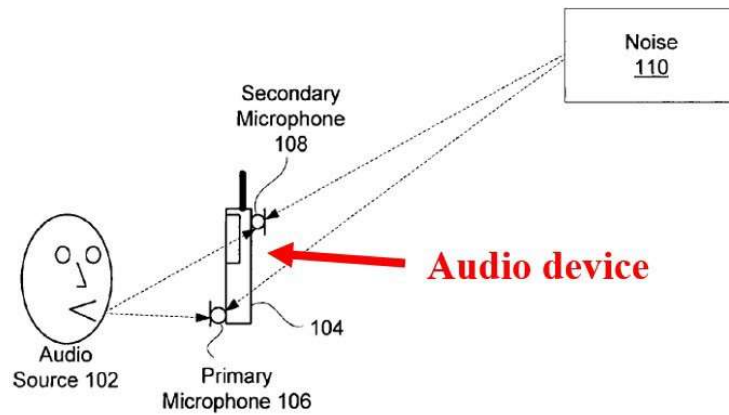


FIG. 1a

EX. 1005, FIG. 1a

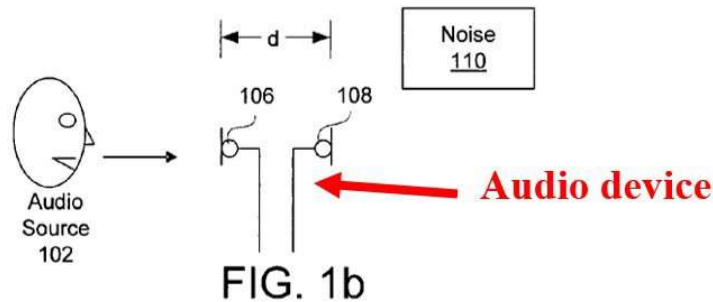


FIG. 1b

EX. 1005, FIG. 1b

Avendano '880's "primary microphone 106 is much closer to [an] audio source 102 than the secondary microphone 108," and thus "the intensity level is higher for the primary microphone 106 resulting in a larger energy level during a speech/voice segment." EX. 1005, 3:45-55, FIGS. 1a-1b; EX. 1003, ¶53.

Avendano '880 uses this "level difference ... to discriminate speech and noise in the time-frequency domain." EX. 1005, 3:55-57; EX. 1003, ¶¶54-55. For example, Avendano '880 receives signals from the two microphones (signals x_1 and x_2), and processes the signals using "differential microphone array (DMA) module 302" to "create two different directional patterns around the audio device 104." EX. 1005, 4:20-41. As Avendano '880 explains, "[e]ach directional pattern is a region about the audio device 104 in which sounds generated by an audio source 102 within the region may be received by the microphones 106 and 108 with little attenuation," and "[s]ounds generated by audio sources 102 outside of the directional pattern may be attenuated." *Id.*, 4:41-46.

Avendano '880's DMA module 302 generates (i) a first processed signal having a directional pattern for receiving sounds "within a front cardioid region around the audio device 104" (*i.e.*, "cardioid primary signal (C_f)"), and (ii) a second processed signal having a directional pattern for receiving sounds "within a back cardioid region around the audio device 104" (*i.e.*, "cardioid secondary signal (C_b)"). *Id.*, 4:47-52, 5:25-35, 9:29-42, FIG. 6 (below); EX. 1003, ¶¶56-59.

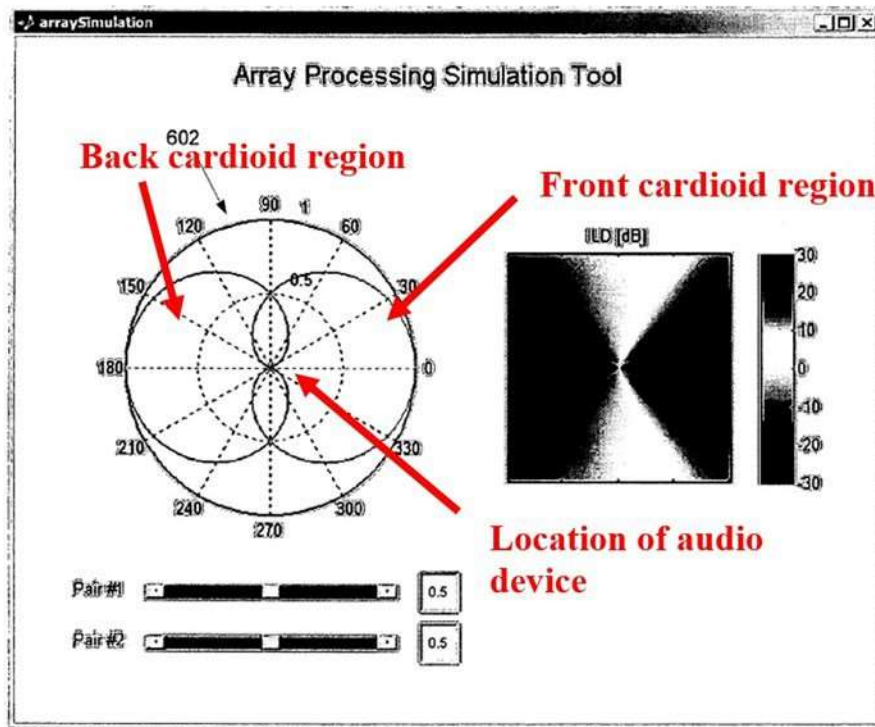


FIG. 6

EX. 1005, FIG. 6

Avendano '880's "cardioid primary signal (Cf)" is generated by combining (i) signal x1 from primary microphone 106, and (ii) signal x2 from secondary microphone 108 (signal x2 having been delayed by "delay node 404" and filtered by "gain module 406"). EX. 1005, 5:15-35, FIG. 4a; EX. 1003, ¶60. Avendano '880's "cardioid secondary signal (Cb)" is generated by combining (i) signal x2 from secondary microphone 108, and (ii) signal x1 from primary microphone 106 (signal x1 having been delayed by "delay node 402"). EX. 1005, 5:15-35, FIG. 4a; EX.

1003, ¶60. The “delay nodes” are implemented using filters (“allpass filters”). EX.

1005, 8:47-51; EX. 1003, ¶60.

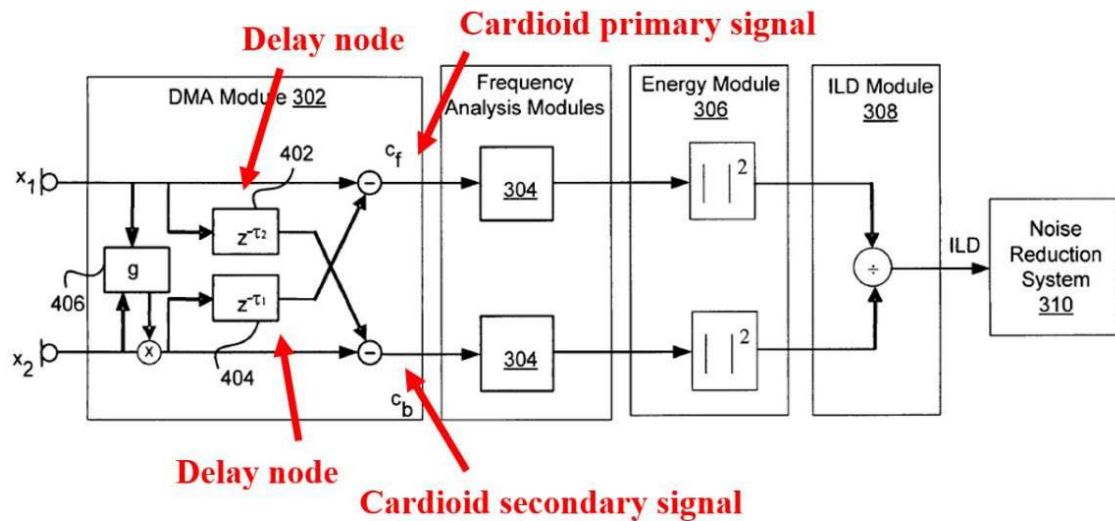


FIG. 4a

EX. 1005, FIG. 4a

Further, Avendano '880 detects speech based on the ratio between (i) the energy of “cardioid primary signal (C_f)” and (ii) the energy of “cardioid secondary signal (C_b).” EX. 1005, 5:49-6:34; EX. 1003, ¶¶61-66. Specifically, an “energy level” (E_f) associated with “cardioid primary signal (C_f)” is calculated:

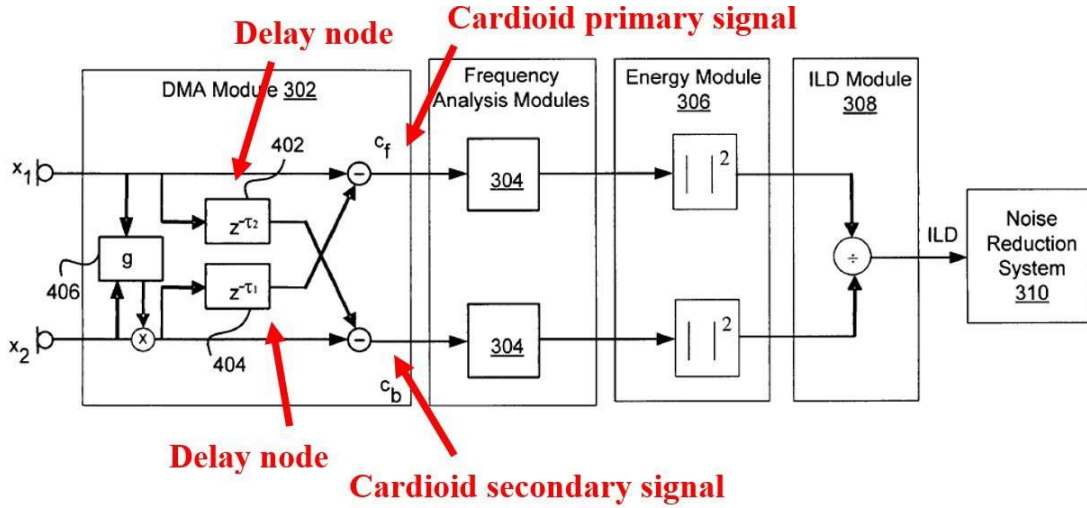


FIG. 4a

$$E_f(t, \omega) = \int_{frame} |C_f(t', \omega)|^2 dt',$$

EX. 1005, 5:60

Further, an “energy level” (E_b) associated with “cardioid secondary signal (C_b)” is calculated:

$$E_b(t, \omega) = \int_{frame} |C_b(t', \omega)|^2 dt'.$$

EX. 1005, 6:5

The ratio between these two energy levels (ILD) is determined:

$$ILD(t, \omega) = \frac{\int |C_f(t', \omega)|^2 dt'}{\int_{frame} |C_b(t', \omega)|^2 dt'}.$$

← Energy level of C_f
 ← Energy level of C_b

EX. 1005, 6:16

Avendano '880 compares the ratio (ILD) to a “threshold” to determine the presence or absence of speech:

$$\lambda_I(t, \omega) = \begin{cases} \approx 0 & \text{if } ILD(t, \omega) < \text{threshold} \\ \approx 1 & \text{if } ILD(t, \omega) > \text{threshold} \end{cases}$$

EX. 1005, 6:61

If the ratio (ILD) is “smaller than a threshold value (e.g., threshold=0.5) above which speech is expected to be,” a value λ_1 is set to zero (e.g., indicating an absence of speech). EX. 1005, 6:58-7:3. However, if the ratio (ILD) “starts to rise (e.g., because speech is present within the large ILD region), λ_1 increases” (e.g., is set to one, indicating a presence of speech). *Id.*

Avendano '880's ratio is used to process audio signals “through a noise reduction system 310” to “enhance the speech of the primary acoustic signal.” *Id.*, Abstract, 6:35-8:23, 10:18-50, FIGS. 7-8; EX. 1003, ¶67.

B. Hou Overview

Hou describes “[i]mproved approaches to matching sensitivities of microphones in multi-microphone directional processing systems ... so that directional noise suppression is robust.” EX. 1008, Abstract; EX. 1003, ¶¶68-78. Specifically, Hou's “two-microphone directional processing system 500” “compensate[s] (or correct[s]) for the relative difference in sensitivity between ...

mismatched first and second microphones” and produces an “output signal ... hav[ing] robust directionality despite a mismatch between the first and second microphones.” EX. 1008, 5:25-56, FIG. 5.

As Hou explains, a system generates directional signals by suppressing sounds (e.g., “interference”) coming from particular directions relative to a system. *Id.*, 1:22-2:2; EX. 1003, ¶70. In particular, an “output signal” that is directional “is dependent on which directions the input signals come from.” EX. 1008, 1:22-2-2. Further, “[t]he sensitivity of the microphones of the sound pick up system must be matched in order to achieve good directionality.” *Id.*

Hou describes various techniques for producing directional signals. EX. 1003, ¶¶71-77. In one example, Hou’s system receives “a first electronic sound signal” from “microphone 502,” and “estimates the minimum for the first electronic sound signal” using “first minimum estimate unit 508” (e.g., by measuring the minimum for the first electronic sound signal “over a time constant duration”). EX. 1008, 5:27-41, FIG. 5.

Further, Hou’s system receives “a second electronic sound signal” from “microphone 504,” delays the “second electronic sound signal” using “delay unit 506,” and “estimates the minimum for the second electronic sound signal” using “second minimum estimate unit 510” (e.g., by measuring the minimum for the second electronic sound signal “over a time constant duration”). *Id.*

Further, “divide unit 512 produces a quotient by dividing the first minimum estimate by the second minimum estimate,” where “[t]he quotient represents a scaling amount that is sent to a multiplication unit 514.” *Id.*, 5:42-45.

Further, “[t]he second electronic sound signal is then multiplied with the scaling amount to produce a compensated sound signal.” *Id.*, 5:45-47. “The compensated sound signal is thus compensated (or corrected) for the relative difference in sensitivity between the mismatched first and second microphones 502

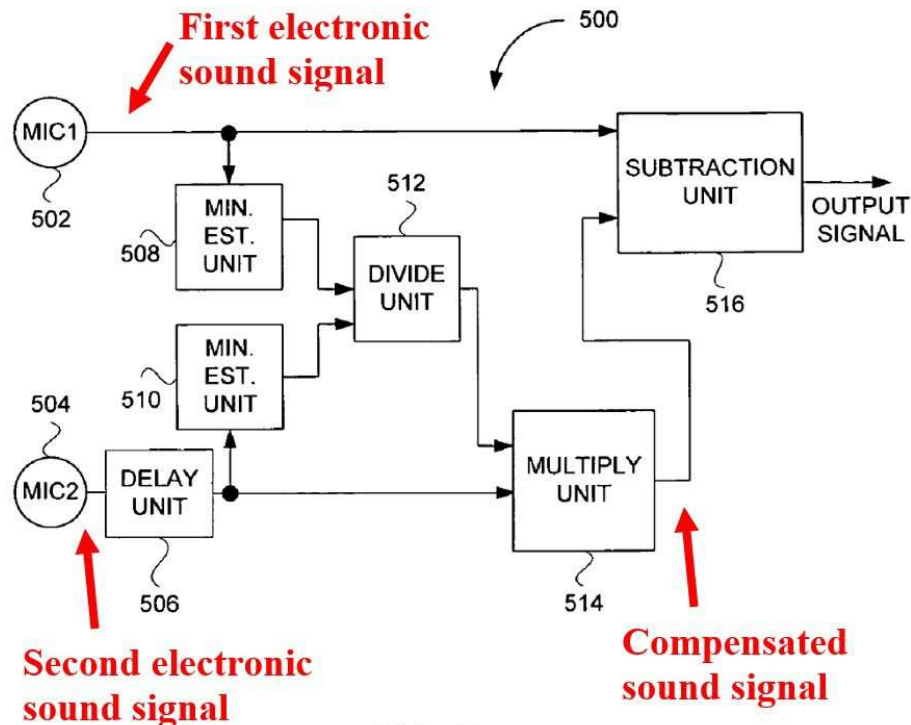


FIG. 5

and 504.” *Id.*, 5:47-50.

EX. 1008, FIG. 5

Further, “subtraction unit 516 then subtracts the compensated electronic sound signal from the first electronic sound signal to produce an output signal ... hav[ing] robust directionality despite a mismatch between the first and second microphones 502 and 504.” *Id.*, 5:50-56.

As Hou describes, generating a compensated sound signal ensures that “directional noise suppression is not affected by microphone mismatch, ... the drift of microphone sensitivity over time, ... [or] the non-uniform distribution of sound pressure in real-life application.” *Id.*, 9:28-41; EX. 1003, ¶78.

C. Combination of Avendano ’880 and Hou

A POSITA would have found it obvious to combine Avendano ’880 with Hou. EX. 1003, ¶¶86-126.

Motivations for Combining Avendano ’880 and Hou

A POSITA would have been motivated to combine Avendano ’880 with Hou for several reasons. EX. 1003, ¶¶87-100.

First, both Avendano ’880 and Hou come from the same field of endeavor of enhancing speech and attenuating noise. EX. 1005, Abstract, 1:24-26, 3:13-26, 3:42-60; EX. 1008, Abstract, 2:44-52, 4:40-49; EX. 1003, ¶88.

Second, both Avendano ’880 and Hou describe enhancing speech and attenuating noise using similar techniques, including (i) capturing signals from at least two physical microphones, and (ii) processing these signals in various ways,

including equalizing the signal levels of two signals and generating directional signals based on the equalized signals. EX. 1003, ¶¶89-94.

For example, Avendano '880's "primary microphone 106 is much closer to [an] audio source 102 than the secondary microphone 108," and thus "the intensity level is higher for the primary microphone 106 resulting in a larger energy level during a speech/voice segment." EX. 1005, 3:27-55; Section III(A); EX. 1003, ¶90. To account for the differences in intensity levels, Avendano '880's "DMA module 302" applies "gain factor, g " to a second signal "to equalize the signal levels" of the first and second signals. EX. 1005, 5:36-39, 9:54-59, FIGS. 4a-4b; EX. 1003, ¶91. Such equalization is beneficial, as "systems can suffer loss of performance when the microphone signals have different levels." EX. 1005, 5:37-39; EX. 1003, ¶91. Further, Avendano '880's "DMA module 302" uses the equalized signal to generate directional signals, such as "cardioid primary signal (C_f)" (front) and "cardioid secondary signal (C_b)" (back). EX. 1005, 4:41-52, 5:25-35, FIGS. 4a-4b, 6; EX. 1003, ¶92.

Hou's "system 500" serves a similar function as Avendano '880's "DMA module 302," namely "compensat[ing] (or correct[ing]) for the relative difference in sensitivity between ... mismatched first and second microphones." EX. 1008, 5:47-50; EX. 1003, ¶¶93-94. Similarly, Hou explains that compensation or correction is beneficial, as "[t]he sensitivity of the microphones of the sound pick up system must

be matched in order to achieve good directionality.” EX. 1008, 1:48-2:2; EX. 1003, ¶93. Further, like Avendano ’880, Hou processes the compensated or corrected signal to generate a directional signal (*e.g.*, “an output signal ... hav[ing] robust directionality”) to aid in “directional noise suppression.” EX. 1008, 5:50-56, 9:28-41; EX. 1003, ¶94.

A POSITA would have recognized that Avendano ’880 teaches the importance of equalizing signal levels of signals generated by two respective microphones, and that Hou discloses a specific “system 500” for performing precisely this function. EX. 1003, ¶95-. Accordingly, a POSITA would have been motivated to implement Hou’s signal compensation or correction components in Avendano ’880 to further improve the equalization of the signal output by the microphones (*e.g.*, to generate a signal “hav[ing] robust directionality” and to enhance “directional noise suppression”). EX. 1008, 5:50-56, 9:28-41; EX. 1003, ¶¶95-99.

For instance, a POSITA would have incorporated aspects of Hou’s “system 500” into Avendano ’880’s “DMA module 302” to compensate (or correct) for the relative difference in sensitivity between ... mismatched first and second microphones” in order to generate a signal “hav[ing] robust directionality” in a backwards direction (*e.g.*, to improve the directionality of Avendano ’880’s rear-facing cardioid secondary signal). EX. 1008, 5:25-56; EX. 1003, ¶96.

Further, a POSITA would have found it obvious to implement Hou's "system 500" in conjunction with Avendano '880's "gain factor, g." EX. 1003, ¶97. For example, a POSITA would have recognized that Avendano '880's "gain factor, g" and Hou's "system 500" are configured to equalize the signal levels of microphone signals at different respective stages in a signal processing operation, and that the combination of the two would provide benefits that may not be obtained with either of the two alone. EX. 1005, 5:36-39, 9:54-59, FIGS. 4a-4b; EX. 1008, 5:17-6:22, FIG. 5; EX. 1003, ¶97.

Specifically, a POSITA would have recognized that Avendano '880's "gain factor, g" is configured to perform signal equalization at an initial stage of a signal processing operation (*e.g.*, prior to performing any other signal processing tasks). EX. 1005, 5:36-39, 9:54-59, FIGS. 4a-4b; EX. 1003, ¶98. Thus, Avendano '880's "gain factor, g" would be suitable for performing an initial signal compensation or correction for two microphone signals, in order to account for a general "loss of performance when the microphone signals have different levels." EX. 1005, 5:36-39; EX. 1003, ¶98.

Further, a POSITA would have recognized that Hou's "system 500" is configured to perform a signal equalization at a late stage of a signal processing operation (*e.g.*, just prior to combining two signals together to create a combined signal having "robust directionality"), specifically based on the estimated minimums

of the signals. EX. 1003, ¶99. Thus, Hou's "system 500" would be suitable for performing an additional signal compensation or correction for two microphone signals, such that the directionality of a combination of the two signals is enhanced. EX. 1008, 5:17-6:22, FIG. 5; EX. 1003, ¶99.

Two example modifications to Avendano '880's system based on the teachings in Hou are described below. EX. 1003, ¶¶100-121.

First Example Modification

As a first example modification, a POSITA would have incorporated aspects of Hou's system 500 (*e.g.*, "delay unit 506," "first minimum estimate unit 508," "second minimum estimate unit 510," "divide unit 512," and "multiplication unit 514") into Avendano '880's system to enhance the signal equalization functionality of Avendano '880's system. EX. 1003, ¶101. Further, a POSITA would have incorporated Hou's subtraction unit 516" into Avendano '880's system to generate a signal having "robust directionality" in a backwards direction. EX. 1008, 5:50-56; EX. 1003, ¶101.

In particular, in the combination, Avendano '880's signal x_2 (*e.g.*, to which Avendano '880's "gain factor, g " is applied) would be processed by Hou's "minimum estimate unit 508" (*e.g.*, along Hou's upper signal pathway). EX. 1008, 5:36-38, FIG. 5; EX. 1003, ¶102. Further, Avendano '880's signal x_1 would be processed by Hou's "delay unit 506" and "minimum estimate unit 510" (*e.g.*, along

Hou's lower signal pathway). EX. 1008, 5:32-39, FIG. 5; EX. 1003, ¶103. Further, Hou's "divide unit 512" would calculate a gain as the quotient of the output of "first minimum estimate unit 508" and the output of "second minimum estimate unit 510." EX. 1008, FIG. 5:42-43; FIG. 5; EX. 1003, ¶104. Further still, the calculated gain would be applied to Avendano '880's signal x_1 by "multiplication unit 514" to generate a compensated signal. EX. 1008, 5:42-50, FIG. 5; EX. 1003, ¶104.

For example, as shown below, Avendano '880's system would provide first and second signals to Hou's lower and upper signal pathways, respectively (EX. 1003, ¶105):

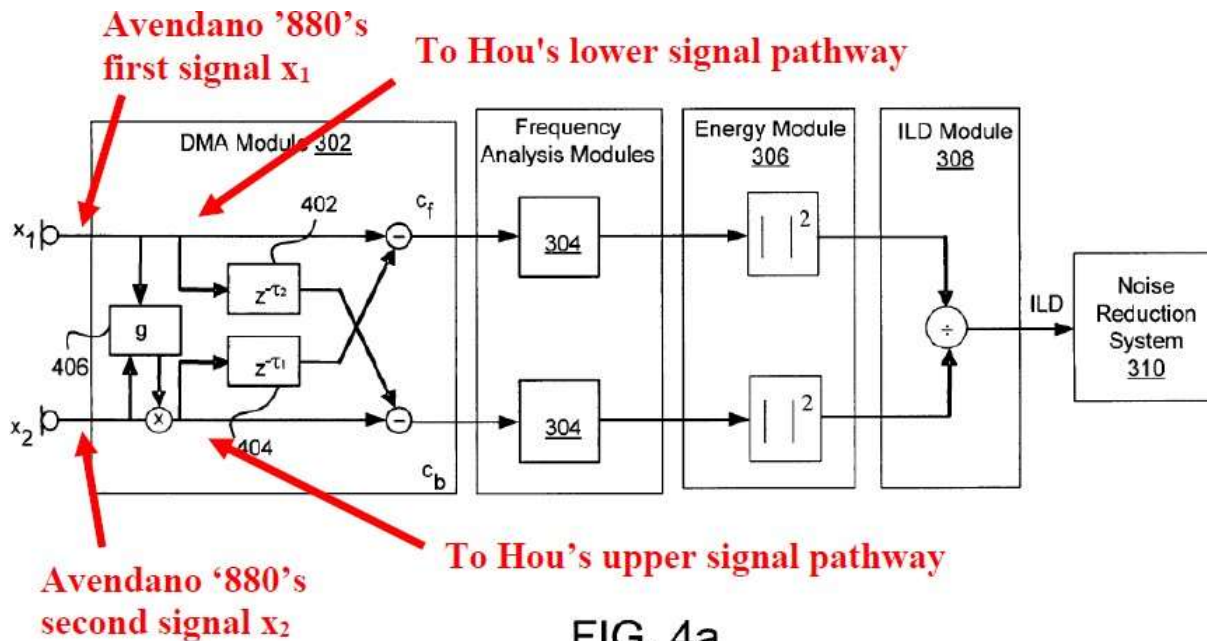


FIG. 4a

EX. 1005, FIG. 4a

Further, as shown below, Hou's system would calculate a gain based on the received signals and generate a compensated signal using the calculated gain (EX. 1003, ¶106):

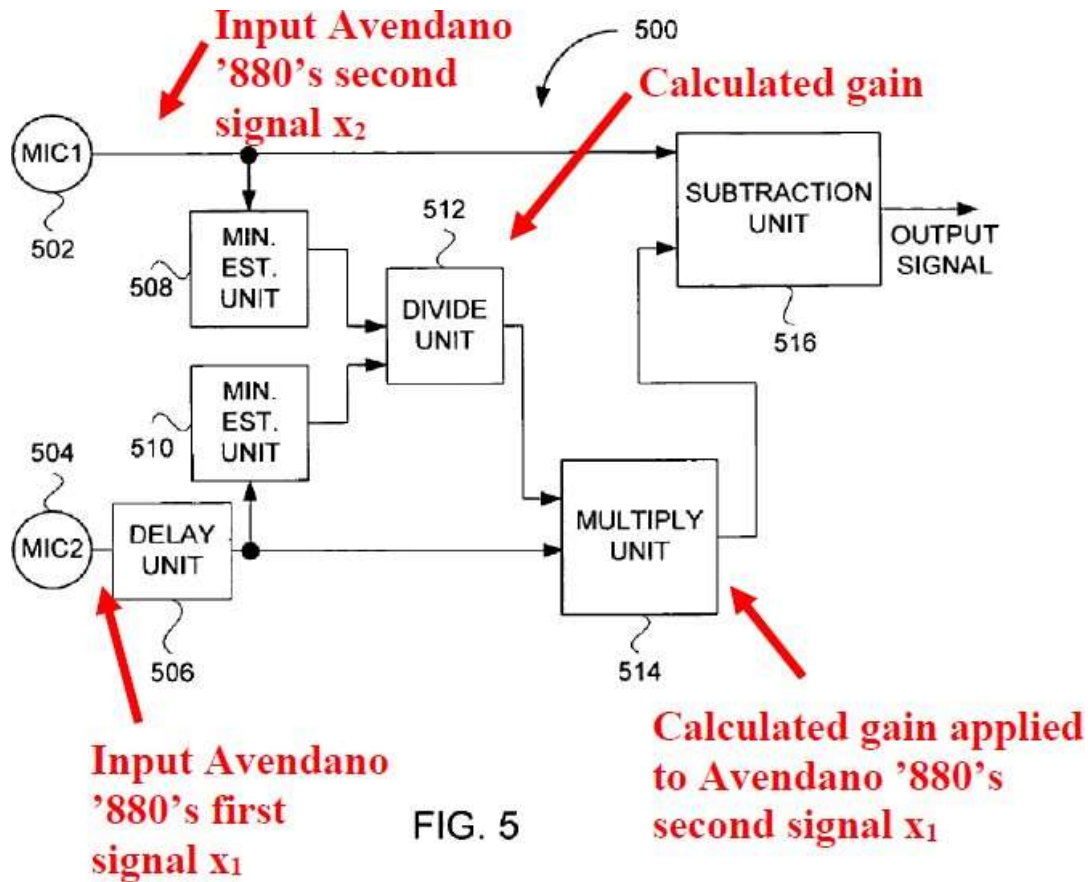


FIG. 5

EX. 1008, FIG. 5

Although Hou multiplies one of the signals by the calculated gain, a similar equalization effect could be achieved by multiplying the other signal by the inverse of the calculated gain. EX. 1003, ¶107.

Further, Hou's "subtraction unit 516" would subtract Avendano '880's first signal x_1 (having been delayed by the "delay unit 506" and compensated by the calculated gain) from Avendano '880's secondary signal x_2 . EX. 1008, 5:49- 56, FIG. 5; EX. 1003, ¶108. The resulting signal would have "robust directionality" in a backwards direction. EX. 1008, 5:52-56; EX. 1003, ¶108.

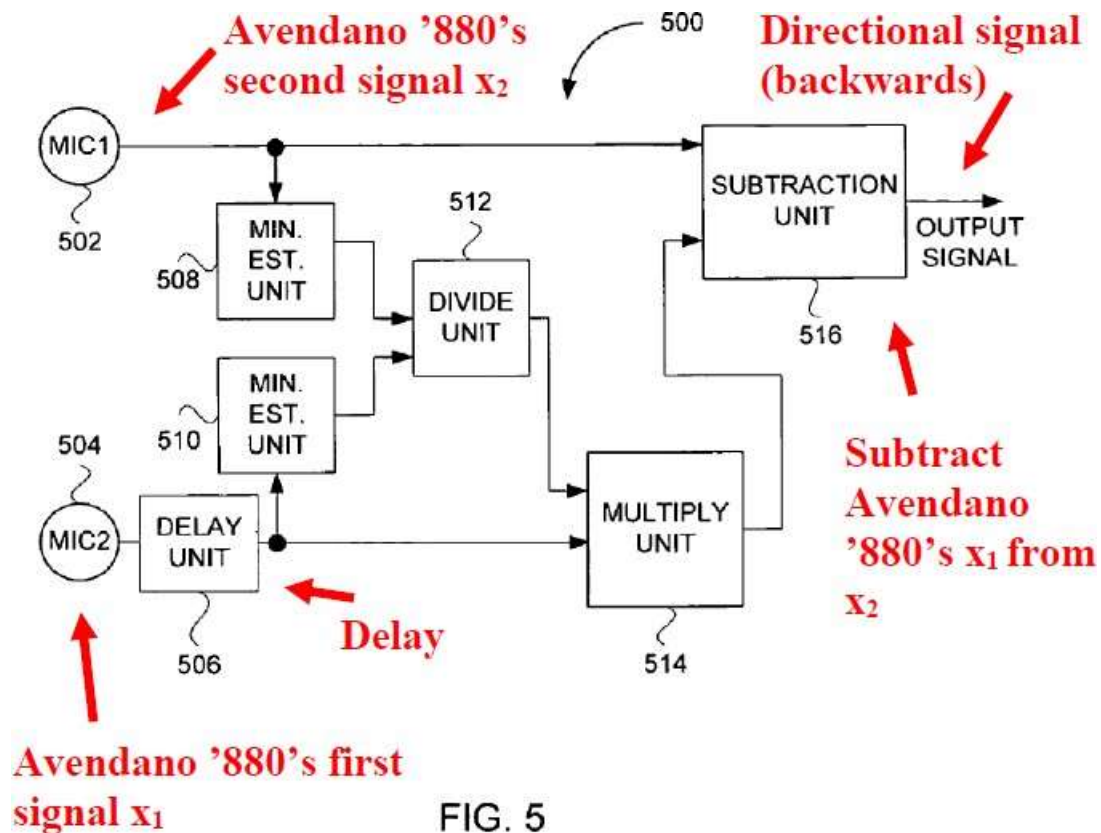


FIG. 5

EX. 1008, FIG. 5

This is analogous to Avendano '880's system in which Avendano '880's first signal x_1 (having been delayed by the "delay node 402") is subtracted from Avendano '880's secondary signal x_2 to generate a "cardioid secondary signal"

directed to the back of “audio device 104.” EX. 1005, 5:15-35, FIG. 4a, 6; EX. 1003, ¶109.

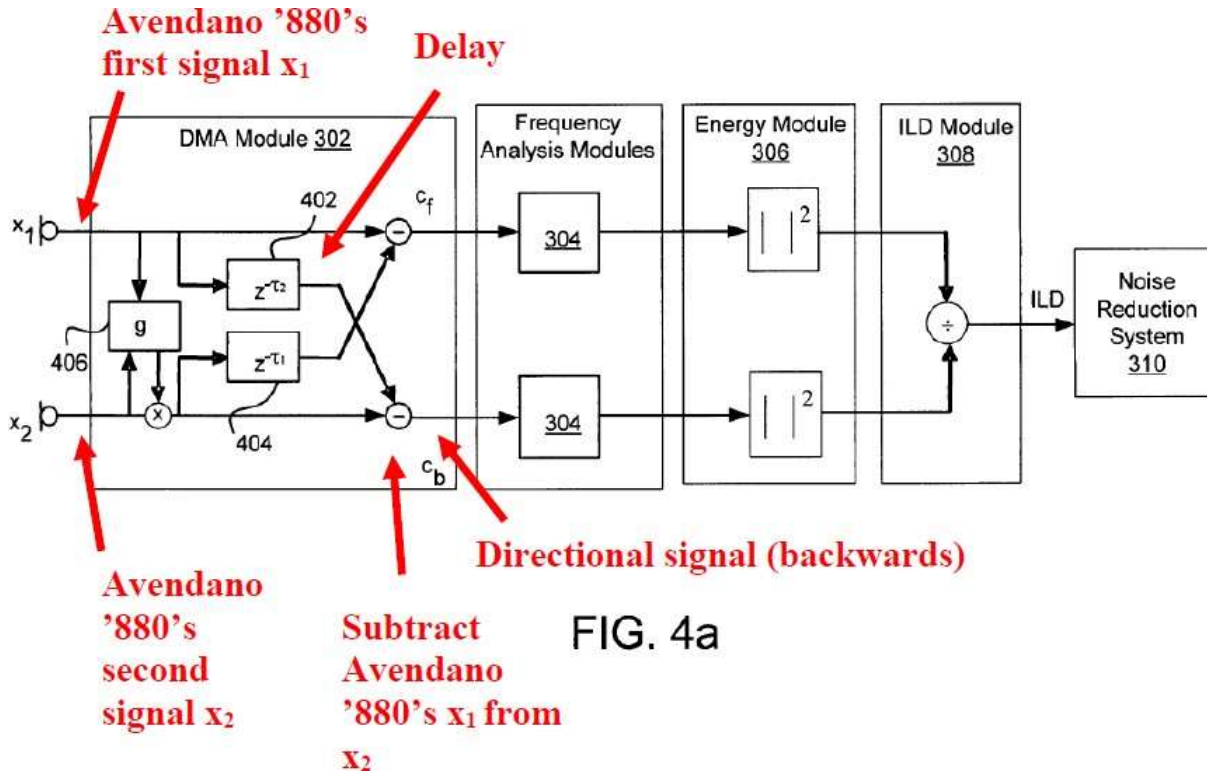


FIG. 4a

EX. 1005, FIG. 4a

Further, as discussed above, configuring Avendano '880's “gain factor, g ” and Hou's “system 500” to equalize the signal levels of microphone signals at different respective stages in a signal processing operation would provide benefits that may not be obtained with either of the two alone (*e.g.*, to not only account for a general “loss of performance when the microphone signals have different levels” at an initial stage of the signal processing operation, but to also provide a finer-tuning of the gain prior to the combination of the signals, and to specifically enhance the

directionality of a combination of the microphone signals at the late stage of the signal processing operation). EX. 1005, 5:36-39; EX. 1008, 5:17-6:22, FIG. 5; EX. 1003, ¶110.

Second Example Modification

As a second example modification, a POSITA would have incorporated Hou's "delay unit 506," "first minimum estimate unit 508," "second minimum estimate unit 510," and "divide unit 512" into Avendano '880's system to enhance the signal equalization functionality of Avendano '880's system. EX. 1003, ¶111.

In particular, a POSITA would have recognized that Hou teaches equalizing signals (*e.g.*, using "multiplication unit 514") immediately prior to subtracting one signal from the other (*e.g.*, using "subtraction unit 516") to produce a directional signal. EX. 1008, 5:45-56, FIG. 5; EX. 1003, ¶112.

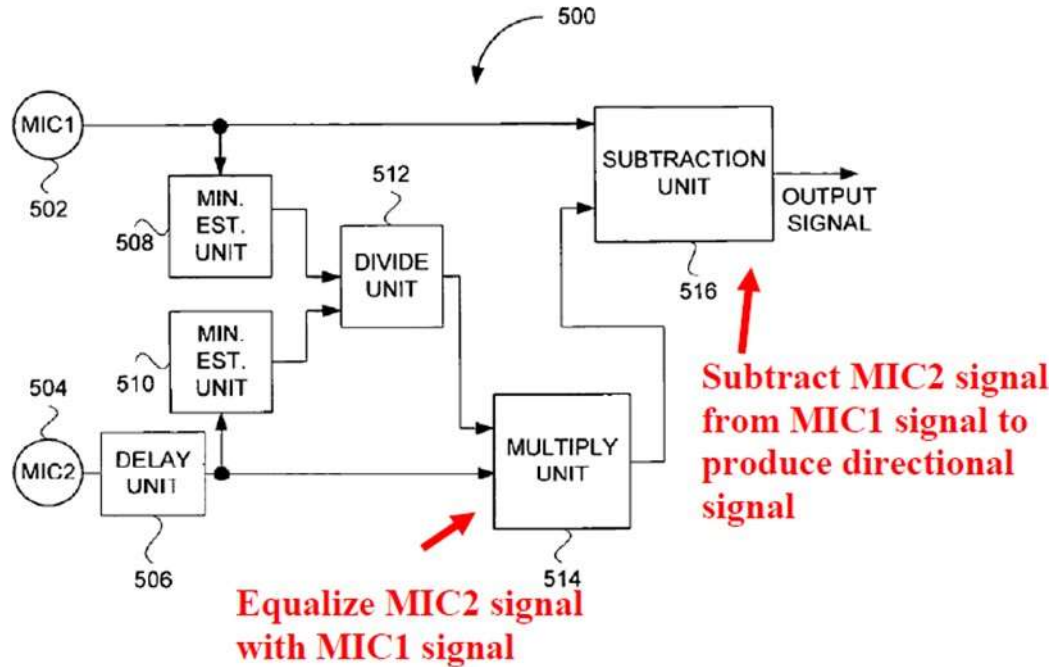
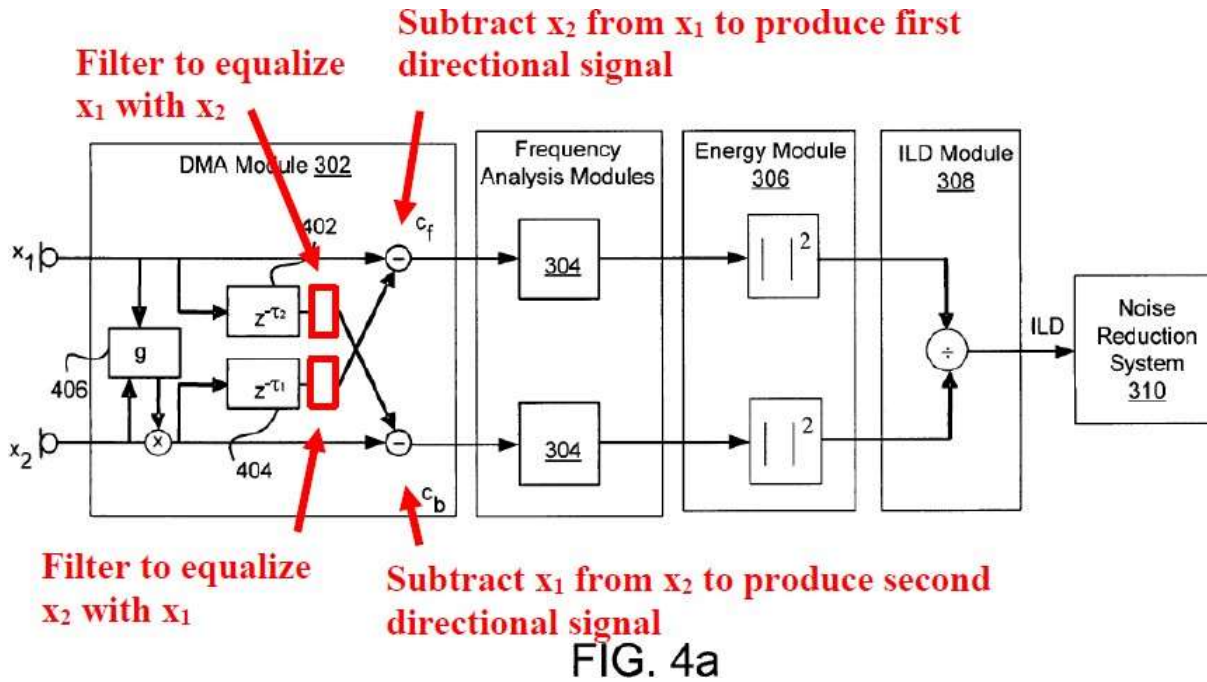


FIG. 5

EX. 1008, FIG. 5

In view of Hou, a POSITA would have found it obvious to modify Avendano '880's system to include filters that equalize Avendano '880's signals with one another immediately prior to subtracting one signal from the other to produce respective directional signals. EX. 1003, ¶113.



EX. 1005, FIG. 4a (modified)

Further a POSITA would have found it obvious to implement such filters using Hou's "delay unit 506," "first minimum estimate unit 508," "second minimum estimate unit 510," "divide unit 512," and "multiplication unit 514." EX. 1003, ¶114.

For example, to generate a filter to equalize Avendano '880's signal x_2 with Avendano '880's signal x_1 , Avendano '880's signal x_2 (e.g., to which Avendano '880's "gain factor, g " is applied) would be input into Hou's system 500 along the upper signal pathway, and would be processed by Hou's "minimum estimate unit 508." EX. 1008, 5:36-38, FIG. 5; EX. 1003, ¶115. Further, Avendano '880's signal x_1 would be input into Hou's system 500 along the lower signal pathway, and would be processed by Hou's "delay unit 506" and "minimum estimate unit 510." EX.

1008, 5:32-39, FIG. 5; EX. 1003, ¶116. Further, Hou's "divide unit 512" would calculate a gain as the quotient of the output of "first minimum estimate unit 508" and the output of "second minimum estimate unit 510." EX. 1008, FIG. 5:42-43; FIG. 5; EX. 1003, ¶117. Further still, the calculated gain would be applied to Avendano '880's signal x_1 by "multiplication unit 514" to generate a first compensated signal. EX. 1008, 5:42-50, FIG. 5; EX. 1003, ¶117.

For example, as shown below, Avendano '880's system would provide first and second signals to Hou's lower and upper signal pathways, respectively (EX. 1003, ¶118):

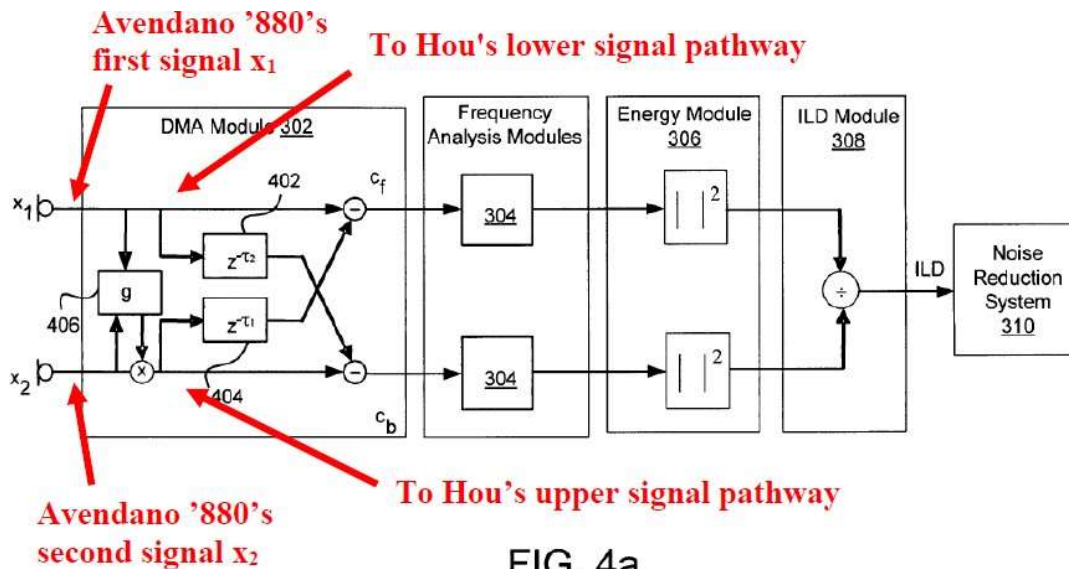


FIG. 4a

EX. 1005, FIG. 4a

Further, as shown below, Hou's system would calculate a gain based on the received signals and generate a compensated signal using the calculated gain (EX. 1003, ¶119):

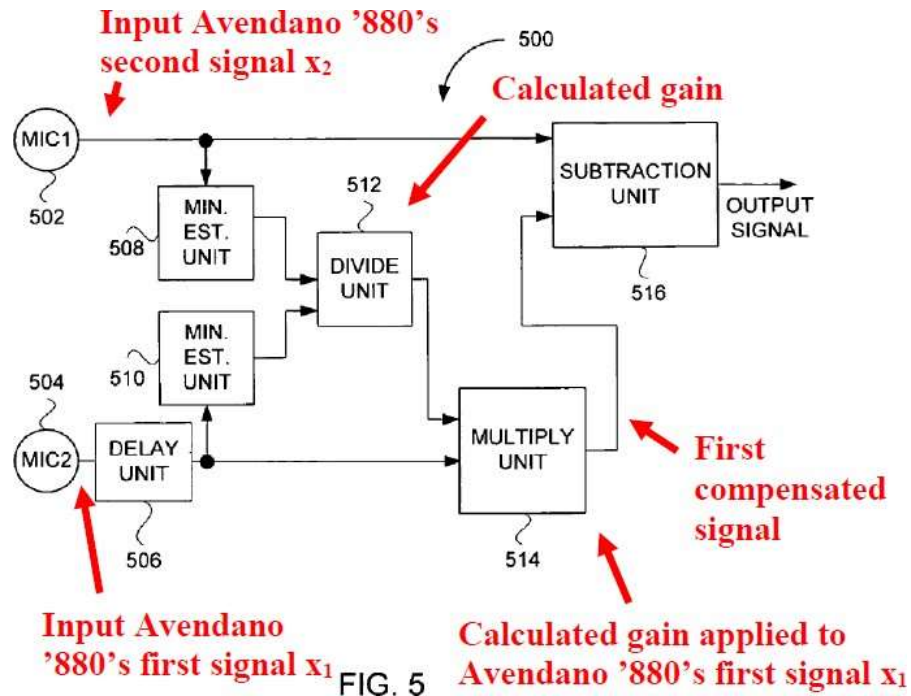


FIG. 5

EX. 1008, FIG. 5

The first compensated signal would be used to generate Avendano '880's "cardioid secondary signal (C_b) (e.g., by subtracting the first compensated signal from Avendano '880's signal x_2). EX. 1005, 5:15-35, FIG. 4a; EX. 1003, ¶120.

Further, a POSITA would have recognized that the inverse of the calculated gain could be used to generate a filter to equalize Avendano '880's signal x_1 with Avendano '880's signal x_2 . EX. 1003, ¶121. For example, the inverse of the calculated gain would be applied to Avendano '880's signal x_2 (e.g., by another

“multiplication unit 514”) to generate a second compensated signal. EX. 1008, 5:45-47, FIG. 5; EX. 1003, ¶121. The second compensated signal would be used to generate Avendano ’880’s “cardioid primary signal (C_f) (*e.g.*, by subtracting the second compensated signal from Avendano ’880’s signal x_1). EX. 1005, 5:15-35, FIG. 4a; EX. 1003, ¶121.

Reasonable Expectation of Success

In each of these example modifications, a POSITA would have had a reasonable expectation of success in incorporating Hou’s “system 500” in Avendano ’880’s system given the similarities between Avendano ’880’s “DMA module 302” and Hou’s “system 500.” EX. 1003, ¶¶122-126. For example, Avendano ’880’s “DMA Module 302” and Hou’s “system 500” receive similar input signals (*e.g.*, from two microphones), and generate similar outputs (*e.g.*, directional signals). EX. 1005, 4:20-54; 5:15-39; 9:53-64, FIGS. 4a-4b; EX. 1008, 4:40-6:22, FIG. 5; EX. 1003, ¶123. Further, Avendano ’880’s “DMA Module 302” and Hou’s “system 500” generate outputs in a similar manner (*e.g.*, by generating “equalized” or “compensated” signals, and subtracting one of the signals from the other). EX. 1005, 4:20-54; 5:15-39; 9:53-64, FIGS. 4a-4b; EX. 1008, 5:25-56; EX. 1003, ¶124. Given these similarities, limited modifications would have been necessary to incorporate Hou’s “system 500” into Avendano ’880’s system and other operations in Avendano ’880’s system would not have been impacted by the combination. EX. 1003, ¶125.

Thus, the combination of Avendano '880 and Hou would have been well within the grasp of a POSITA and a POSITA would have had a reasonable expectation of success in making the combination. *Id.*, ¶126.

D. Claim 1

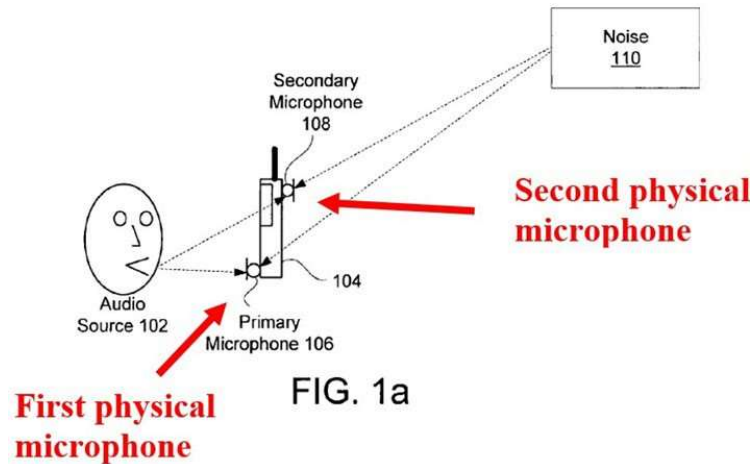
[1pre]: An acoustic voice activity detection system comprising:

To the extent the preamble of claim 1 is limiting, Avendano '880 discloses an acoustic voice activity detection system. EX. 1005, 3:13-26 (“[e]mbodiments of the present invention may be practiced on any audio device that is configured to receive sound such as, but not limited to, cellular phones, phone handsets, headsets, and conferencing systems”), 6:66-7:9 (“exemplary embodiments of the present invention may use a combination of minimum statistics and voice activity detection to determine the noise estimate”), FIGS. 1a-2; EX. 1003, ¶127.

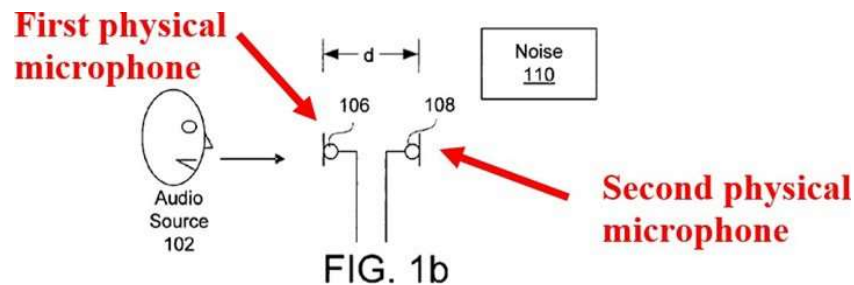
[1a]: a first virtual microphone comprising a first combination of a first signal and a second signal, wherein the first signal is received from a first physical microphone and the second signal is received from a second physical microphone;

Avendano '880 describes a first virtual microphone comprising a first combination of a first signal and a second signal, wherein the first signal is received from a first physical microphone and the second signal is received from a second physical microphone. EX. 1003, ¶¶128-131.

In Avendano '880, the first physical microphone is “primary microphone 106” and the second physical microphone is “secondary microphone 108.” EX. 1005, 3:27-55, 4:20-27, FIGS. 1a-1b; EX. 1003, ¶129.



EX. 1005, FIG. 1a



EX. 1005, FIG. 1b

Further, in Avendano '880, the first signal is “primary acoustic signal (X_1)” and the second signal is “secondary acoustic signal (X_2).” EX. 1005, 4:20-27, FIGS. 4a-4b; EX. 1003, ¶130. Further, the first virtual microphone is “cardioid primary signal (C_f),” which is formed as a combination of “primary acoustic signal” and “secondary acoustic signal.” EX. 1005, 4:27-6:10, FIGS. 4a-4b; EX. 1003, ¶131.

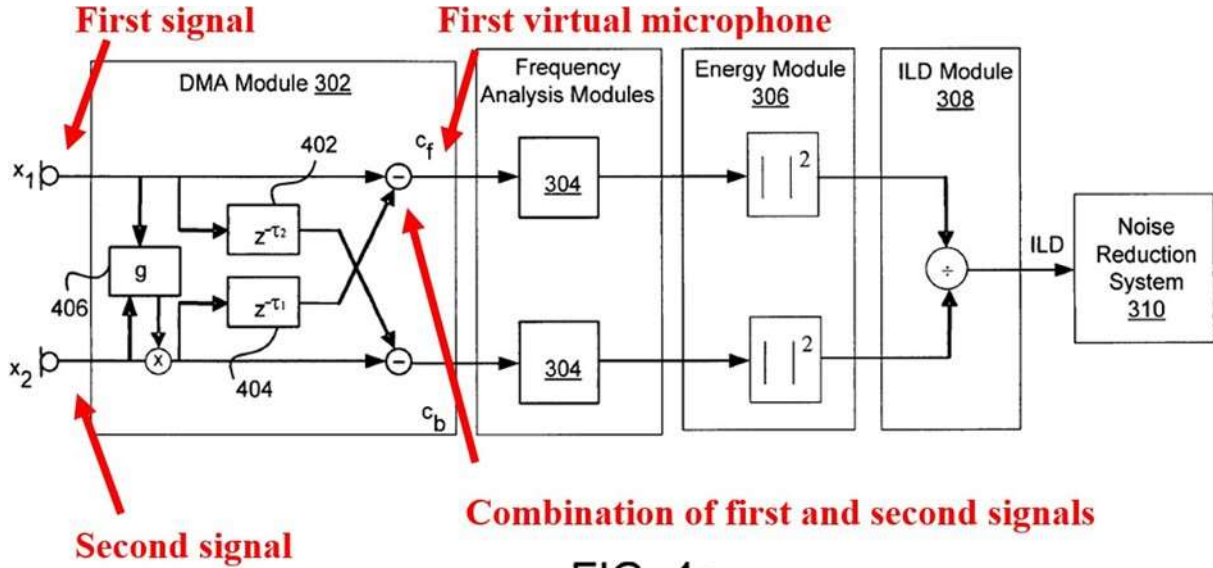


FIG. 4a

EX. 1005, FIG. 4a

In exemplary embodiments, a cardioid primary signal (C_f) is mathematically determined in the frequency domain (Z transform) as

$$C_f = X_1 - z^{-\tau_1} g X_2$$

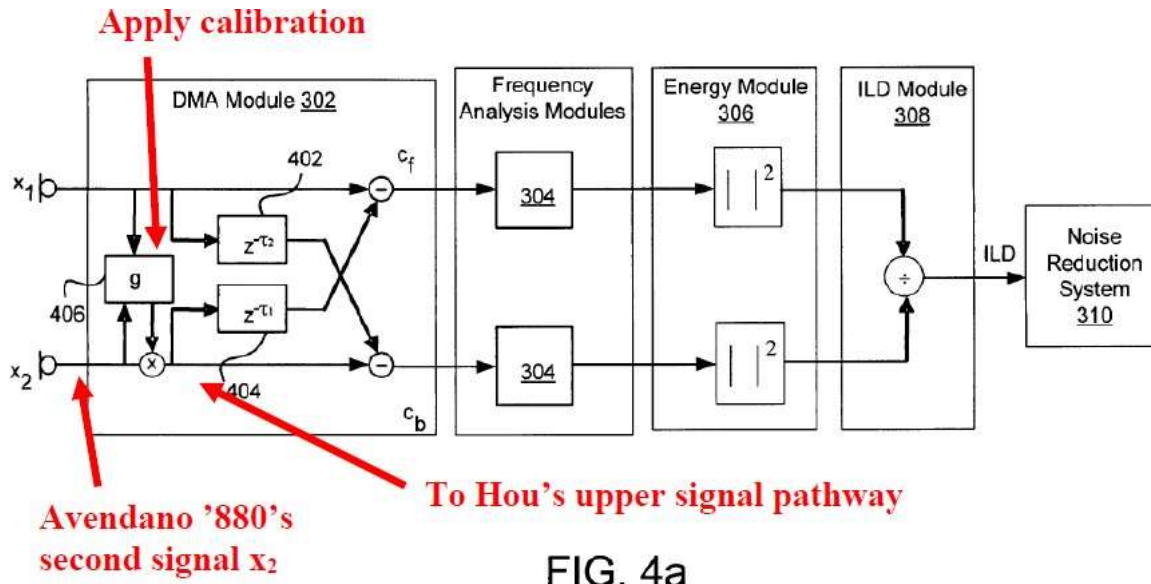
First virtual microphone
First signal
Second signal

EX. 1005, 5:25-30

[1b]: a filter, wherein the filter is formed by generating a first quantity by applying a calibration to at least one of the first signal and the second signal, generating a second quantity by applying a delay to the first signal, and forming the filter as a ratio of the first quantity to the second quantity

The combination of Avendano '880 and Hou would include a filter that is formed by generating a first quantity by applying a calibration to at least one of the first signal and the second signal, generating a second quantity by applying a delay to the first signal, and forming the filter as a ratio of the first quantity to the second quantity. EX. 1003, ¶¶132-137.

In the combination of Avendano '880 and Hou, Hou's "system 500" would form a filter based on Avendano '880's first signal x_1 and second signal x_2 (*e.g.*, from Avendano '880's first physical microphone 106 and second physical microphone 108, respectively). Section III(C); EX. 1003, ¶133. For example, a calibration would be applied to the second signal x_2 using Avendano '880's "gain factor, g " and/or multiplexer. Section III(C); EX. 1005, 5:36-39, 9:54-59, FIGS. 4a-4b. EX. 1003, ¶134. The calibrated second signal x_2 would be subsequently processed to generate a "first quantity" (*e.g.*, by processing the calibrated second signal x_2 using Hou's "first minimum estimate unit 508"). Section III(C); EX. 1008, 5:36-38, FIG. 5; EX. 1003, ¶134.



EX. 1005, FIG. 4a

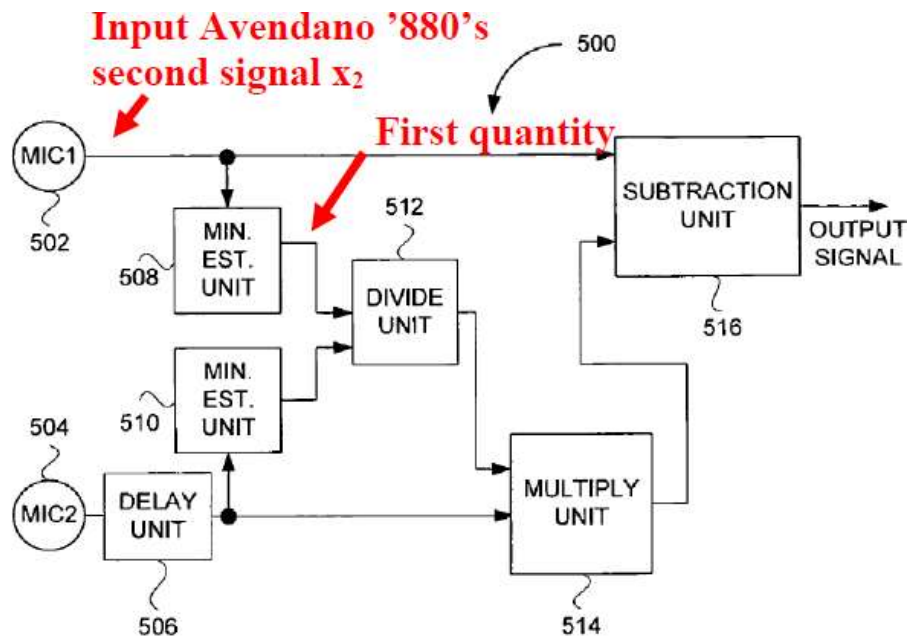


FIG. 5

EX. 1008, FIG. 5

As another example, a calibration also would be applied to the second signal x_2 by Hou's "first minimum estimate unit 508" to generate a first quantity. Section III(C); EX. 1008, 5:36-38, FIG. 5; EX. 1003, ¶135.

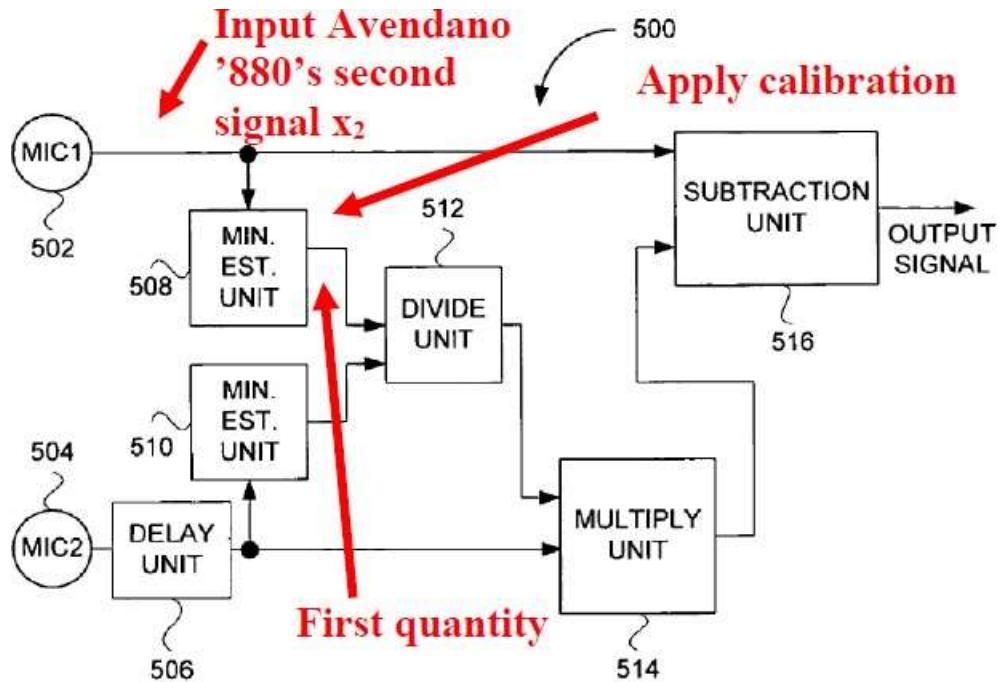
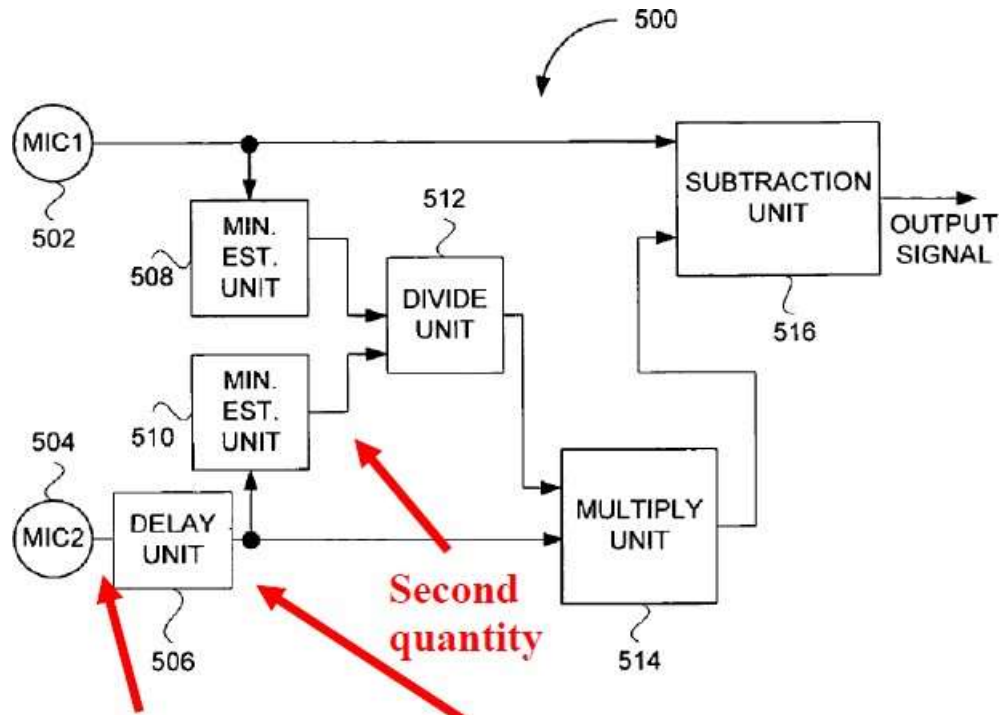


FIG. 5

EX. 1008, FIG. 5

Further, Hou's "delay unit 506" would receive Avendano '880's first signal x_1 , and apply a delay to that first signal x_1 to generate a second quantity. Section III(C); EX. 1008, 5:32-33, FIG. 5; EX. 1003, ¶136.



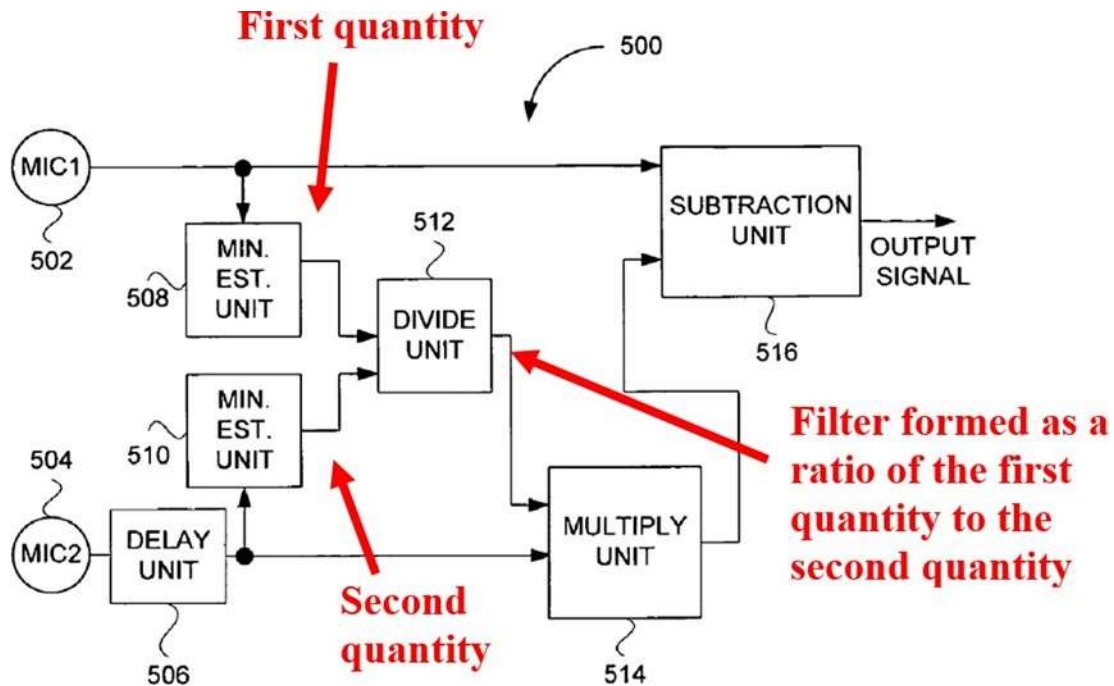
Input Avendano
'880's first
signal x_1

Second
quantity

Apply delay

EX. 1008, FIG. 5

Further, Hou's "divide unit 512" forms a filter as a ratio of the first quantity to the second quantity. Section III(C); EX. 1008, 5:42-45, FIG. 5; EX. 1003, ¶137. Specifically, Hou's "divide unit 512 produces a quotient by dividing the first minimum estimate by the second minimum estimate," "[t]he quotient represent[ing] a scaling amount that is sent to a multiplication unit 514." EX. 1008, 5:42-45.



EX. 1008, FIG. 5

[1c]: a second virtual microphone formed by applying the filter to the first signal to generate a first intermediate signal and summing the first intermediate signal and the second signal

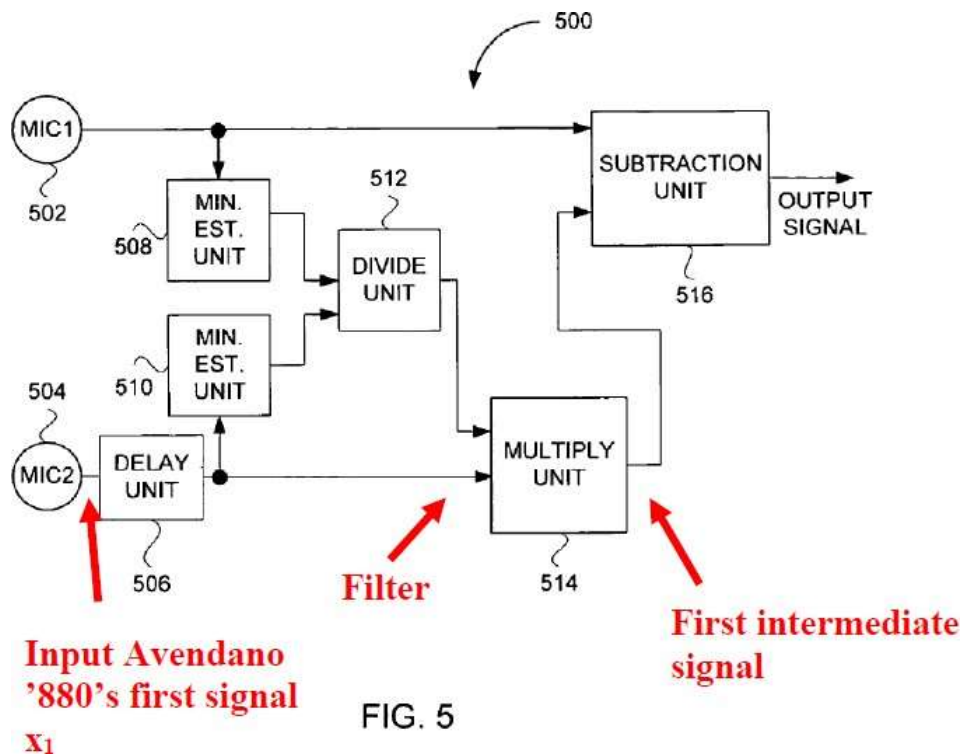
The combination of Avendano '880 and Hou would include a second virtual microphone formed by applying the filter to the first signal to generate a first intermediate signal and summing the first intermediate signal and the second signal.

EX. 1003, ¶¶138-155.

Two example modifications to Avendano '880's system based on the teachings in Hou are described below.

First Example Modification

In a first example combination of Avendano '880 and Hou, Hou's "divide unit 512" forms a filter (*e.g.*, as a ratio of the first quantity to the second quantity). Section III(C); Section III(D), [1b]; EX. 1008, 5:42-45, FIG. 5; EX. 1003, ¶140. This filter is applied to Avendano '880's first signal (*e.g.*, by "multiplication unit 514") to generate a first intermediate signal. Section III(C); EX. 1008, 5:43-49, FIG. 5; EX. 1003, ¶140.



EX. 1008, FIG. 5

Further, a second virtual microphone (“output signal”) is generated by subtracting the first intermediate signal from Avendano ’880’s second signal (e.g., using “subtraction unit 516”). EX. 1008, 5:50-56, FIG. 5; EX. 1003, ¶141.

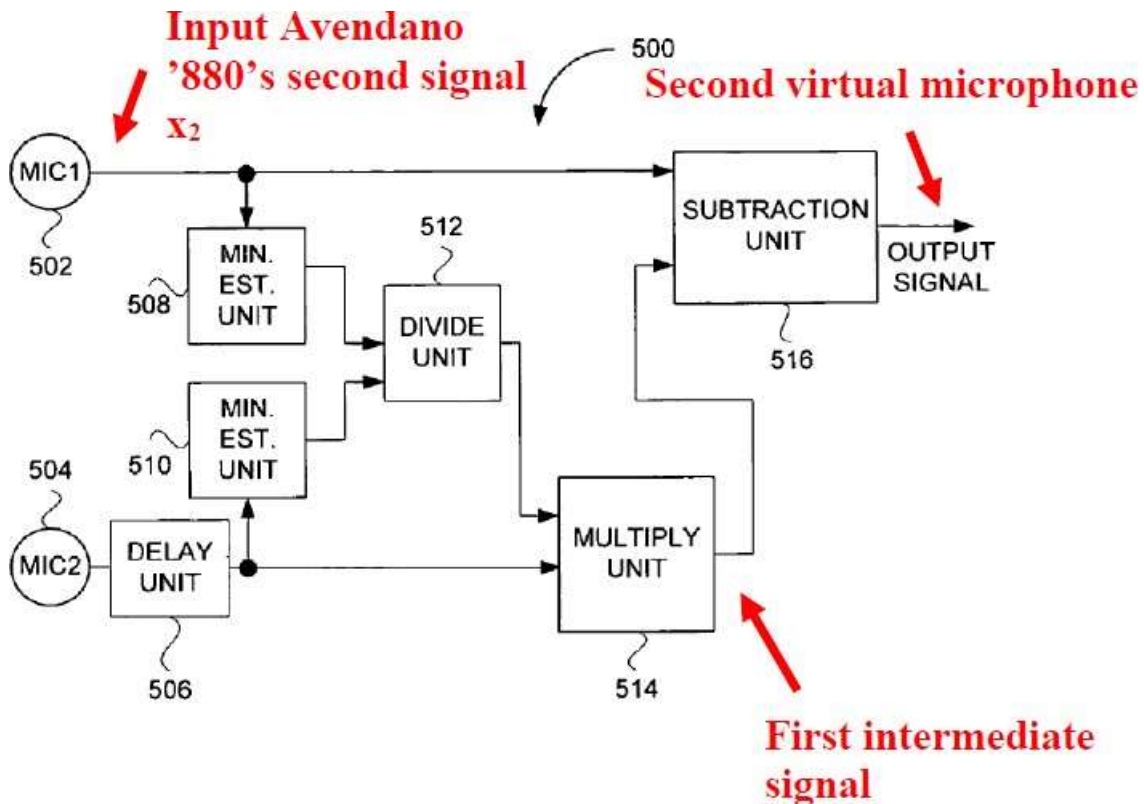


FIG. 5

EX. 1008, FIG. 5

The second virtual microphone (“output signal”) would have “robust directionality” in a backwards direction. EX. 1008, 5:50-56, 9:28-41; EX. 1003, ¶142. This is analogous to Avendano ’880’s system in which Avendano ’880’s first signal x_1 (having been delayed by the “delay node 402”) is subtracted from Avendano ’880’s secondary signal x_2 to generate a directional second virtual

microphone (“cardioid secondary signal”) facing the backwards direction. Section III(C); EX. 1005, 5:15-35, FIG. 4a; EX. 1003, ¶143.

This subtraction is mathematically the equivalent of summing (i) Avendano ’880’s second signal, and (ii) the inverse of the first intermediate signal. EX. 1003, ¶144. This is consistent with the ’213 patent, which describes that “processing paths” are “summed to form virtual microphones,” and that “varying the magnitude and sign of the delays and gains of the processing paths leads to a wide variety of virtual microphones.” EX. 1001, 21:24-51, FIGS. 25-26; EX. 1003, ¶145.

Further, FIG. 3 of the ’213 patent indicates that a summation (signified by “ Σ ”) includes summing a first value with the inverse of a second value (signified using a negative sign by an input to “ Σ ”) to form a second virtual microphone V_2 (*i.e.*, subtracting the second value from the first value). EX. 1003, ¶146.

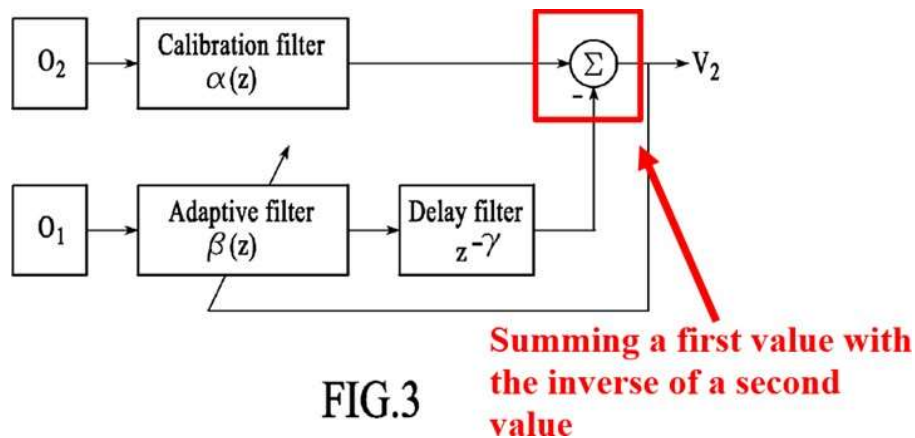


FIG.3

EX. 1001, FIG. 3

Accordingly, as in the '213 patent, the combination of Avendano '880 and Hou forms a second virtual microphone by applying the filter to the first signal to generate a first intermediate signal, and summing the first intermediate signal and the second signal. EX. 1003, ¶147.

Further, configuring Avendano '880's "gain factor, g " and Hou's "system 500" to equalize the signal levels of microphone signals at different respective stages in a signal processing operation would provide benefits that may not be obtained with either of the two alone (*e.g.*, to not only account for a general "loss of performance when the microphone signals have different levels" at an initial stage of the signal processing operation, but to also specifically enhance the directionality of a combination of the microphone signals at the late stage of the signal processing operation). Section III(C); EX. 1005, 5:36-39; EX. 1008, 5:17-6:22, FIG. 5; EX. 1003, ¶148.

Second Example Modification

In a second example combination of Avendano '880 and Hou, Hou's "divide unit 512" forms a filter (*e.g.*, as a ratio of the first quantity to the second quantity). Section III(C); Section III(D), [1b]; EX. 1008, 5:42-45, FIG. 5; EX. 1003, ¶149. This filter is applied to Avendano '880's first signal x_1 (*e.g.*, to equalize Avendano '880's first signal x_1 with Avendano '880's second signal x_2) to generate a first intermediate signal. Section III(C); EX. 1003, ¶149.

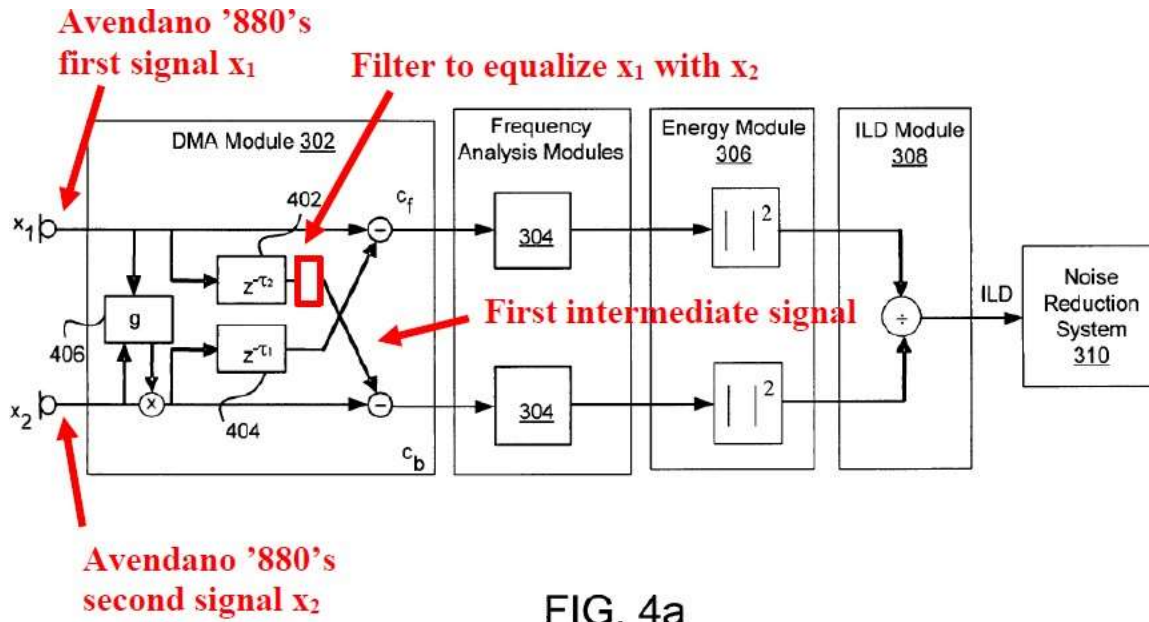
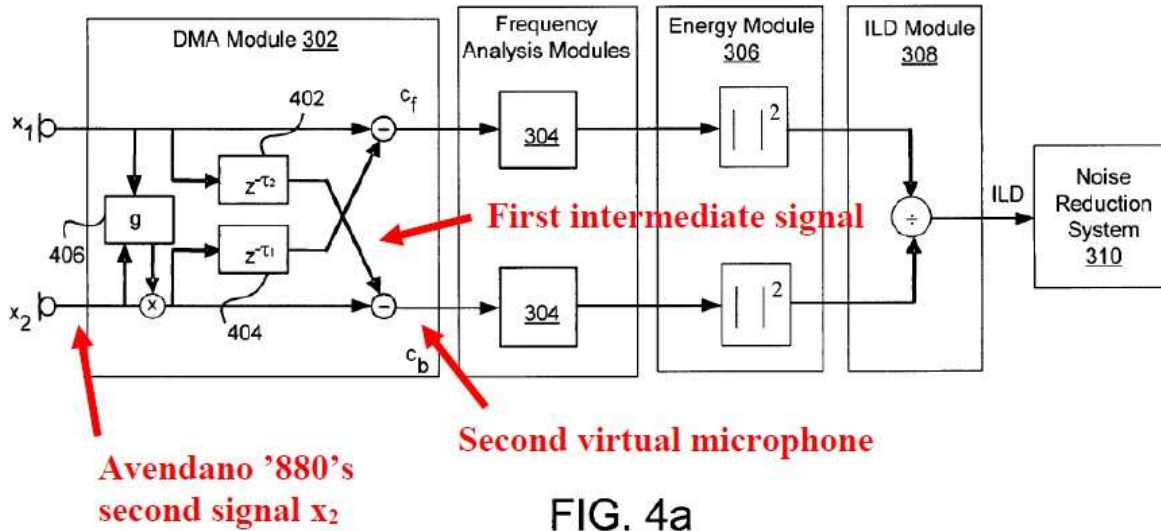


FIG. 4a

EX. 1005, FIG. 4a (modified)

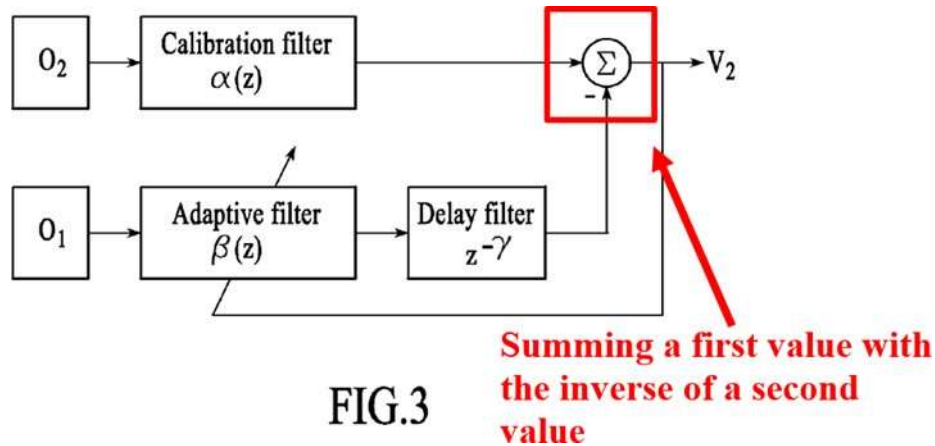
Further, a second virtual microphone is generated by subtracting the first intermediate signal from Avendano '880's second signal. EX. 1005, 5:15-35, FIG. 4a; EX. 1003, ¶150.



EX. 1005, FIG. 4a

This subtraction is mathematically the equivalent of summing (i) Avendano '880's second signal, and (ii) the inverse of the first intermediate signal. EX. 1003, ¶151. As discussed above, this is also consistent with the '213 patent, which describes that “processing paths” are “summed to form virtual microphones,” and that “varying the magnitude and sign of the delays and gains of the processing paths leads to a wide variety of virtual microphones.” EX. 1001, 21:24-51, FIGS. 25-26; EX. 1003, ¶152.

Further, FIG. 3 of the '213 patent indicates that a summation (signified by “Σ”) includes summing a first value with the inverse of a second value (signified using a negative sign by an input to “Σ”) to form a second virtual microphone V_2 (*i.e.*, subtracting the second value from the first value). EX. 1003, ¶153.



EX. 1001, FIG. 3

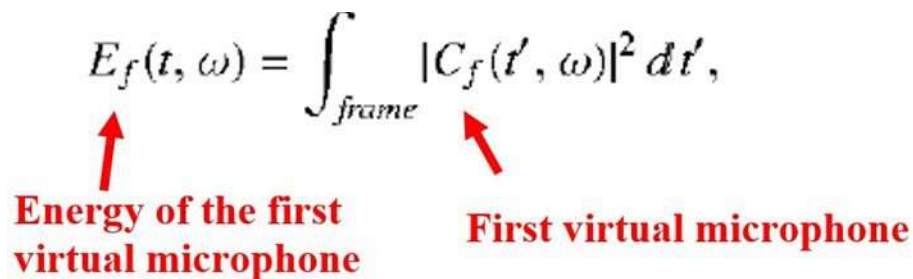
Accordingly, as in the '213 patent, the combination of Avendano '880 and Hou forms a second virtual microphone by applying the filter to the first signal to generate a first intermediate signal, and summing the first intermediate signal and the second signal. EX. 1003, ¶154.

Further, configuring Avendano '880's "gain factor, g" and Hou's "system 500" to equalize the signal levels of microphone signals at different respective stages in a signal processing operation would provide benefits that may not be obtained with either of the two alone (*e.g.*, to not only account for a general "loss of performance when the microphone signals have different levels" at an initial stage of the signal processing operation, but to also specifically enhance the directionality of a combination of the microphone signals at the late stage of the signal processing operation). Section III(C); EX. 1005, 5:36-39; EX. 1008, 5:17-6:22, FIG. 5; EX. 1003, ¶155.

[1d]: wherein acoustic voice activity of a speaker is determined to be present when an energy ratio of energies of the first virtual microphone and the second virtual microphone is greater than a threshold value.

Avendano '880 (and in combination with Hou) discloses that acoustic voice activity of a speaker is determined to be present when an energy ratio of energies of the first virtual microphone and the second virtual microphone is greater than a threshold value. EX. 1003, ¶¶156-164.

In Avendano '880, the energy of the first virtual microphone is E_f , which is calculated by integrating the square of the first virtual microphone over time. EX. 1005, 5:49-61; EX. 1003, ¶158.

$$E_f(t, \omega) = \int_{frame} |C_f(t', \omega)|^2 dt',$$


Energy of the first virtual microphone

First virtual microphone

EX. 1005, 5:61

The energy of the second virtual microphone is E_b , which is calculated by integrating the square of the second virtual microphone over time. EX. 1005, 5:49-6:5; EX. 1003, ¶159.

$$E_b(t, \omega) = \int_{\text{frame}} |C_b(t', \omega)|^2 dt'.$$

Energy of the second virtual microphone **Second virtual microphone**

EX. 1005, 6:5

Further, the energy ratio is “Inter-Level Difference” (ILD), which is determined by dividing the energy of the first virtual microphone by the energy of the second virtual microphone. EX. 1005, 6:8-34; EX. 1003, ¶160.

$$ILD(t, \omega) = \frac{\int_{\text{frame}} |C_f(t', \omega)|^2 dt'}{\int_{\text{frame}} |C_b(t', \omega)|^2 dt'}.$$

Energy of the first virtual microphone **Energy of the second virtual microphone**

EX. 1005, 6:16

Avendano ’880 compares the energy ratio (ILD) to a “threshold” to determine whether acoustic voice activity of a speaker is present (*e.g.*, the presence or absence of speech). EX. 1005, 6:35-7:9; EX. 1003, ¶161-164.

$$\lambda_I(t, \omega) = \begin{cases} \approx 0 & \text{if } ILD(t, \omega) < \text{threshold} \\ \approx 1 & \text{if } ILD(t, \omega) > \text{threshold} \end{cases}$$

EX. 1005, 6:61

If the ratio (ILD) is “smaller than a threshold value (e.g., threshold=0.5) above which speech is expected to be,” a value λ_1 is set to zero (e.g., indicating an absence of speech). EX. 1005, 6:58-7:3; EX. 1003, ¶163. However, if the ratio (ILD) “starts to rise (e.g., because speech is present within the large ILD region), λ_1 increases” (e.g., set to one, indicating a presence of speech). EX. 1005, 6:58-7:3; EX. 1003, ¶164.

E. Claim 2

[2]: The system of claim 1, wherein the first virtual microphone and the second virtual microphone have approximately similar responses to noise and approximately, dissimilar responses to speech

Avendano '880 (and in combination with Hou) discloses that the first virtual microphone and the second virtual microphone have approximately similar responses to noise and approximately, dissimilar responses to speech. EX. 1003, ¶¶165-174.

In the combination of Avendano '880 and Hou, the first virtual microphone has a directional pattern directed to the front of “audio device 104,” and the second virtual microphone has a directional pattern directed to the back of “audio device 104.” Section III(D), [1a], [1c]; EX. 1005, 4:47-54, 5:15-39, 9:29-42, FIG. 6; EX. 1003, ¶166.

Further, in Avendano '880, noise is typically generated in the “background” or “far field,” rather than from a location near the audio device, and “may include reverberations and echoes.” EX. 1005, 3:12-55, FIGS. 1a-1b; EX. 1003, ¶167.

A POSITA would have recognized that, according to Avendano '880's configuration, Avendano '880's virtual microphones would have approximately similar responses to noise. EX. 1003, ¶168-170

For example, although Avendano '880 (and in combination with Hou) describes two virtual microphones having respective directional patterns, neither of these virtual microphones is directed to a “background” or “far field.” EX. 1005, 3:12-55, FIGS. 1a-1b; EX. 1003, ¶169. Accordingly, neither virtual microphone would be more sensitive to noise generated in the “background” or “far field” than the other. EX. 1003, ¶169.

Further, according to Avendano '880's configuration (and the configuration in combination with Hou), an audio device would not merely detect noise propagating directly from a noise source to the audio device, but would also detect reverberations and echoes of that noise from multiple other locations relative to the audio device. EX. 1005, 3:35-41; EX. 1003, ¶170. Due to the non-directionally specific nature of these reverberations and echoes, neither virtual microphone would be more sensitive to detecting noise (and the reverberations and echoes thereof) than the other. EX. 1003, ¶170.

A POSITA also would have recognized that, according to Avendano '880's configuration (and the configuration in combination with Hou), Avendano '880's virtual microphones would have approximately dissimilar responses to speech. *Id.*, ¶¶171-174.

In Avendano '880, speech is typically generated near the front of the device. EX. 1005, 3:42-55, FIGS. 1a-1b; EX. 1003, ¶174. According to this configuration, Avendano '880's virtual microphones would have approximately dissimilar responses to speech (e.g., first virtual microphone is directed towards the source of speech, whereas the second virtual microphone is directed away from the source of speech). EX. 1003, ¶174.

F. Claim 3

[3]: The system of claim 1, wherein a calibration is applied to the second signal, wherein the calibration compensates a second response of the second physical microphone so that the second response is equivalent to a first response of the first physical microphone

Avendano '880 (and in combination with Hou) discloses that a calibration is applied to the second signal, wherein the calibration compensates a second response of the second physical microphone so that the second response is equivalent to a first response of the first physical microphone. EX. 1003, ¶¶175-177.

Avendano '880 applies a calibration ("gain factor, g ") to at least the second signal "to equalize the signal levels" of the first and second signals. EX. 1005, 5:36-39, 9:54-59; FIGS. 4a-4b; Section III(C); EX. 1003, ¶176.

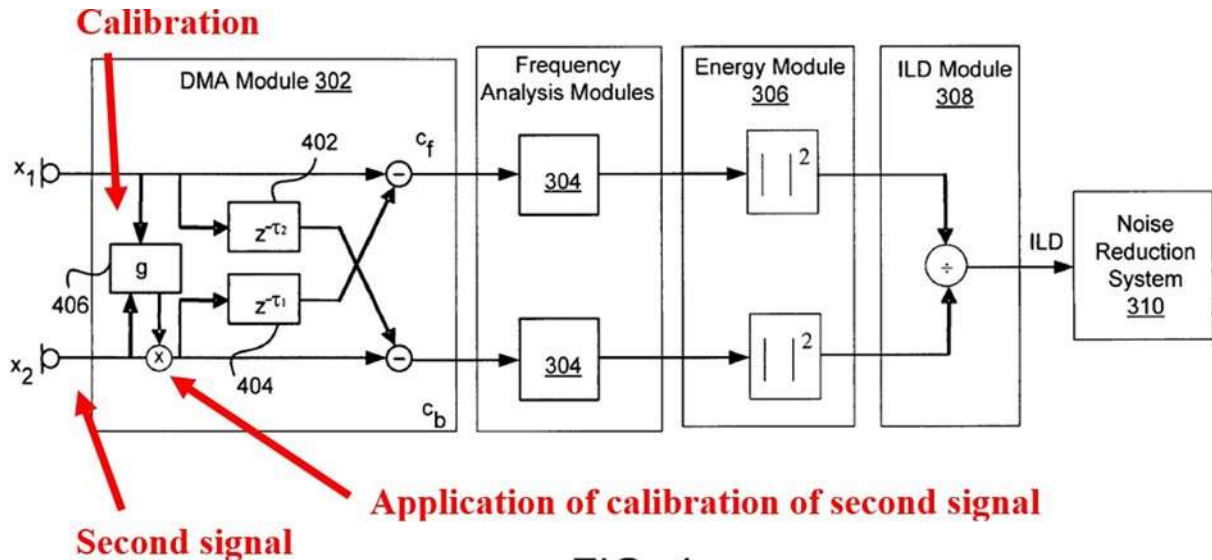


FIG. 4a

EX. 1005, FIG. 4a

Accordingly, Avendano '880's calibration compensates a second response of the second physical microphone so that the second response is equivalent to a first response of the first physical microphone. EX. 1003, ¶177.

G. Claim 5

[5]: The system of claim 1, wherein the first virtual microphone is formed by applying the filter to the second signal

In the combination of Avendano '880 and Hou, the first virtual microphone is formed by applying the filter to the second signal. EX. 1003, ¶¶178-190.

As discussed in Sections III(C)-(D), a POSITA would have recognized that Avendano '880 teaches the importance of equalizing signal levels of signals generated by two respective microphones, and that Hou discloses a specific “system 500” for performing precisely this function. Sections III(C)-(D); EX. 1003, ¶179. Accordingly, a POSITA would have been motivated to implement Hou’s signal compensation or correction components in Avendano '880 to further improve the equalization of the signal output by the microphones (*e.g.*, to generate a signal “hav[ing] robust directionality” and to enhance “directional noise suppression”). Sections III(C)-(D); EX. 1008, 5:50-56, 9:28-41; EX. 1003, ¶179.

Further, a POSITA would have recognized that the combination of Avendano '880 and Hou could be used to produce (i) a signal having “hav[ing] robust directionality” in the forward direction and (ii) a signal having “hav[ing] robust directionality” in the backwards direction. EX. 1003, ¶180.

Two example modifications to Avendano '880’s system based on the teachings in Hou are described below.

First Example Modification

As discussed in Sections III(C)-(D), in a first example modification, a POSITA would have incorporated Hou’s filter (*e.g.*, implemented by components of Hou’s system 500) into Avendano '880’s “DMA module 302” to generate a signal “hav[ing] robust directionality” in a backwards direction (*e.g.*, to improve the

directionality of Avendano '880's rear-facing cardioid secondary signal). Sections III(C)-(D); EX. 1003, ¶182.

Similarly, a POSITA would have also implemented Hou's filter in Avendano '880's "DMA module 302" to additionally generate a signal "hav[ing] robust directionality" in a forward direction (*e.g.*, to improve the directionality of Avendano '880's front-facing cardioid secondary signal). Sections III(C)-(D); EX. 1003, ¶183. This modification would merely involve the implementation of additional instances of Hou's "delay unit 506," "multiplication unit 314," and "subtraction unit 516" to additionally generate a front-facing signal, using the same processing techniques that were used to generate the back-facing signal. *Id.*

According to a first example modification, Hou's system 500 would include additional instances of Hou's "delay unit 506," "multiplication unit 314," and "subtraction unit 516" to additionally generate a front-facing signal. EX. 1003, ¶184. The additional instances of Hou's components would process Avendano '880's first signals x_1 and x_2 in a manner that mirrors that of the first instance of Hou's components (*e.g.*, to produce a directional signal that is directed in the opposite direction as that generated by the first instance of Hou's components). *Id.*, ¶184.

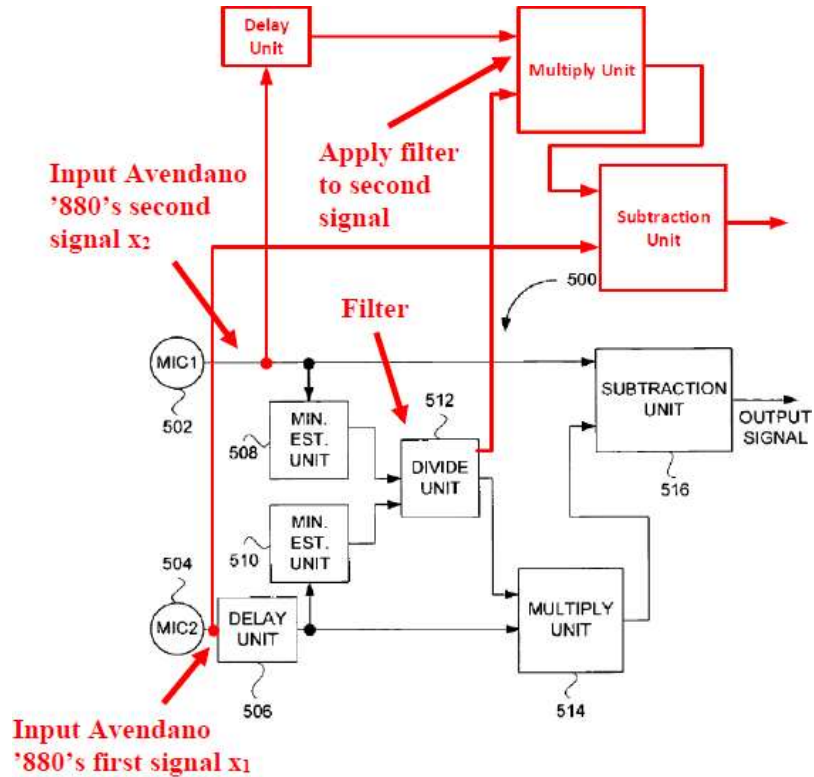


FIG. 5

EX. 1008, FIG. 5 (modified)

Specifically, a delay would be applied to Avendano '880's second signal (*e.g.*, by a second instance of Hou's "delay unit 506"), and Hou's filter would be applied to the delayed version of Avendano '880's second signal (*e.g.*, by a second instance of "multiplication unit 514") to generate a compensated second signal.

EX. 1008, 5:36-47, FIG. 5; EX. 1003, ¶185. The instance of Hou's filter that is applied to Avendano '880's second signal would be formed in a similar manner as the instance of Hou's filter that is applied to Avendano '880's first signal (*e.g.*, formed as a ratio of a first quantity and a second quantity). EX. 1003, ¶185.

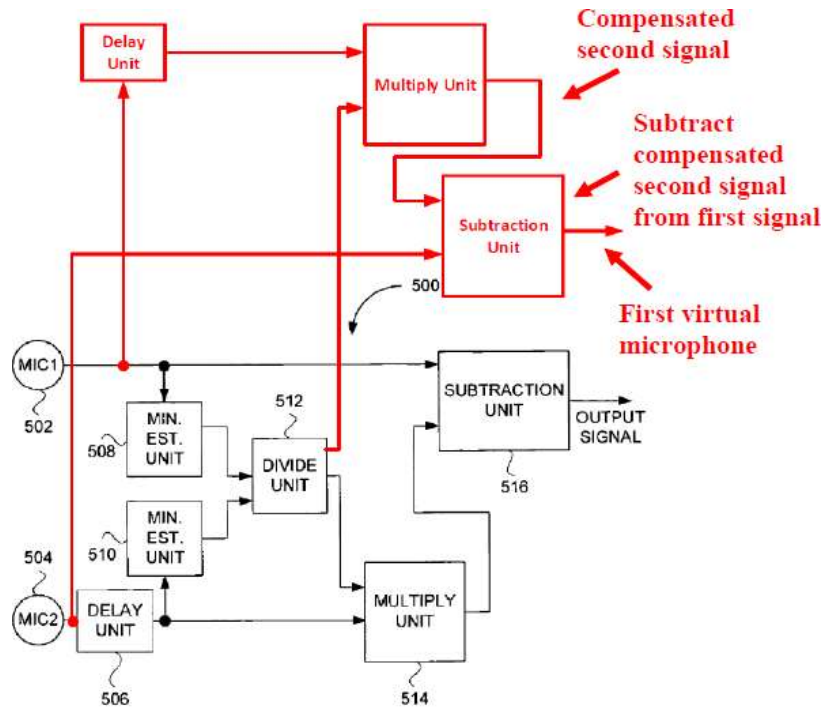


FIG. 5

EX. 1008, FIG. 5 (modified)

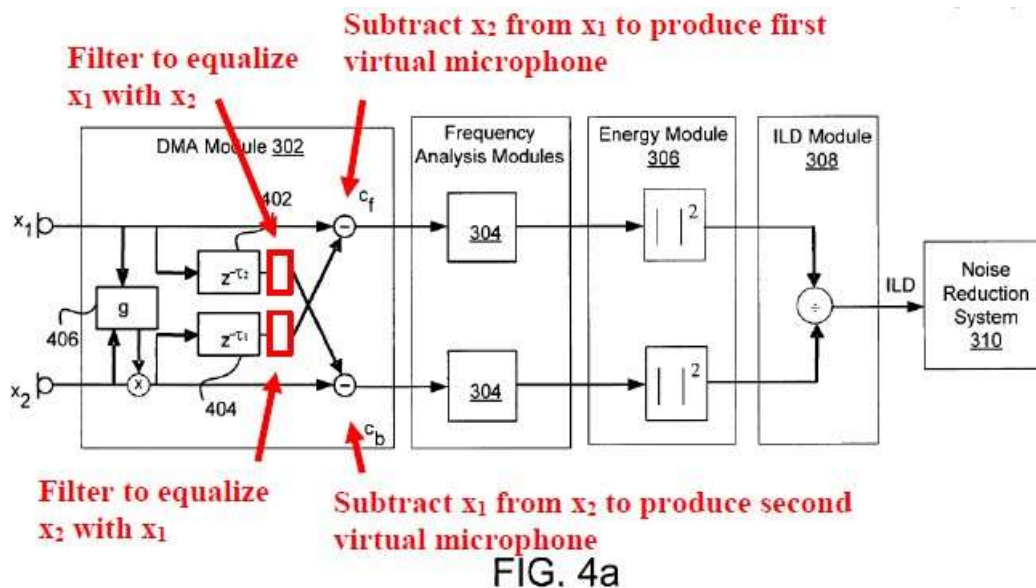
Further, a first virtual microphone would be generated by subtracting the second compensated signal from Avendano '880's first signal (*e.g.*, using a second instance of Hou's "subtraction unit 516"). EX. 1008, 5:50-56, FIG. 5; EX. 1003, ¶186.

The first virtual microphone would have "robust directionality" in a forward direction. EX. 1003, ¶187. This is analogous to Avendano '880's system in which Avendano '880's secondary signal x_2 (having been delayed by the "delay node 402") is subtracted from Avendano '880's first signal x_2 to generate a directional first

virtual microphone (“cardioid primary signal”) facing the forward direction. *Id.*, ¶187.

Second Example Modification

As discussed in Sections III(C)-(D), in a second example modification, a POSITA would have found it obvious to modify Avendano ’880’s system to include filters that equalize Avendano ’880’s signals with one another immediately prior to subtracting one signal from the other to produce respective directional virtual microphones. Sections III(C)-(D); EX. 1003, ¶188.



EX. 1005, FIG. 4a (modified)

According to this example modification, a first virtual microphone (e.g., a front-facing directional signal) would be formed by applying a filter to the second signal x_2 to equalize the second signal x_2 with the first signal x_1 . EX. 1003, ¶189.

This filter would be formed in a similar manner as the filter that is applied to the first signal x_1 to equalize the first signal x_1 with the second signal x_2 (e.g., formed as a ratio of a first quantity and a second quantity). EX. 1003, ¶189.

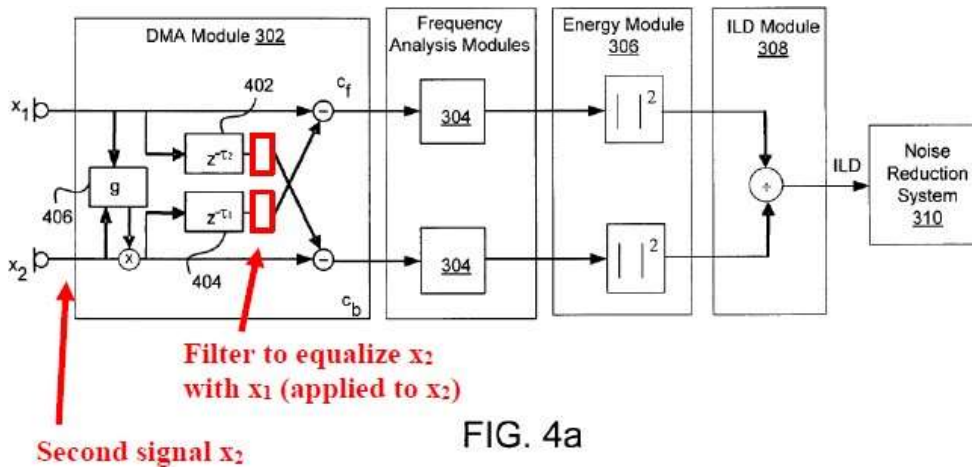


FIG. 4a

EX. 1005, FIG. 4a (modified)

Further, a first virtual microphone would be generated by subtracting the second signal x_2 from the first signal x_1 . EX. 1005, 6:15-39, FIG. 4a; EX. 1003, ¶190.

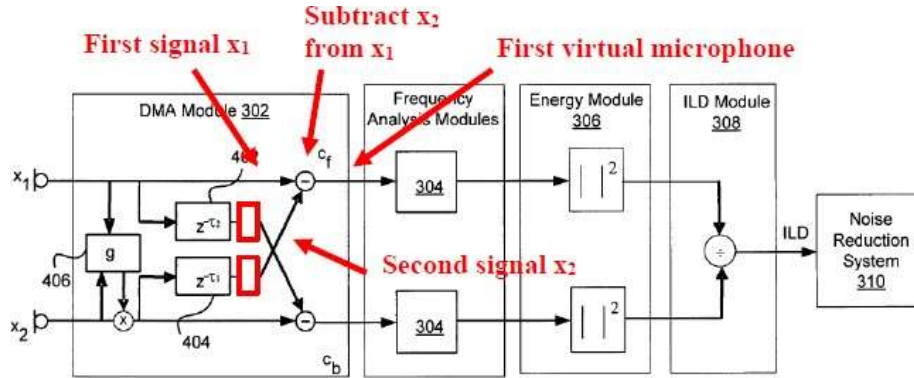


FIG. 4a

EX. 1006, FIG. 4a (modified)

H. Claim 6

[6]: The system of claim 5, wherein the first virtual microphone is formed by applying the calibration to the second signal

In the combination of Avendano '880 and Hou, the first virtual microphone is formed by applying the calibration to the second signal. EX. 1003, ¶¶191-192.

To form a first virtual microphone (*e.g.*, a front-facing directional signal), a calibration would be applied to the second signal x_2 using Avendano '880's "gain factor, g " and/or multiplexer. Section III(C); EX. 1005, 5:36-39, 9:54-59, FIGS. 4a-4b; EX. 1003, ¶192. The calibrated second signal x_2 and the first signal x_1 would be provided to Hou's system 500 for further processing (*e.g.*, to Hou's upper signal pathway and lower signal pathway, respectively) to form the first virtual microphone. Sections III(C)-(D), (G); EX. 1003, ¶192.

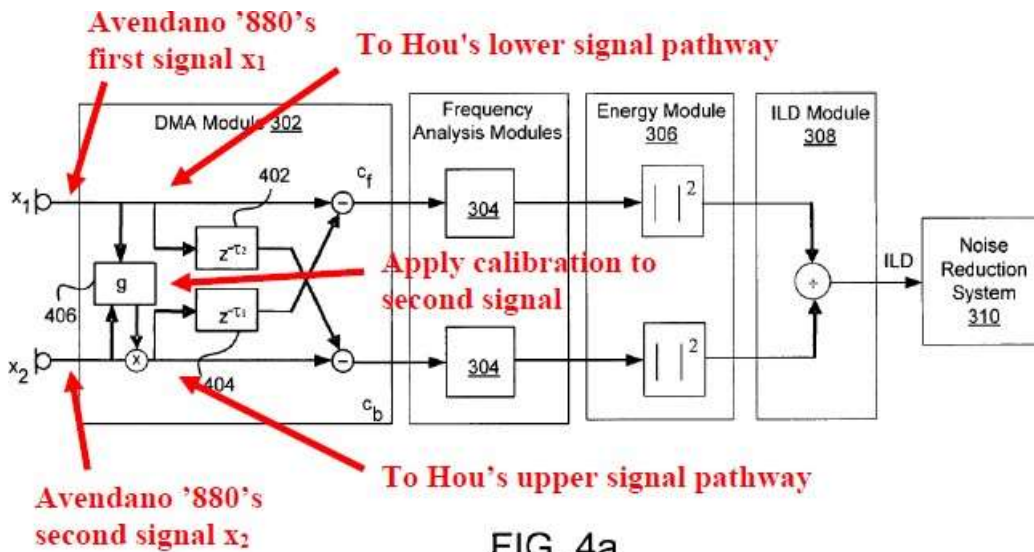


FIG. 4a

EX. 1006, FIG. 4a

I. Claim 7

[7]: The system of claim 6, wherein the first virtual microphone is formed by applying the delay to the first signal

In the combination of Avendano '880 and Hou, the first virtual microphone is formed by applying the delay to the first signal. EX. 1003, ¶¶193-194.

Avendano '880 describes that, in a “practical implementation of [Avendano '880's] DMA module 302” shown in FIG. 4b, a delay is applied to the first signal x_1 via “delay node 414” prior to providing the first signal x_1 to other components of Avendano '880's system for further processing. EX. 1005, 8:38-51, FIG. 4b; EX. 1003, ¶194. Further, the first signal x_1 is provided to Hou's system 500 (*e.g.*, to Hou's lower signal pathway) to form a first virtual microphone. Sections III(C)-(D), (G)-(H); EX. 1003, ¶194.

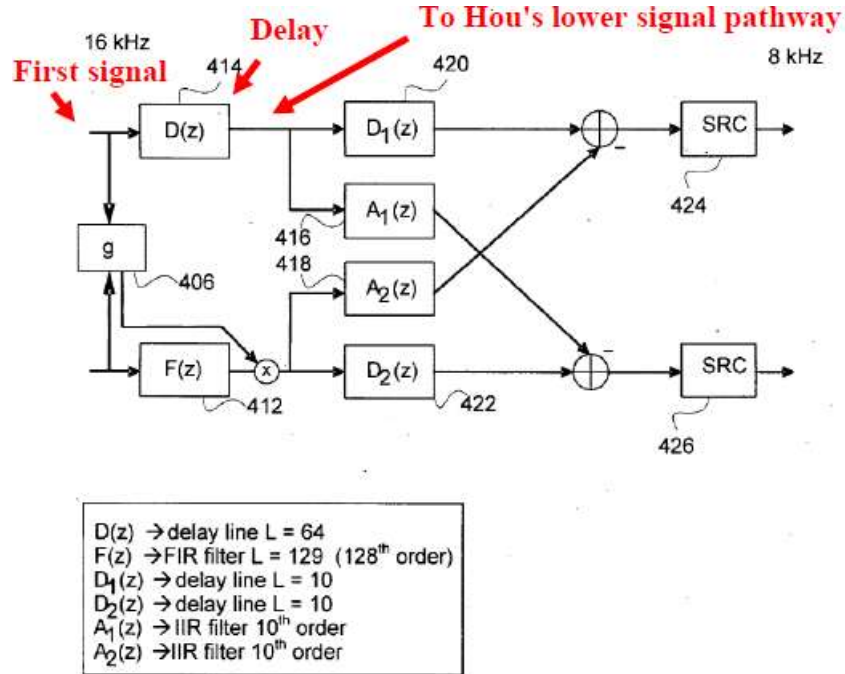


FIG. 4b

EX. 1005, FIG. 4b

J. Claim 8

[8]: The system of claim 7, wherein the first virtual microphone is formed by subtracting the second signal from the first signal

In the combination of Avendano '880 and Hou, the first virtual microphone is formed by subtracting the second signal from the first signal. EX. 1003, ¶¶195-198.

Two example modifications to Avendano '880's system based on the teachings in Hou are described below.

First Example Modification

As discussed with respect to Claim 5, in a first example modification, a first virtual microphone would be generated by subtracting the second compensated signal from Avendano '880's first signal (e.g., using a second instance of Hou's "subtraction unit 516"). Sections III(C)-(D), (G); EX. 1008, 5:50-56, FIG. 5; EX. 1003, ¶197.

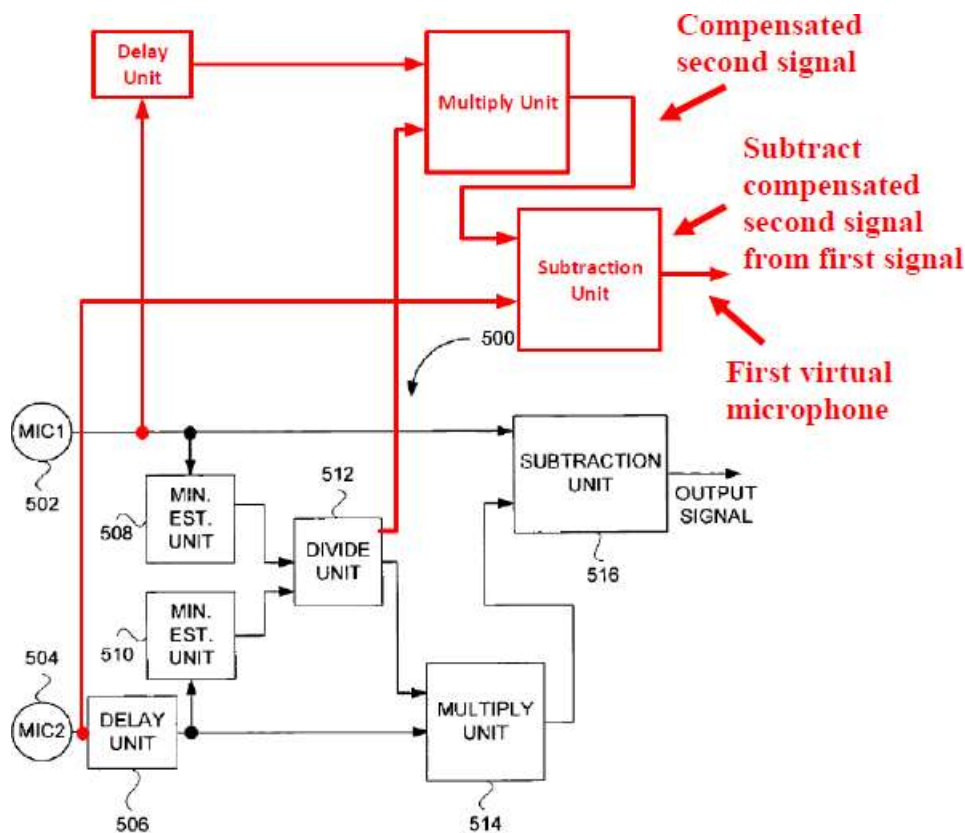


FIG. 5

EX. 1008, FIG. 5 (modified)

Second Example Modification

In a second example modification, a first virtual microphone would be generated by subtracting the second signal x_2 from the first signal x_1 . Sections III(C)-(D), (G); EX. 1005, 6:15-39, FIG. 4a; EX. 1003, ¶198.

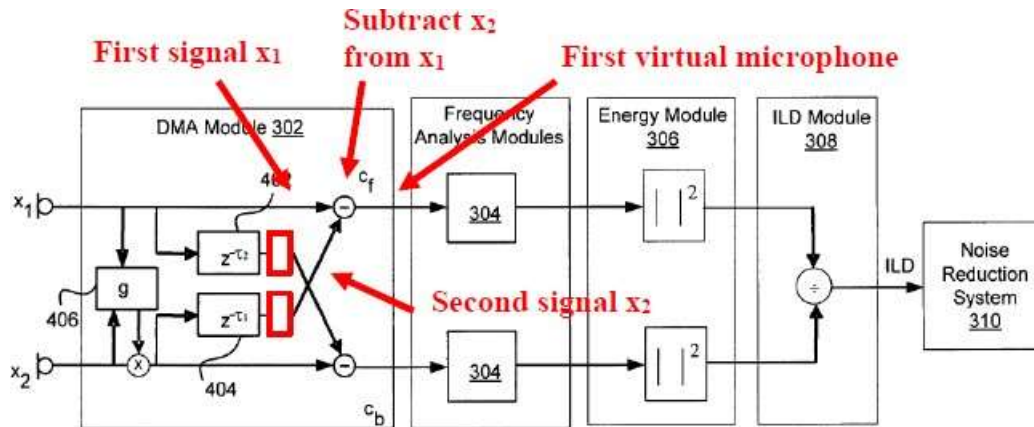


FIG. 4a
EX. 1006, FIG. 4a (modified)

K. Claim 9

[9]: The system of claim 1, wherein the filter is an adaptive filter

In the combination of Avendano '880 and Hou, the filter is an adaptive filter. EX. 1003, ¶¶199-200. In the combination of Avendano '880 and Hou, Hou's "divide unit 512" forms a filter as a ratio of the first quantity to the second quantity. Section III(C); Section III(D), [1b]; EX. 1008, 5:42-45, FIG. 5; EX. 1003, ¶200. Accordingly, the filter is adapted according to both the first quantity and the second quantity. EX. 1003, ¶200.

L. Claims 12 and 13

[12]: The system of claim 1, wherein the energy ratio comprises an energy ratio for a frequency band

[13]: The system of claim 1, wherein the energy ratio comprises an energy ratio for a frequency subband

Avendano '880 (and in combination with Hou) discloses that the energy ratio comprises an energy ratio for a frequency band or subband. EX. 1003, ¶¶201-212.

Avendano '880's "frequency analysis module 304 takes the cardioid signals and mimics the frequency analysis of the cochlea (i.e., cochlear domain) simulated by a filter bank." EX. 1005, 4:54-5:2; EX. 1003, ¶¶203, 209; Section III(D), [1d]. Specifically, Avendano '880's "frequency analysis module 304 separates the cardioid signals into frequency bands," and performs "sub-band analysis on the acoustic signal [to] determine[] what individual frequencies are present in the complex acoustic signal during a frame." EX. 1005, 4:54-5:2.

"Once the frequencies are determined," Avendano '880's "energy module 306" calculates the energy ratio ("ILD") based on signals that are output by "frequency analysis module 304." *Id.*, 5:3-10. Specifically, the energy ratio is calculated "based on bandwidth of the cochlea channel" (e.g., frequency band(s) or subband(s) for which "frequency analysis module 304 ... mimics the frequency analysis of the cochlea"). *Id.*; EX. 1003, ¶¶204, 210.

Accordingly, Avendano '880 generates the energy ratio for a frequency band or subband. EX. 1003, ¶¶205, 211.

This is also reflected in Avendano '880's equation for the energy ratio ("ILD"), which indicates that the energy ratio is generated as a vector for a frequency band or subband (ω) (EX. 1003, ¶¶206, 212):

Energy ratio 

$$ILD(t, \omega) = \frac{\int |C_f(t', \omega)|^2 dt'}{\int_{frame} |C_b(t', \omega)|^2 dt'}$$

EX. 1005, 6:16

IV. GROUND 2: Avendano '880, Hou, And Avendano '252 (Claims 4, 10, 11)

A. Avendano '252 Overview

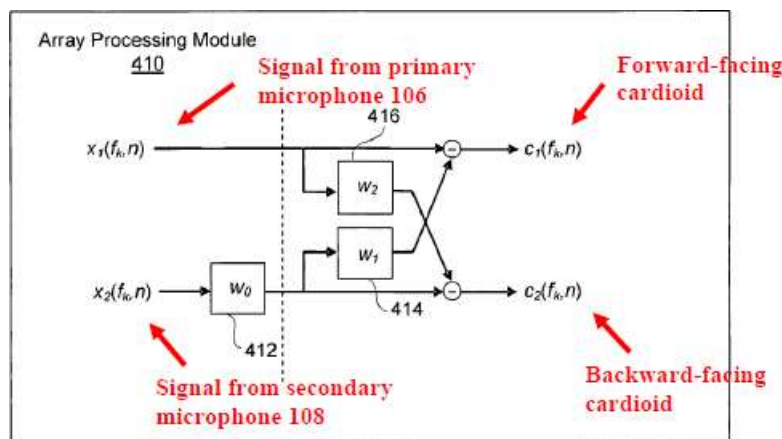
Avendano '252 is a continuation-in-part of Avendano '880, and incorporates the entirety of Avendano '880's disclosure by reference. EX. 1006, 1:8-23; EX. 1003, ¶79.

Avendano '252 additionally describes an "array processing module 410" and an "adaptive array processing (AAP) engine 304" that are similar to the "DMA Module 302" originally described in Avendano '880. EX. 1006, 5:17-7:64, FIGS. 4b-5; EX. 1003, ¶80. For example, as with Avendano '880's "DMA Module 302," each of Avendano '252's "array processing module 410" and "AAP engine 304" generates (i) a forward facing direction signal (e.g., "forward-facing cardioid

pattern,” “ c_1 ”) and (ii) a backward facing directional signal (e.g., “backward-facing cardioid pattern,” “ c_2 ”). EX. 1006, 5:17-7:64, FIGS. 4b-5; EX. 1003, ¶80.

Similarly, each of the “array processing module 410” and the “AAP engine 304” generates the forward-facing cardioid pattern c_1 by combining (i) signal x_1 from primary microphone 106, and (ii) signal x_2 from secondary microphone 108 (signal x_2 having been delayed by “delay node 414” and filtered by “equalization module 412”). EX. 1006, 5:17-7:64, FIGS. 4b-5; EX. 1003, ¶81. Further, each of the “array processing module 410” and the “AAP Engine 304” generates the backward-facing cardioid pattern c_2 by combining (i) signal x_2 from secondary microphone 108, and (ii) signal x_1 from primary microphone 106 (signal x_1 having been delayed by “delay node 416”). EX. 1006, 5:17-7:64, FIGS. 4b-5; EX. 1003, ¶81.

To illustrate, example inputs and outputs of Avendano ’252’s “array processing module 410” are shown below (EX. 1003, ¶82):



EX. 1006, FIG. 4b

Further, example inputs and outputs of Avendano '252's "AAP engine 304" are shown below, which are similar to those in Avendano '252's "array processing module 410" (EX. 1003, ¶83):

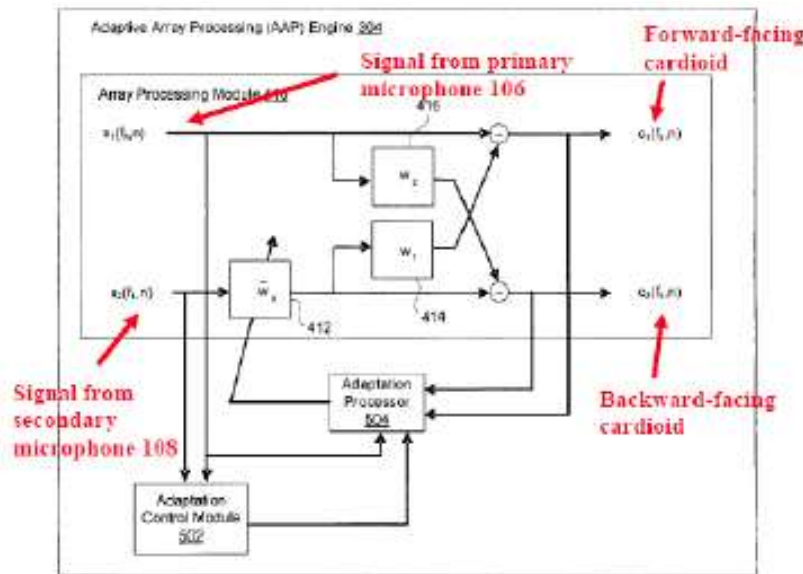
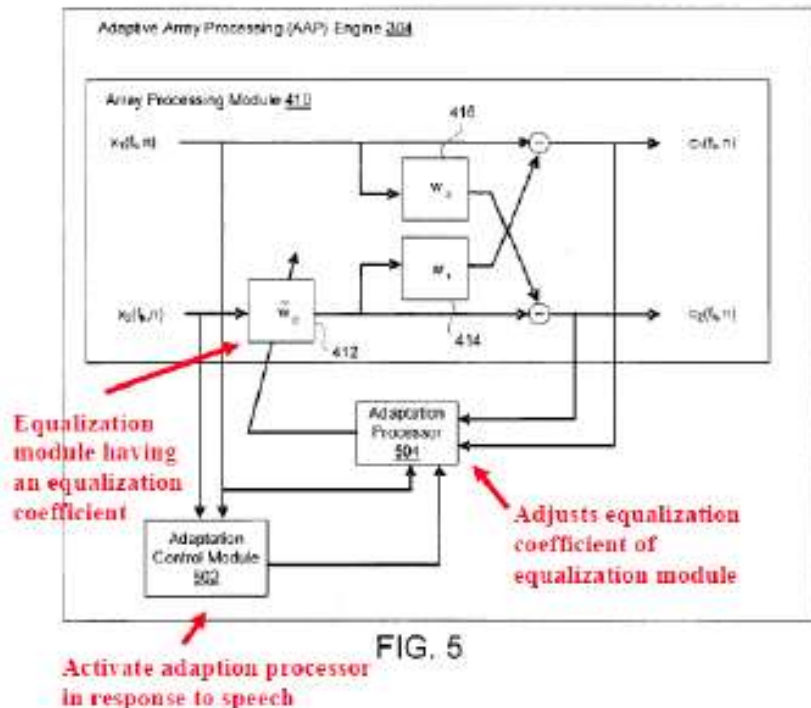


FIG. 5

EX. 1006, FIG. 5

However, the "AAP engine 304" additionally includes an "adaption control module 502" and an "adaption processor 504" to control "an adaptive equalization coefficient" of the "equalization module 412." EX. 1005, 10:1-59; 11:56-12:10; FIGS. 5, 7; EX. 1003, ¶84. The "adaptation control module 502 is configured to operate as a switch to activate the adaptation processor 504, which will adjust the equalization coefficient." EX. 1005, 10:9-11. Specifically, "the adaptation may be triggered by identifying frames dominated by speech." *Id.*, 10:11-15. Further, the "adaptation processor 504 is configured to adjust the equalization coefficient such

that a desired speech signal is cancelled by a backward-facing cardioid pattern” (e.g., by “adapt[ing] the equalization coefficient to essentially cancel the desired signal in order to create a zero or null in that direction”). *Id.*, 10:37-46.



EX. 1006, FIG. 5

B. Combination of Avendano '880, Hou, and Avendano '252

A POSITA would have found it obvious to further combine Avendano '880 and Hou with Avendano '252. EX. 1003, ¶¶213-219.

First, a POSITA would have recognized that each of (i) Avendano '880's “gain factor, g ,” (ii) Hou's filter (e.g., implemented at least in part by Hou's divide unit 512” and/or “multiplication unit 514”), and (iii) Avendano '252's “equalization module 412” serves a similar purpose, namely compensating for a difference in

sensitivity between mismatched microphones to generate directional signals. EX. 1005, 5:36-39, 9:54-59, FIGS. 4a-4b; EX. 1008, 5:26-6:22, 9:28-41, FIG. 5; EX. 1006, 6:30-38, 10:1-59, FIGS. 4b-5; EX. 1003, ¶214.

Further, a POSITA would have recognized that Avendano '252's "adaption control module 502" and "adaption processor 504" are provided specifically to enhance the signal equalization or compensation process (*e.g.*, by selectively adapting an "equalization coefficient" of a compensation or equalization filter based on inputs received from the microphones). EX. 1006, 6:30-38, 10:1-59, FIG. 5; EX. 1003, ¶215.

Accordingly, a POSITA would have found it obvious to modify Avendano '880's system and/or Hou's system to include Avendano '252's "adaption control module 502" and "adaption processor 504" to enhance the performance of Avendano '880's "gain factor, *g*" and/or Hou's filter. EX. 1003, ¶216. For example, in one example modification, a POSITA would have incorporated Avendano '252's "adaption control module 502" and "adaption processor 504" to selectively adapt one or more "equalization coefficient[s]" in Avendano '880's "gain factor, *g*" and/or Hou's filter, in order to further enhance the separation of speech and noise in the resulting directional signals (*e.g.*, "such that a desired speech signal is cancelled by a backward-facing cardioid pattern"). EX. 1006, 10:37-46; EX. 1003, ¶217.

Further, a POSITA would have had a reasonable expectation of success in modifying Avendano '880's system and/or Hou's system in view of Avendano '252, as such a modification would have simply been an application of known methods (*e.g.*, selectively adapting an "equalization coefficient" of a compensation or equalization filter based on inputs received from the microphones) to achieve a predictable result (*e.g.*, improving the separation of speech and noise using the compensation or equalization filter). EX. 1006, 10:1-59; EX. 1003, ¶218. Further, given the similarities between Avendano '880's "gain factor, *g*," Hou's filter, and Avendano '252's "equalization module 412," limited modifications would have been necessary to incorporate Avendano '252's "adaption control module 502" and "adaption processor 504" into Avendano '880's system and/or Hou's filter, and other operations in Avendano '880's system and/or Hou's filter would not have been impacted by the combination. EX. 1003, ¶218.

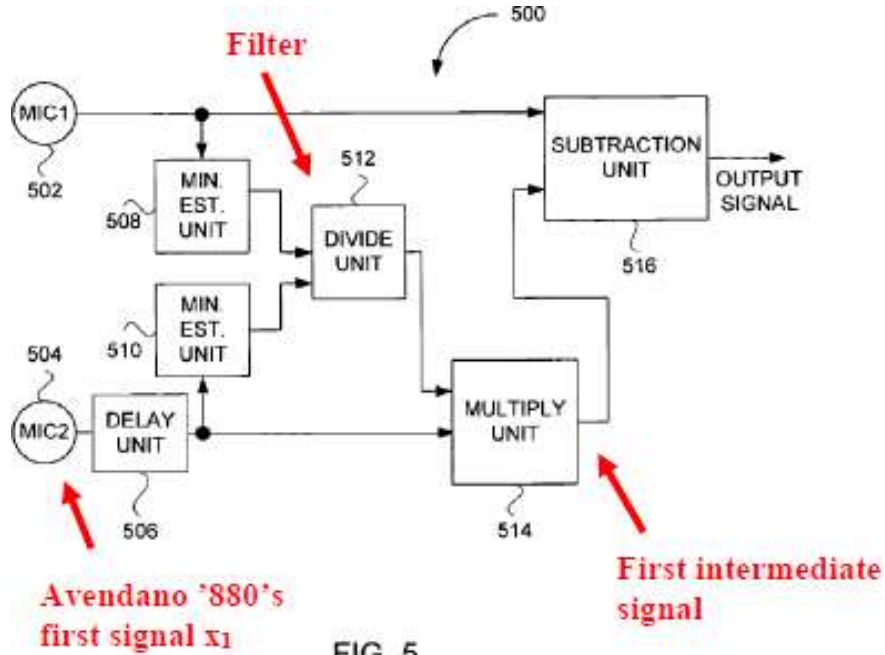
Thus, the combination of Avendano '880, Hou, and Avendano '252 would have been well within the grasp of a POSITA and a POSITA would have had a reasonable expectation of success in making the combination. *Id.*, ¶219.

C. Claim 4

[4]: The system of claim 1, wherein the delay is applied to the first intermediate signal, wherein the delay is proportional to a time difference between arrival of the speech at the second physical microphone and arrival of the speech at the first physical microphone

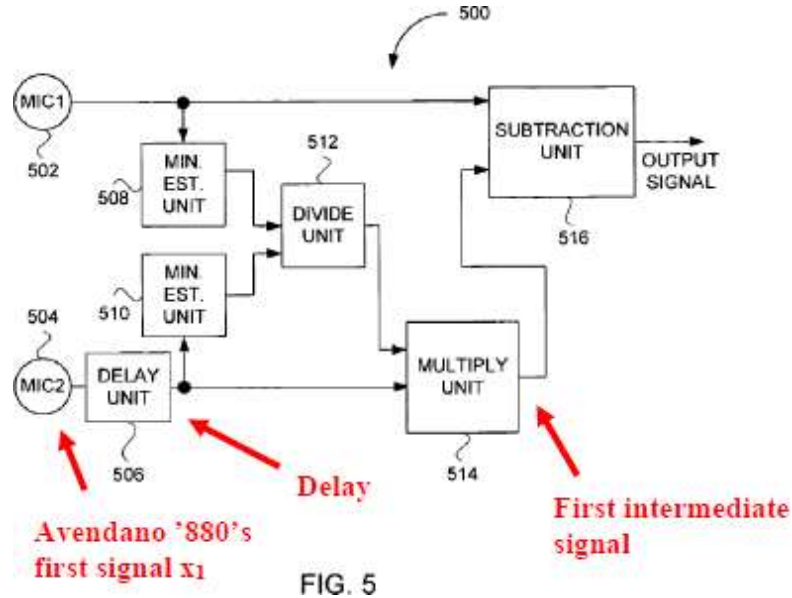
In the combination of Avendano '880 and Hou (and in combination with Avendano '252), the delay is applied to the first intermediate signal, wherein the delay is proportional to a time difference between arrival of the speech at the second physical microphone and arrival of the speech at the first physical microphone. EX. 1003, ¶¶220-234.

In a first example combination of Avendano '880 and Hou, Hou's "divide unit 512" forms a filter (*e.g.*, as a ratio of the first quantity to the second quantity). Sections III(B)-(C); Section III(D), [1b]; EX. 1008, 5:42-45, FIG. 5; EX. 1003, ¶221. This filter is applied to Avendano '880's first signal (*e.g.*, by "multiplication unit 514") to generate a first intermediate signal. Sections III(B)- (C); Section III(D), [1c]; EX. 1008, 5:45-47, FIG. 5; EX. 1003, ¶221.



EX. 1008, FIG. 5

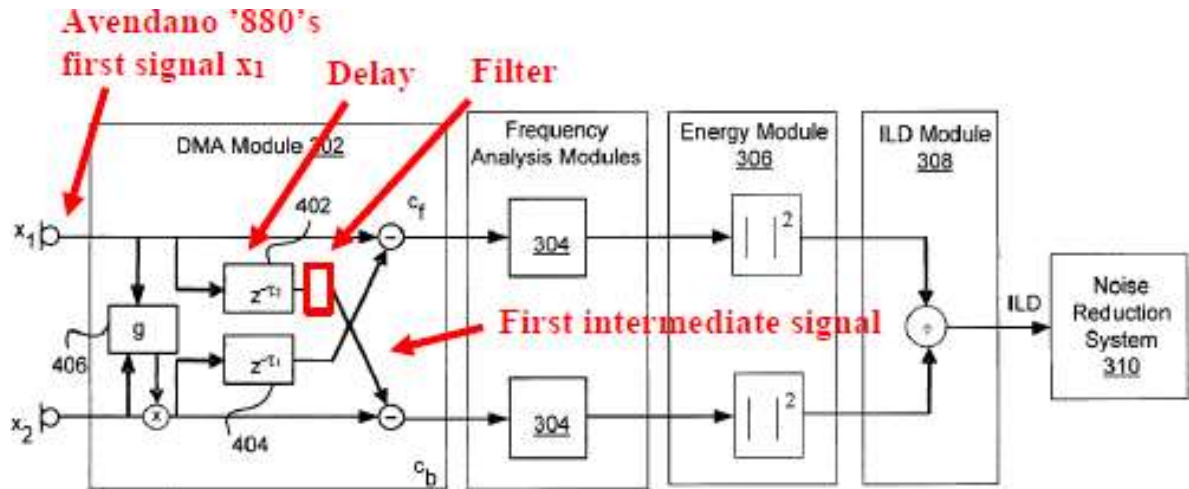
Further, the first intermediate signal includes a delay applied by Hou's "delay unit 506." Sections III(B)-(C), III(D), [1b]; EX. 1008, 5:27-41, FIG. 5; EX. 1003, ¶222.



EX. 1008, FIG. 5

In a second example combination of Avendano '880 and Hou, Hou's "divide unit 512" forms a filter (*e.g.*, as a ratio of the first quantity to the second quantity). Section III(C); Section III(D), [1b]; EX. 1008, 5:42-45, FIG. 5; EX. 1003,

¶223. This filter is applied to Avendano '880's first signal to generate a first intermediate signal. Section III(C); Section III(D), [1c]; EX. 1003, ¶223. Further, the first intermediate signal includes a delay applied by Avendano '880's "delay node 402." Sections III(A)-(C), III(D), [1b]; EX. 1005, 6:15-39, FIG. 4a; EX. 1003, ¶223.



EX. 1005, FIG. 4a (modified)

Accordingly, in both of the example combinations of Avendano '880 and Hou, a delay has been applied to the first intermediate signal. EX. 1003, ¶224.

Further, a POSITA would have found it obvious to configure the delay such that it is proportional to a time difference between arrival of the speech at the second physical microphone and arrival of the speech at the first physical microphone. EX. 1003, ¶¶225-234

As Avendano '880 explains, “due to a space difference between the microphones, the difference in times of arrival of the signals from a speech source to the microphones may be utilized to localize the speech source.” EX. 1005, 1:28-38. Further, “embodiments may use a combination of energy level differences and time delays to discriminate speech.” *Id.*, 3:27-60; EX. 1003, ¶226.

Specifically, like Hou, Avendano '880 describes applying a delay (*e.g.*, using a “delay node 402”) to a signal from a physical microphone, and combining the delayed signal with the signal from another physical microphone to generate a directional virtual microphone (“cardioid secondary signal”) facing the backwards direction. EX. 1005, 6:15-39, FIG. 4a; EX. 1003, ¶227.

A POSITA would have recognized that, to account for the “space difference between the microphones,” the delays would need to be proportional to a time difference between the arrivals of the speech at the first and second physical microphones. EX. 1003, ¶228. For example, a POSITA would have recognized that, if the “space difference between the microphones” were to increase, the delay would likewise proportionally increase to account for the increase in propagation time, and vice versa. *Id.*, ¶228.

To the extent that the combination of Avendano '880 and Hou does not describe that the delay is proportional to a time difference between arrival of the speech at the second physical microphone and arrival of the speech at the first physical microphone,” the combination of Avendano '880, Hou, and Avendano '252 would have rendered this feature obvious. EX. 1003, ¶¶229-234.

As with Avendano '880 and Hou, Avendano '252 describes applying a delay (*e.g.*, using a “delay node 412”) to a signal from a physical microphone, and combining the delayed signal with the signal from another physical microphone to

generate a directional virtual microphone (“backward-facing cardioid pattern”) facing the backwards direction. EX. 1006, 5:17-7:64, FIGS. 4b-5; EX. 1003, ¶231.

Avendano ’252’s directional virtual microphones are generated using “differential arrays.” EX. 1006, 5:17-7:64, FIGS. 4a-5. As Avendano ’252 explains, “[p]attern generation using differential arrays (DA) requires use of fractional delays whose value may depend on a distance between the microphones,” which enables directional virtual microphones to be generated using “two omni-directional microphones” rather than “two cardioid or directional microphones.” *Id.* Specifically, “[f]or sound arriving from a back of the array ($\theta=180$ deg) an output $y_1(t)$ is zero if a delay line 402 introduces a delay equal to an acoustic delay between the primary and secondary microphones 106 and 108. This may be represented by $\tau = d / c$ where c is the speed of sound in air (i.e., 340 m/s).” *Id.* According to this relationship, the delay “ τ ” would be proportional of the time difference between arrival of the speech at the second physical microphone and arrival of the speech at the first physical microphone. EX. 1003, ¶¶232-233.

In view of Avendano ’252, a POSITA would have found it obvious to implement a delay (*e.g.*, Avendano ’880’s delay nodes and/or Hou’s delay unit), such that the delay is proportional to a time difference between arrival of the speech at the second physical microphone and arrival of the speech at the first physical microphone (*e.g.*, to generate directional virtual microphone using “two omni-

directional microphones” rather than “two cardioid or directional microphones”).
EX. 1006, 5:17-7:64, FIGS. 4a-5; EX. 1003, ¶234.

D. Claim 10

[10]: The system of claim 1, wherein the filter is adapted to minimize a second virtual microphone output when only speech is being received by the first physical microphone and the second physical microphone

In the combination of Avendano '880, Hou, and Avendano '252, the filter is adapted to minimize a second virtual microphone output when only speech is being received by the first physical microphone and the second physical microphone. EX. 1003, ¶¶235-242.

In the combination of Avendano '880 and Hou (and in combination with Avendano '252), Hou's “divide unit 512” forms a filter for “compensat[ing] (or correct[ing]) for the relative difference in sensitivity between ... mismatched first and second microphones.” Section III(B)-(C); Section III(D), [1b]; EX. 1008, 5:42-50, FIG. 5; EX. 1003, ¶236.

Avendano '252 teaches that such a filter can be adapted to minimize a second virtual microphone output when only speech is being received by the first physical microphone and the second physical microphone. EX. 1003, ¶¶237-240.

For example, Avendano '252 discloses an “equalization module 412” having a similar signal compensation or correction function as Hou's filter. EX. 1006, 2:17-

28, 6:9-38, 10:1-59, FIG. 5; EX. 1003, ¶238. Specifically, Avendano '252's "equalization module 412 applies an adaptive equalization coefficient determined based on an adaptation control module 502 and an adaptation processor 504" and "is configured to compensate for microphone mismatch post- manufacturing." EX. 1006, 10:1-8.

Further, Avendano '252 discloses that an "adaptation processor 504 is configured to adjust the equalization coefficient such that a desired speech signal is cancelled by a backward-facing cardioid pattern." *Id.*, 10:37-39; EX. 1003, ¶239. Specifically, "[w]hen the adaptation control module 502 indicates there is a desired signal coming from the front/forward direction (i.e., value=1), the adaptation processor 504 adapts the equalization coefficient to essentially cancel the desired signal in order to create a zero or null in that direction." EX. 1006, 10:40-46; *see also id.*, 10:9-36. Accordingly, when only speech is being received by a first physical microphone and a second physical microphone, the output of a secondary virtual microphone (*e.g.*, a backward-facing cardioid pattern) would be minimized due to the "cancel[ation]" of the speech from the output. EX. 1006, 10:37-46; EX. 1003, ¶239.

Further, as Avendano '252 explains, this process is beneficial in adapting "cardioid patterns ... to compensate for microphone mismatch," such as by generating "a null of a backward-facing cardioid pattern to be directed towards a

desired audio source.” EX. 1006, 10:1-8; EX. 1003, ¶240. Further, “[t]he resulting signals from the adaptation may then be utilized in a noise suppression system and/or speech enhancement system.” EX. 1006, 2:63-3:7; EX. 1003, ¶240.

A POSITA would have recognized that Avendano ’252’s “equalization module 412” and Hou’s filter serve a similar purpose (*e.g.*, compensating for a difference in sensitivity between mismatched microphones to generate directional signals). EX. 1006, 6:30-38, 10:1-59, FIGS. 4b-5; EX. 1008, 5:26-6:22, 9:28-41, FIG. 5; EX. 1003, ¶241. Further, a POSITA would have recognized that adapting Hou’s filter to minimize a second virtual microphone output (*e.g.*, a directional signal facing a rear of the device) when only speech is being received by the first physical microphone and the second physical microphone (as taught by Avendano ’252) would improve the performance of a noise suppression system and/or speech enhancement system. EX. 1006, 2:63-3:7; EX. 1003, ¶241. Accordingly, a POSITA would have found it obvious to adapt Hou’s filter to minimize a second virtual microphone output when only speech is being received by the first physical microphone and the second physical microphone. EX. 1003, ¶242.

E. Claim 11

[11]: The system of claim 1, wherein coefficients of the filter are generated during a period when only speech is being received by the first physical microphone and the second physical microphone

In the combination of Avendano '880 and Hou, coefficients of the filter are generated during a period when only speech is being received by the first physical microphone and the second physical microphone. EX. 1003, ¶¶243-250.

In the combination of Avendano '880 and Hou (and in combination with Avendano '252), Hou's "divide unit 512" forms a filter for "compensat[ing] (or correct[ing]) for the relative difference in sensitivity between ... mismatched first and second microphones." Section III(C); Section III(D), [1b]; EX. 1008, 5:42-50, FIG. 5; EX. 1003, ¶244.

Avendano '252 teaches that the coefficients of such a filter can be generated during a period when only speech is being received by the first physical microphone and the second physical microphone. EX. 1003, ¶245.

For example, Avendano '252 discloses an "equalization module 412" having a similar signal compensation or correction function as Hou's filter. EX. 1006, 2:17-28, 6:9-38, 10:1-59, FIG. 5; EX. 1003, ¶246. Specifically, Avendano '252's "equalization module 412 applies an adaptive equalization coefficient determined based on an adaptation control module 502 and an adaptation processor 504" and "is

configured to compensate for microphone mismatch post- manufacturing.” EX. 1006, 10:1-8.

Further, Avendano '252 discloses that the “equalization coefficient” of the “equation module 412” can be selectively adapted or adjusted based on the presence or absence of speech. EX. 1006, 10:9-59, 11:56-61; EX. 1003, ¶247. Specifically, Avendano '252's system includes an “adaptation control module 502 ... configured to operate as a switch to activate the adaptation processor 504, which will adjust the equalization coefficient.” EX. 1005, 10:9-11. This adaption process is “triggered by identifying frames dominated by speech” in two microphones. *Id.*, 10:11-15. As Avendano '252 explains:

The power ratio between the front-facing and back-facing cardioid signals produced by this array may be tracked and used to determine if a signal is active in the forward direction, in which case the adaptive equalization coefficient can be updated. In some embodiments, the equalization coefficient is only adapted for taps with high signal-to-noise ratio (SNR). Thus, the adaptation control module 502 may look for both a signal and proper direction. Adaptation may be performed when the probability that the observed components correspond to speech coming from the desired direction (e.g., from the front direction). In these situations, the adaptation control module 502 may

have a value of one. However, if a weak signal or no signal is being received from the front/forward direction, then the value from the adaption control module 502 may be zero. If adaptation is determined to be required, then the adaptation control module 502 sends instructions to the adaptation processor 504.

Id., 10:20-36.

Further, as Avendano '252 explains, this process is beneficial in adapting “cardioid patterns ... to compensate for microphone mismatch,” such as by generating “a null of a backward-facing cardioid pattern to be directed towards a desired audio source.” EX. 1006, 10:1-8; EX. 1003, ¶248. Further, “[t]he resulting signals from the adaptation may then be utilized in a noise suppression system and/or speech enhancement system.” EX. 1006, 2:63-3:7; EX. 1003, ¶248.

A POSITA would have recognized that Avendano '252's “equalization module 412” and Hou's filter serve a similar purpose (*e.g.*, compensating for a difference in sensitivity between mismatched microphones to generate directional signals). EX. 1006, 6:30-38, 10:1-59, FIGS. 4b-5; EX. 1008, 5:26-6:22, 9:28-41,

FIG. 5; EX. 1003, ¶249. Further, in view of Avendano '252, a POSITA would have recognized that selectively adapting Hou's filter based on the presence or absence of speech would enhance the separation of speech and noise in a directional signal (*e.g.*, a cardioid signal) and improve the performance of a noise suppression

system and/or speech enhancement system. EX. 1006, 10:1-8, 2:63-3:7; EX. 1003, ¶249. Accordingly, a POSITA would have found it obvious to generate the coefficients of Hou’s filter during a period when only speech is being received by the first physical microphone and the second physical microphone, as specifically taught by Avendano ’252. EX. 1003, ¶250.

V. INSTITUTION IS APPROPRIATE HERE

A. Co-Pending Litigation Does Not Warrant Discretionary Denial (*Fintiv*)

The *Fintiv* factors support institution.

1. Factor 1: Stay

On September 23, 2021, PO sued Petitioner for infringement of the ’213 patent in *Jawbone Innovations, LLC v. Google LLC*, No. 6:21-cv-00985 (W.D. Tex.). On February 1, 2023, the case was transferred from the Western District of Texas to the Northern District of California (“NDCA”), *Jawbone Innovations, LLC v. Google LLC*, 3:23-cv-00466 (N.D. Cal.) (“the Litigation”). Ex. 1012. On March 13, 2023, Google filed a motion to stay the Litigation pending *inter partes* reviews. On April 27, 2023, the Court granted Google’s motion to stay, vacating all pending dates and deadlines pending final resolution of Google’s IPR proceedings. Ex. 1013. Thus, this factor weighs against discretionary denial.

2. Factor 2: Proximity to Trial to FWD

The NDCA has not set a trial date. In fact, the Court vacated all dates in the stay order. Thus, this factor weighs against discretionary denial. *Global Tel*Link Corp. v. HLFIP Holding, Inc.*, IPR2021-00444, Paper 14, at 16-19 (P.T.A.B. Jul. 22, 2021) (“The lack of a scheduled trial date...typically weighs against exercising discretion to deny the Petition.”).

3. Factor 3: Investment in Parallel Proceeding

PO filed its complaint on September 23, 2021 and served its infringement contentions on January 13, 2022. Aside from those contentions, the parties have invested little in the Litigation. Fact discovery opened but is now stayed pending IPR. No expert reports have been served.

The NDCA has not established a case schedule. An initial case management conference has not yet taken place in the NDCA due to the Court’s stay order vacating all dates and deadlines, including the date for the initial case management conference. Minimal investment has been made in the case because fact discovery remains in its infancy. Also, the “remaining investment,” including fact discovery and expert discovery, significantly outweighs any investment made thus far, which weighs against discretionary denial. *Samsung Elecs. Am. Inc. v. Snik LLC*, IPR2020-01428, Paper 10, at 11 (P.T.A.B. Mar. 9, 2021); *Huawei Techs. Co. v. WSOU Invs., LLC*, IPR2021-00226, Paper 10, at 13-14 (P.T.A.B. Jun. 10, 2021).

4. Factor 4: Overlapping Issues

If this IPR is instituted, Petitioner cannot pursue in the Litigation any invalidity grounds raised or that could have been reasonably raised in this IPR. *Cal. Inst. of Tech. v. Broadcom Ltd.*, 25 F.4th 976, 991 (Fed. Cir. 2022). Thus, duplicative efforts or conflicting decisions are unlikely.

Petitioner hereby stipulates that, if this Petition is instituted, Petitioner will not pursue the grounds identified in this petition (i.e., Grounds 1 and 2 in the Amazon IPR based on Avendano '880, Avendano '252, and Hou) in district court. Thus, duplicative efforts or conflicting decisions are unlikely. This factor weighs against discretionary denial. *Sand Revolution II, LLC v. Cont'l Intermodal Grp.-Trucking LLC*, IPR2019-01393, Paper 24, at 11-12 (P.T.A.B. Jun. 16, 2020) (informative).

5. Factor 5: The Parties

The parties are the same, but trial in the Litigation will not start before this IPR reaches a final written decision based on the NDCA's stay order pending IPR. Thus, this factor is neutral. *Google LLC v. Jawbone Innovations, LLC*, IPR2022-00630, Paper 10, at 17 (P.T.A.B. Sept. 13, 2022).

6. Factor 6: Other Circumstances

To Petitioner's knowledge, other than Amazon's co-pending IPR petition on the same grounds that Petitioner is seeking to join in its accompanying motion for joinder, the '213 patent has never been compared to this combination of references

by the PTO, any court, or any jury. Despite this, PO has asserted the '213 patent against Petitioner and nine other defendants, including Apple, Amazon.com, Meta Platforms, ZTE, Panasonic Holdings, Guangdong Oppo Mobile Telecommunications, LG Electronics, HTC, and Sony Electronics. Given the Amazon's co-pending IPR petition has been instituted and placed the patentability of claims 1-13 of the '213 patent at issue, the Board should institute review to resolve the cloud over these claims.

The petition's merits are particularly strong, as the Board recognized by instituting Amazon's co-pending IPR petition (which this petition copies). This strongly favors institution. *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11, at 18.

Accordingly, the *Fintiv* analysis favors institution.

B. Google's Previously Filed IPR Petition Does Not Warrant Discretionary Denial (*General Plastic*)

As explained in Petitioner's accompanying motion for joinder, the *General Plastic* factors on balance weigh in favor of institution and joinder with the Amazon IPR. While Google previously challenged the '213 patent, this case is distinguishable from *Apple Inc. v. Uniloc 2017 LLC*, IPR2020-00854, Paper 9 (P.T.A.B. Oct. 28, 2020) (precedential), because Google received Patent Owner's preliminary response and the Board's decision denying its first petition after Apple's

petition that Amazon copied in the Amazon IPR was filed. Google therefore could not have engaged in improper road-mapping. Google was also time-barred just weeks after Apple's petition was filed. Because Google could not file another petition until Amazon's IPR was instituted, it was reasonable for Google to wait to file this joinder petition. Google's joinder petition will also not affect the current Amazon IPR schedule or additionally burden Patent Owner or the Board.

1. Factors 1-3: Same Petitioner, Knowledge of Art, Road-Mapping

Factors 1-3 seek to preclude a joinder petitioner from using a prior Board decision or preliminary response as a "roadmap" to cure deficiencies in a second filed petition. *Code200, UAB v. Bright Data Ltd.*, IPR2022-00861, Paper 18, at 5 (P.T.A.B. Aug. 23, 2022) ("*Code200*") (precedential). When "the later petition is not refined based on lessons learned from later developments," road-mapping concerns are "minimized." *Id.*; *Cisco Sys., Inc. v. Centripetal Networks, Inc.*, IPR2022-01151, Paper 12 at 48 (P.T.A.B. Jan. 4, 2023) ("*Cisco*").

Google previously filed a petition challenging claims 1-13 of the '213 patent that was denied based on claim construction. *Google LLC v. Jawbone Innovations, LLC*, IPR2022-00888, Paper 12 (P.T.A.B. Nov. 28, 2022). This Petition does not map any prior Board decision or Patent Owner paper. Google instead seeks to join an already-instituted case, without altering the instituted grounds or evidence. *Intel*

Corp. v. VLSI Tech. LLC, IPR2022-00479, Paper 13 at 8-11 (P.T.A.B. Jun. 6, 2022) (“*Intel*”) (“[W]e do not agree that roadmapping affects our decision here. The [instituted] IPR presents challenges that are nearly identical to Intel’s initial petition, and Intel’s current petition follows them in step.”); *Cisco* at 51-52 (“[C]opying a previously instituted petition is common in the joinder context and an accepted approach” and favors institution under factor 3) (citations and internal quotations omitted).

Google could not have road-mapped any prior paper by this Petition. The Petition is a copy of an Amazon petition that, in turn, is a copy of an Apple petition filed on September 2, 2022. *Apple Inc. v. Jawbone Innovations, LLC*, IPR2022-01494, Paper 2 (P.T.A.B. Sept. 2, 2022). The Apple petition was filed before Patent Owner’s preliminary response to Google’s first petition (September 9, 2022) and before the Board’s subsequent denial of institution (November 11, 2022). *See Google*, IPR2022-00888, Paper 6 (P.T.A.B. Sept. 9, 2022); *Google*, IPR2022-00888, Paper 12 (P.T.A.B. Nov. 11, 2022). With no papers available when Apple filed its petition, there was nothing to map. The Board in *Google LLC v. Express Mobile, Inc.* granted joinder under similar circumstances for a petitioner whose first petition was denied on the merits, finding that “[a]lthough Petitioner might, in the end, benefit from the filing of [another party’s] IPR, there is no reason to conclude that Petitioner used the filings or decision . . . to obtain an unfair advantage in this

[joinder] [p]etition, which was essentially prepared by someone else.”). IPR2022-00790, Paper 15 at 8 (P.T.A.B. Sept. 27, 2022) (“*Express Mobile*”).

Google similarly has not “strategically stage[d] [its] prior art and arguments in multiple petitions” to gain an unfair advantage over Patent Owner. *General Plastic Indus. Co. v. Canon Kabushiki Kaisha*, IPR2016-01357, Paper 19, at 17 (P.T.A.B. Sept. 6, 2017) (“*General Plastic*”). Google is not a real party in interest in either the Apple or Amazon petition. While Google was aware the prior art asserted in Apple’s petition, none of that art overlaps with Google’s first petition.

It was reasonable for Google to wait until Apple’s petition was instituted before seeking joinder in that case. Apple settled before institution, *Apple Inc. v. Jawbone Innovations, LLC*, IPR2022-01494, Paper 8 (P.T.A.B. Jan. 10, 2023), so Google had no opportunity to seek joinder in that proceeding during the appropriate joinder window, *see* 35 U.S.C. § 315(c); 37 C.F.R. § 42.122(b). Google was instead obligated to wait until Amazon’s copycat petition was instituted. *Express Mobile* at 10 (“After [petitioner’s first] IPR was denied, [p]etitioner was unable to file this [joinder] [p]etition until the Facebook IPR was instituted, and then did so within the time provided by our rules”) (citing 37 C.F.R. § 42.122(b); 35 U.S.C. § 315(d)). Like the situation in *Express Mobile*, Google was time-barred from filing a petition just after Apple’s petition was filed, and Google’s delay was not gamesmanship or strategic staging of prior art but the reality that Google could not be granted joinder

absent institution in the Apple (and then Amazon) proceeding. *Id.* at 10-11 (“[I]t was not unreasonable for Petitioner to not have filed an IPR using Anderson before the bar date because Petitioner had another petition pending, and [] it was not unreasonable for Petitioner to not file between the bar date and the institution of the Facebook IPR because such a filing would have been prohibited by § 315(b).”).

Because Google has not road-mapped any prior Board decision or Patent Owner paper, and because Patent Owner would not be prejudiced by Google seeking solely to maintain the one *inter partes* proceeding against claims 1-13 of the ’213 patent, the Board should find these factors, taken together, do not weigh in favor of exercising discretion to deny institution. *Express Mobile* at 7-9.

This case also stands apart because Google is not filing multiple, subsequent petitions from lessons learned, or piling on to multiple IPR challenges to the same patent. Google instead is seeking to join the Amazon IPR to ensure the existing proceeding reaches a final written decision. This adds no additional burden to Patent Owner and requires no additional resources from the Board. *Express Mobile* at 9 (“This ‘me too’ Petition is not a new ‘serial attack,’ but rather an attempt to join a proceeding that has already been instituted.”)

2. Factors 4 and 5: Length of Time and Explanation

The Board considers *General Plastic* factors 4 (length of time from knowledge of art) and factor 5 (explanation for time between petitions) “to assess

and weigh whether a petitioner should have or could have raised the new challenges earlier.” *Intel* at 11 (quoting *General Plastic* at 18). As explained above, and like the case in *Express Mobile*, it was reasonable for Google to wait and seek joinder until after the Amazon IPR was instituted because Google could not join the proceeding before institution.

It was also reasonable for Google to file its joinder petition and seek to maintain the Amazon IPR based on the institution decision in Google’s first petition. In Google’s first petition, the Board denied institution on a claim construction issue that arose after the petition was filed. *Google*, IPR2022-00888, Paper 12 at 30 (“For forming the ‘first virtual microphone’ and the ‘second virtual microphone’ claim 1 recites three different signals.”). This claim interpretation arose at institution (November 28, 2022), after Apple’s petition was filed (September 2, 2022) and after Google was time-barred. *See General Plastic* at 10-11. Once institution was denied, Google reasonably waited until it could join Apple’s petition (e.g., when the Amazon IPR was instituted). *Express Mobile* at 10-11 (“it was not unreasonable for Petitioner to not file between the bar date and the institution of the Facebook IPR”). Google did not unnecessarily delay its joinder petition and it was “not unreasonable” not to have filed a separate IPR with the art from the Amazon IPR because Google’s first petition “was then pending.” *Express Mobile* at 10.

3. Factors 6 and 7: Finite Resources and One-Year Deadline

Factor 6 (finite resources) and Factor 7 (one-year deadline) weigh in favor of institution because this Petition introduces no new issues that are not already in the Amazon IPR and no changes to the existing schedule. As the Board found in *Intel*, “instituting this Petition will [not] significantly affect the resources of the Board or our ability to issue a final determination within the one-year statutory timeline.” *Intel* at 14. The Board should permit joinder because it already “found the challenges reasonably likely to be successful” and it will “continue expending resources to decide the merits of the [petition] regardless of joinder.” *Id.*

The Director in *Code200* moreover found that “the one year statutory time period may be adjusted for a joined case under 35 U.S.C. § 316(a)(11),” if necessary, and the “the Board’s mission ‘to improve patent quality and restore confidence in the presumption of validity that comes with issued patents’” favors resolving a pending IPR petition. *Code200* at 6. Google seeks to join the Amazon IPR as an understudy to ensure the case reaches a final written decision. This will not unduly burden the Board or Patent Owner. *Ericsson Inc. v. Uniloc 2017 LLC*, IPR2020-00376, Paper 16 at 13 (P.T.A.B. May 22, 2020) (“Given the conditions of joinder agreed to by Petitioner, we see no substantial burden, if any, to Patent Owner to join Petitioner to [the instituted IPR]”); *Express Mobile* at 12 (same).

C. DISCRETIONARY DENIAL UNDER §325(D) IS NOT APPROPRIATE.

The Board may deny institution if the Office previously considered “the same or substantially the same prior art or arguments.” 35 U.S.C. §325(d). Here, all grounds rely on Avendano ’880, Avendano ’252, and Hou all of which the PTO never considered during original examination of the ’213 patent.

Further, though this petition presents the same grounds as the petition filed by Amazon (IPR2023-00279), Petitioner is filing this petition to preserve its ability to maintain an IPR on the merits in the event that Amazon terminates its involvement. If Amazon does not terminate and Petitioner is joined to the Amazon IPR, Petitioner will take an understudy role in the Amazon IPR. Thus, the proposed grounds will not be cumulative of references previously considered by the Board.

VI. MANDATORY NOTICES UNDER 37 C.F.R § 42.8(A)(1)

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

Google LLC is the real party-in-interest for this petition.⁴

⁴ Google LLC is a subsidiary of XXVI Holdings Inc., which is a subsidiary of Alphabet Inc. XXVI Holdings Inc. and Alphabet Inc. are not real parties in interest to this proceeding.

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

To the best knowledge of Petitioner, the '213 patent is or has been involved in the following district court litigations and petitions for *inter partes* review:

Name	Number	Court	Filed
<i>Jawbone Innovations, LLC v. Amazon.com, Inc.</i>	5:22-cv-06727	N.D. Cal.	Nov. 29, 2021 (transferred from E.D. Tex. on Nov. 1, 2022)
<i>Jawbone Innovations, LLC v. Amazon.com, Inc.</i>	2:21-cv-00435	E.D. Tex.	Nov. 29, 2021
<i>Jawbone Innovations, LLC v. Apple Inc.</i>	6:21-cv-00984	W.D. Tex.	Sept. 23, 2021
<i>Jawbone Innovations, LLC v. Google LLC</i>	6:21-cv-00985	W.D. Tex.	Sept. 23, 2021
Petition for <i>Inter Partes</i> Review	IPR2022-00797	PTAB	April 7, 2022
Petition for <i>Inter Partes</i> Review	IPR2022-00888	PTAB	May 20, 2022
Petition for <i>Inter Partes</i> Review	IPR2022-01084	PTAB	June 3, 2022
Petition for <i>Inter Partes</i> Review	IPR2022-01494	PTAB	Sept. 2, 2022
<i>Jawbone Innovations, LLC v. Amazon.com, Inc.</i>	3-22-cv-06727	N.D. Cal.	Nov. 1, 2022

Name	Number	Court	Filed
Petition for <i>Inter Partes</i> Review	IPR2023-00279	PTAB	Nov. 28, 2022
Petition for <i>Inter Partes</i> Review	IPR2023-00276	PTAB	Nov. 28, 2022
<i>Jawbone Innovations, LLC v. Google LLC</i>	3-23-cv-00466	N.D. Cal.	Feb. 1, 2023
<i>Jawbone Innovations, LLC v. Meta Platforms, Inc. d/b/a Meta</i>	6-23-cv-00158	W.D. Tex.	Feb. 28, 2023
<i>Jawbone Innovations, LLC v. ZTE Corp.</i>	2-23-cv-00082	E.D. Tex.	Feb. 28, 2023
<i>Jawbone Innovations, LLC v. Panasonic Holdings Corp.</i>	2-23-cv-00081	E.D. Tex.	Feb. 28, 2023
<i>Jawbone Innovations, LLC v. Guangdong Oppo Mobile Telecomm.</i>	2-23-cv-00079	E.D. Tex.	Feb. 28, 2023
<i>Jawbone Innovations, LLC v. LG Elecs., Inc.</i>	2-23-cv-00078	E.D. Tex.	Feb. 28, 2023
<i>Jawbone Innovations, LLC v. HTC Corp.</i>	2-23-cv-00077	E.D. Tex.	Feb. 28, 2023
<i>Jawbone Innovations, LLC v. Sony Elecs., Inc.</i>	2-23-cv-01161	D.N.J.	Feb. 28, 2023

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

Petitioner provides the following designation of counsel.

Lead Counsel	Back-Up Counsel
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D. Service Information

Please address all correspondence to lead and back-up counsel at the addresses shown above and Google-v-Jawbone-IPRs@finnegan.com.

Petitioner also consents to electronic service by e-mail.

VII. Conclusion

Petitioner has established a reasonable likelihood of prevailing with respect to the challenged claims and requests the Board institute *inter partes* review and cancel each challenged claim as unpatentable.

Date: June 23, 2023

Respectfully submitted,

/Erika H. Arner/

Erika H. Arner, Lead Counsel
Reg. No. 57,540

CERTIFICATE OF COMPLIANCE

The undersigned hereby certifies that the foregoing **Petition for *Inter Partes* Review** contains 13,881 words, excluding those portions identified in 37 C.F.R. § 42.24(a), as measured by the word-processing system used to prepare this paper.

/Erika H. Arner/

Erika H. Arner, Lead Counsel

Reg. No. 57,540

CERTIFICATE OF SERVICE

The undersigned certifies that the foregoing **Petition for *Inter Partes* Review** was served on June 23, 2023, by FedEx Priority Overnight on the following address of record for the subject patent. The associated **Exhibits 1001 through 1013** and the **Power of Attorney** were also served on June 23, 2023.

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